

Development of Predictive Models for Migratory Landbirds and Estimation of Cumulative Effects of Human Development in the Oil Sands Areas of Alberta

Project Name:

Joint Oil Sands Monitoring: Cause-Effects Assessment of Oil Sands Activity on
Migratory Landbirds

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5.67	Western Tanager (<i>Piranga ludoviciana</i>)	718
5.68	Western Wood Pewee (<i>Contopus sordidulus</i>)	728
5.69	White-breasted Nuthatch (<i>Sitta carolinensis</i>)	738
5.70	White-crowned Sparrow (<i>Zonotrichia leucophrys</i>)	748
5.71	White-throated Sparrow (<i>Zonotrichia albicollis</i>)	758
5.72	White-winged Crossbill (<i>Loxia leucoptera</i>)	768
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Executive Summary

We used the most extensive standardized point count data collected and compiled by the Boreal Avian Modelling Project (BAM), Environment Canada (EC), the Alberta Biodiversity Monitoring Institute (ABMI), and the North American Breeding Bird Survey (BBS) was combined with geospatial information to build predictive models for bird species. We described the habitat associations and responses to human footprint at different spatial scales (local and quarter-section) for 77 Passerine breeding birds. We created province wide predictive maps, assessed model performance and prediction uncertainty. We determined changes in suitable habitats for bird populations in the Boreal region of Alberta in general, and specifically in the oil sands region based on current and “backfilled” habitat data. We found that species showing largest expected changes in their suitable habitats are either associated with habitats created more frequently by anthropogenic disturbances in the landscape, or species whose habitats are most often affected by disturbances related to various forms of resource extraction in the oil sands region. We compare estimated population sizes for birds within Boreal Alberta and compare these to existing estimates by Partners in Flight. We found that our estimates were on average 6 times higher than the estimates provided by Partners in Flight for the same area. We compared the different assumptions inherent in the estimators and found that the bias related to the use of roadside surveys (from BBS) affected species specific population size estimates in different ways, while the effect of the assumption regarding the effective area sampled during surveys accounted for most of the bias consistently across the 77 species.

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Chapter 1

Introduction

The Boreal Avian Modelling Project (BAM), Environment Canada (EC), and the Alberta Biodiversity Monitoring Institute (ABMI) collaborated under the Joint Oil Sands Monitoring (JOSM) on using the most extensive standardized point count data collected and compiled by these agencies (BAM, EC, ABMI) and the North American Breeding Bird Survey (BBS) program. The avian data set was combined with available geospatial information to build predictive models for bird species. Objectives

1.1 Objectives

The models were used to (1) describe the habitat associations of the bird species and their responses to human footprint at different spatial scales; (2) determine change in suitable habitats for bird populations in the Boreal region of Alberta in general, and specifically in the oil sands region based on current and “backfilled” habitat data; (3) compare estimated population sizes for birds within Boreal Alberta and compare these to existing estimates by Partners in Flight.

Chapter 2

Methods

2.1 Point counts

The point count data set included a total of 51023 surveys taken at 21043 locations between 1993 and 2013. When multiple point count surveys were replicated at the same location more than once within a year, we retained a single randomly chosen from the revisits. Replicates collected in different years were kept in the data set.

The data were contributed by ABMI (5833 surveys from 5130 location), BAM (16491 surveys from 9259 locations), BBS (25084 surveys from 3039 locations), and EC (3615 surveys from 3615 locations).

We used counts of 77 species that had at least 25 detections and had available estimates for singing rates and effective detection radii (Table 2.1; according to Sólomos et al. 2013).

Table 2.1: List of species used in this report. AOU codes are used to refer to species in figures and tables.

AOU codes	Common name	Scientific name
ALFL	Alder Flycatcher	<i>Empidonax alnorum</i>
AMCR	American Crow	<i>Corvus brachyrhynchos</i>
AMGO	American Goldfinch	<i>Spinus tristis</i>
AMRE	American Redstart	<i>Setophaga ruticilla</i>
AMRO	American Robin	<i>Turdus migratorius</i>
BBWA	Bay-breasted Warbler	<i>Setophaga castanea</i>
BCCH	Black-capped Chickadee	<i>Poecile atricapillus</i>
BTNW	Black-throated Green Warbler	<i>Setophaga virens</i>
BAWW	Black and White Warbler	<i>Mniotilta varia</i>
BLPW	Blackpoll Warbler	<i>Setophaga striata</i>
BHVI	Blue-headed (Solitary) Vireo	<i>Vireo solitarius</i>
BLJA	Blue Jay	<i>Cyanocitta cristata</i>
BOCH	Boreal Chickadee	<i>Poecile hudsonicus</i>
BHCO	Brown-headed Cowbird	<i>Molothrus ater</i>
BRCR	Brown Creeper	<i>Certhia americana</i>
CAWA	Canada Warbler	<i>Cardellina canadensis</i>
CMWA	Cape May Warbler	<i>Setophaga tigrina</i>
CEDW	Cedar Waxwing	<i>Bombycilla cedrorum</i>

Table 2.1: (continued)

AOU codes	Common name	Scientific name
CSWA	Chestnut-sided Warbler	<i>Setophaga pensylvanica</i>
CHSP	Chipping Sparrow	<i>Spizella passerina</i>
CCSP	Clay-colored Sparrow	<i>Spizella pallida</i>
COGR	Common Grackle	<i>Quiscalus quiscula</i>
CORA	Common Raven	<i>Corvus corax</i>
COYE	Common Yellowthroat	<i>Geothlypis trichas</i>
CONW	Connecticut Warbler	<i>Oporornis agilis</i>
DEJU	Dark-eyed Junco	<i>Junco hyemalis</i>
EAPH	Eastern Phoebe	<i>Sayornis phoebe</i>
EVGR	Evening Grosbeak	<i>Coccothraustes vespertinus</i>
FOSP	Fox Sparrow	<i>Passerella iliaca</i>
GCKI	Golden-crowned Kinglet	<i>Regulus satrapa</i>
GRAJ	Gray Jay	<i>Perisoreus canadensis</i>
HETH	Hermit Thrush	<i>Catharus guttatus</i>
HOLA	Horned Lark	<i>Eremophila alpestris</i>
HOWR	House Wren	<i>Troglodytes aedon</i>
LCSP	Le Conte's Sparrow	<i>Ammodramus leconteii</i>
LEFL	Least Flycatcher	<i>Empidonax minimus</i>
LISP	Lincoln's Sparrow	<i>Melospiza lincolnii</i>
MAWA	Magnolia Warbler	<i>Setophaga magnolia</i>
MAWR	Marsh Wren	<i>Cistothorus palustris</i>
MOWA	Mourning Warbler	<i>Geothlypis philadelphia</i>

Table 2.1: (continued)

AOU codes	Common name	Scientific name
NOWA	Northern Waterthrush	<i>Parkesia noveboracensis</i>
OSFL	Olive-sided Flycatcher	<i>Contopus cooperi</i>
OCWA	Orange-crowned Warbler	<i>Oreothlypis celata</i>
OVEN	Ovenbird	<i>Seiurus aurocapilla</i>
PAWA	Palm Warbler	<i>Setophaga palmarum</i>
PHVI	Philadelphia Vireo	<i>Vireo philadelphicus</i>
PIGR	Pine Grosbeak	<i>Pinicola enucleator</i>
PISI	Pine Siskin	<i>Spinus pinus</i>
PUFI	Purple Finch	<i>Carpodacus purpureus</i>
RBNU	Red-breasted Nuthatch	<i>Sitta canadensis</i>
REVI	Red-eyed Vireo	<i>Vireo olivaceus</i>
RWBL	Red-winged Blackbird	<i>Agelaius phoeniceus</i>
RECR	Red Crossbill	<i>Loxia curvirostra</i>
RBGR	Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>
RCKI	Ruby-crowned Kinglet	<i>Regulus calendula</i>
RUBL	Rusty Blackbird	<i>Euphagus carolinus</i>
SAVS	Savannah Sparrow	<i>Passerculus sandwichensis</i>
SOSP	Song Sparrow	<i>Melospiza melodia</i>
SWTH	Swainson's Thrush	<i>Catharus ustulatus</i>
SWSP	Swamp Sparrow	<i>Melospiza georgiana</i>
TEWA	Tennessee Warbler	<i>Oreothlypis peregrina</i>
TRES	Tree Swallow	<i>Tachycineta bicolor</i>
VATH	Varied Thrush	<i>Ixoreus naevius</i>
VEER	Veery	<i>Catharus fuscescens</i>
VESP	Vesper Sparrow	<i>Poocetes gramineus</i>
WAVI	Warbling Vireo	<i>Vireo gilvus</i>
WETA	Western Tanager	<i>Piranga ludoviciana</i>
WEWP	Western Wood Pewee	<i>Contopus sordidulus</i>
WBNU	White-breasted Nuthatch	<i>Sitta carolinensis</i>
WCSP	White-crowned Sparrow	<i>Zonotrichia leucophrys</i>
WTSP	White-throated Sparrow	<i>Zonotrichia albicollis</i>
WWCR	White-winged Crossbill	<i>Loxia leucoptera</i>
WIWA	Wilson's Warbler	<i>Cardellina pusilla</i>
WIWR	Winter Wren	<i>Troglodytes hiemalis</i>
YBFL	Yellow-bellied Flycatcher	<i>Empidonax flaviventris</i>
YRWA	Yellow-rumped Warbler	<i>Setophaga coronata</i>
YWAR	Yellow Warbler	<i>Setophaga petechia</i>

2.2 Geospatial information

2.2.1 Land cover

We used a composite wall-to-wall land cover map of Alberta developed by ABMI to characterize vegetation at sampling location and within spatial units (quarter-sections) used for prediction. The wall-to-wall vegetation map (Alberta Biodiversity Monitoring Institute, 2013b) was used with footprint classes removed to create the “backfilled” vegetation layer (Alberta Biodiversity Monitoring Institute, 2014). The wall-to-wall human footprint map (Alberta Biodiversity Monitoring Institute, 2013a) was merged with the backfilled map in the end (see Figure 2.1 for an example of this process). The “backfilled” layer was also combined with other sources of information to better describe habitat conditions, i.e. percent pine and forest age from Alberta AVI, wetness information from various sources ((for full description see Alberta Biodiversity Monitoring Institute, 2014)).

Areas of land cover types in the “backfilled” (reference) and current vegetation+footprint maps are listed in Table2.2. We refer to these products as *reference* and *current* maps, respectively. The *reference vegetation* map describes the vegetation that would have been present in the study area if there was no human footprint (updated to the year 2010). This backfilled reference vegetation map incorporates information about fires, describes the ages of natural vegetation for 2010 conditions, and projects ages of the backfilled polygons (areas where human footprint currently exists) for 2010 conditions. This *current vegetation* map describes the vegetation and human footprint that currently exists within the OSA (updated to the year 2010).

Land cover classes were grouped into major units as in listed Table2.2 and shown in Figure 2.4. Human footprint types were also grouped into classes (Figure 2.2) which were further combined into larger units (Figure 2.3). See Subsection 2.3.1 for a complete list of land cover (vegetation and footprint) classes used in modeling.

Table 2.2: Area (km²) of land cover types in the JOSM study area. XCLUDE = habitat classes considered as non-habitat.

Land cover	Habitat class	Current area	Reference area
Barren	XCLUDE	85.219	87.508
Grass	Grass	2206.511	4908.855
Shrub	Shrub	4143.361	5474.584
Water	XCLUDE	12178.854	12247.206
Wet	Wet	13022.967	13212.799
Pine1	PineA	2202.103	2269.562
Pine2	PineB	6408.952	6482.376
Pine3	PineC	608.142	649.197
Pine4	PineC	3805.639	4093.004
Pine5	PineD	2267.157	2431.427
Pine6	PineD	745.562	797.642
Pine7	PineD	265.335	325.379
Pine8	PineD	97.793	114.003
Pine9	PineD	35.690	41.021
Pine10	PineD	3.705	4.692
Conif1	ConifA	2410.078	2739.966

Table 2.2: *(continued)*

Land cover	Habitat class	Current area	Reference area
Conif2	ConifB	1847.369	2056.686
Conif3	ConifC	460.688	574.463
Conif4	ConifC	2965.496	3387.916
Conif5	ConifD	1566.800	1863.151
Conif6	ConifD	1161.257	1415.226
Conif7	ConifD	1118.728	1350.528
Conif8	ConifD	928.306	1084.722
Conif9	ConifD	435.651	500.512
Conif10	ConifD	87.708	105.750
Mixed1	MixedA	233.740	318.084
Mixed2	MixedB	309.687	356.548
Mixed3	MixedC	208.943	249.324
Mixed4	MixedD	1945.569	2331.986
Mixed5	MixedD	1083.555	1292.229
Mixed6	MixedD	721.802	862.459
Mixed7	MixedD	570.210	654.388
Mixed8	MixedD	318.672	358.636
Mixed9	MixedD	110.969	123.455
Mixed10	MixedD	28.504	31.462
Decid1	DecidA	545.948	838.212
Decid2	DecidB	1812.926	2346.089
Decid3	DecidC	2958.608	3876.450
Decid4	DecidD	12546.722	16163.438
Decid5	DecidD	6307.264	8411.957

Table 2.2: *(continued)*

Land cover	Habitat class	Current area	Reference area
Decid6	DecidD	2246.179	2984.289
Decid7	DecidD	1087.649	1364.258
Decid8	DecidD	500.582	625.735
Decid9	DecidD	130.494	169.677
Decid10	DecidD	57.567	73.628
WetConif1	WetConifA	4245.020	4402.808
WetConif2	WetConifB	4355.618	4483.046
WetConif3	WetConifC	2875.715	2995.017
WetConif4	WetConifC	16020.763	16672.844
WetConif5	WetConifD	11908.767	12349.239
WetConif6	WetConifD	7417.531	7724.565
WetConif7	WetConifD	3133.587	3288.366
WetConif8	WetConifD	1370.206	1462.088
WetConif9	WetConifD	442.411	477.919
WetConif10	WetConifD	187.022	200.573
Cult	Cult	10144.156	0.000
HWater	HWater	1.883	0.000
UrbInd	UrbInd	1814.225	0.000
HardLin	HardLin	242.582	0.000
SoftLin	SoftLin	2462.876	0.000
HFor	HFor	4170.713	0.000

2.2.2 Climate

We used mean annual temperature (MAT), mean annual precipitation (MAP), potential evapotranspiration (PET), and climate moisture deficit (CMD) to account for spatial trends in abundance. Climate variables were derived bioclimatic variables calculated at a 4-km resolution using monthly climate normals of temperature and precipitation averaged over 1961–1990. The monthly climate normals are based on instrument-measured climate data that were interpolated by PRISM (Daly et al., 2002) and WorldClim (Hijmans et al., 2005). The western North American portion of these data are described by (Wang et al., 2011). These variables were used at 500 m resolution in all analyses and predictions. The spatial variation in these climate variables in Alberta is shown in Figure 2.5.

2.3 Modeling

Count model We used Poisson generalized linear models with a log link. The response variable was the total number of species j counted per survey i (y_{ij} , $i = 1, \dots, n$, $j = 1, \dots, m$).

Variable selection We applied ‘branching’ forward stepwise variable selection to minimize bias in predictions. The ‘branching’ process was applied instead of a simple add-one type of variable search in order to minimize model misspecification due to co-linearity is some of

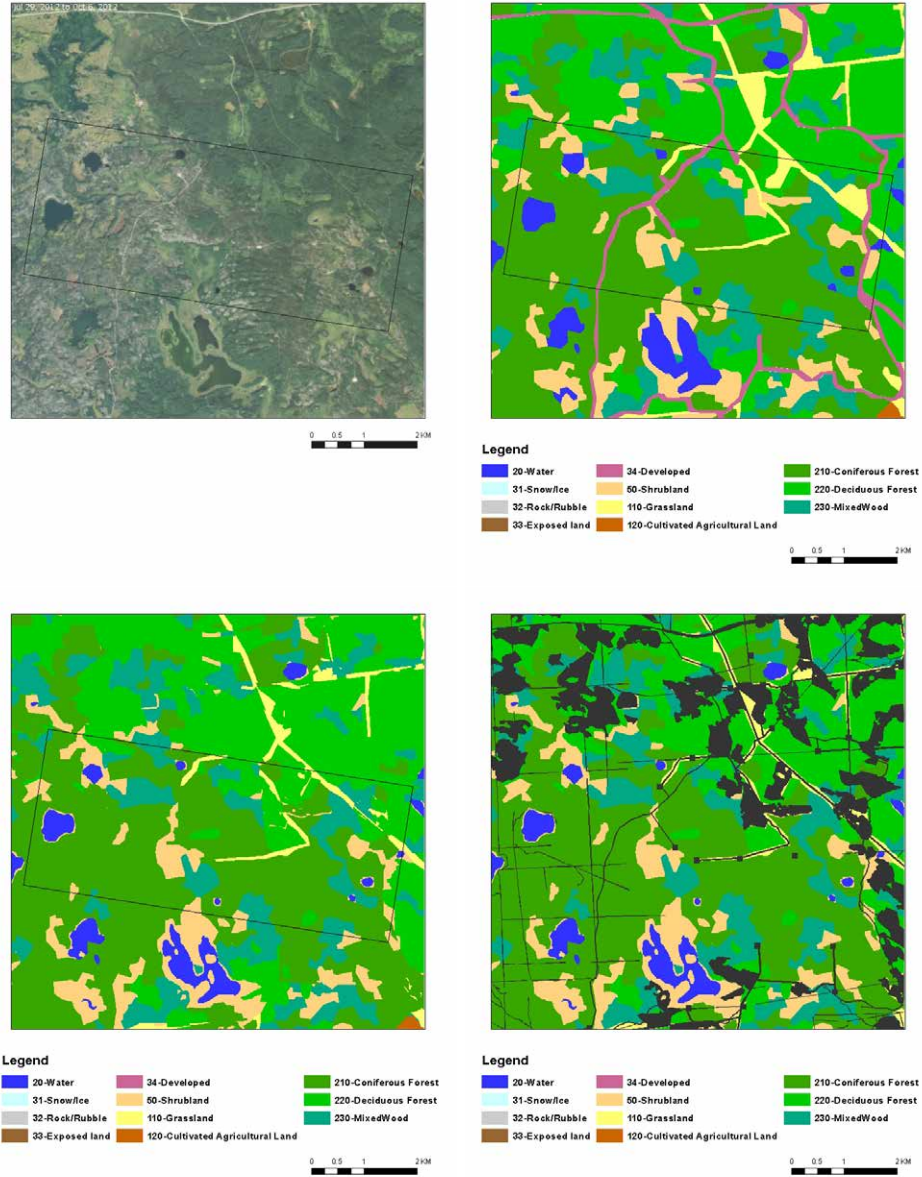


Figure 2.1: Example of vegetation and footprint information used in the modeling (around ABMI site 792). Top left insert shows an air photo of the area; top right insert is the wall-to-wall land cover map; bottom left insert shows the “backfilled” vegetation map with footprint present in the original land cover interpretation removed; bottom right insert shows the “backfilled” vegetation map with ABMI’s human footprint layer on top.

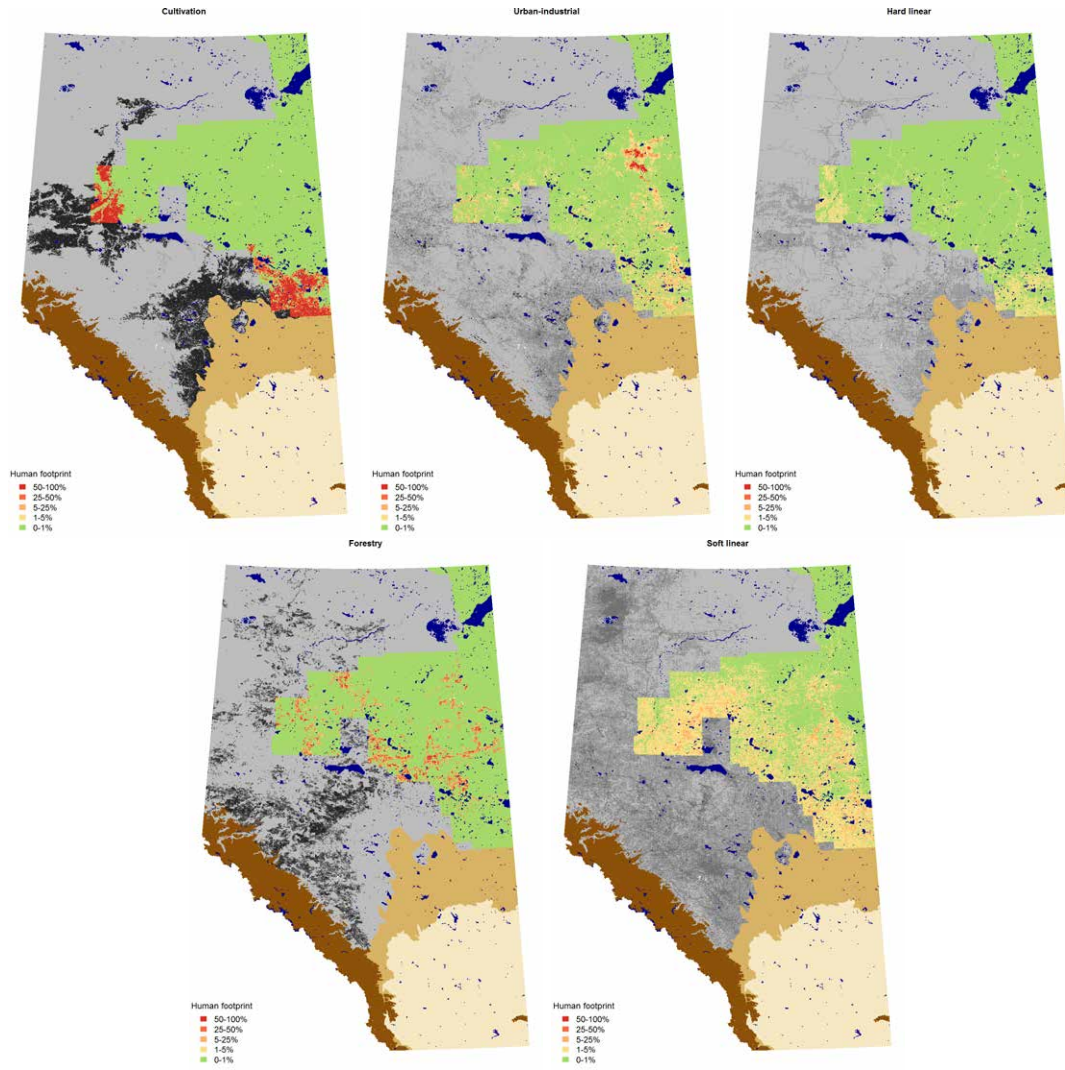


Figure 2.2: Map of standard human footprint types used in modeling.

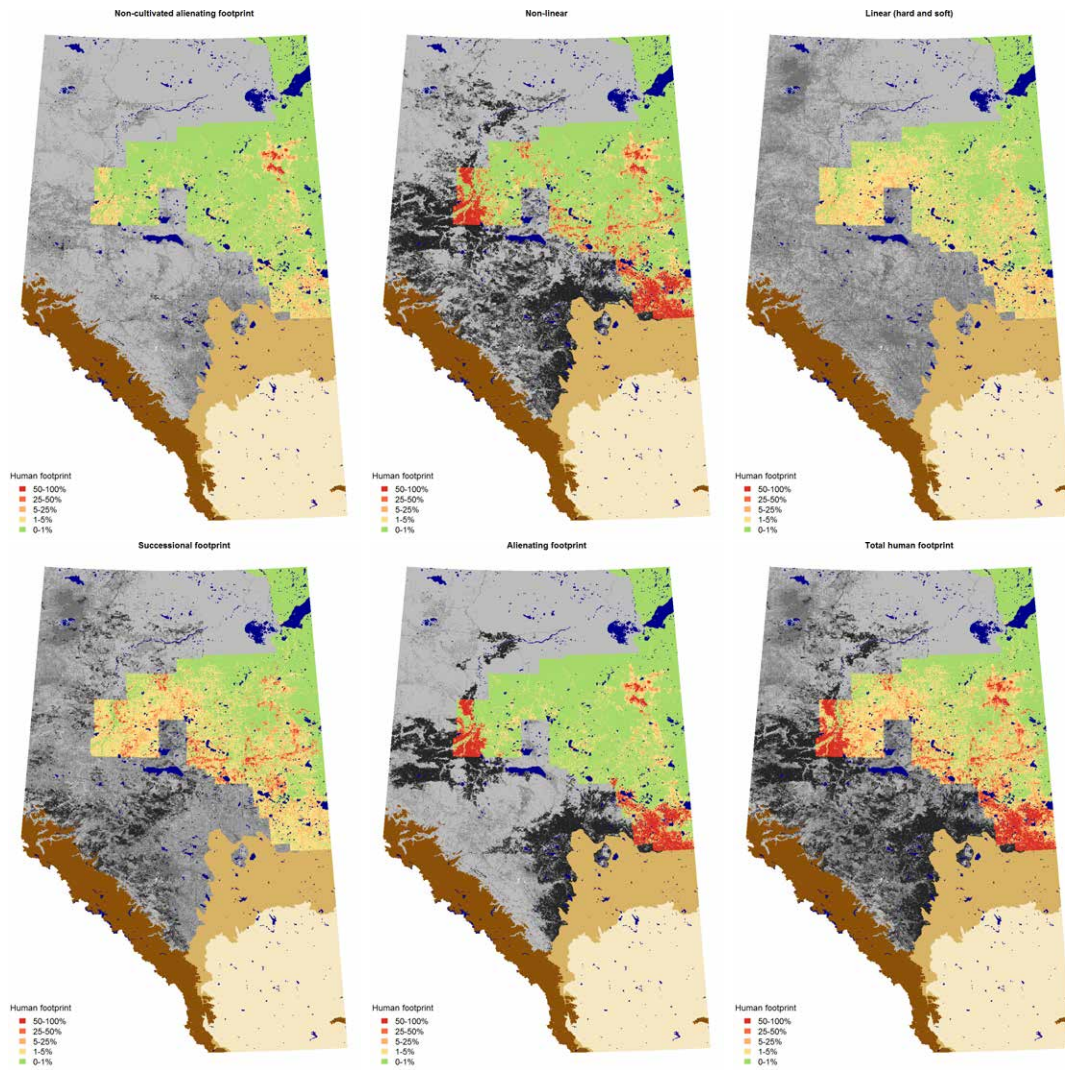


Figure 2.3: Map of combined human footprint types used in modeling.

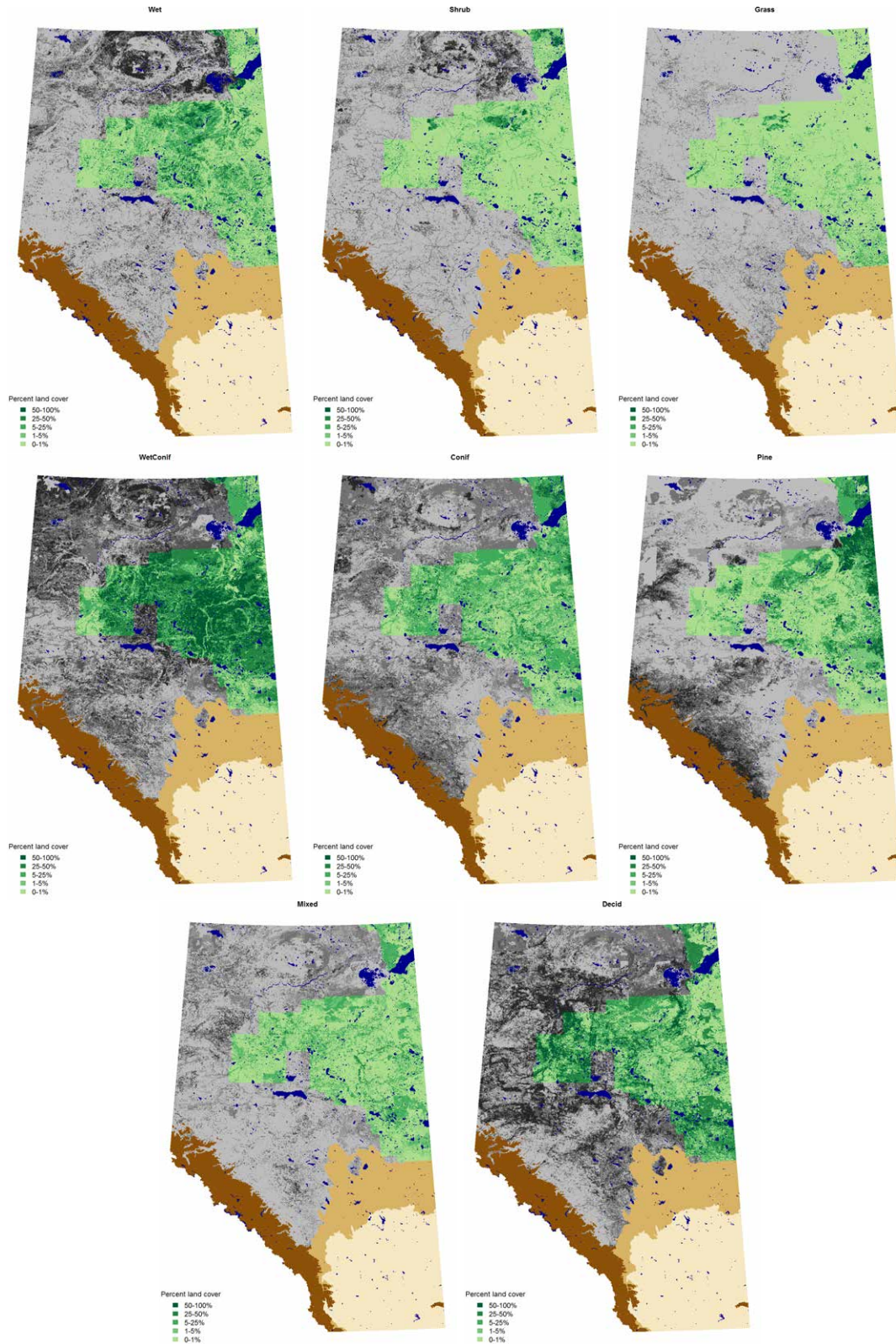


Figure 2.4: Map of natural land cover types used in modeling.

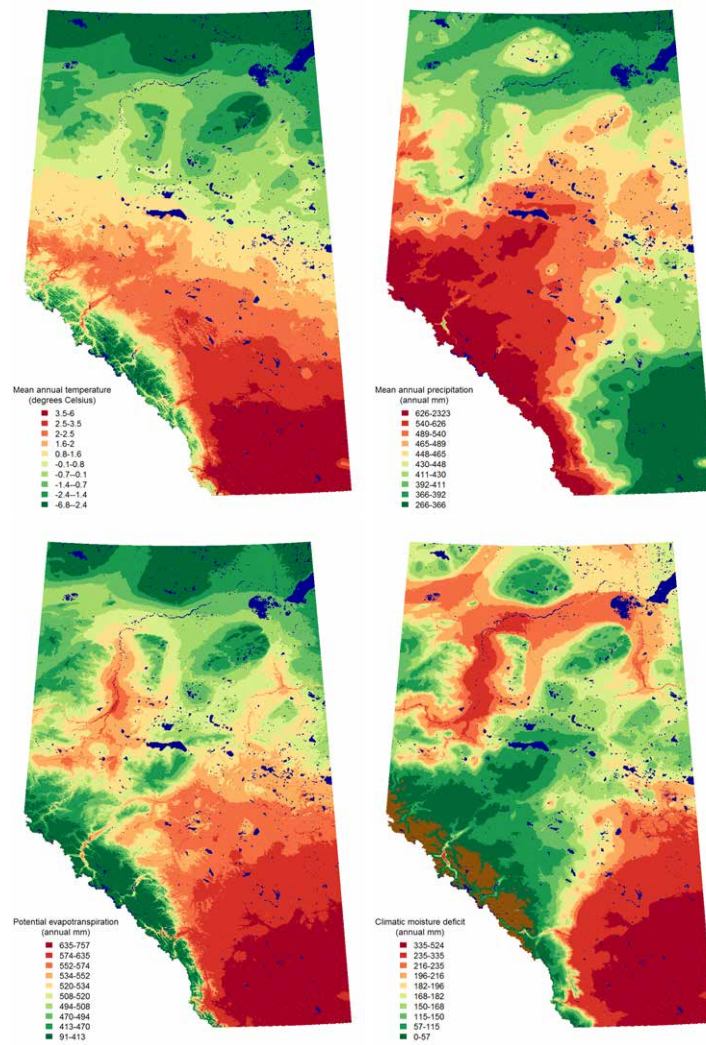


Figure 2.5: Map of climate variables used in the modeling.

the covariates (i.e. spatial variables and footprint). The best supported model was determined based on lowest value of the Consistent AIC ($CAIC = 0.5 AIC + 0.5 BIC$) among competing models (Bozdogan, 1987; Taper, 2004). CAIC is less prone to produce large models compared to AIC and is less conservative than BIC.

Bootstrap The ‘branching’ process was combined with bootstrap aggregation (bagging, or bootstrap smoothing) (Breiman, 1996) to minimize variance in the predictions. Bootstrap replicates were drawn with replacement for each spatio-temporal blocking units. Spatial blocks were established by dividing the sampling area into 4 quadrants within which the distributions of surveys were even. In terms of temporal distribution, 3959 surveys were done between 1993 and 1997, 18422 surveys between 1998 and 2003, 14487 surveys between 2004 and 2008, and 14155 surveys between 2009 and 2013. These 5-year periods were used as temporal blocks. This ensured that bootstrap replicates represented the whole sample distribution. The number of bootstrap iterations was $B = 199$. Each draw resulted in a vector of IDs, same IDs were used across species to allow for comparisons across them. With the response data vector this resulted in a total of 200 independent runs. Within spatio-temporal units, we sampled survey stations with replacement using the number of survey visits within each selected station as weights with replacement. This ensured that the spatial sampling pattern of the point counts was retained in the bootstrap samples but abundant projects did not dominate the samples. We weighted each survey visit by the inverse square root of the number of observations in $4 \text{ km} \times 4 \text{ km}$ grid cells to account for the non-independence (clustered nature) of the data set. Otherwise observations were assumed to be independent conditional on the value of the predictors.

Offsets We used the QPAD approach (Sólymos et al., 2013) to calculate offsets that account for differences in sampling protocol and nuisance parameters affecting detectability (time of day, time of year, tree cover). We calculated offsets within each of the bootstrap iterations from a parametric bootstrap sample of the estimated singing rate and effective detection radius parameters to account for uncertainty in the QPAD parameter estimation.

Model stages At each stage of the branching hierarchy we compared support among several models using CAIC. Variables for the top ranked model in a given stage were fixed and added to models in the subsequent level. Model sets at each level also considered a null model, which was the top model from the previous level or, in the case of level 1, a constant density model without covariates (Stage 0, or NULL). We considered variables describing local scale habitat conditions at the first three stages (150 m buffer, Stages 1–3). Variables describing conditions around the sites at the quarter-section scale were considered at Stages 4–6. At Stage 7 we used spatial smoothing terms (latitude, longitude, climate). The year effect was considered at Stage 8 (see Subsection 2.3.1 and Table 2.3).

Each higher stage modifies coefficients carried forward from previous stages (corresponding to terms that have already entered the model and are already part of the “active set”). For example quarter-section scale effects modify local effects depending on habitat composition and disturbance context. We repeated the multi-stage branching variable selection procedure for each bootstrap iteration, which resulted in 200 sets of parameter estimates (see e.g. Efron 2013). We stored the IDs of best supported models at each level of each iteration to be able to recover the variable selection process.

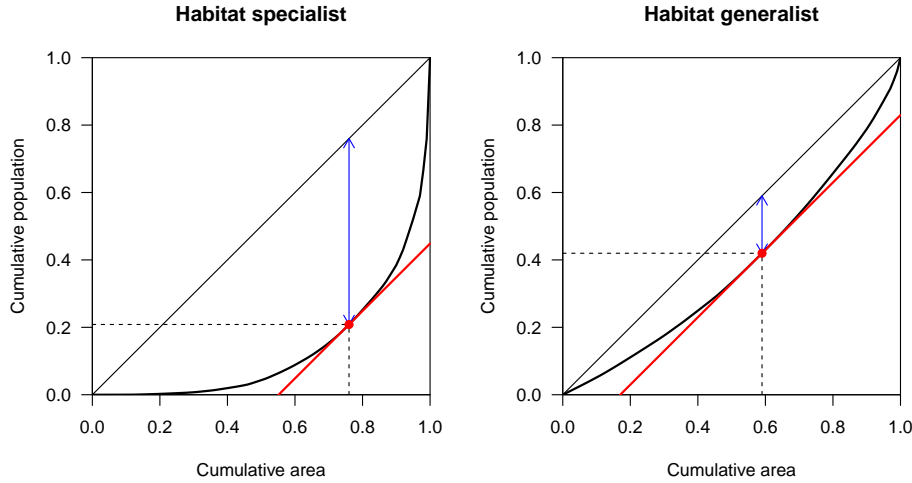


Figure 2.6: Generalized Lorenz-curves indicating thresholds (broken lines) based on the tangent (slope = 1; red line) for hypothetical species considered habitat specialist and habitat generalist. The intersection of the tangent and the curve is where the distance between the curve and the line of equality is maximal.

Lorenz-tangent approach We used the Lorenz-tangent approach to determine the threshold for delineating high suitability land cover classes. First, we fitted a model with land cover types listed in Table 2.4 as categorical predictors. This model was used to predict expected density (“fitted”) values for each observation used. Fitted values were then sorted from the smallest to largest. The cumulative sum of sorted fitted values represented a strictly monotonically increasing convex function (i.e. Lorenz-curve; Figure 2.6). We determined the value of the sorted (not cumulated) density value (λ_J) that corresponded to the point in the Lorenz-curve where the slope is 1 (tangent). This point corresponds to the Youden statistic (J) (Youden, 1950) which is the maximum difference between the Lorenz-curve and the diagonal. The maximum difference is located at the tangent. A land cover class was defined as highly suitable when expected density was equal or higher than the threshold λ_J . By converting densities to probabilities ($1 - e^{-\lambda A}$, where λ is fitted value and A is area), the Youden index and the corresponding threshold lead to an optimal separation that balances sensitivity and specificity related to the ROC curve (Schisterman et al., 2005). The amount of high suitability land cover classes were summarized at the quarter-section scale at each point during the modeling, repeating the thresholding procedure for each bootstrap iteration.

2.3.1 Predictor variables

Predictor variables were chosen based on our current understanding of songbird ecology across Alberta. We used two spatial scales to derive predictor variables for each survey station. Local scale variables were assessed in a 150 m radius of each station. quarter-section scale variables were assessed in a 451 m radius of each survey station, which corresponds to quarter-section area (64 ha) and is the unit for predictive mapping across Alberta.

The predictor variables were grouped to facilitate variables selection (Table 2.3). NULL refers to the selected model at the previous stage. NULL is an intercept only model for stage

1.

Hab description of local habitat conditions within a 150 m radius circular buffer, based on current land cover composition. Feature types were collapsed into main vegetation and footprint categories. Proportional areas within each 150 m radius buffer were calculated for each habitat class. Dominant habitat type was assigned to each survey station based on a simple majority rule.

Habitat land cover with 10 levels (Decid as reference):

Decid deciduous forest,
Mixed mixedwood,
Conif upland non-pine coniferous forest,
Pine pine forest
WetConif lowland coniferous forest,
Shrub shrubs,
Grass grasslands, early seral vegetation,
Wet non-treed wetlands,
Cult cultivation,
UrbInd urban and industrial cover types.

HabitatB land cover with 11 levels: same as for Habitat, but there is a separate category for 'Burn'.

isHForC indicator function for forestry that can modify the habitat effect (i.e. origin is not fire but clearcut). The value changes with years since disturbance (YSD = year of survey – year of origin): the value is 1 when YSD = 0 and 0 when YSD = 50, linear decrease in between. This assumes that the growth trajectory converges to natural disturbance trajectory at year 50 post disturbance. When the dominant habitat type was forestry footprint, the likely pre-disturbance forested vegetation type was assumed based on the next dominant non-footprint habitat class. This was done so that forestry activities did not form a separate habitat class but instead was treated as young forest.

Age age effects and interactions (indicated by colons) between forest type and age (Decid is reference category therefore no indicator variable for this class). Age was calculated as the difference between year of the bird survey and the year of origin. Year of origin was estimated based on area-weighted age of forest polygons within the 150 m radius circular buffer.

Age forest age at the year of bird survey divided by 200, 0 for non-forest land cover types,

Age2 Age²,

isMix dummy variable: 1 when Habitat = Mixed, 0 otherwise;

isPine dummy variable: 1 when Habitat = Pine, 0 otherwise;

isUplConif dummy variable: 1 when Habitat = Conif, 0 otherwise;

isWetConif dummy variable: 1 when Habitat = WetConif, 0 otherwise.

Contrast modifiers for habitat and age, this stage accounts for ‘contamination’ so that we can better predict for non-contaminated land cover types by statistically removing effects of linear features. Linear features also had small combined area within the 150 m buffers and as a result did not form a dominant habitat type.

ROAD dummy variable indicating that a road intersected the 150 m radius point count buffer. It was either known (BBS) or inferred based on hard linear features being $>4\%$ of the 150 m radius buffer (this corresponds to a 9 m wide road).

SoftLin_PC proportion (0–1) of soft linear features within the 150 m radius buffer.

QSIP proportion of suitable habitat within 451 m radius buffers around points, land cover types that are suitable were determined by the Lorenz-tangent approach. We used the classes listed in Table 2.4. Summed amount of high suitability habitat classes were used.

Remn_QS proportion of suitable habitat;

Remn2_QS Remn_QS^2 .

QSWet proportion of wet habitats within 451 m radius buffers around points:

pWet_QS proportion (0–1) of non-treed wetlands;

pWetWater_QS proportion (0–1) of non-treed wetlands and open water.

QSHF proportion of different types of human footprint within 451 m radius buffers around points:

Lin_QS linear (hard and soft linear) footprint;

Nonlin_QS $\text{THF_QS} - \text{Lin_QS}$;

Nonlin2_QS Nonlin_QS^2 ;

Cult_QS cultivation;

Noncult_QS $\text{THF_QS} - \text{Cult_QS}$

Noncult2_QS Noncult_QS^2

Succ_QS ‘successional’ footprint types, where the footprint can regenerate and it does not disturb the soil (forestry and soft linear footprint);

Succ2_QS Succ_QS^2 ;

Alien_QS ‘alienating’ footprint types, where the footprint is assumed permanent and it disturbs the soil ($\text{THF_QS} - \text{Succ_QS}$; includes urban-industrial, cultivation, and hard linear features);

Alien2_QS Alien_QS^2 ;

THF_QS total human footprint;

THF2_QS THF_QS^2 ;

Space spatial smoothing terms (‘x’ stands for transformation).

xlat latitude (in decimal degrees) transformed as: $(\text{latitude} - (-113.8)) / 2.14$.

xlong longitude (in decimal degrees) transformed as: $(\text{longitude} - 53.7) / 2.26$.

xMAP mean annual precipitation divided by 2220;

xMAT mean annual temperature divided by 6;

xPET potential evapotranspiration divided by 600;

xCMD climate moisture deficit divided by 800.

Year year effect (‘x’ stands for transformation):

xYEAR year since minimum year (1993) divided by 10;

YR5 year as categorical variables divided into 4 intervals: 1993–1997, 1998–2003, 2004–2008, 2008–2013, the first interval was used as reference.

Table 2.4: List of habitat–age classes used in the delimitation of high suitability habitat patches using the Lorenz-tangent approach.

Habitat–age classes	Land cover	Age
Grass	Grass	
Shrub	Shrub	
Wet	Wet	
PineA	Pine	0–20
PineB	Pine	20–40
PineC	Pine	40–80
PineD	Pine	>80
ConifA	Conif	0–20
ConifB	Conif	20–40
ConifC	Conif	40–80
ConifD	Conif	>80
MixedA	Mixed	0–20
MixedB	Mixed	20–40
MixedC	Mixed	40–60
MixedD	Mixed	>60
DecidA	Decid	0–20
DecidB	Decid	20–40
DecidC	Decid	40–60
DecidD	Decid	>60
WetConifA	WetConif	0–20
WetConifB	WetConif	20–40
WetConifC	WetConif	40–80
WetConifD	WetConif	>80
Cult	Cult	
UrbInd	UrbInd	

Table 2.3: Model terms used in the multi-stage variable selection procedure. Dot at the beginning of the formulae indicates that terms from the previous stage are already entered the variable set.

ID	Stage	Model	Terms
1.0	Hab	0	NULL
1.1	Hab	1	. + Habitat
1.2	Hab	2	. + HabitatB
1.3	Hab	3	. + Habitat + isHForC
1.4	Hab	4	. + HabitatB + isHForC
2.0	Age	0	NULL
2.1	Age	1	. + Age
2.2	Age	2	. + Age + Age2
2.3	Age	3	. + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
3.0	Contrast	0	NULL
3.1	Contrast	1	. + ROAD
3.2	Contrast	2	. + SoftLin_PC
3.3	Contrast	3	. + ROAD + SoftLin_PC
4.0	QSIP	0	NULL
4.1	QSIP	1	. + Remn_QS
4.2	QSIP	2	. + Remn_QS + Remn2_QS
5.0	QSWet	0	NULL
5.1	QSWet	1	. + pWet_QS
5.2	QSWet	2	. + pWetWater_QS
6.0	QSHF	0	NULL
6.1	QSHF	1	. + THF_QS
6.2	QSHF	2	. + Lin_QS + Nonlin_QS
6.3	QSHF	3	. + Succ_QS + Alien_QS
6.4	QSHF	4	. + Succ_QS + Noncult_QS + Cult_QS
6.5	QSHF	5	. + THF_QS + THF2_QS
6.6	QSHF	6	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.7	QSHF	7	. + Succ_QS + Alien_QS + Succ2_QS
6.8	QSHF	8	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	QSHF	9	. + Succ_QS + Alien_QS + Alien2_QS
6.10	QSHF	10	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.11	QSHF	11	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
6.12	QSHF	12	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.0	Space	0	NULL
7.1	Space	1	. + xlat
7.2	Space	2	. + xlat + xlong
7.3	Space	3	. + xlat + xlong + xlat:xlong
7.4	Space	4	. + xMAP + xPET + xMAT + xCMD
7.5	Space	5	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	Year	0	NULL
8.1	Year	1	. + xYEAR
8.2	Year	2	. + YR5F

2.4 Model evaluation

Model uncertainty By using bootstrap procedures and creating the various model forms, we provided visual measures of model uncertainty. Model uncertainty was represented as a variable selection path along the stages of the modeling approach described above. A tabular summary of model selection frequencies at different stages of the modeling process represent importance weights for the model terms (Efron, 2013). The combination of the bootstrap results thus represented model averaging through variable importance weighting keeping the basic model structure (i.e. Poisson linear model) unchanged.

Classification Within sample classification accuracy was assessed by constructing receiver operating characteristic (ROC) curves and calculated area under the curve (AUC) values based on the observations ($w = I(y > 0)$) as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda^C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability according the QPAD approach (Sólymos et al., 2013). These measures were measured at Stages 3, 6, and 7, where we expected that classification should improve by model complexity as bias decreases. The bootstrap based median prediction represents the model averaged predictions. Out-of sample measure of classification accuracy was not calculated due to the lack of left-out cases in our bootstrap approach. Although there is always a non-used portion of observations from bootstrap, but those rarely overlap, thus the bootstrap based prediction cannot be calculated.

Ranking We assessed how our prediction were able to discriminate observed counts (y), not only $y = 0$ vs. $y > 0$ cases. We used the left-out cases in each bootstrap iteration and calculated mean predicted densities ($\bar{C}\lambda_0, \bar{C}\lambda_1, \bar{C}\lambda_2, \dots$) corresponding to each count values ($y = 0, 1, 2, \dots$), where C corresponds to correction factor based on methodology and detectability according the QPAD approach (Sólymos et al., 2013). We graphically assessed the distribution of these mean predictions across the 200 out-of-sample vector-pairs to get a sense of the discriminating ability of the models. Good separation by counts indicate that the model is capable of ranking habitat classes according to habitat suitability. This summary was produced at Stages 3, 6, and 7, where we expected, again, that discrimination ability should improve by model complexity as bias decreases.

In general, discriminatory power should be considered a better measure of model performance than binary classification, because: (1) 0 and 1 observations are confounded by detectability and methodological differences (that is accounted for by QPAD corrections), and higher counts lead to a wider spectrum of possible values; (2) habitat suitability for common species is better described by discriminating ability for higher ($y > 1$) counts.

2.5 Habitat associations

Local scale effects Habitat associations and forest-age relationships were predicted based on model parameter estimates at Stage 3. We used the bootstrap distribution and used the median (50% percentile) as the point estimate and the 5% and 95% percentiles as lower and upper confidence limits, respectively, for a confidence interval with 90% nominal coverage. Values are presented in males/ha units.

quarter-section scale effects quarter-section scale predictions need to represent an average effect over the study area. We “integrated” over the possible predictor value combinations in the study area by randomly resampling locations with their predictor values. Landscape scale effects were held at known fixed values while values of the other variables were randomized. Predicted relationships were based on model parameter estimates at Stage 7.

Year effects The same approach was used for estimating approximate year effects using estimates from Stage 8. Note that the analysis was not optimally set up for reliable estimation of trend in abundance. For example observations from same locations were down weighted, thus time series data did not have large influence on results.

2.6 Predictive maps

Distribution We predicted pixel level abundance values based on the reference ($\hat{N}_k^{(RF)}$ for pixel k , $k = 1, \dots, K$) and current ($\hat{N}_k^{(CR)}$) vegetation maps. We summarized provincial land cover information (reference and current conditions) for predictive mapping at the quarter-section scale for the entire study area and calculated density for each species for quarter-section units (pixels) within the study area based on model parameter estimates from the first model run (i.e. without the rest of the bootstrap iterations) at Stage 7. The attributes (footprint and vegetation) for each quarter-section pixel were calculated based on all polygon attributes found within that pixel. The centroid of the pixel was used to determine latitude/longitude and climate (from 500 m resolution raster layers) variable values. The mean predicted density for a pixel was the weighted average of the polygon-level densities weighted by corresponding polygon areas. We used the median instead of the mean to avoid the distorting effects of outliers. Outliers caused problems for rare predictor combinations (<1%) when predicting outside of the sample space.

Intactness We calculated pixel level species intactness as $SI = 100 \times \frac{\min(\hat{N}_k^{(RF)}, \hat{N}_k^{(CR)})}{\max(\hat{N}_k^{(RF)}, \hat{N}_k^{(CR)})}$. We differentiated increase ($\hat{N}_k^{(RF)} < \hat{N}_k^{(CR)}$) and decrease ($\hat{N}_k^{(RF)} > \hat{N}_k^{(CR)}$) by using $200 - SI$ for pixel level increase. This way SI is in the range 0–100 for local decline in potential population and 100–200 for increase.

To highlight the effects of local scale, quarter-section scale and spatial/climatic effects on mapping, we produced current and reference abundance maps based on Stage 3, Stage 6 and Stage 7 model parameter estimates.

2.7 Predictive uncertainty

Pixel level uncertainty For 10% random sample of the pixels (Figure 2.7) in the JOSM study area, the pixel (quarter-section) level prediction procedure was repeated for all 200 bootstrap runs. Point prediction for a pixel was calculated as the median of the 200 predicted values. We calculated the coefficient of variation (standard deviation of the bootstrap estimates divided by the mean of the bootstrap estimates) for each pixel as an estimate of prediction uncertainty. We calculated the coefficient of variation based on predicted reference and current population, and species intactness. Predictions from the 10% random sample were mapped at a 10 km² resolution based on mean values within grid cells.

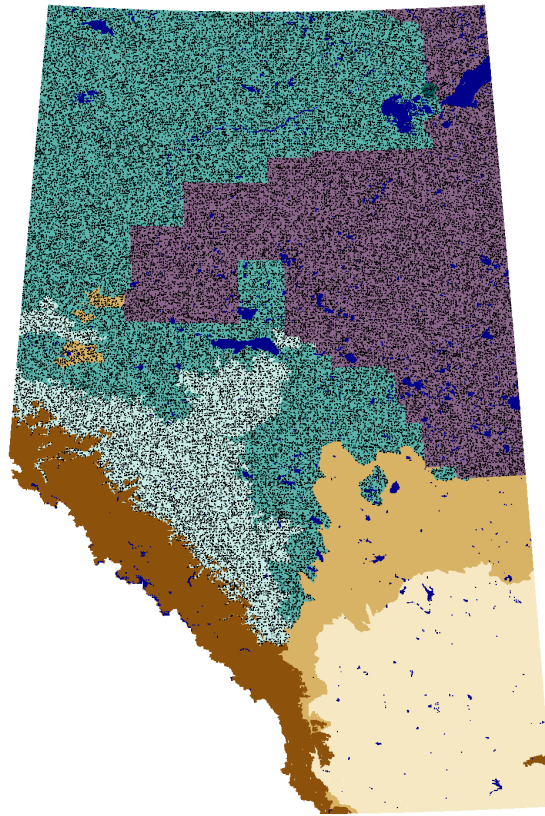


Figure 2.7: 10% random sample of quarter-sections used for population estimation.

Concordance Scale and location shifts across bootstrap based predictions were evaluated by the overall concordance correlation coefficient (OCCC) (Barnhart et al., 2002; Lin, 1980a,b). OCCC measures the deviation from 45° line through origin, i.e. perfect agreement between two measures. OCCC is product of two measures, the overall precision (measures of how far each observation deviated from the best fitted line), and the overall accuracy (measures how far the best line deviates from the 45° line).

2.8 Population size estimation

Oil Sands population Population size in the JOSM study area for each species was estimated as the sum of pixel (quarter-section) level prediction from the 10% random sample multiplied by 10. We calculated reference ($\hat{N}^{(RF)} = 10 \sum_{k=1}^K \hat{N}_k^{(RF)}$) and current ($\hat{N}^{(CR)} = 10 \sum_{k=1}^K \hat{N}_k^{(CR)}$) population sizes for the 200 bootstrap runs. This way we could express 90% confidence intervals around population size estimates.

Losses and gains From pixel level differences between reference and current abundances ($\hat{N}^{(CR)} - \hat{N}^{(RF)}$), we calculated losses as the sum of negative differences and gains as the sum of positive differences.

Population in habitats When calculating polygon level densities in each mapping unit, we also summed up population sizes for each habitat classes listed in Table 2.4. The sums of habitat specific medians and pixel specific medians are not equal (equality holds for the mean only, but median is robust to outliers). Thus we used habitat level predictions as relative measures and expressed habitat based population sizes by combining relative proportions based on total population size within the JOSM study area.

Habitat specific losses and gains We created plots to depict differences between reference and current population sizes by habitat classes. Habitat specific attribution of losses and gains by footprint types was not possible with currently available land cover information.

Boreal population We also estimated total population sizes for the three northern Natural Regions (Boreal, Foothills, Canadian Shield) which correspond to Bird Conservation Regions 6, 7, and 8 (Boreal Taiga Plains, Taiga Shield & Hudson Plains, and Boreal Softwood Shield, respectively). We refer to these as “Boreal” population estimates and were calculated by first determining the proportion of the Boreal populations within the JOSM study area ($u^{(JOSM)} = \hat{N}^{(JOSM)} / \hat{N}^{(Boreal)}$) based on abundance estimates in all mapping units (using the first iteration of the modeling only). Then we multiplied the Oil Sands population size by the proportion of the population within JOSM ($\hat{N}^{(QPAD)} = \hat{N}^{(CR)} / u^{(JOSM)}$).

Responsibility Responsibility (r) was calculated as the proportion of the Boreal population found within the JOSM area ($u^{(JOSM)}$) divided by the area of the JOSM study area relative to area of the three northern Natural Regions ($a^{(JOSM)} = A^{(JOSM)} / A^{(Boreal)}$; $r = u^{(JOSM)} / a^{(JOSM)}$ for a species). The value of responsibility is 1 when the JOSM population is the same as expected based on area. A value <1 indicates that a higher proportion of the Boreal population can be found outside of the JOSM area. A value >1 indicates that

higher than expected proportion of the Boreal population can be found within the JOSM area.

Population concentration We used pixel level population estimates to construct Lorenz-curves which highlights the concentration in the spatial distribution of the population. A curve close to the line of equality means that abundance is evenly distributed across the mapping units. Larger deviations between the curve and the diagonal refer to higher spatial concentrations. We also used prediction around sampled locations to express the distribution of the population among habitat classes. We also calculated relative selection by comparing population proportions across habitat classes to an evenly distributed situation (no selection).

Chapter 3

Results

3.1 A tour of species specific results: Canada Warbler

We demonstrate the results and their interpretations for Canada Warbler. Similar results are available for the other 76 species in Chapter 5.

3.1.1 Model variability

The variable selection path diagram (Figure 3.1) indicates the selection frequencies of predefined variable sets (see Table 2.3) entering the model along the model stages (from bottom to top). Size of dots are proportional to selection frequencies. Width of the lines are proportional to transition frequencies among the stages. Model 0 indicates that the model from the previous step (below) was carried forward. A numerical representation of variable selection frequencies can be found in Table 3.1.

Variable selection was highly congruent among bootstrap runs up to Stage 5. This included the local (150 m radius buffer) habitat descriptors (Habitat with quadratic age response) and the lack of quarter-section level effect if available high suitability habitat patches (Stage 4). At Stage 5, the effect of wet areas was often selected. The quarter-section level footprint effect was more variable: it was selected as important in 33% of the runs. A linear year effect was selected in 76.5% of the cases (Table 3.1).

3.1.2 Point level habitat associations

Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically in Figure 3.2. Local expected density for Canada Warbler was highest in old-growth deciduous and mixedwood stands. Density was low in young forests, old coniferous stands, and in open and disturbed areas.

The effect of linear features (Figure 3.3) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel

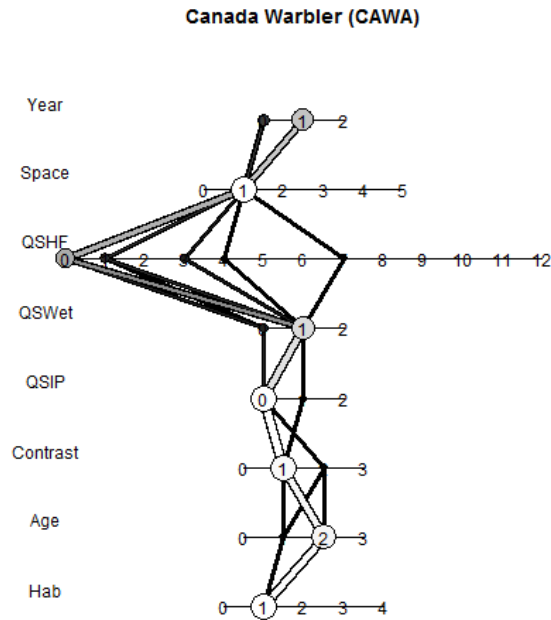


Figure 3.1: Stage-wise variable selection path for Canada Warbler.

Table 3.1: Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	100.0	200	. + Habitat
2.1	4.0	8	. + Age
2.2	96.0	192	. + Age + Age2
3.1	97.5	195	. + ROAD
3.2	2.5	5	. + SoftLin_PC
4.0	99.5	199	NULL
4.1	0.5	1	. + Remn_QS
5.0	14.0	28	NULL
5.1	86.0	172	. + pWet_QS
6.0	67.0	134	NULL
6.1	18.5	37	. + THF_QS
6.3	12.5	25	. + Succ_QS + Alien_QS
6.4	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS
6.7	1.5	3	. + Succ_QS + Alien_QS + Succ2_QS
7.1	100.0	200	. + xlat
8.0	23.5	47	NULL
8.1	76.5	153	. + xYEAR

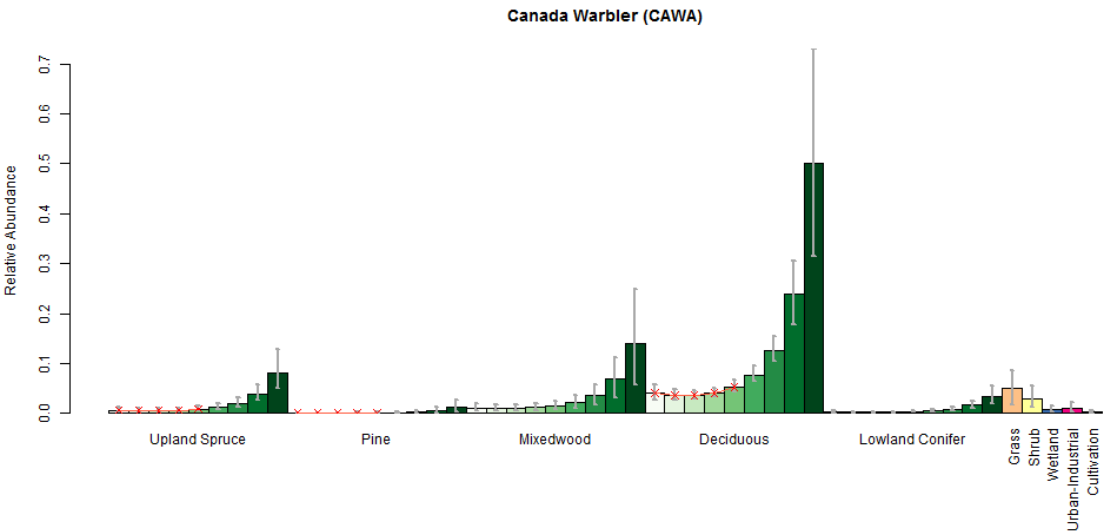


Figure 3.2: Local scale habitat associations for Canada Warbler.

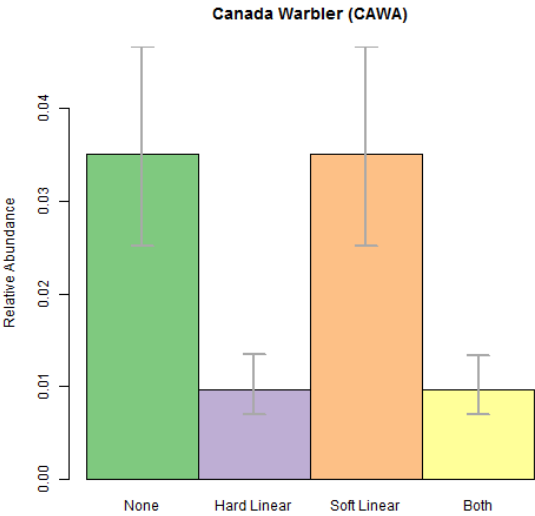


Figure 3.3: Local scale road effect for Canada Warbler.

road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars. Canada Warbler showed a negative response to road, but the density of cutlines did not significantly affect expected density relative to non-disturbed habitats (Figure 3.3).

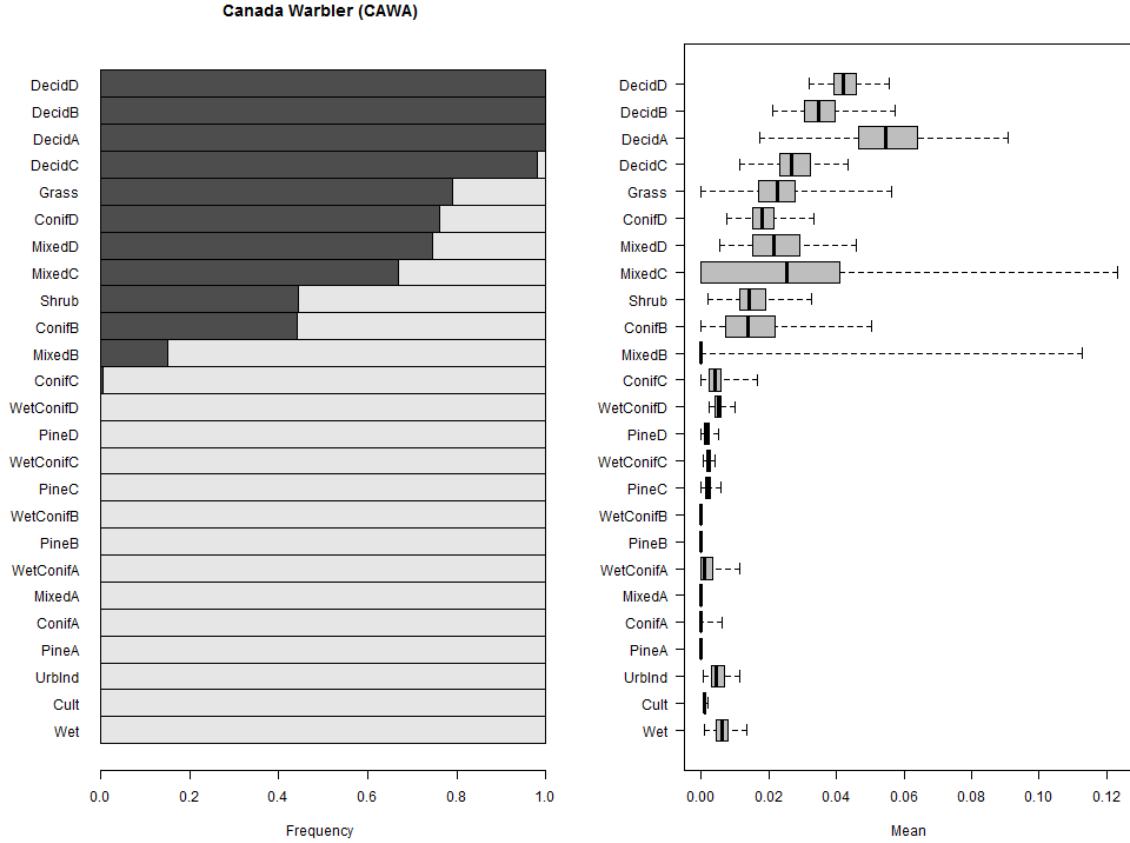


Figure 3.4: Selection frequencies as high suitability patches (left) and expected mean densities (right) in different habitat classes. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

3.1.3 Habitat suitability ranking for patch delineation

Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter-section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. High suitability habitat rankings in Figure 3.4 are consistent with local scale habitat associations (Figure 3.2). Young deciduous stands (DecidA) are selected because expected density in young deciduous forests was higher than density in older coniferous stands. The inclusion of Grass habitat class is an artefact of not controlling for road effect in the Lorenz-tangent approach (roads tend to co-occur with habitats classified as Grass, i.e. road verges). The bias due to Grass being “highly suitable” is minimal due to the small percent availability of this land cover type in the Boreal.

3.1.4 Quarter-section level responses

Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects (Stage 6). The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Canada Warbler did not show response to amount of high suitability patches in the quarter-section scale buffer defined on the basis of the optimal threshold by Lorenz-tangent approach. Expected abundance showed a decline with increasing amount of treed and non-treed wetlands and various kinds of footprint in the quarter-section scale buffers around the points (Figure 3.5).

3.1.5 Maps

We created maps to depict the distribution of the detections in our data set (Figure 3.6). Current and reference abundance maps follow the distribution of deciduous forests (c.f. Figure 2.4). The colors in the current and reference abundance maps correspond to Lorenz-curve based concentration of abundance. The red pixels delineate spatial units where 50% of the potential population is expected to be found. The pixels outside of the deep blue areas represent 95% of the potential population. The Canada Warbler population is highly concentrated, as reflected by the Lorenz-curve itself (Figure 3.8). The concentration is driven by a positive selection towards old deciduous habitats (Figure 3.9).

Intactness map reflects loss of suitable habitats due to agriculture, surface mining, and forestry (c.f. Figure 2.2). Relative change in habitat specific population sizes also indicates the loss of suitable habitats (Figure 3.8). The spatial smoothing effect of considering quarter-section scale variables affected the spatial distribution and concentration of abundance (Figure 3.7).

3.1.6 Population size

Estimated current population size of Canada Warbler in the JOSM study area was 0.32 million male birds. This is 40,000 less than would be expected under reference vegetation conditions (0.36 million males; Table 3.2)

3.1.7 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Canada Warbler showed an increasing trend in Boreal Alberta (Figure 3.10). Such a trend is the opposite of the decline reported for the whole breeding range of the species based on Breeding Bird Survey data, but consistent with observations at Calling Lake long term study site in Alberta. The Calling Lake data set was part of the data analyzed, thus it might influence the year effect contrary to the down-weighting of repeat observations.

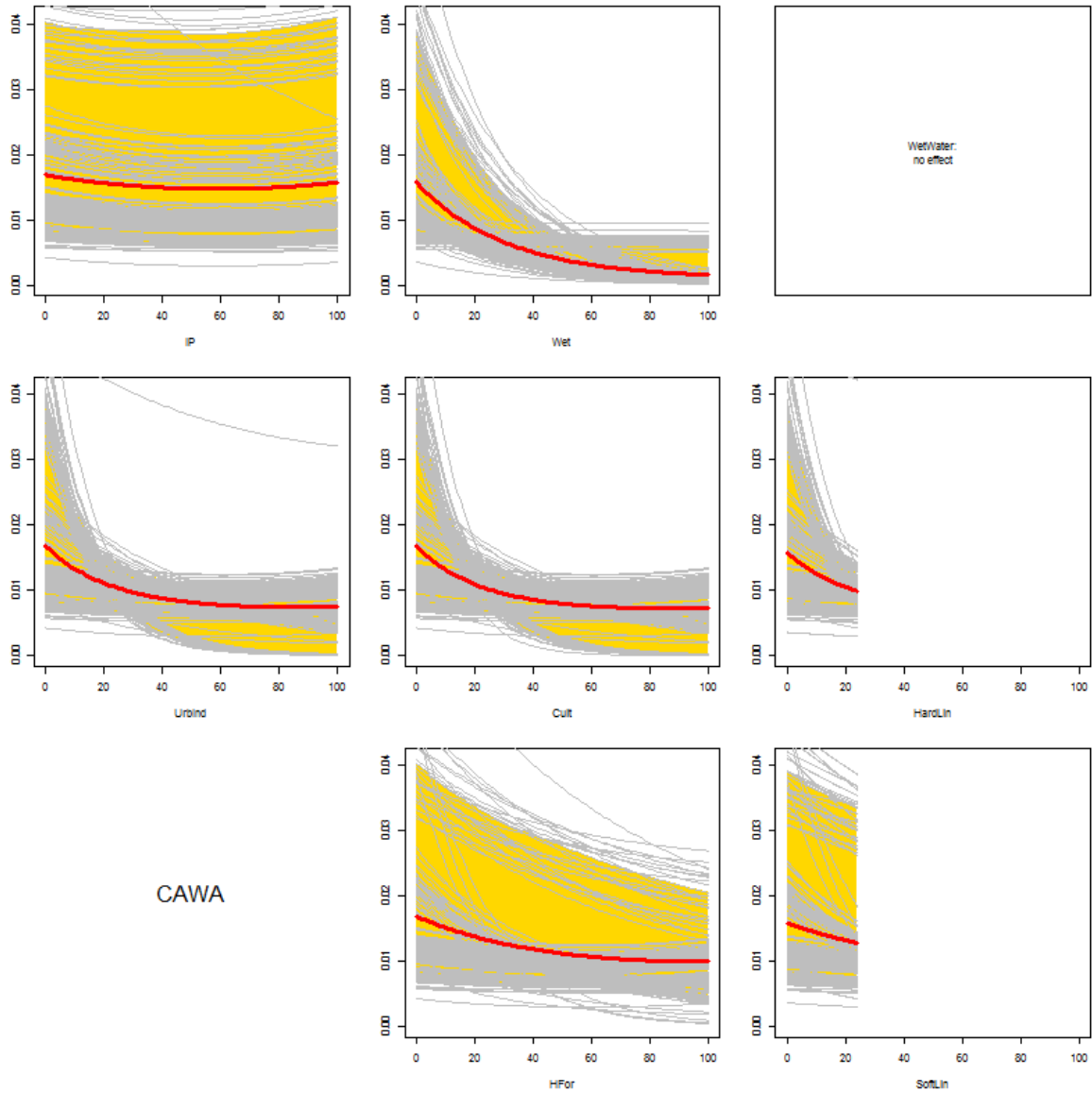


Figure 3.5: Quarter-section scale responses for Canada Warbler. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter-section) around points.

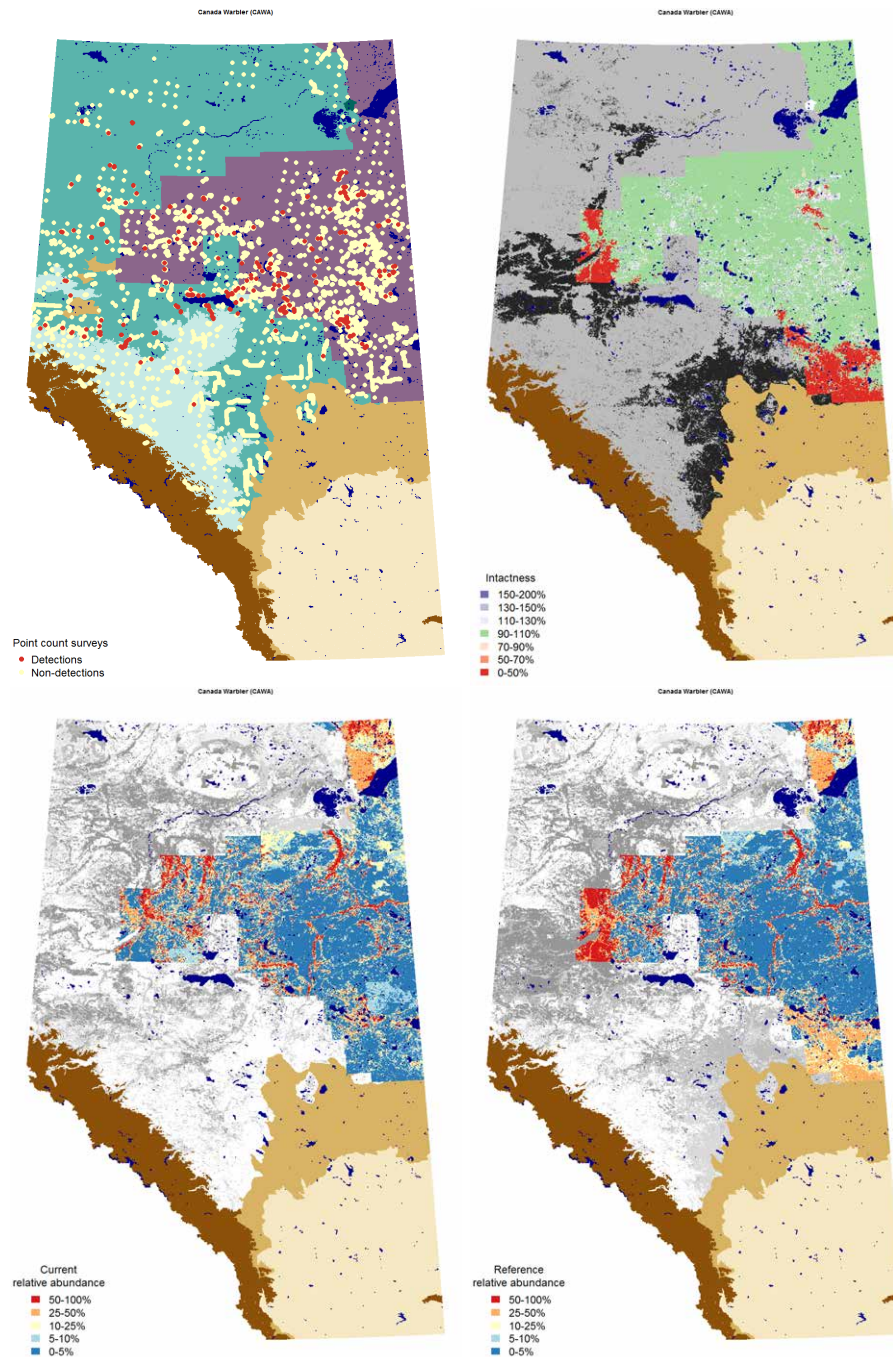


Figure 3.6: Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections of Canada Warbler (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on Stage 7 of the variable selection procedure (no year effect).

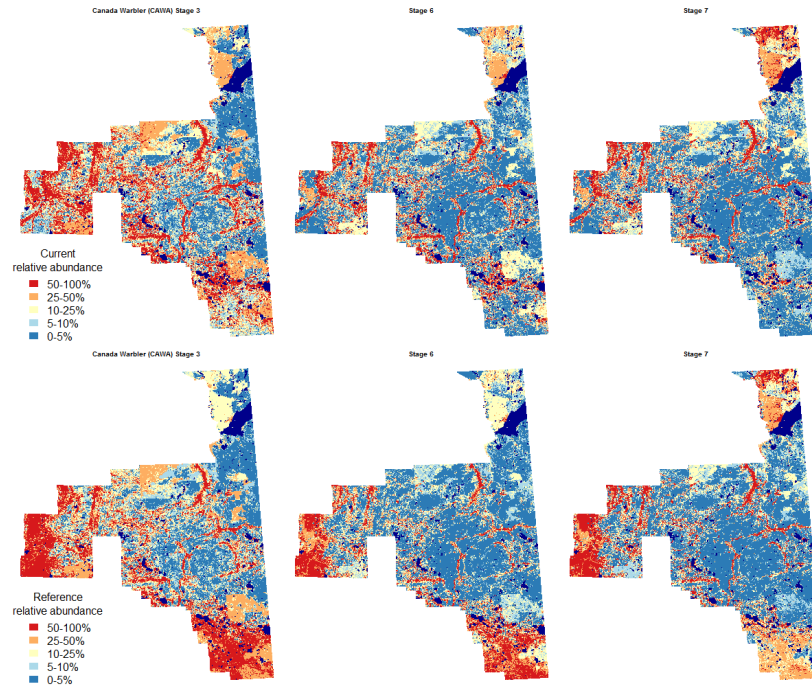


Figure 3.7: Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance for Canada Warbler. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

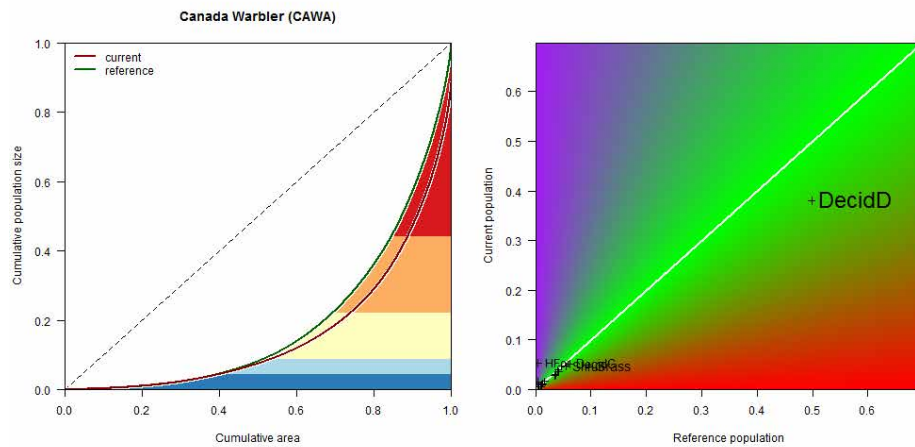


Figure 3.8: Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area for Canada Warbler. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

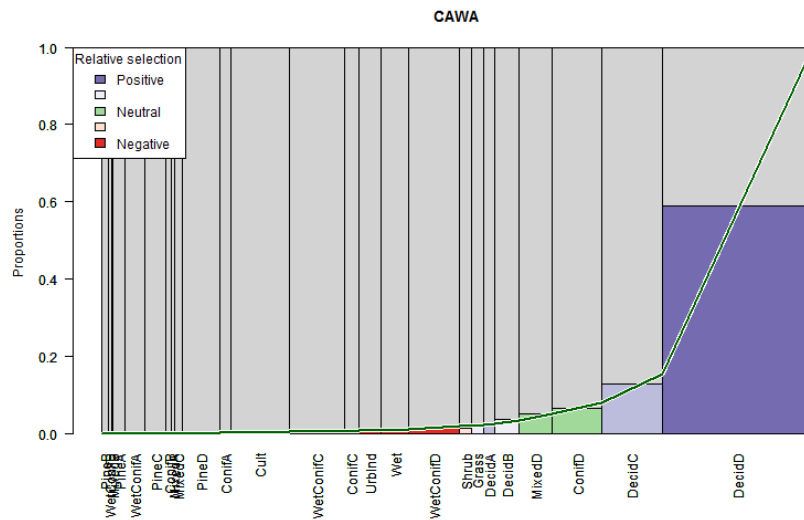


Figure 3.9: Relative selection index and population concentration for Canada Warbler. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

Table 3.2: Population size estimates for Canada Warbler in the JOSM study area based on a 10% sample.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1400	0.1152	0.1715	0.1806	0.1468	0.2254
Grass	0.0170	0.0140	0.0208	0.0346	0.0282	0.0432
DecidC	0.0190	0.0156	0.0232	0.0223	0.0181	0.0278
Shrub	0.0172	0.0141	0.0210	0.0200	0.0163	0.0250
Wet	0.0174	0.0143	0.0213	0.0172	0.0140	0.0214
ConifD	0.0130	0.0107	0.0159	0.0152	0.0124	0.0190
WetConifD	0.0144	0.0119	0.0177	0.0147	0.0120	0.0184
MixedD	0.0114	0.0094	0.0140	0.0129	0.0105	0.0161
DecidB	0.0107	0.0088	0.0131	0.0125	0.0101	0.0156
WetConifC	0.0060	0.0049	0.0074	0.0061	0.0050	0.0076
ConifA	0.0045	0.0037	0.0055	0.0047	0.0038	0.0059
ConifC	0.0036	0.0030	0.0044	0.0040	0.0032	0.0050
ConifB	0.0037	0.0031	0.0046	0.0038	0.0031	0.0048
DecidA	0.0024	0.0020	0.0029	0.0035	0.0028	0.0044
PineB	0.0024	0.0020	0.0030	0.0024	0.0020	0.0030
WetConifB	0.0018	0.0015	0.0022	0.0018	0.0015	0.0022
WetConifA	0.0013	0.0011	0.0016	0.0013	0.0011	0.0016
PineD	0.0011	0.0009	0.0014	0.0012	0.0010	0.0015
PineA	0.0010	0.0008	0.0012	0.0009	0.0008	0.0012
PineC	0.0009	0.0007	0.0010	0.0009	0.0007	0.0011
MixedB	0.0008	0.0006	0.0010	0.0008	0.0007	0.0010
MixedA	0.0004	0.0003	0.0005	0.0005	0.0004	0.0006
MixedC	0.0004	0.0003	0.0005	0.0004	0.0004	0.0006
Cult	0.0042	0.0034	0.0051	0.0000	0.0000	0.0000
UrbInd	0.0023	0.0019	0.0028	0.0000	0.0000	0.0000
HardLin	0.0003	0.0003	0.0004	0.0000	0.0000	0.0000
SoftLin	0.0055	0.0045	0.0068	0.0000	0.0000	0.0000
HFor	0.0197	0.0162	0.0241	0.0000	0.0000	0.0000
Total	0.3223	0.2652	0.3950	0.3624	0.2947	0.4524
Loss	0.0479	0.0311	0.0928			
Gain	0.0101	0.0025	0.0135			

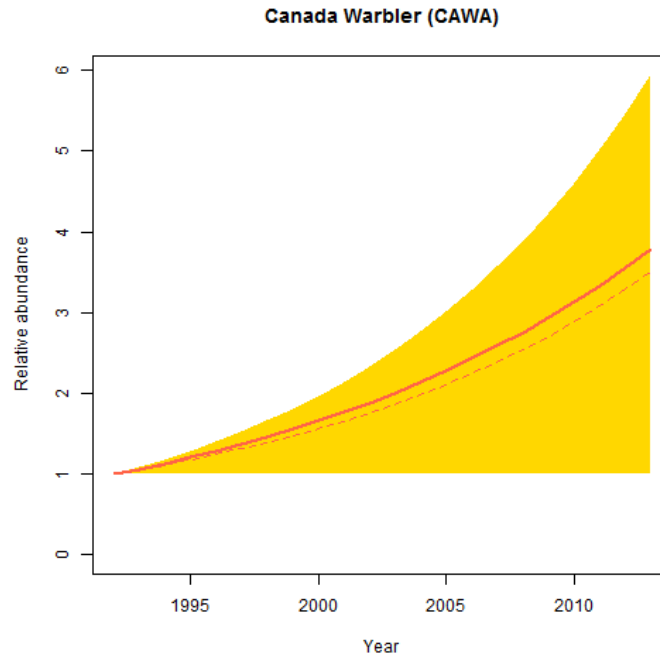


Figure 3.10: Year effect for Canada Warbler relative to the 1st year in the data set (1993).

3.1.8 Model validation

AUC values improved slightly with the inclusion of quarter-section and spatial covariates in the models. Predicted habitat suitability values could adequately rank observed counts (Figure 3.11).

3.1.9 Mapping uncertainty

Mapping uncertainty as expressed by the coefficient of variation (CV) based on the bootstrap samples (Figure 3.12) were relatively high, similar in magnitude to the expected mean abundance ($CV = 1$; Figure 3.13). The high concordance measures across the bootstrap estimates indicate that the relatively high pixel level uncertainty is probably related to the variable selection variation with respect to quarter-section level footprint variables and possibly to varying slope of the latitude effect (as also indicated by the spatial distribution of the high CV areas in Figure 3.12).

3.2 Community level results

3.2.1 Variable selection

Looking at the variable selection frequencies across the 77 species we found that NULL (no additional model term improved the model fit at a given stage) was virtually absent for the stages describing habitat classes, road effect and space (latitude/longitude, climate). The selection frequency for NULL varied more and was on average higher for stages describing age effects, quarter-section scale wetness and footprint, and year effect (Figure 3.14). Surprisingly,

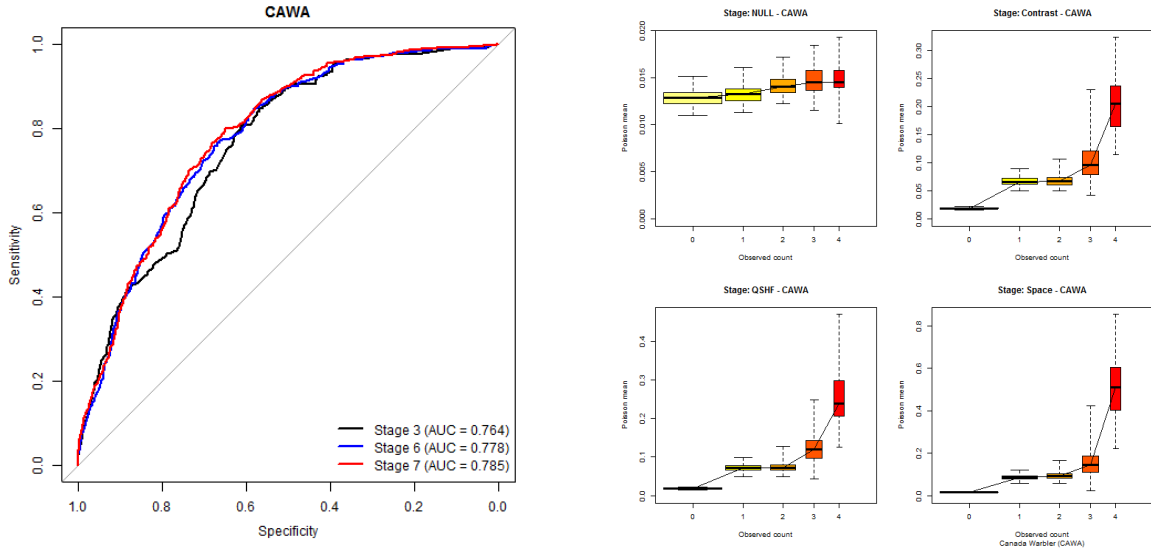


Figure 3.11: Goodness-of-fit measures for Canada Warbler. The receiver operating characteristic (ROC) curve and area under the curve (AUC) values in the left were constructed based on the observations from the Boreal and Foothills study area. Boxplots in the right represents the improvements in discriminating different counts along the stages of the variable selection process (based on out-of-sample cross-validation). Stages in variable selection represent the “NULL” model where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” (Stage 3) corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” (Stage 6) corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” (Stage 7) corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).

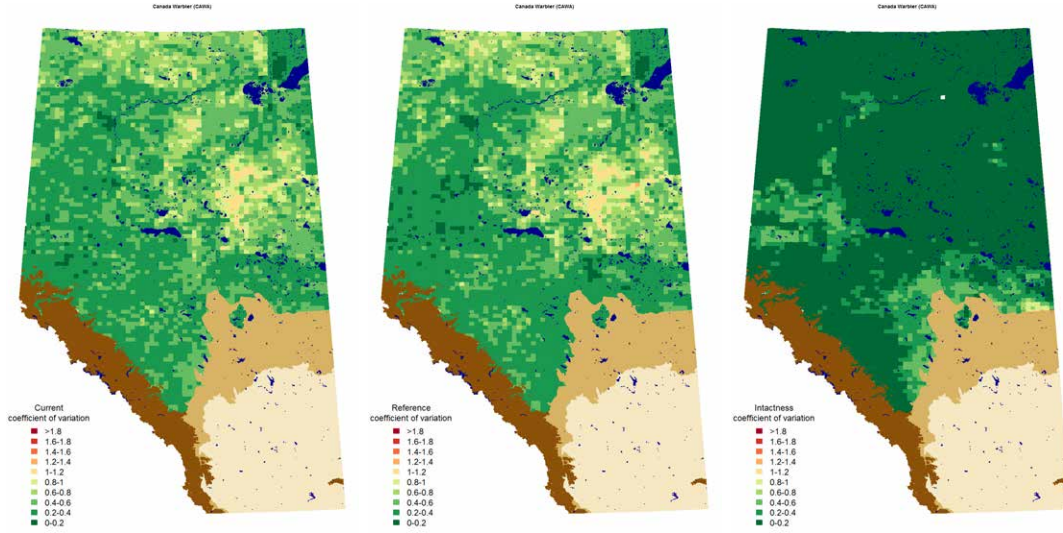


Figure 3.12: Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter-sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).

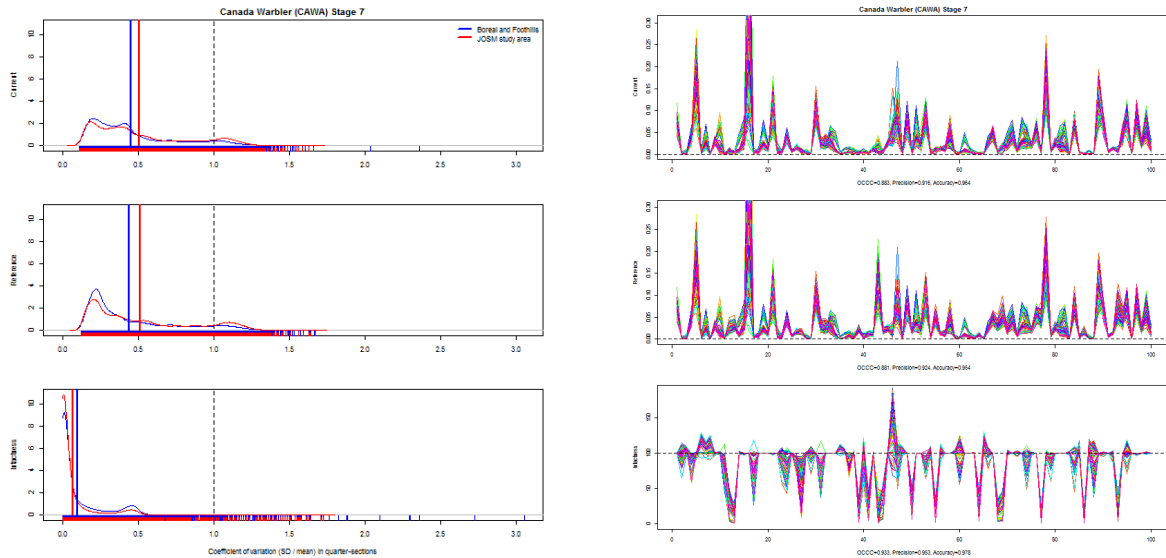


Figure 3.13: Density of CV values for Canada Warbler based on 10% sample and 200 bootstrap iterations (left). Illustration of bootstrap variation for 100 random quarter-sections (right). Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

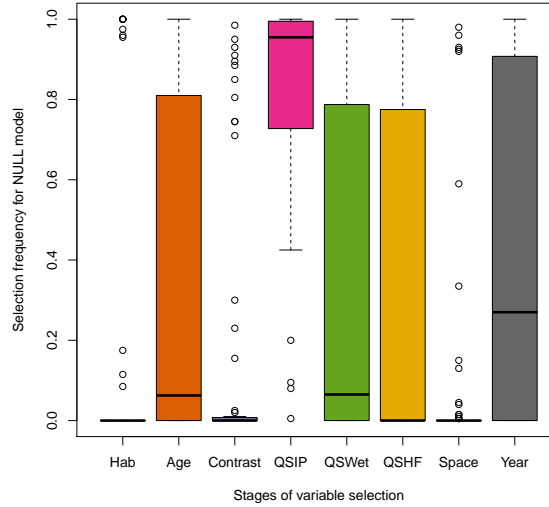


Figure 3.14: Frequency of selecting NULL. Distributions are based on all 77 species.

NULL was frequently selected for the stage describing quarter-section level suitable habitat patch effects. It is likely that quarter-section scale is too small to find a significant effect. Haché et al. (2014) found that amount of suitable habitat patch was significant for three species at a 16 km² scale (4 km × 4 km grid) which is 25 times larger area that used in this report.

When looking at each stage separately (Figure 3.15; c.f. Table 2.3), we can see that at Stage 1 (habitat classes) habitat including burn as separate class and also the modifier for clearcuts was most often selected. At Stage 2 (age), the selection frequency decreased with model complexity, forest type specific age response being the less frequent. At Stage 3 (contrast), road seemed to be most important, followed by the interaction of roads and soft linear features. Quarter-section level suitable patch effect (Stage 4) was rarely selected. For quarter-section level wetness (Stage 5) we found that mostly wetlands were selected, the term incorporating open water was less frequent. Quarter-section level footprint (Stage 6) varied greatly across species, the most often selected model (6.9) combined linear effect of successional and quadratic effect of alienating footprint types. For spatial predictors (Stage 7) more complex models including climate rather than latitude/longitude were selected more frequently, probably due to better potential for describing complex spatial trends across species. Selection frequencies for year effect (Stage 8) varied greatly across species.

3.2.2 Habitat associations

Regardless of the low selection frequency of quarter-section level suitable habitat amount in the multi-stage modeling, the habitat associations based on the Lorenz-tangent approach (that were used to delineate suitable habitats) provided simple means for summarizing habitat associations across species. We compiled bootstrap based selection frequencies for habitat classes and performed a canonical correspondence analysis. The biplot (Figure 3.16) shows the separation of disturbed and open habitats and closed canopy undisturbed habitats along

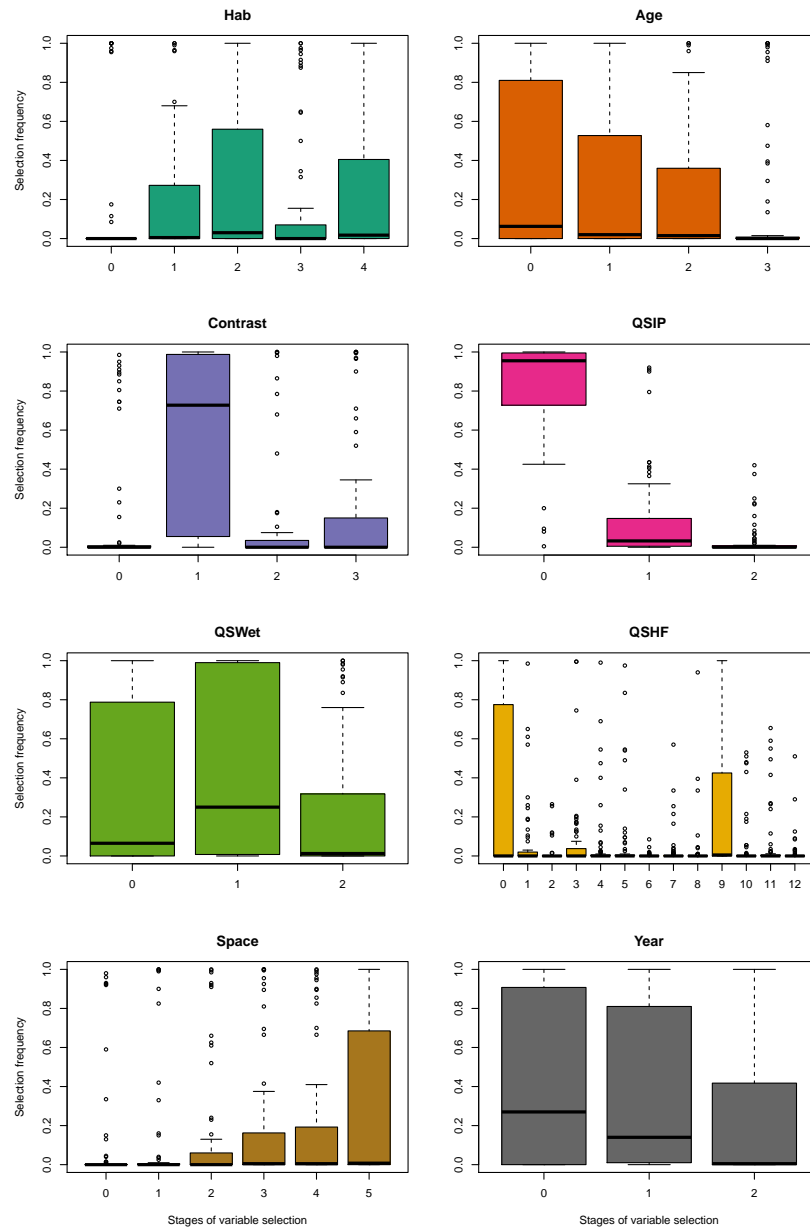


Figure 3.15: Frequency of selecting mods. Distributions are based on all 77 species.

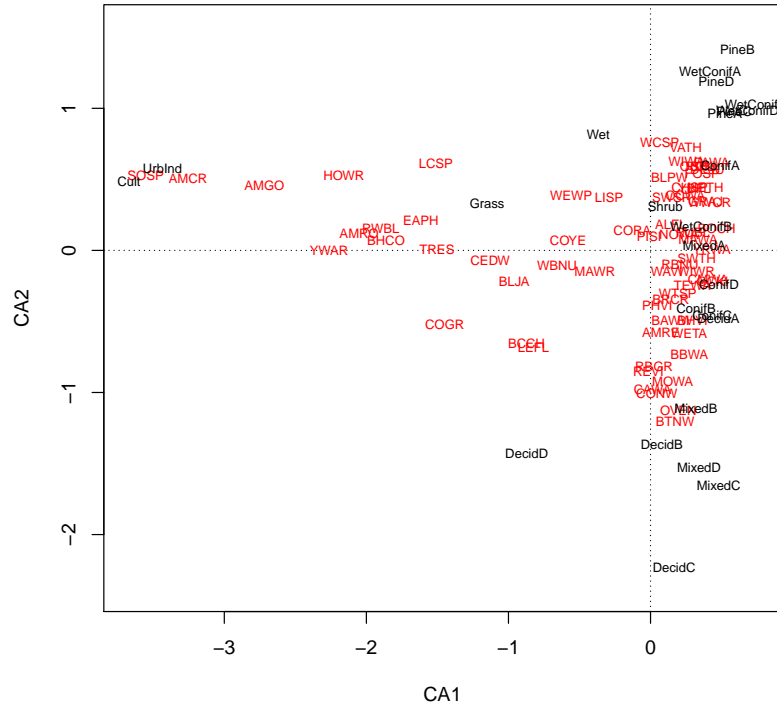


Figure 3.16: Canonical correspondence analysis of habitat suitabilities for species based on Lorenz-tangent approach. Input data was selection frequency of habitat patches from 200 bootstrap runs. AOU codes represent the 77 species (red), names of habitat classes are in black.

the first axis (CA1) with species that are associated to these habitat classes. The second canonical axis (CA2) showed a gradient from old-growth mixed and deciduous forests to old coniferous stands with early-seral (young forests, shrubs) and wetlands in between.

3.2.3 Point level effects of linear features

The point level effects of linear features (roads, soft linear features) varied greatly, and effect sizes for the two kinds of linear features showed little congruence (Figure 3.17). The majority of the effect sizes for soft linear features were closer to 0 than effect sizes for roads for same species. Interpretation of these results with respect to estimating numerical consequences for populations is not straightforward. Effect sizes can reflect different numerical or behavioural responses to linear features, or simply a detectability effect, or combinations of these effects.

3.2.4 Quarter-section level responses and year effect

We calculated the change in relative abundances between 0% and maximum value of quarter-section level predictors from species specific graphs (e.g. Figure 3.5). The change was expressed as ratio on the log scale to roughly indicate the direction and magnitude of the

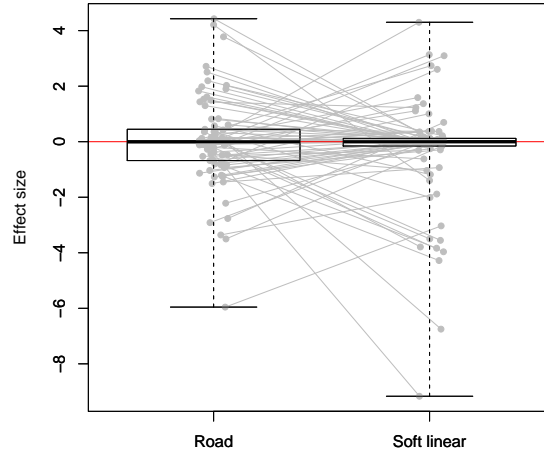


Figure 3.17: Point level effects of linear features. Dots and lines indicate same species.

change for each quarter-section level predictor, and also for the year effect (e.g. Figure 3.10). We explored pairwise correlations among these effects in a scatterplot matrix (Figure 3.18). We found that the year effect showed no strong association with quarter-section level responses. Relatively strong correlations were found among quarter-section level responses for cultivation, urban-industrial features and hard linear features (alienating disturbances); and also between responses to forestry and soft linear (successional) disturbances.

3.2.5 Goodness-of-fit

Goodness-of-fit (classification accuracy) as measured by AUC increased through the stages of the modeling as expected (Figure 3.19). The overall increase in classification accuracy was relatively small, indicating that local habitat effects strongly determine habitat suitability and modifying effects at larger spatial scales have relatively minor contribution.

3.2.6 Footprint effects on suitable habitats

Table 3.3 summarizes current and reference population size estimates. Proportional change was expressed relative to the reference population estimate. This change does not reflect real temporal change, but rather indicates the amount of suitable habitat lost or gained due to the presence of footprint in the landscape. The largest proportional losses of suitable habitats were found for old-growth forest species, while largest proportional gains of suitable habitats were found for human associated species (Figure 3.20).

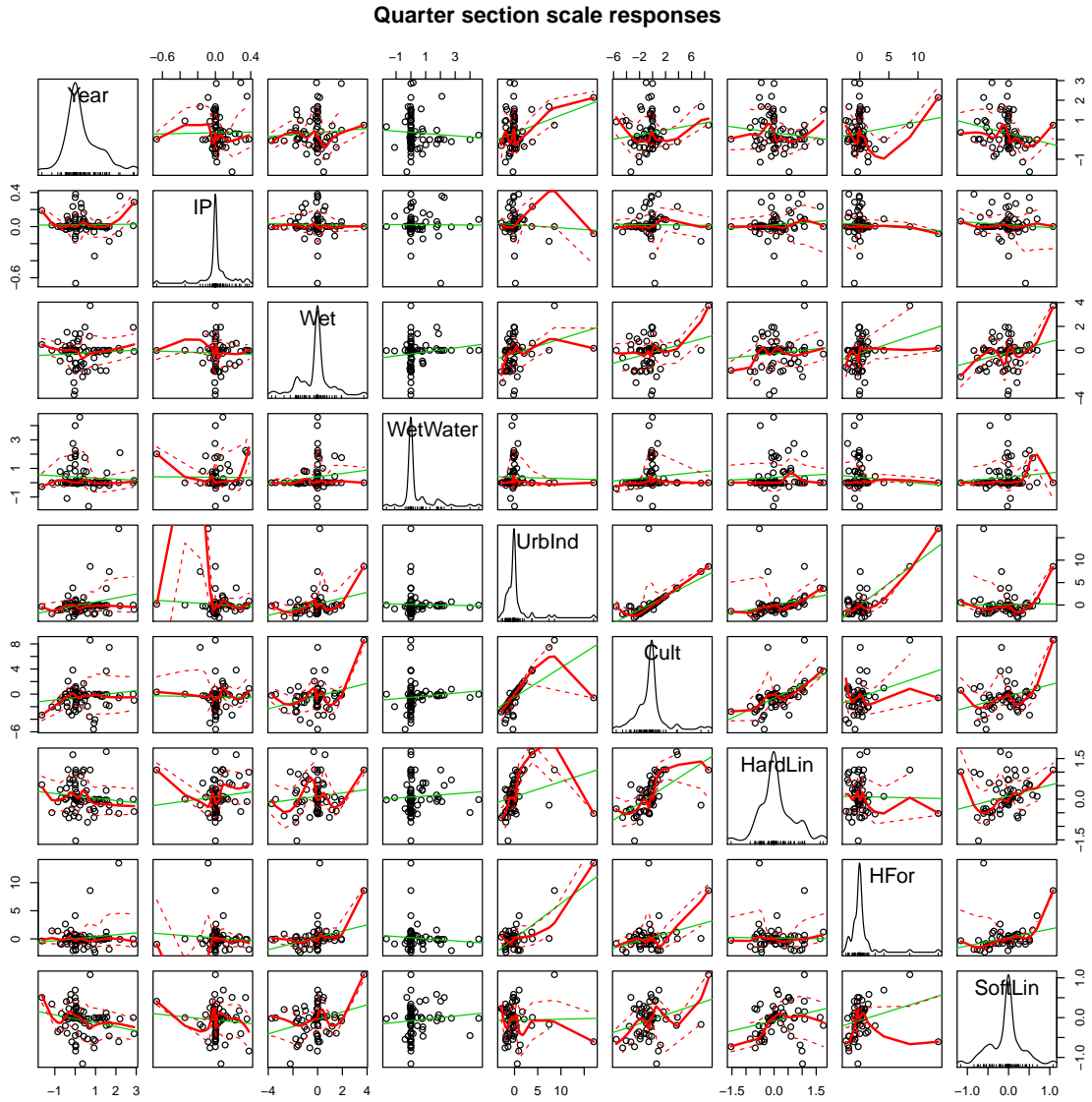


Figure 3.18: Correlations for quarter-section scale responses and year effect. Effects are on the log scale, negative values indicate decreasing abundance with increasing values of the variable. Each dot correspond to a species. Red lines correspond to locally weighted trend estimates, green line is a linear fit through the points to aid the interpretation.

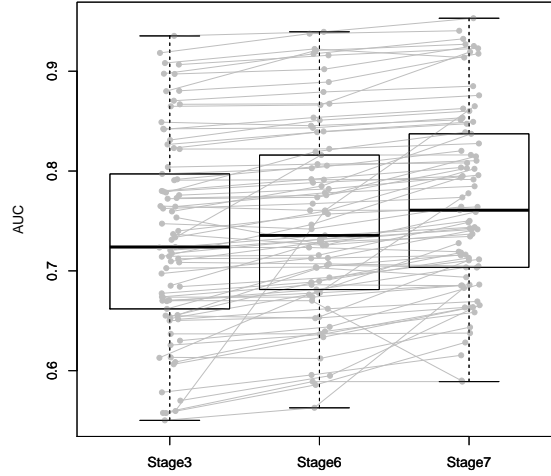


Figure 3.19: Area under the curve (AUC) values for the species based on model stages 3, 6, and 7. Dots represent species, lines connect dots for same species.

Table 3.3: Current and reference population size estimates in the JOSM study area based on a 10% random sample of quarter sections. Population sizes are in millions of male birds within the JOSM study area. The column JOSM stands for the proportion of the Boreal population found within the JOSM study area. Change is the proportional difference between reference and current population sizes relative to the reference.

AOU codes	Current	Reference	Gain	Loss	Change	JOSM	Responsibility
BTNW	0.3930	0.5215	0.0131	0.1416	-0.2464	0.2748	0.7721
BHCO	0.6180	0.8080	0.0022	0.1921	-0.2351	0.2417	0.6791
LEFL	2.5296	3.2831	0.0041	0.7577	-0.2295	0.3065	0.8611
OVEN	5.4864	6.5006	0.0399	1.0541	-0.1560	0.3777	1.0609
WETA	1.0869	1.2873	0.0011	0.2015	-0.1557	0.3443	0.9673
BRCR	0.7456	0.8649	0.0095	0.1287	-0.1379	0.3794	1.0659
WIWR	0.6473	0.7457	0.0056	0.1040	-0.1320	0.4974	1.3974
CONW	0.3724	0.4286	0.0027	0.0589	-0.1310	0.3863	1.0853
MOWA	0.3575	0.4083	0.0195	0.0704	-0.1246	0.2992	0.8404
YRWA	13.2518	15.0936	0.0013	1.8432	-0.1220	0.3325	0.9340
CEDW	0.9170	1.0356	0.0054	0.1240	-0.1145	0.3243	0.9111
BCCH	0.9465	1.0648	0.0098	0.1281	-0.1111	0.3138	0.8817
BBWA	2.7033	3.0239	0.0027	0.3233	-0.1060	0.4572	1.2844
CAWA	0.3223	0.3602	0.0101	0.0479	-0.1052	0.2796	0.7855
RECR	0.0539	0.0600	0.0000	0.0061	-0.1021	0.6353	1.7847
CMWA	3.1446	3.4961	0.0010	0.3525	-0.1006	0.4634	1.3018

Table 3.3: *(continued)*

AOU codes	Current	Reference	Gain	Loss	Change	JOSM	Responsibility
RBGR	0.9191	1.0183	0.0600	0.1592	−0.0975	0.3471	0.9751
WEWP	0.2830	0.3128	0.0020	0.0317	−0.0951	0.3281	0.9216
YWAR	0.6773	0.7481	0.0262	0.0970	−0.0947	0.2688	0.7552
GCKI	1.0053	1.1082	0.0185	0.1213	−0.0928	0.1842	0.5176
WAVI	0.4978	0.5475	0.0182	0.0679	−0.0907	0.1401	0.3935
PISI	1.4088	1.5472	0.0049	0.1433	−0.0894	0.2072	0.5821
AMRE	1.5751	1.7284	0.0623	0.2156	−0.0887	0.2647	0.7435
SWTH	5.9446	6.5085	0.0036	0.5674	−0.0866	0.3030	0.8512
TEWA	15.4319	16.7404	0.0113	1.3197	−0.0782	0.4021	1.1297
DEJU	3.9635	4.2859	0.0047	0.3271	−0.0752	0.3832	1.0766
BOCH	2.5758	2.7724	0.0011	0.1977	−0.0709	0.3984	1.1193
BHVI	1.0185	1.0869	0.0211	0.0894	−0.0629	0.3486	0.9794
NOWA	0.2287	0.2435	0.0007	0.0155	−0.0610	0.2710	0.7614
RBNU	0.8216	0.8724	0.0343	0.0852	−0.0583	0.2630	0.7388
FOSP	0.1082	0.1147	0.0002	0.0067	−0.0565	0.1479	0.4154
WWCR	0.9885	1.0436	0.0135	0.0686	−0.0528	0.2986	0.8390
WCSP	0.0013	0.0014	0.0000	0.0001	−0.0524	0.0228	0.0640
GRAJ	3.8415	4.0526	0.0069	0.2181	−0.0521	0.3780	1.0618
BLPW	0.5384	0.5675	0.0037	0.0328	−0.0513	0.2285	0.6420
HETH	2.8212	2.9629	0.0162	0.1579	−0.0478	0.3993	1.1216
PAWA	2.4143	2.5339	0.0107	0.1303	−0.0472	0.4791	1.3458
SWSP	0.8285	0.8671	0.0083	0.0469	−0.0445	0.4412	1.2395
REVI	2.6321	2.7531	0.0519	0.1729	−0.0439	0.3260	0.9157
WIWA	0.5050	0.5280	0.0022	0.0252	−0.0436	0.3677	1.0328

Table 3.3: (continued)

AOU codes	Current	Reference	Gain	Loss	Change	JOSM	Responsibility
RCKI	4.8250	5.0201	0.0320	0.2271	-0.0389	0.4364	1.2259
BAWW	2.1172	2.1957	0.0220	0.1006	-0.0358	0.3137	0.8812
MAWA	2.1606	2.2364	0.0138	0.0897	-0.0339	0.3427	0.9627
RUBL	0.0793	0.0820	0.0001	0.0029	-0.0334	0.4180	1.1742
EVGR	0.2269	0.2343	0.0012	0.0086	-0.0318	0.3404	0.9563
VATH	0.0069	0.0071	0.0000	0.0002	-0.0293	0.0515	0.1448
OSFL	0.0940	0.0965	0.0012	0.0037	-0.0260	0.3778	1.0612
YBFL	1.0022	1.0238	0.0034	0.0250	-0.0211	0.4006	1.1254
WTSP	4.1739	4.2253	0.2671	0.3185	-0.0122	0.3383	0.9505
MAWR	0.2085	0.2101	0.0044	0.0060	-0.0075	0.3769	1.0587
CORA	0.3205	0.3228	0.0019	0.0042	-0.0071	0.3332	0.9359
PHVI	0.5982	0.6011	0.0172	0.0201	-0.0048	0.3175	0.8920
OCWA	0.3771	0.3778	0.0175	0.0182	-0.0018	0.3255	0.9144
TRES	0.3633	0.3637	0.0212	0.0216	-0.0009	0.3276	0.9203
VEER	0.0234	0.0234	0.0000	0.0000	0.0000	0.3560	1.0000
PUFI	0.1444	0.1444	0.0000	0.0000	0.0000	0.3560	1.0000
CSWA	0.0102	0.0102	0.0000	0.0000	0.0000	0.7421	2.0848
WBNU	0.0108	0.0108	0.0000	0.0000	0.0031	0.1903	0.5345
CHSP	6.0278	5.9785	0.1326	0.0832	0.0083	0.3752	1.0540
PIGR	0.0047	0.0047	0.0001	0.0000	0.0119	0.3560	1.0000
COGR	0.0067	0.0065	0.0002	0.0000	0.0335	0.0774	0.2176
COYE	0.8789	0.8463	0.0513	0.0187	0.0385	0.3566	1.0017
EAPH	0.0287	0.0273	0.0015	0.0001	0.0515	0.3257	0.9151
BLJA	0.0748	0.0703	0.0077	0.0032	0.0645	0.4097	1.1509
AMRO	0.6914	0.6354	0.0684	0.0124	0.0882	0.2755	0.7739
RWBL	0.3024	0.2716	0.0355	0.0048	0.1131	0.2970	0.8342
ALFL	1.3520	1.1519	0.2056	0.0055	0.1737	0.2984	0.8383
LCSP	0.5568	0.4448	0.1126	0.0005	0.2520	0.3317	0.9317
HOWR	0.2645	0.2065	0.0726	0.0146	0.2809	0.2286	0.6422
LISP	2.1844	1.6797	0.5091	0.0044	0.3005	0.2696	0.7575
AMGO	0.0231	0.0150	0.0086	0.0005	0.5428	0.4663	1.3101
CCSP	1.2553	0.7262	0.5298	0.0007	0.7285	0.2960	0.8314
SOSP	0.3344	0.1835	0.1594	0.0085	0.8224	0.3086	0.8668
AMCR	0.0855	0.0463	0.0392	0.0000	0.8447	0.2978	0.8365
HOLA	0.0031	0.0015	0.0016	0.0000	1.0418	0.6588	1.8508
SAVS	0.7501	0.1408	0.6111	0.0018	4.3282	0.2210	0.6207
VESP	0.3503	0.0312	0.3191	0.0000	10.2242	0.3345	0.9398

3.2.7 Population size estimates

Our estimates of current Boreal population sizes ($\hat{N}^{(QPAD)}$) are based on an exhaustive model based prediction approach using province wide vegetation and footprint maps. Existing populations size estimates provided by Partners in Flight (PIF) provide another set of population

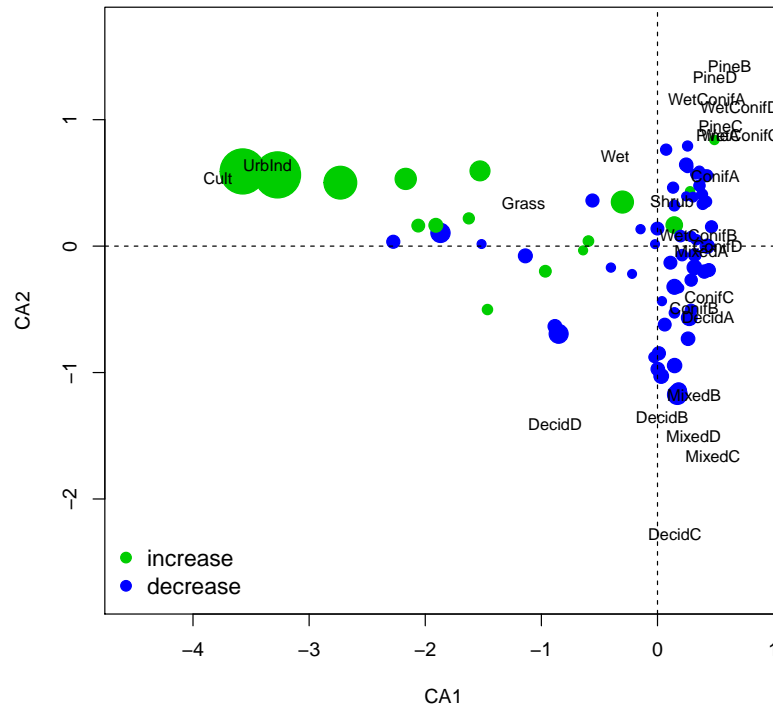


Figure 3.20: Canonical correspondence analysis of habitat suitabilities for species based on Lorenz-tangent approach as in Figure 3.16. Size of the dots for each species is proportional to proportional change in habitat suitability based on current and reference population size estimates from Table 3.3.

size estimates ($\hat{N}^{(PIF)}$; we used numbers referring to singing individuals, i.e. dividing the original PIF estimates by the pair adjustment) for the same species within Birds Conservation Regions (BCRs) 6–8.

PIF used a population-size estimator developed by Rosenberg and Blancher (2004) for analyzing the species-specific counts from the roadside North American Breeding Bird Survey (BBS). PIF organized a peer review of the PIF approach (Thogmartin et al., 2006) to address concerns by the ornithological community. The criticism by Thogmartin et al. (2006) identified the following main assumptions that might bias populations size estimates by PIF:

1. *Time adjustment*: factors were derived based on average counts as a function of time of day and time of year to come up with a factor for each species (T) that would adjust mean counts relative to the yearly and daily maximum for counts.
2. *Maximum detection distance*: the detection-distance adjustment defines the effective area surveyed based on a species-specific maximum detection distance (MDD) that birds can be heard or seen by observers.
3. *Roadside counts*: roadside-survey counts are equivalent to survey counts in off-road areas.
4. *Habitat sampling*: BBS routes sample avian habitats in proportion to their availability.

Our procedure, in contrast to the PIF approach, makes different assumptions and tries to improve the estimators:

1. *Time adjustment*: we have used offsets based on probabilities derived from removal-sampling to take into account availability bias ((Sólymos et al., 2013)).
2. *Maximum detection distance*: we have used effective detection distances (EDR) derived from distance-sampling to take into account detectability bias ((Sólymos et al., 2013)).
3. *Roadside counts*: we combined roadside and off-road surveys and estimated the effect of road.
4. *Habitat sampling*: we have used a wider set of surveys in Alberta (roadside and off-road surveys) and applied a model based approach (whereas the PIF approach was a design based approach).

The ratio of the population estimates derived from our approach and the PIF approach gives us the *observed bias*: $\Delta^{(OBS)} = \hat{N}^{(QPAD)} / \hat{N}^{(PIF)}$ (the term ‘bias’ is used here without implying that any of these numbers are the truth). We expected that the magnitude and direction of the observed bias was related to the different sets assumptions. To evaluate this, we compared the estimators. The QPAD estimator is defined as: $\hat{N}^{(QPAD)} = A Y (1/p_3) (1/\pi EDR^2)$. The PIF estimator is defined as: $\hat{N}^{(PIF)} = A Y^{(ROAD)} T (1/\pi MDD^2)$. We used the inverse of the probability of singing within a 3-minutes survey interval (p_3) as an equivalent to the time adjustment because BBS surveys are 3-minutes unlimited distance counts, thus the correction factor for those would be defined as $1/p_3$.

It follows that the *expected bias* is $\Delta^{(EXP)} = (\frac{Y}{Y^{(ROAD)}}) (\frac{1/p_3}{T}) (\frac{\pi MDD^2}{\pi EDR^2})$ (note that area A cancels out). For notational simplicity, we refer to the components of the bias as: $\Delta^{(EXP)} =$

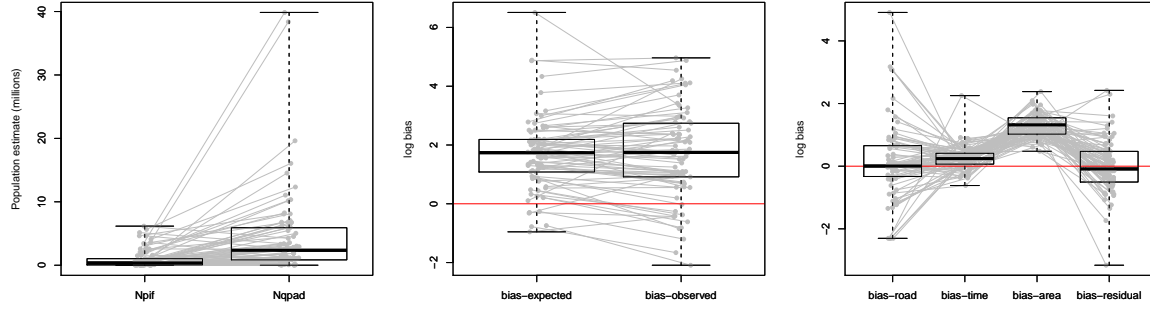


Figure 3.21: Decomposition of population size estimation bias. Dots represent species, lines connect dots for same species.

$\delta^{(ROAD)}\delta^{(TIME)}\delta^{(DIST)}$. The time and distance components of the bias were calculated from known estimates. The road related component was estimated by the road effect presented in graphs like in Figure 3.3 from our modeling, as that represents the effect of road relative to an off-road point location. We further assumed that the observed and expected bias will differ, thus we introduced the residual bias as: $\Delta^{(OBS)} = \Delta^{(EXP)}\delta^{(RESID)}$.

Our estimates for the bias and its components are listed in Table 3.4. The bias is 1 when QPAD and PIF components equal. A larger than 1 value indicate that the QPAD component is larger than the PIF component. The median observed bias between QPAD and PIF population estimates was 5.7 and ranged between 0.12 and 143.15. The median of the expected bias across the 77 species was 5.6, very close to the median of the observed bias (Figure 3.21). The components of the bias showed interesting trends: the road related bias and the residual bias showed large variation across the species with a close to 0 median value. The time related bias was on average positive, but relatively small. Whereas the distance related bias was consistently higher for all species, with magnitudes between 1.61 and 10.82 which is consistent with the expected distance related biases reported by Matsuoka et al. (2012).

Table 3.4: Bias components between QPAD and PIF based population estimates in in Boreal Alberta.

AOU codes	Nqpad	Npif	bias-expected	bias-observed	bias-road	bias-time	bias-area	bias-residual	road-avoidance
YRWA	39.8572	2.5750	13.5752	15.4785	1.9403	1.5516	4.5090	1.1402	0.9650
TEWA	38.3755	2.0700	8.9598	18.5389	1.7578	1.2715	4.0088	2.0691	0.9629
SWTH	19.6199	1.0400	8.0422	18.8653	1.4665	1.0459	5.2431	2.3458	0.9637
CHSP	16.0651	5.6550	2.9779	2.8409	1.0632	0.8381	3.3419	0.9540	0.9524
OVEN	14.5272	0.6520	14.1718	22.2810	2.2450	1.1034	5.7210	1.5722	0.9565
WTSP	12.3365	4.1150	3.7285	2.9979	1.2320	0.7205	4.2002	0.8041	0.9450
RCKI	11.0564	1.5450	7.4056	7.1563	1.9261	1.4801	2.5977	0.9663	0.9675
DEJU	10.3420	2.0600	4.7819	5.0204	0.9669	1.4492	3.4126	1.0499	0.9686
GRAJ	10.1632	0.8270	8.9905	12.2892	1.8658	1.4085	3.4211	1.3669	0.9692
LEFL	8.2527	2.0600	6.5832	4.0062	1.0039	1.2366	5.3027	0.6085	0.9092
LISP	8.1013	3.0950	2.1571	2.6175	1.0000	0.8415	2.5635	1.2135	0.9252
REVI	8.0749	4.6350	1.7085	1.7422	0.6741	1.0680	2.3730	1.0197	0.9221
HETH	7.0658	0.7220	4.7661	9.7864	0.9954	1.1124	4.3044	2.0533	0.9678
PISI	6.7988	3.4333	3.5335	1.9802	0.6376	1.2744	4.3484	0.5604	0.9430
CMWA	6.7858	0.1030	16.1709	65.8819	2.8652	1.3558	4.1626	4.0741	0.9723
BAWW	6.7495	0.2575	13.2003	26.2117	2.6113	1.4152	3.5719	1.9857	0.9596
BOCH	6.4650	0.3288	21.4507	19.6623	3.2709	2.0591	3.1849	0.9166	0.9668
MAWA	6.3051	0.1555	15.4687	40.5472	2.5243	1.5107	4.0564	2.6213	0.9740
AMRE	5.9513	0.6510	7.7218	9.1425	1.3234	1.4829	3.9347	1.1840	0.9521
BBWA	5.9123	0.0413	129.9473	143.1550	21.7133	1.5509	3.8589	1.1016	0.9664
GCKI	5.4566	0.5155	12.2905	10.5850	4.8354	1.5799	1.6088	0.8612	0.9622
PAWA	5.0395	0.0823	23.6169	61.2332	6.0419	1.1624	3.3626	2.5928	0.9840
ALFL	4.5309	2.5750	2.5521	1.7596	1.0000	1.0337	2.4688	0.6895	0.9355
CCSP	4.2412	6.1650	1.5616	0.6879	0.4697	0.7361	4.5161	0.4405	0.7510
WAVI	3.5539	1.0200	4.1215	3.4842	1.0668	1.0161	3.8023	0.8454	0.9384
SAVS	3.3947	5.1500	1.6141	0.6592	0.8523	0.9576	1.9777	0.4084	0.6389
WWCR	3.3099	0.5768	4.8837	5.7383	0.9696	1.4899	3.3808	1.1750	0.9667
WETA	3.1565	0.1030	6.1664	30.6459	1.0036	1.0419	5.8975	4.9698	0.9576

Table 3.4: *(continued)*

AOU codes	Nqpad	Npif	bias-expected	bias-observed	bias-road	bias-time	bias-area	bias-residual	road-avoidance
RBNU	3.1242	0.5891	8.3085	5.3029	1.8551	1.7560	2.5505	0.6382	0.9534
BCCH	3.0156	1.0350	5.8043	2.9137	0.8421	1.4728	4.6798	0.5020	0.9066
BHVI	2.9216	0.3605	13.9718	8.1043	2.5557	1.6261	3.3620	0.5801	0.9437
CEDW	2.8275	0.9417	4.9771	3.0025	0.7332	1.3745	4.9386	0.6033	0.9078
RBGR	2.6479	0.2500	12.2565	10.5917	1.9894	1.3009	4.7360	0.8642	0.9405
BHCO	2.5564	0.9226	6.5046	2.7708	0.6634	1.2996	7.5446	0.4260	0.8334
YWAR	2.5194	2.5750	2.4059	0.9784	0.4095	1.3121	4.4776	0.4067	0.8376
AMRO	2.5099	4.6300	1.2315	0.5421	0.3554	0.6852	5.0566	0.4402	0.8522
YBFL	2.5017	0.0412	43.9777	60.7213	8.6986	1.6195	3.1218	1.3807	0.9769
COYE	2.4648	0.8542	3.2757	2.8857	0.9437	1.2577	2.7598	0.8809	0.9185
BLPW	2.3558	0.0412	20.0130	57.1786	4.1070	1.7958	2.7134	2.8571	0.9773
BRCR	1.9651	0.0150	76.1882	131.0039	23.8942	1.1402	2.7965	1.7195	0.9544

Table 3.4: (continued)

AOU codes	Nqpad	Npif	bias-expected	bias-observed	bias-road	bias-time	bias-area	bias-residual	road-avoidance
PHVI	1.8839	0.2035	6.4588	9.2574	1.0779	1.4108	4.2472	1.4333	0.9462
SWSP	1.8778	0.3090	3.1021	6.0769	0.9971	1.2653	2.4587	1.9589	0.9571
LCSP	1.6789	0.8235	3.7856	2.0388	0.8799	0.7264	5.9225	0.5386	0.8376
BTNW	1.4300	0.0152	132.5430	94.0783	21.8679	1.5098	4.0144	0.7098	0.9511
WIWA	1.3736	0.1550	3.4397	8.8621	1.0075	1.6721	2.0419	2.5764	0.9698
WIWR	1.3012	0.0457	671.5420	28.4633	135.4103	1.0581	4.6869	0.0424	0.9647
MOWA	1.1948	0.4645	3.6784	2.5723	1.0555	1.0890	3.2002	0.6993	0.9422
OCWA	1.1586	0.4635	1.7933	2.4997	0.5406	1.0977	3.0218	1.3939	0.9591
HOWR	1.1571	1.5000	1.3843	0.7714	0.3275	1.1293	3.7426	0.5573	0.7083
CAWA	1.1527	0.0850	8.5023	13.5595	2.3203	1.2799	2.8630	1.5948	0.9397
TRES	1.1091	0.5309	3.7395	2.0892	0.2924	1.1816	10.8217	0.5587	0.8067
SOSP	1.0837	3.6000	0.7702	0.3010	0.3188	0.8716	2.7717	0.3908	0.6971
VESP	1.0470	0.3535	4.2458	2.9619	0.7544	0.6953	8.0945	0.6976	0.6409
RWBL	1.0182	1.5680	0.7451	0.6494	0.2665	1.0468	2.6708	0.8716	0.7774
CONW	0.9639	0.1500	5.3562	6.4261	2.3736	0.9378	2.4063	1.1998	0.9464
CORA	0.9620	0.2090	7.5041	4.6029	0.8558	1.2402	7.0698	0.6134	0.9110
WEWP	0.8627	0.1500	7.6249	5.7514	1.0017	1.3968	5.4495	0.7543	0.9070
NOWA	0.8437	0.0516	5.6871	16.3659	1.0099	1.5129	3.7224	2.8777	0.9576
FOSP	0.7316	0.0104	6.2520	70.3457	1.1573	2.1499	2.5127	11.2517	0.9812
EVGR	0.6664	0.0345	5.7936	19.3315	1.0774	1.9327	2.7824	3.3367	0.9433
MAWR	0.5533	0.0500	1.1132	11.0660	0.4240	0.5397	4.8647	9.9404	0.9318
PUFI	0.4057	0.0704	7.6975	5.7626	0.9814	2.0578	3.8114	0.7486	0.9270
AMCR	0.2871	0.6469	1.3004	0.4439	0.2597	0.9190	5.4479	0.3413	0.6869
OSFL	0.2487	0.0154	11.4374	16.1001	1.0838	1.4626	7.2152	1.4077	0.9718
RUBL	0.1896	0.0177	8.9250	10.7407	2.4301	1.6898	2.1734	1.2034	0.9582
BLJA	0.1826	0.0320	8.7748	5.7065	1.0050	2.3250	3.7553	0.6503	0.9044
VATH	0.1343	0.0500	2.9498	2.6857	1.0172	0.7941	3.6521	0.9105	0.9557
EAPH	0.0882	0.4645	0.4597	0.1899	0.1000	2.4973	1.8409	0.4130	0.7796
COGR	0.0871	0.0329	0.7282	2.6476	0.1000	1.2270	5.9354	3.6355	0.8605

Table 3.4: (*continued*)

AOU codes	Nqpad	Npif	bias-expected	bias-observed	bias-road	bias-time	bias-area	bias-residual	road-avoidance
RECR	0.0848	0.0137	3.8469	6.1757	1.1118	1.3215	2.6184	1.6054	0.9598
VEER	0.0657	0.0080	4.7301	8.2140	0.7198	1.0680	6.1531	1.7365	0.9256
WBNU	0.0569	0.0467	2.3581	1.2183	0.3111	2.4270	3.1227	0.5167	0.8758
WCSP	0.0566	0.0870	0.3849	0.6502	0.1000	1.0867	3.5423	1.6891	0.9313
AMGO	0.0495	0.4000	0.4771	0.1237	0.1000	1.2538	3.8051	0.2593	0.6622
CSWA	0.0137	0.0030	5.7734	4.5686	1.3991	1.3407	3.0777	0.7913	0.9299
PIGR	0.0133	0.0309	2.4382	0.4293	0.1000	9.5219	2.5606	0.1761	0.9050
HOLA	0.0048	0.0027	6.1290	1.7793	1.0000	1.1016	5.5639	0.2903	0.7616

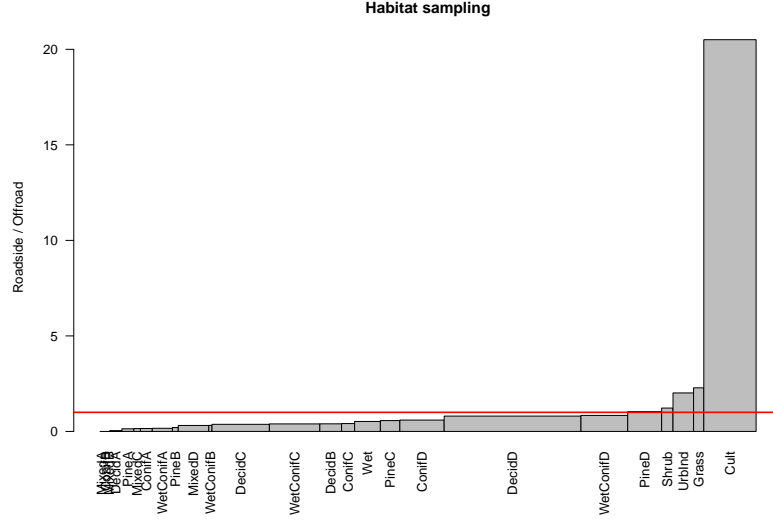


Figure 3.22: Relationships between components of bias between QPAD and PIF based population estimates in Boreal Alberta. Measures of the bias and its components are shown on log scale.

The time, distance and road components of the bias were quantified by estimated model parameters and published values. The residual bias is the only piece that was not quantified. The residual bias must be related to the last assumption, namely that BBS routes sample avian habitats in proportion to their availability. It has been demonstrated (e.g. Matsuoka et al. 2011) that this assumption is violated, at least in the Northern Boreal where BBS routes. For our data set, Figure 3.22 shows the sampling bias in different habitat classes. Disturbed (cultivation, urban-industrial development) and open (grass, shrub) areas are disproportionately over-sampled, whereas forest habitats are generally under-sampled.

As a consequence, we expected that residual bias should be associated to this habitat sampling bias by roads. Therefore we expected large residual bias for species whose preferred habitats are under-sampled by roads. To express the relationship between roads and preferred habitats of the species, we calculated the road avoidance index: $RAI = 1 - \sum_{h=1}^H ROAD_h O_h$, a covariance type measure where O_i is proportion of predicted population expected in habitat class h (based on relative selection graphs such as in Figure 3.9). $ROAD_h$ was the proportion of roadside samples within habitat class h . The product indicates the joint occurrence of a road and the species, thus the one-complement of the index refers to road avoidance. We found high agreement between the value of the residual bias and road avoidance index (Figure 3.23). Residual bias was less than one for species with small RAI values, whereas the residual bias was greater than one for species with RAI close to 1 (high avoidance).

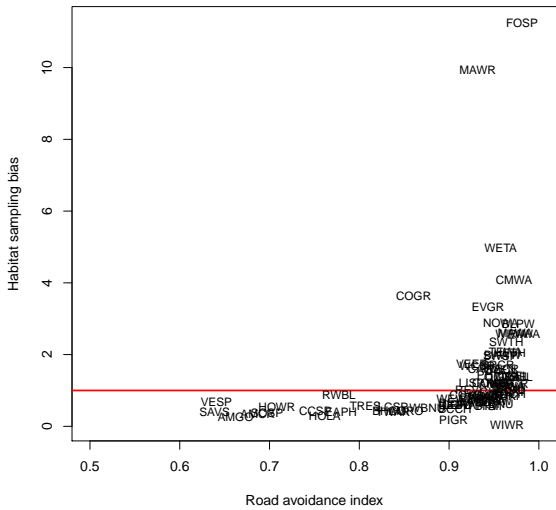


Figure 3.23: Relationship between residual bias and road avoidance for the species.

Chapter 4

Discussion

We used the most extensive standardized point count data collected and compiled by the Boreal Avian Modelling Project (BAM), Environment Canada (EC), the Alberta Biodiversity Monitoring Institute (ABMI), and the North American Breeding Bird Survey (BBS) was combined with geospatial information to build predictive models for bird species.

We described the habitat associations and responses to human footprint at different spatial scales (local and quarter-section) for 77 Passerine breeding birds. We created province wide predictive maps, assessed model performance and prediction uncertainty.

We determined changes in suitable habitats for bird populations in the Boreal region of Alberta in general, and specifically in the oil sands region based on current and “backfilled” habitat data. We found that species showing largest expected changes in their suitable habitats are either associated with habitats created more frequently by anthropogenic disturbances in the landscape, or species whose habitats are most often affected by disturbances related to various forms of resource extraction in the oil sands region. Our inferred changes in suitable habitats due to anthropogenic disturbances are not necessarily translated into numerical responses. Trend estimation and the attribution of population changes to various industry sectors were out of the scope of the present report.

We compare estimated population sizes for birds within Boreal Alberta and compare these to existing estimates by Partners in Flight. We found that our estimates were on average 6 times higher than the estimates provided by Partners in Flight for the same area. We compared the different assumptions inherent in the estimators and found that the bias related to the use of roadside surveys (from BBS) affected species specific population size estimates in different ways, while the effect of the assumption regarding the effective area sampled during surveys accounted for most of the bias consistently across the 77 species.

4.1 Caveats

- The current abundance estimate has no reference to a particular year, it represents average habitat conditions over the time span of the data set with inter annual variation present.
- Reference abundances were estimated based on the backfilled vegetation map and using the same statistical models as current abundance. Reference abundance represent the predictions conditional on the layer where footprint was removed and the original habitat “restored” based on vegetation in the neighborhood. We did not estimate the actual

abundance of the species prior to footprint. The reference abundance estimates is best interpreted as a measure of change in habitat suitability of species as a result of footprint. The scale of this change is relative to the current abundance estimate, and measured in same units.

- Some predictors used in the modeling might be measured with error (e.g. forest age) or misclassified (e.g. habitat classes). These errors might have biased our results and increased the variance of our estimates. These errors are also present in the predictions.
- Our models did not account for aging/regeneration of footprint except for forestry. Predictions, however, did not reflect recovery in the forestry footprint because of the lack of age information for those. As a result, effects of some footprint types that might have been recovered (forestry, soft linear features) are overestimated.

4.2 Next steps

- Updates of the modeling procedure need to improve the modeling of habitat ages by (1) incorporating information on age of footprint and footprint recovery, (2) linking early-seral vegetation (shrubs, grasses) to young forest habitats, (3) better description of age relationships allowing for different and more flexible response curve types besides linear and quadratic functions.
- Better design (filtering data) and model based (through correction factors) approaches are needed to estimate effects of linear features. The better understanding of factors contributing to linear feature effects (numerical, behavioural, detectability) also required further research and development, and new field data through collaborative efforts.
- Estimation and attribution of sector specific effects of anthropogenic disturbances in the landscape require improved geospatial information where attributes of the “backfilled” layers are retained when combined with the footprint layers.

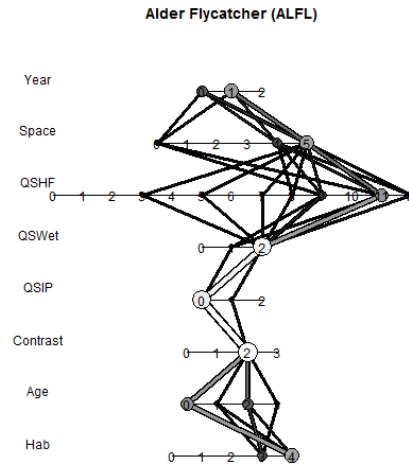
Chapter 5

Species specific results

5.1 Alder Flycatcher (*Empidonax alnorum*)

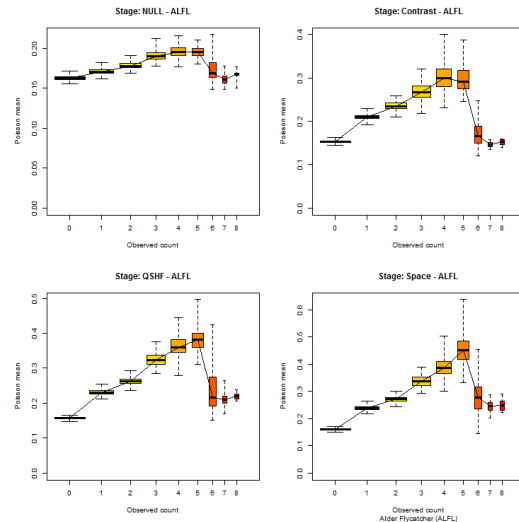
5.1.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

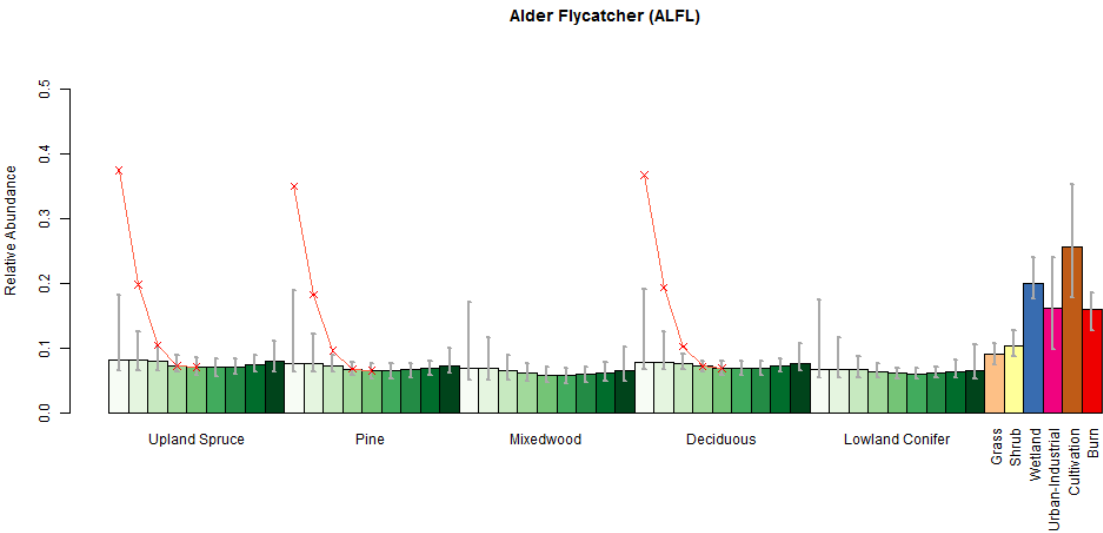


5.1.2 Cross validation

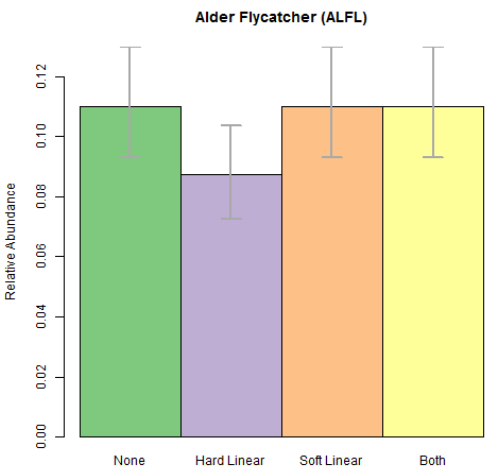
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.1.3 Point level habitat associations

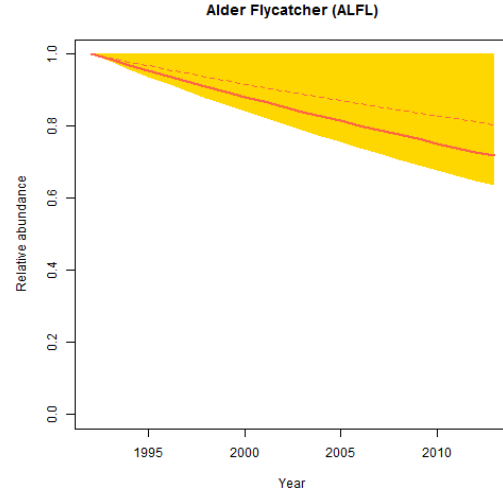


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

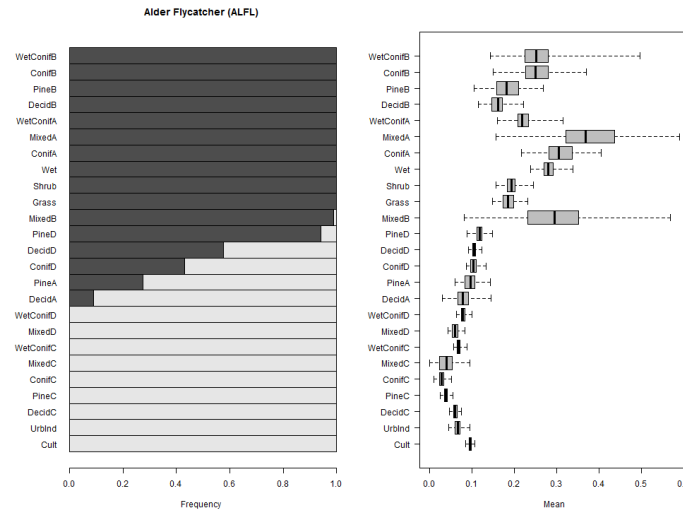


5.1.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



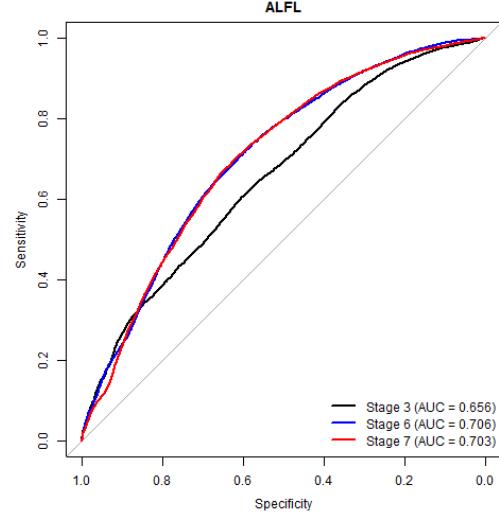
5.1.5 Habitat suitability ranking for patch delineation



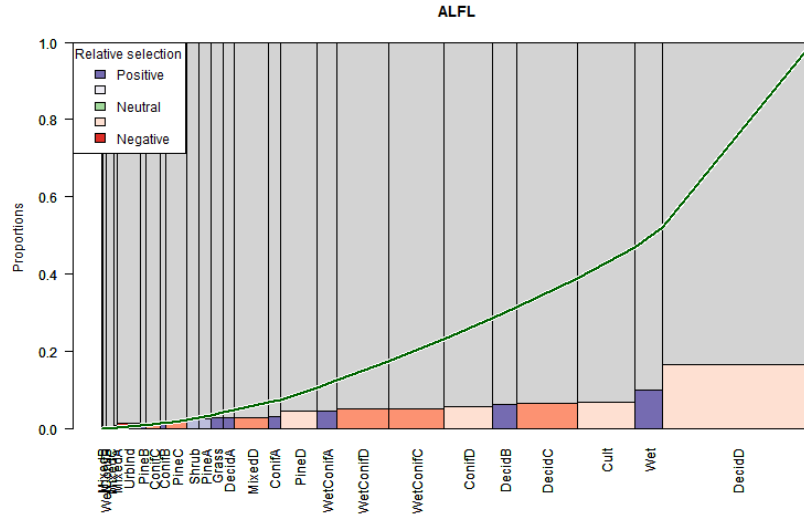
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.1.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

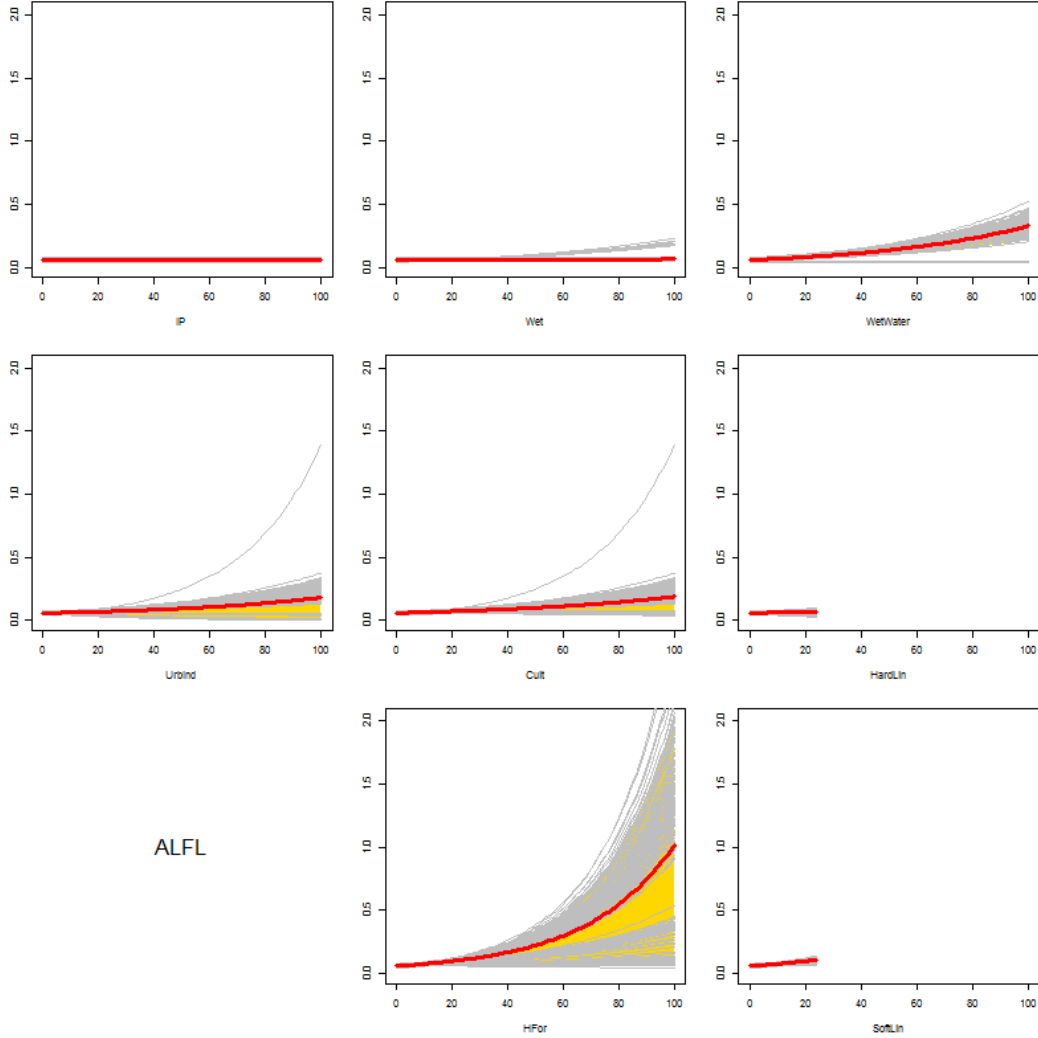


5.1.7 Relative habitat selection



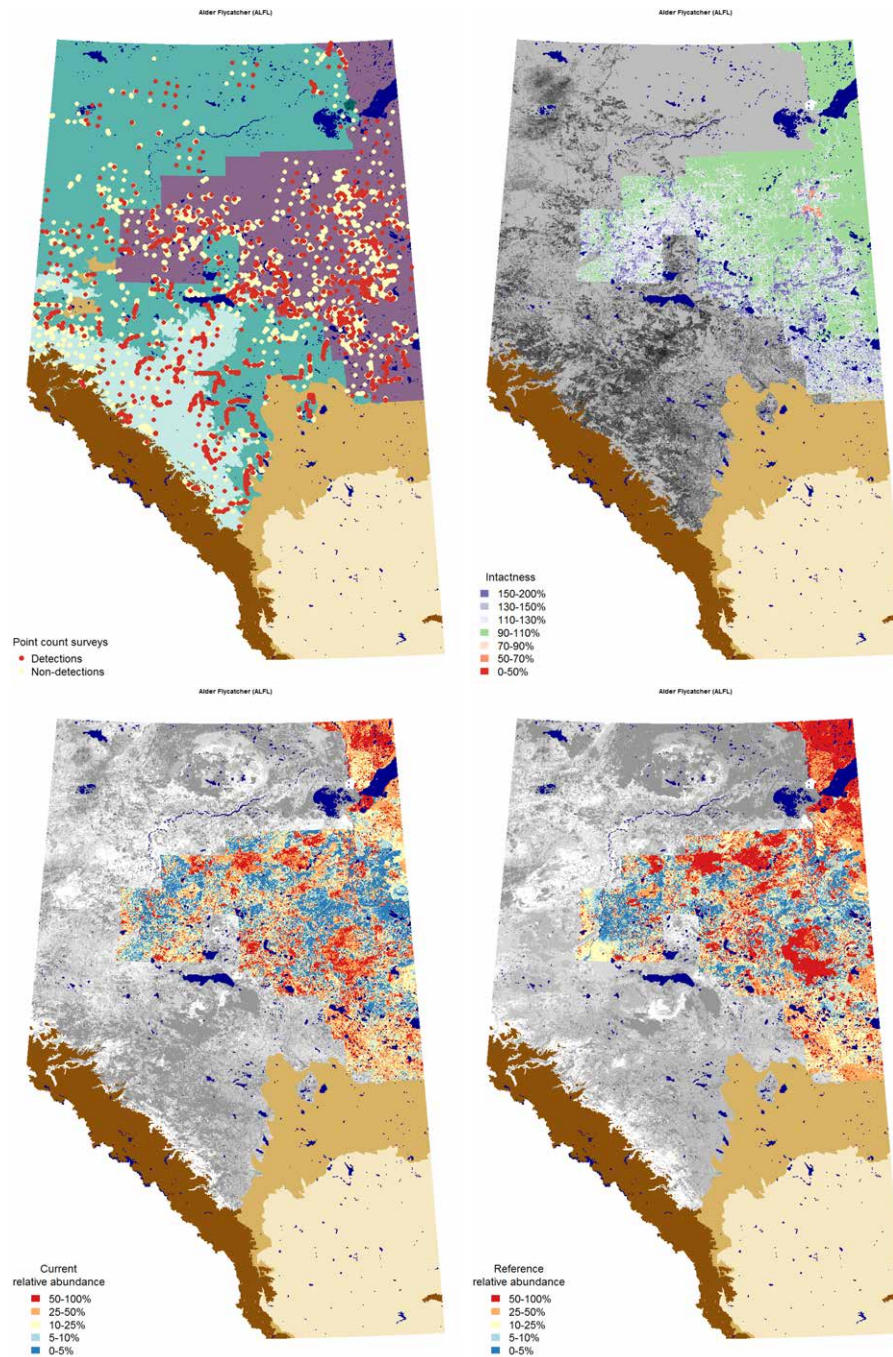
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.1.8 Quarter-section level responses



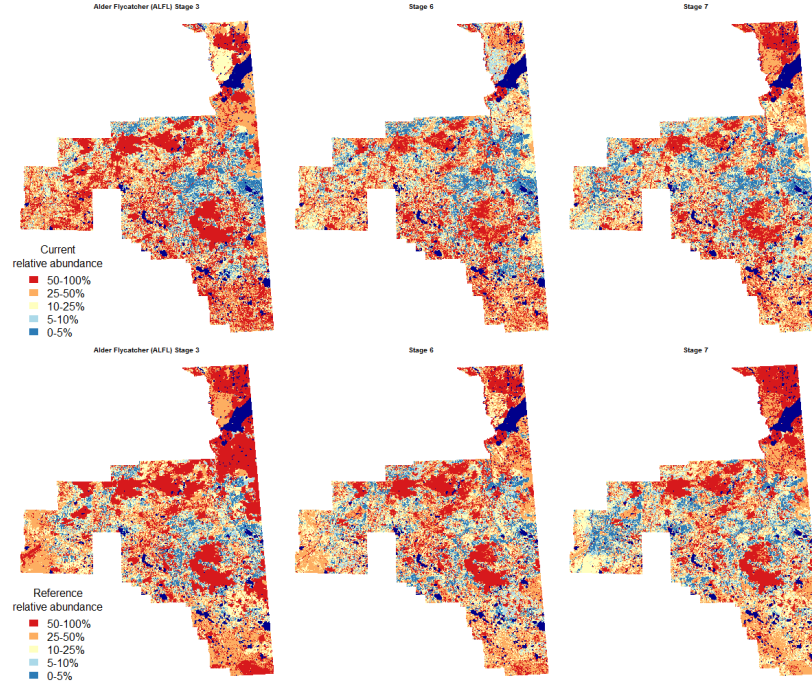
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.1.9 Maps



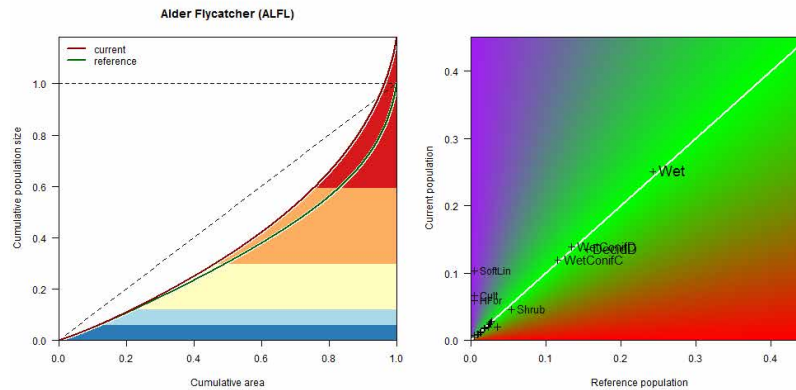
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.1.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.1.11 Population concentration



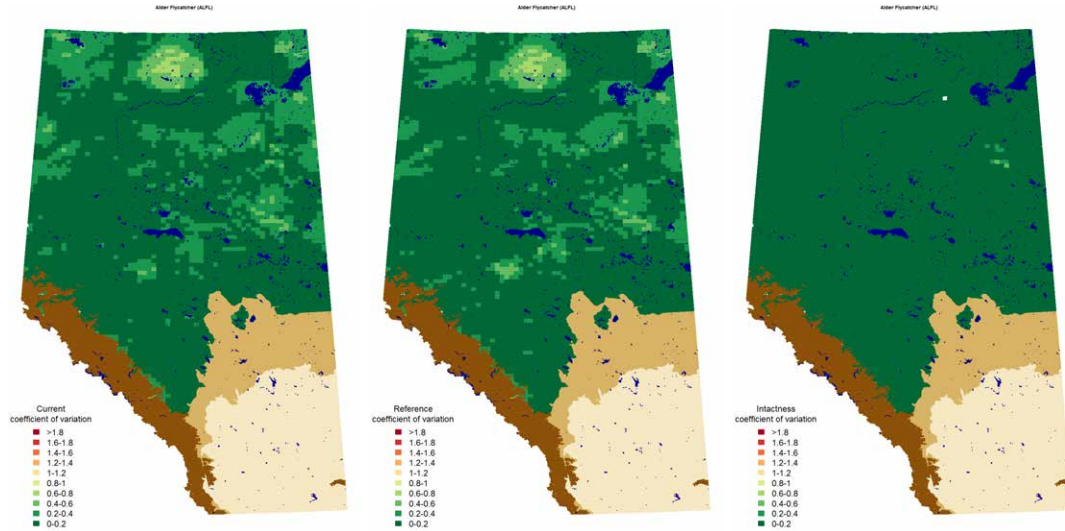
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.1.12 Potential population size

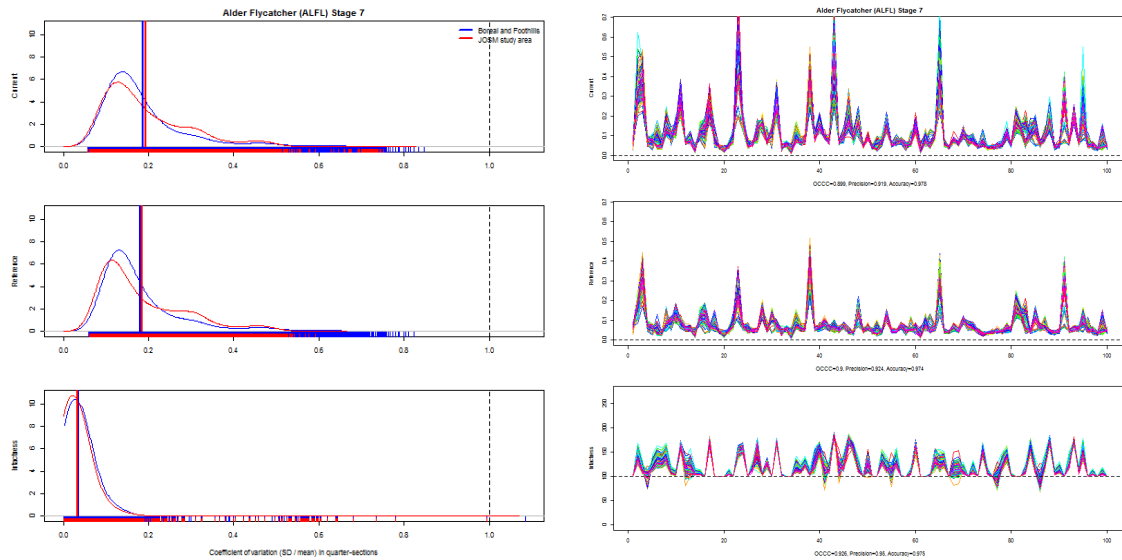
Estimated potential population size of Alder Flycatcher in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.2840	0.2488	0.3409	0.2741	0.2403	0.3264
DecidD	0.1527	0.1337	0.1832	0.1755	0.1539	0.2090
WetConifD	0.1570	0.1375	0.1884	0.1515	0.1328	0.1804
WetConifC	0.1348	0.1181	0.1618	0.1313	0.1151	0.1563
Shrub	0.0516	0.0452	0.0619	0.0617	0.0540	0.0734
Grass	0.0224	0.0196	0.0268	0.0401	0.0352	0.0478
WetConifA	0.0324	0.0284	0.0389	0.0315	0.0276	0.0375
ConifD	0.0299	0.0262	0.0359	0.0305	0.0267	0.0363
WetConifB	0.0295	0.0259	0.0355	0.0298	0.0262	0.0355
PineB	0.0294	0.0257	0.0352	0.0293	0.0257	0.0349
MixedD	0.0269	0.0235	0.0322	0.0283	0.0248	0.0337
DecidC	0.0224	0.0196	0.0269	0.0264	0.0231	0.0314
ConifC	0.0202	0.0177	0.0242	0.0216	0.0190	0.0258
PineC	0.0202	0.0177	0.0243	0.0207	0.0181	0.0246
DecidB	0.0127	0.0111	0.0153	0.0151	0.0132	0.0180
PineD	0.0146	0.0128	0.0175	0.0149	0.0131	0.0177
ConifA	0.0133	0.0117	0.0160	0.0144	0.0127	0.0172
ConifB	0.0103	0.0091	0.0124	0.0114	0.0100	0.0136
PineA	0.0101	0.0088	0.0121	0.0100	0.0088	0.0120
DecidA	0.0044	0.0039	0.0053	0.0060	0.0053	0.0071
MixedB	0.0018	0.0016	0.0021	0.0020	0.0017	0.0023
MixedA	0.0016	0.0014	0.0019	0.0020	0.0017	0.0023
MixedC	0.0013	0.0011	0.0015	0.0014	0.0012	0.0016
Cult	0.0747	0.0655	0.0897	0.0000	0.0000	0.0000
UrbInd	0.0083	0.0073	0.0100	0.0000	0.0000	0.0000
HardLin	0.0021	0.0018	0.0025	0.0000	0.0000	0.0000
SoftLin	0.1166	0.1022	0.1399	0.0000	0.0000	0.0000
HFor	0.0666	0.0584	0.0800	0.0000	0.0000	0.0000
Total	1.3520	1.1843	1.6225	1.1295	0.9901	1.3449
Loss	0.0055	0.0027	0.0102			
Gain	0.2056	0.1555	0.3383			

5.1.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.1.14 Variable selection frequencies

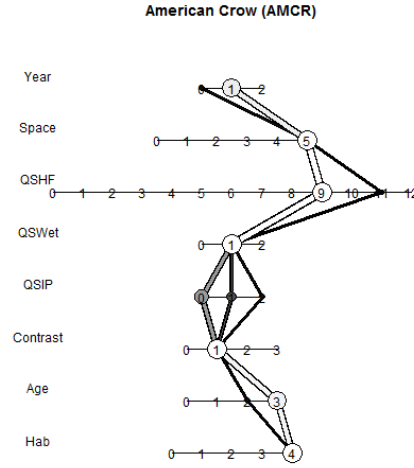
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.3	34.5	69	. + Habitat + isHForC
1.4	65.5	131	. + HabitatB + isHForC
2.0	56.0	112	NULL
2.1	4.0	8	. + Age
2.2	39.0	78	. + Age + Age2 . + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
2.3	1.0	2	
3.2	100.0	200	. + SoftLin_PC
4.0	92.0	184	NULL
4.1	8.0	16	. + Remn_QS
5.1	4.5	9	. + pWet_QS
5.2	95.5	191	. + pWetWater_QS
6.3	1.5	3	. + Succ_QS + Alien_QS
6.5	0.5	1	. + THF_QS + THF2_QS
6.7	2.5	5	. + Succ_QS + Alien_QS + Succ2_QS
6.8	4.5	9	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	23.0	46	. + Succ_QS + Alien_QS + Alien2_QS
6.11	59.0	118	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
6.12	9.0	18	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.0	4.0	8	NULL
7.4	32.0	64	. + xMAP + xPET + xMAT + xCMD
7.5	64.0	128	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	38.0	76	NULL
8.1	62.0	124	. + xYEAR

5.2 American Crow (*Corvus brachyrhynchos*)

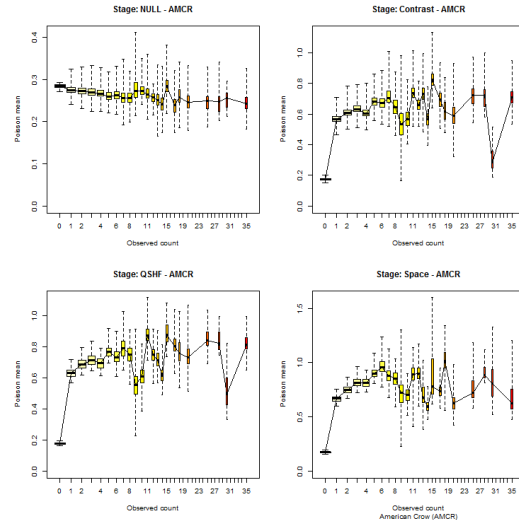
5.2.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

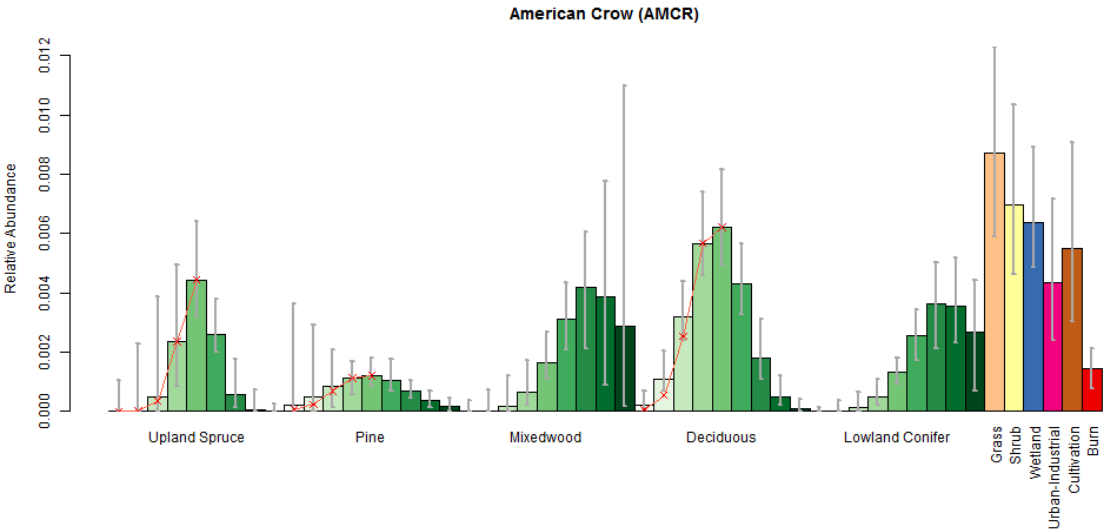


5.2.2 Cross validation

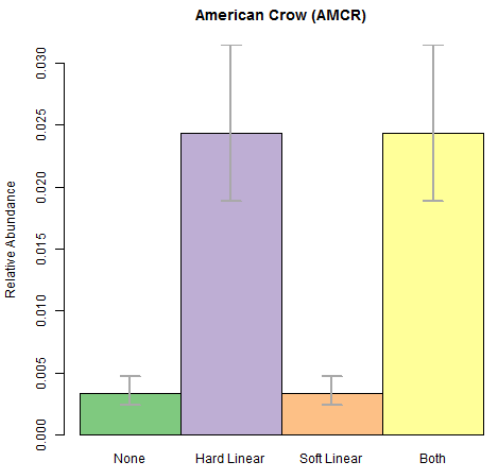
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.2.3 Point level habitat associations

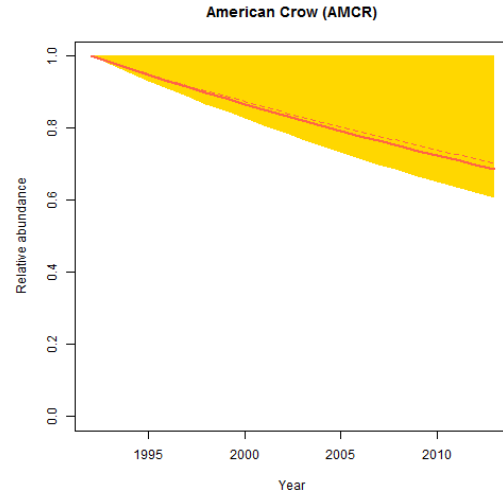


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

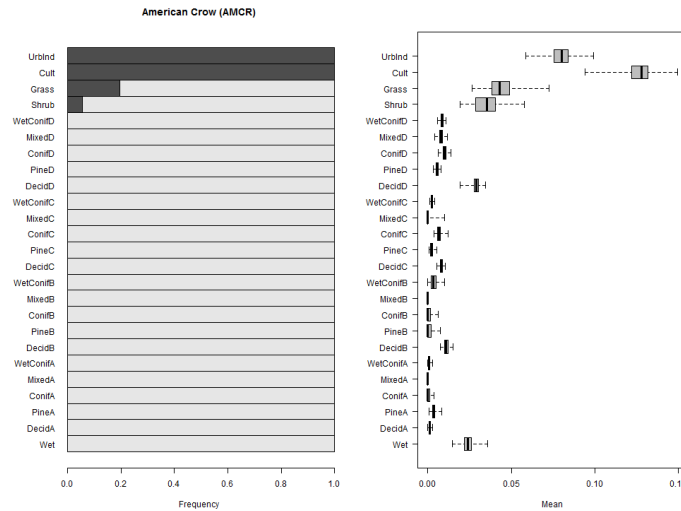


5.2.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



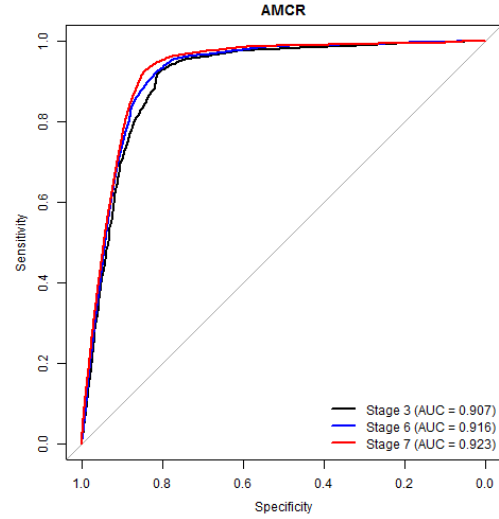
5.2.5 Habitat suitability ranking for patch delineation



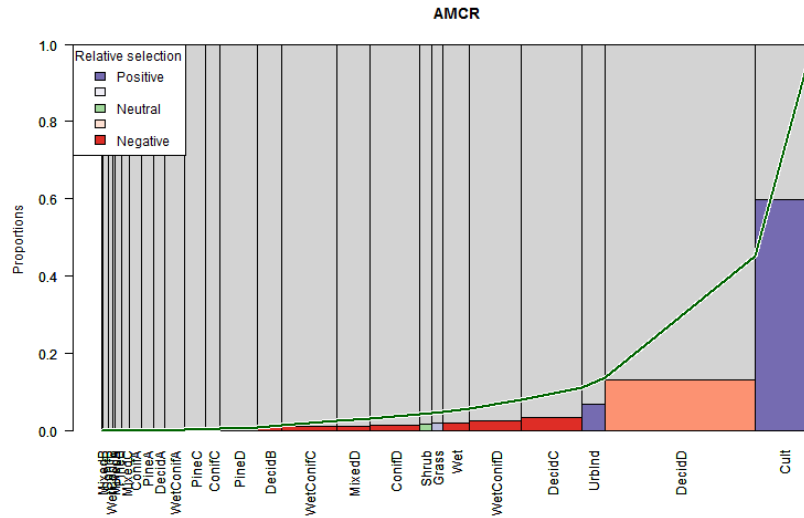
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.2.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

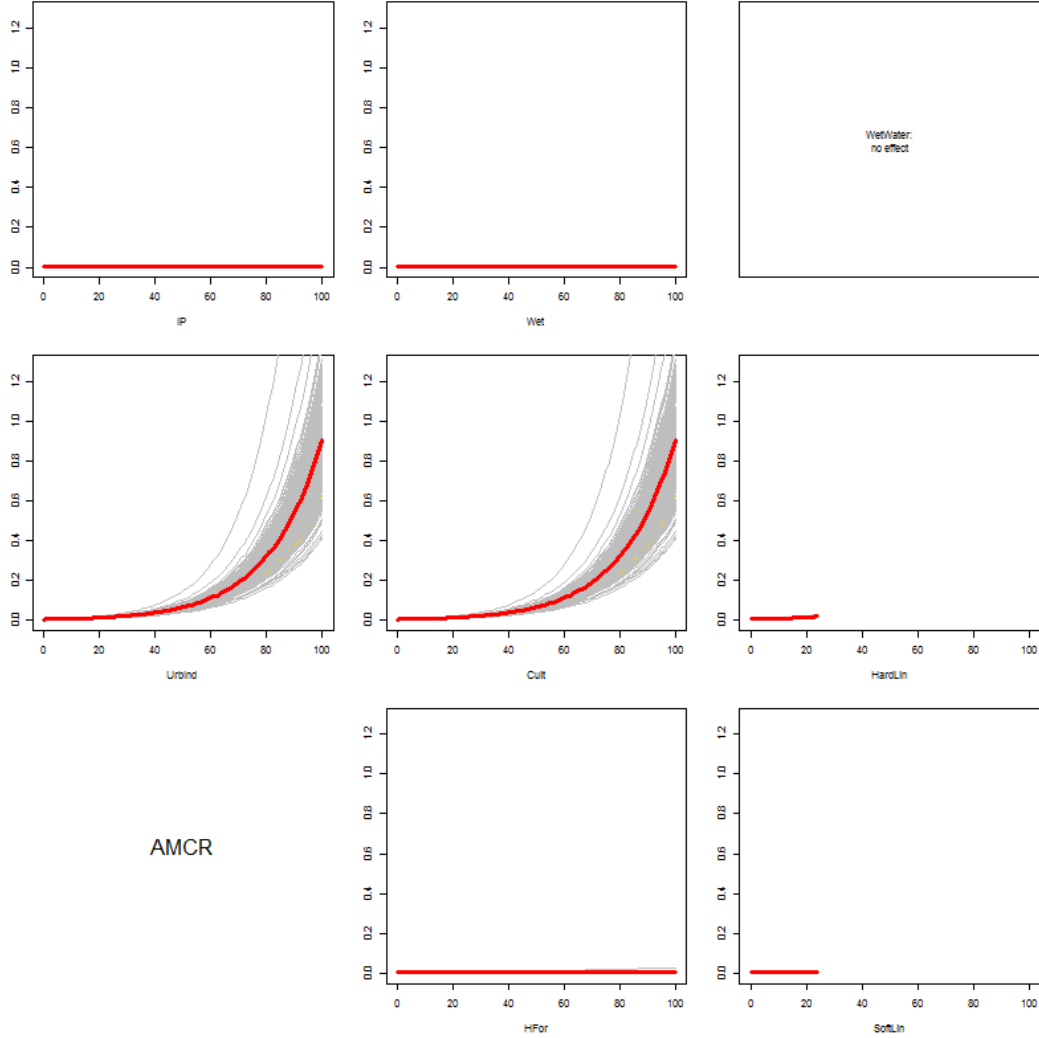


5.2.7 Relative habitat selection



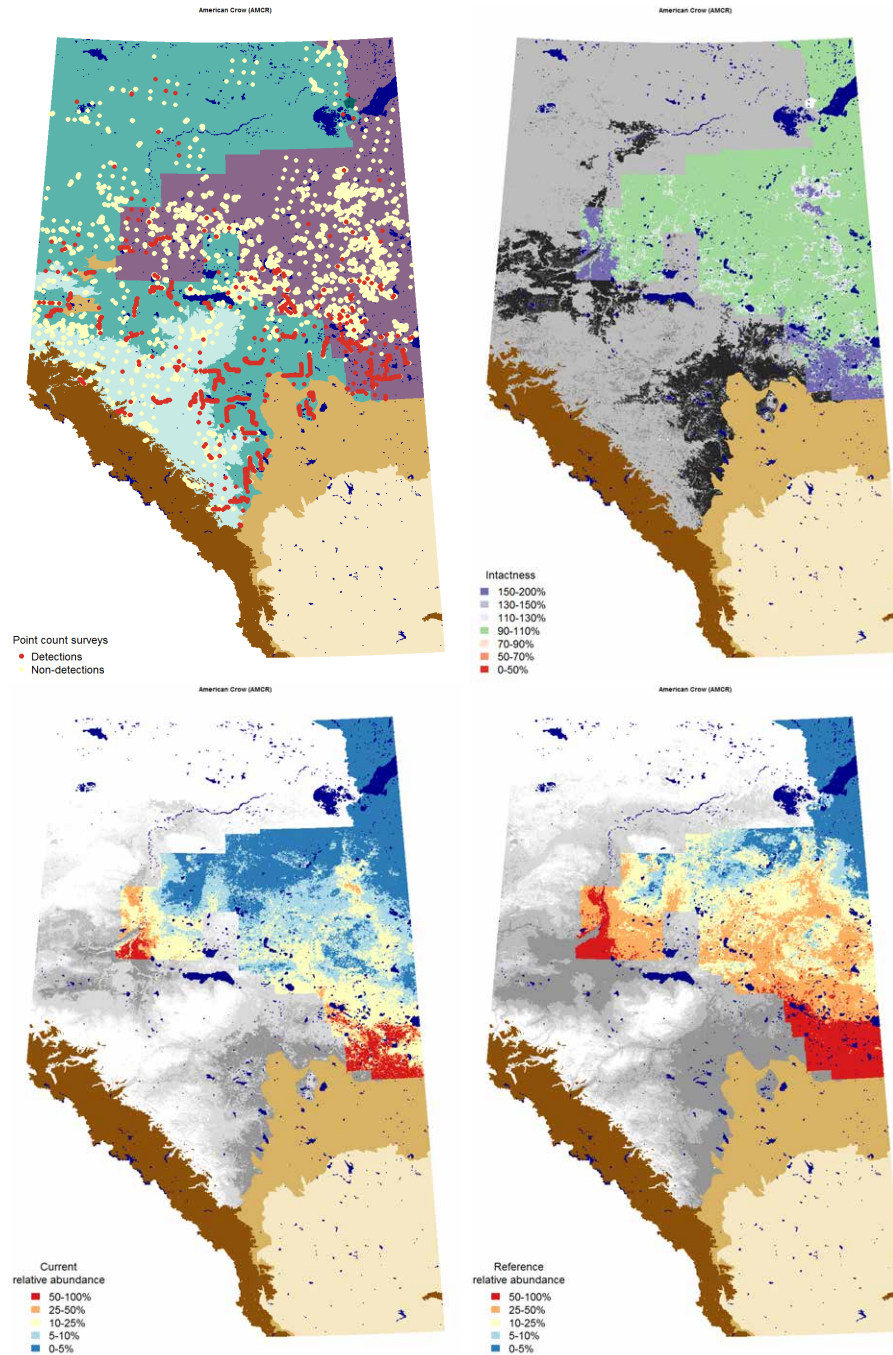
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.2.8 Quarter-section level responses



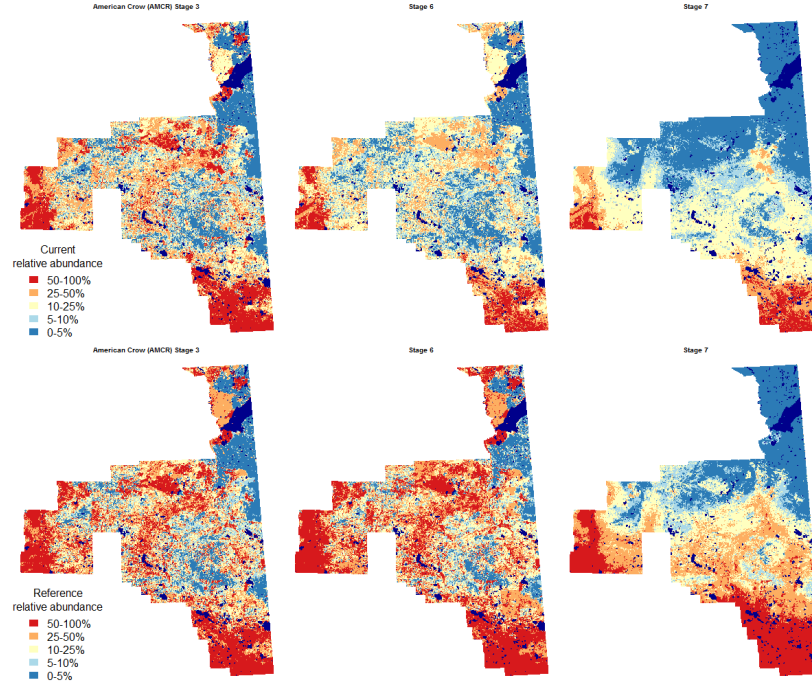
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.2.9 Maps



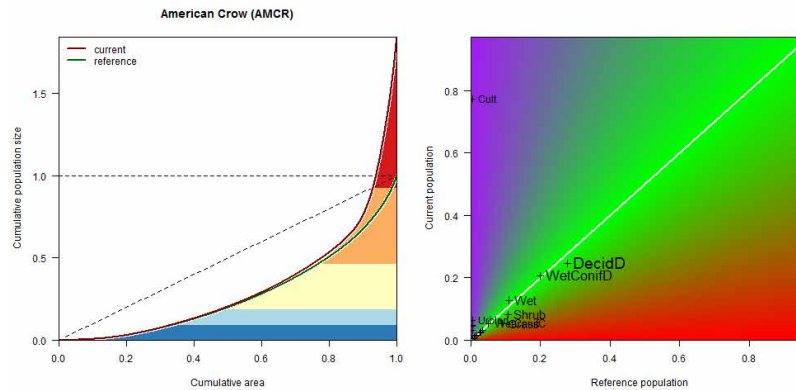
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on "Space" stage of the variable selection procedure (no year effect).

5.2.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.2.11 Population concentration



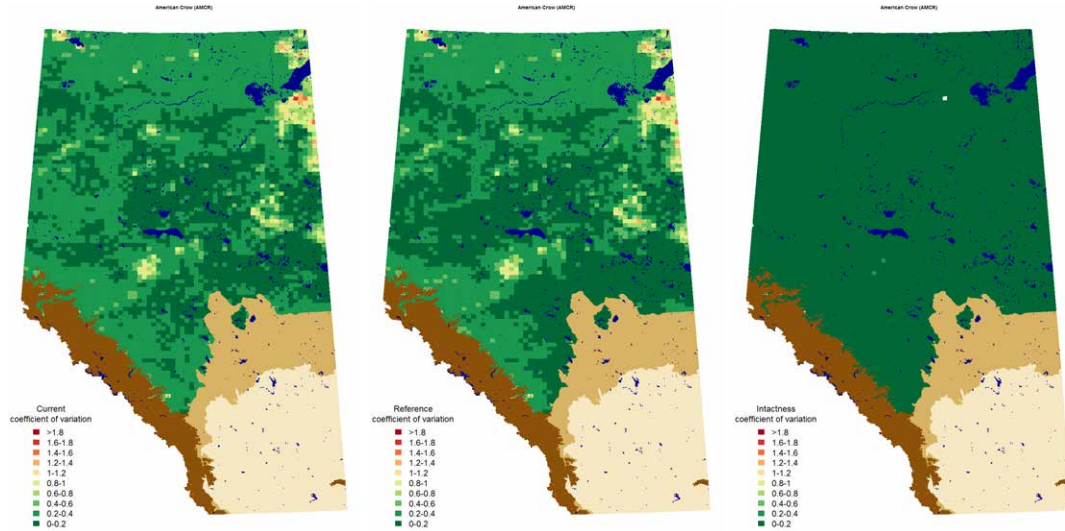
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.2.12 Potential population size

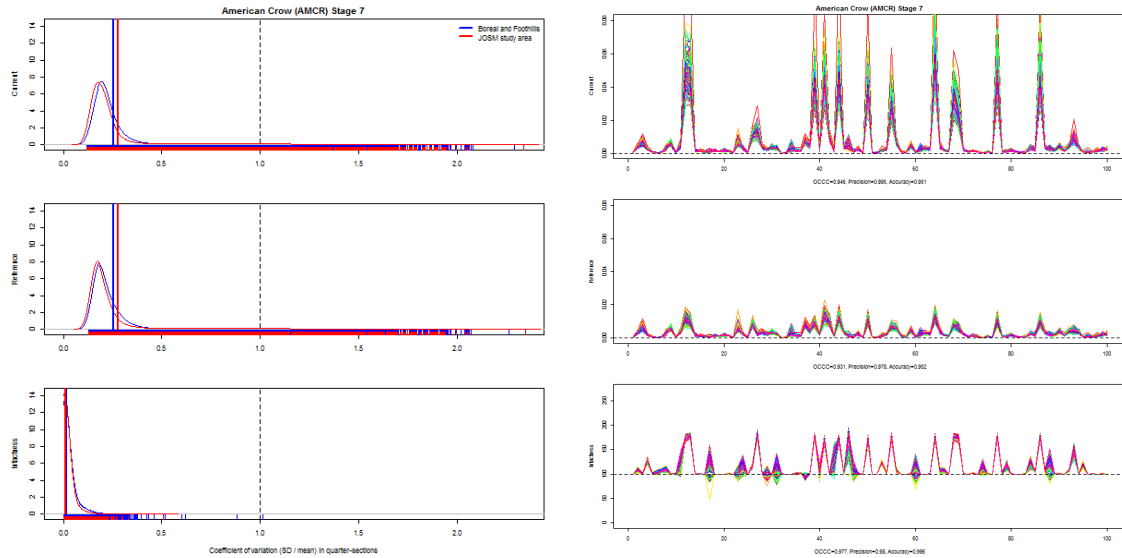
Estimated potential population size of American Crow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0112	0.0088	0.0150	0.0131	0.0105	0.0161
WetConifD	0.0094	0.0074	0.0126	0.0094	0.0076	0.0116
Wet	0.0058	0.0046	0.0078	0.0052	0.0041	0.0064
Shrub	0.0038	0.0030	0.0050	0.0051	0.0041	0.0063
Grass	0.0024	0.0019	0.0032	0.0043	0.0034	0.0053
WetConifC	0.0024	0.0019	0.0032	0.0024	0.0020	0.0030
DecidC	0.0015	0.0012	0.0020	0.0016	0.0013	0.0020
ConifD	0.0012	0.0010	0.0016	0.0014	0.0012	0.0018
MixedD	0.0011	0.0009	0.0015	0.0013	0.0010	0.0016
ConifC	0.0008	0.0006	0.0010	0.0009	0.0007	0.0011
PineC	0.0006	0.0005	0.0008	0.0006	0.0005	0.0008
PineD	0.0006	0.0004	0.0007	0.0006	0.0005	0.0008
DecidB	0.0004	0.0003	0.0006	0.0005	0.0004	0.0007
PineB	0.0003	0.0002	0.0003	0.0003	0.0002	0.0003
DecidA	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
WetConifB	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
PineA	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
WetConifA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ConifB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ConifA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0351	0.0276	0.0469	0.0000	0.0000	0.0000
UrbInd	0.0029	0.0023	0.0039	0.0000	0.0000	0.0000
HardLin	0.0022	0.0017	0.0029	0.0000	0.0000	0.0000
SoftLin	0.0021	0.0016	0.0028	0.0000	0.0000	0.0000
HFor	0.0014	0.0011	0.0019	0.0000	0.0000	0.0000
Total	0.0855	0.0673	0.1142	0.0471	0.0377	0.0580
Loss	0.0000	0.0000	0.0002			
Gain	0.0392	0.0284	0.0562			

5.2.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.2.14 Variable selection frequencies

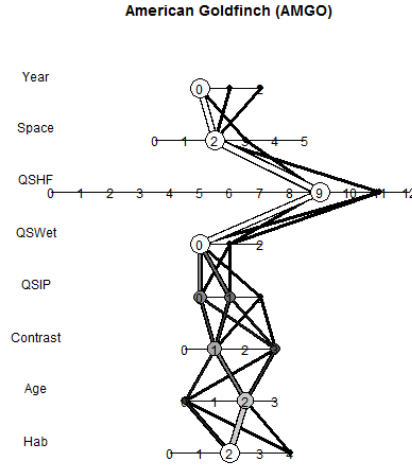
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.4	100.0	200	. + HabitatB + isHForC
2.2	4.5	9	. + Age + Age2
			. + Age + Age2 + Age:isMix + Age:isPine
2.3	95.5	191	+ Age:isUplConif + Age:isWetConif +
			Age2:isMix + Age2:isPine + Age2:isUplConif
			+ Age2:isWetConif
3.1	100.0	200	. + ROAD
4.0	60.5	121	NULL
4.1	32.5	65	. + Remn_QS
4.2	7.0	14	. + Remn_QS + Remn2_QS
5.1	100.0	200	. + pWet_QS
6.9	99.5	199	. + Succ_QS + Alien_QS + Alien2_QS
6.11	0.5	1	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.5	100.0	200	. + xMAP + xPET + xMAT + xCMD +
			xMAP:xPET + xMAT:xCMD
8.0	6.5	13	NULL
8.1	93.5	187	. + xYEAR

5.3 American Goldfinch (*Spinus tristis*)

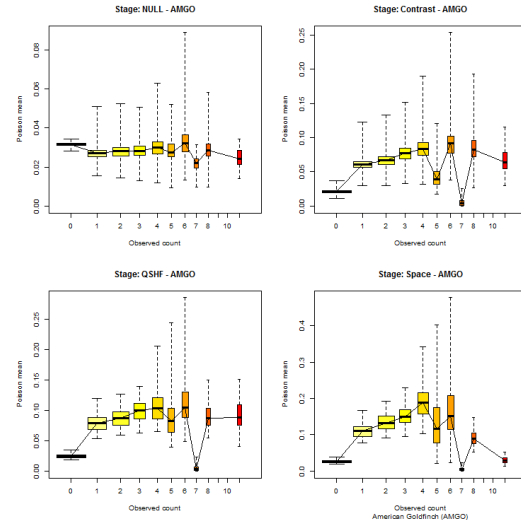
5.3.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

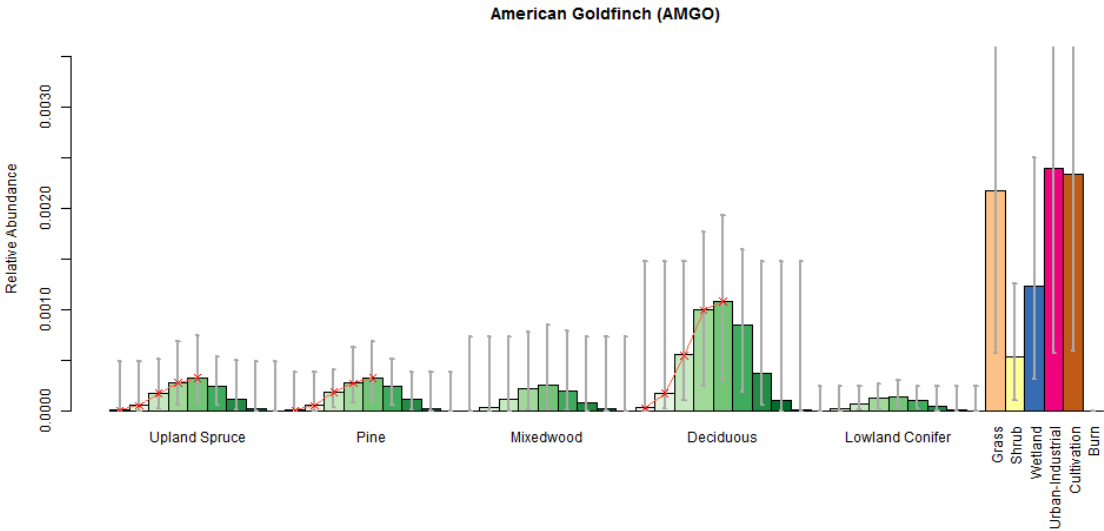


5.3.2 Cross validation

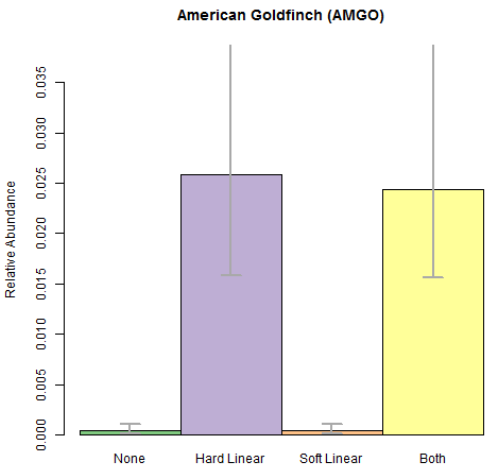
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.3.3 Point level habitat associations

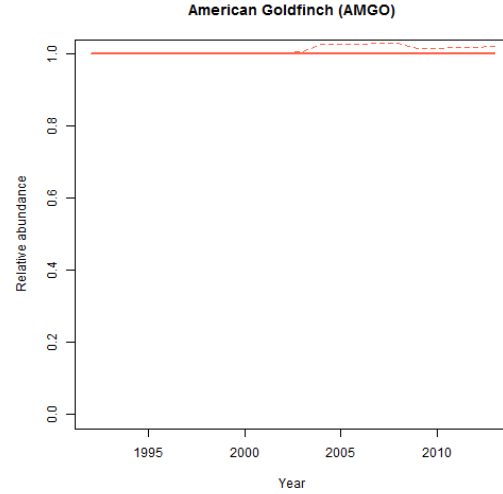


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

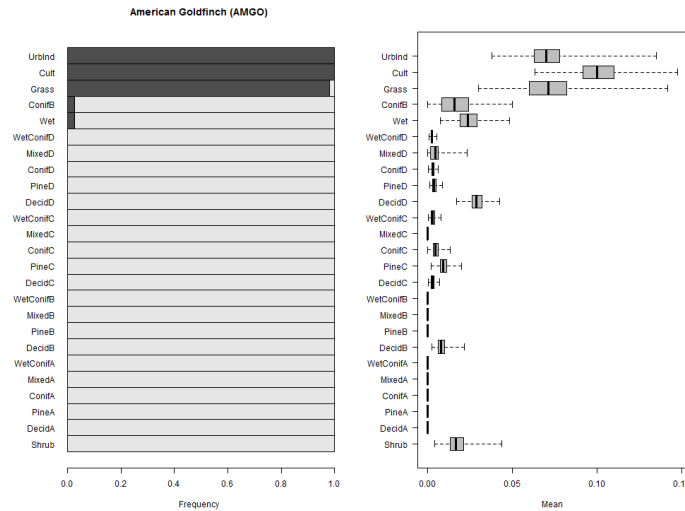


5.3.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



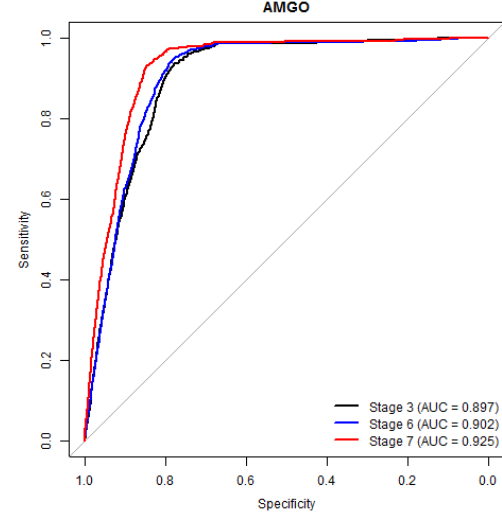
5.3.5 Habitat suitability ranking for patch delineation



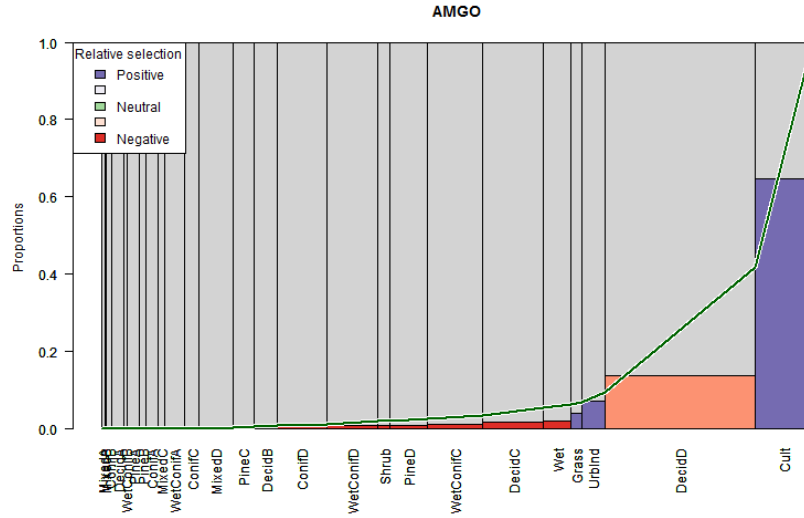
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.3.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

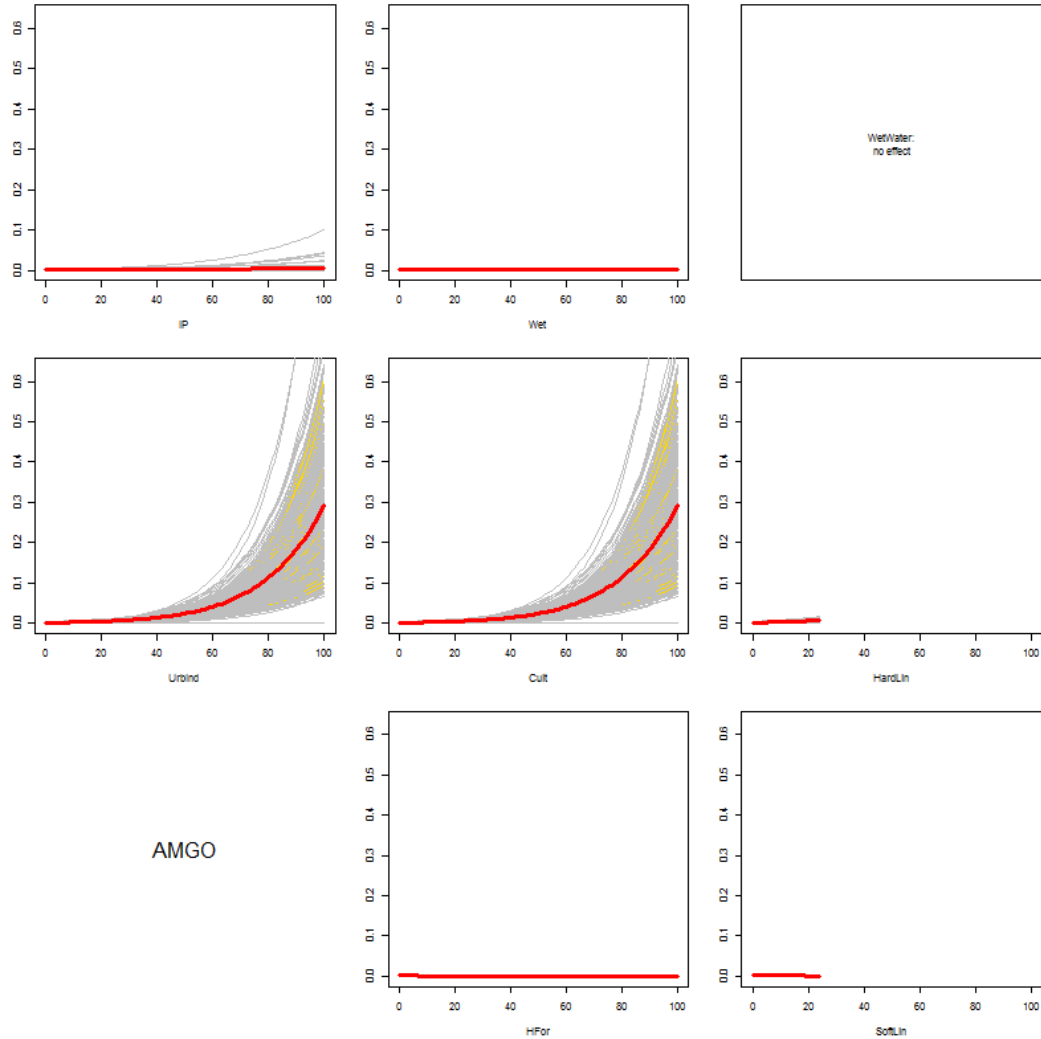


5.3.7 Relative habitat selection



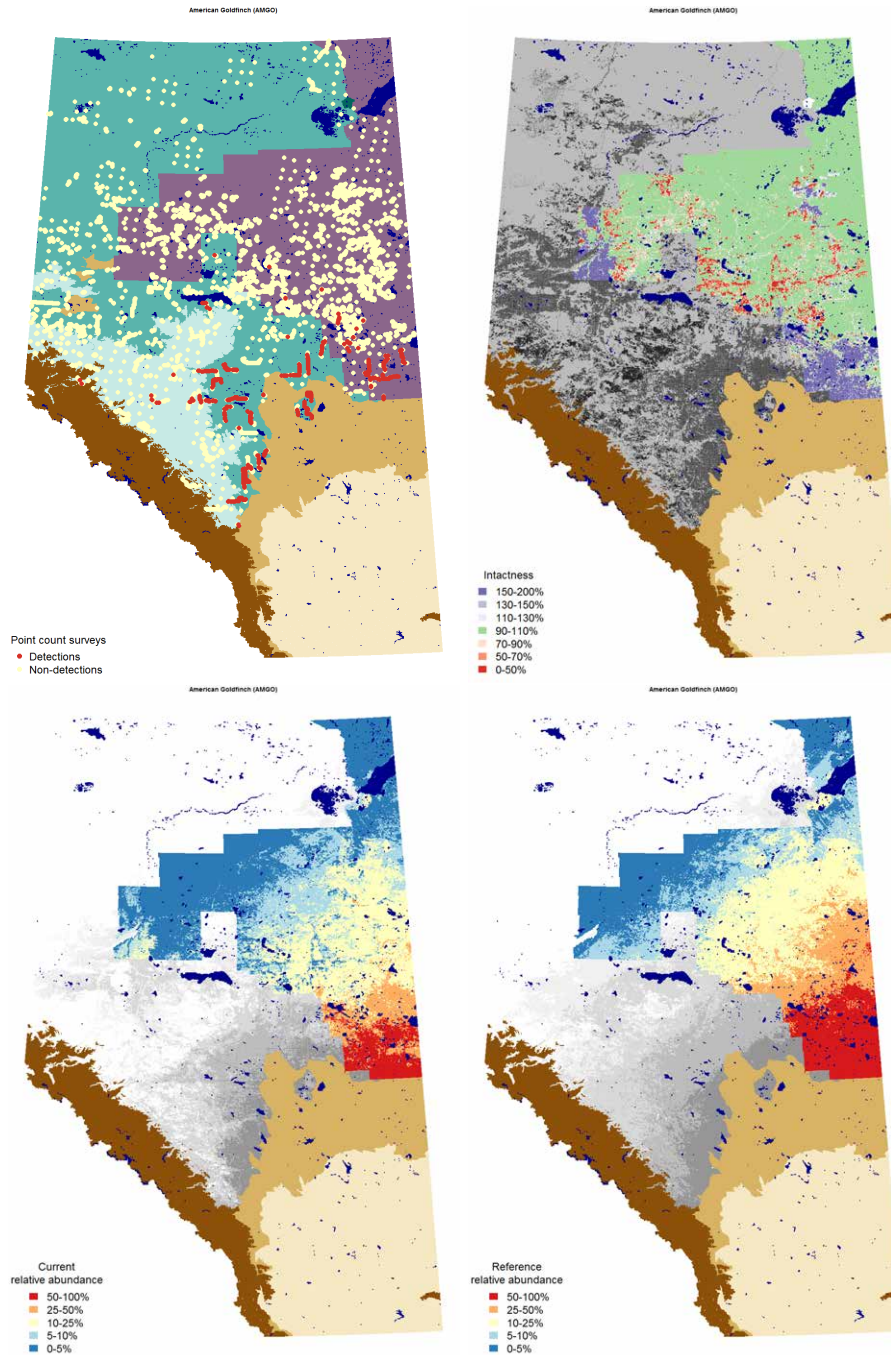
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.3.8 Quarter-section level responses



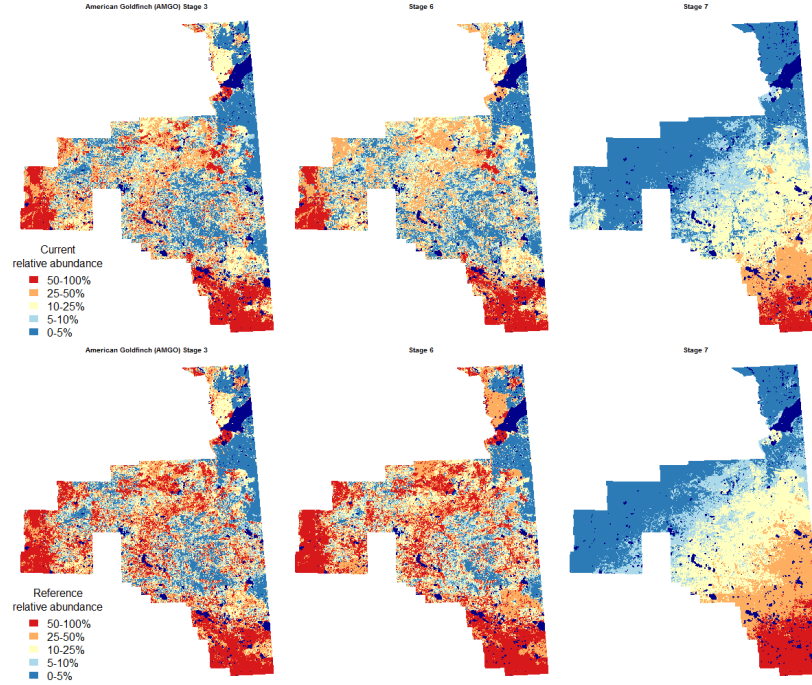
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.3.9 Maps



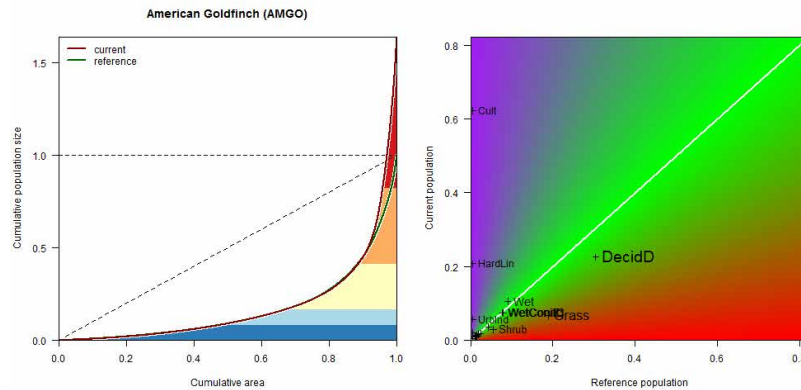
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.3.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.3.11 Population concentration



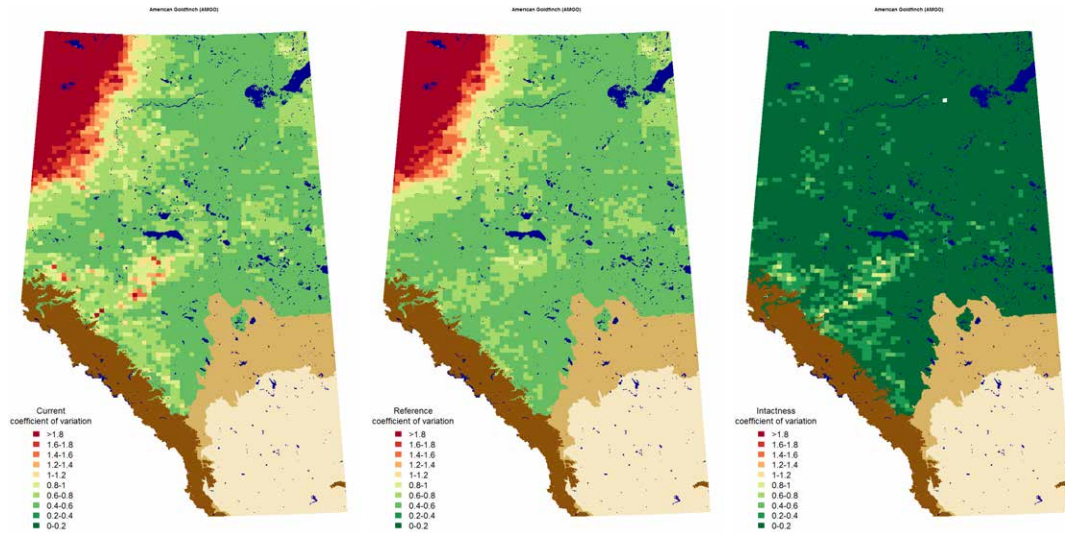
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.3.12 Potential population size

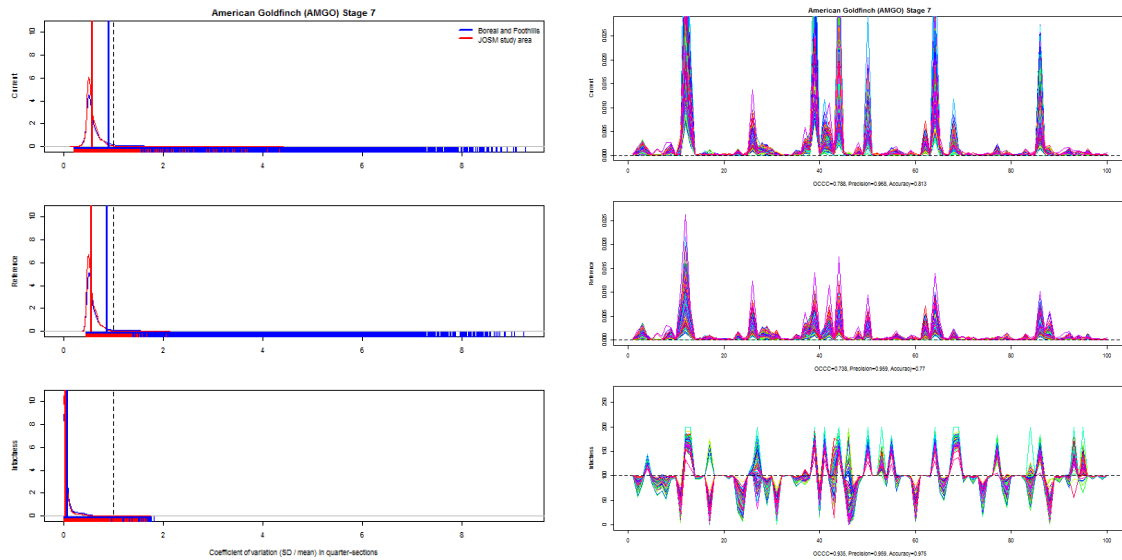
Estimated potential population size of American Goldfinch in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0031	0.0010	0.0055	0.0041	0.0012	0.0075
Grass	0.0009	0.0003	0.0016	0.0026	0.0007	0.0047
Wet	0.0015	0.0005	0.0025	0.0012	0.0004	0.0022
WetConifC	0.0010	0.0003	0.0018	0.0011	0.0003	0.0019
WetConifD	0.0010	0.0003	0.0018	0.0010	0.0003	0.0019
Shrub	0.0004	0.0001	0.0007	0.0007	0.0002	0.0013
DecidC	0.0005	0.0002	0.0009	0.0006	0.0002	0.0011
MixedD	0.0003	0.0001	0.0005	0.0003	0.0001	0.0006
PineB	0.0003	0.0001	0.0004	0.0003	0.0001	0.0005
PineC	0.0002	0.0001	0.0004	0.0002	0.0001	0.0004
ConifD	0.0001	0.0000	0.0003	0.0002	0.0001	0.0004
WetConifB	0.0002	0.0001	0.0003	0.0002	0.0001	0.0004
PineD	0.0002	0.0001	0.0003	0.0002	0.0001	0.0003
DecidB	0.0001	0.0000	0.0002	0.0002	0.0001	0.0003
ConifC	0.0001	0.0000	0.0002	0.0002	0.0000	0.0003
WetConifA	0.0001	0.0000	0.0002	0.0001	0.0000	0.0003
ConifA	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
PineA	0.0001	0.0000	0.0001	0.0001	0.0000	0.0001
DecidA	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
ConifB	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0086	0.0027	0.0152	0.0000	0.0000	0.0000
UrbInd	0.0008	0.0002	0.0014	0.0000	0.0000	0.0000
HardLin	0.0029	0.0009	0.0050	0.0000	0.0000	0.0000
SoftLin	0.0003	0.0001	0.0005	0.0000	0.0000	0.0000
HFor	0.0001	0.0000	0.0002	0.0000	0.0000	0.0000
Total	0.0231	0.0072	0.0405	0.0135	0.0039	0.0246
Loss	0.0005	0.0002	0.0012			
Gain	0.0086	0.0033	0.0172			

5.3.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.3.14 Variable selection frequencies

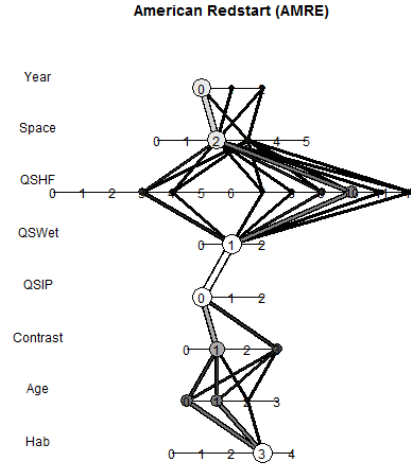
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	98.5	197	. + HabitatB
1.4	1.5	3	. + HabitatB + isHForC
2.0	22.0	44	NULL
2.2	78.0	156	. + Age + Age2
3.1	65.5	131	. + ROAD
3.3	34.5	69	. + ROAD + SoftLin_PC
4.0	53.0	106	NULL
4.1	43.5	87	. + Remn_QS
4.2	3.5	7	. + Remn_QS + Remn2_QS
5.0	97.5	195	NULL
5.1	2.5	5	. + pWet_QS
6.9	97.5	195	. + Succ_QS + Alien_QS + Alien2_QS
6.11	2.5	5	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.2	98.5	197	. + xlat + xlong
7.3	1.5	3	. + xlat + xlong + xlat:xlong
8.0	96.0	192	NULL
8.1	1.5	3	. + xYEAR
8.2	2.5	5	. + YR5F

5.4 American Redstart (*Setophaga ruticilla*)

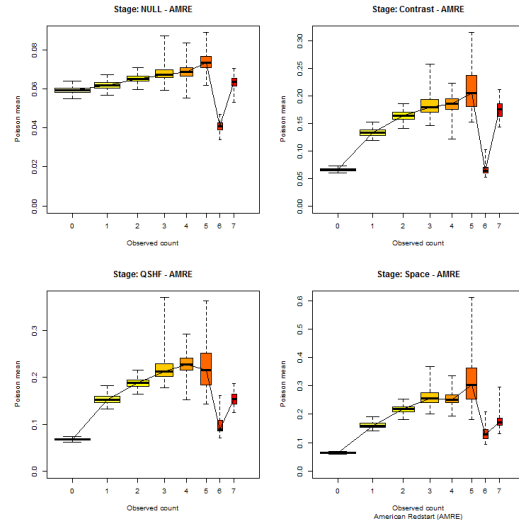
5.4.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

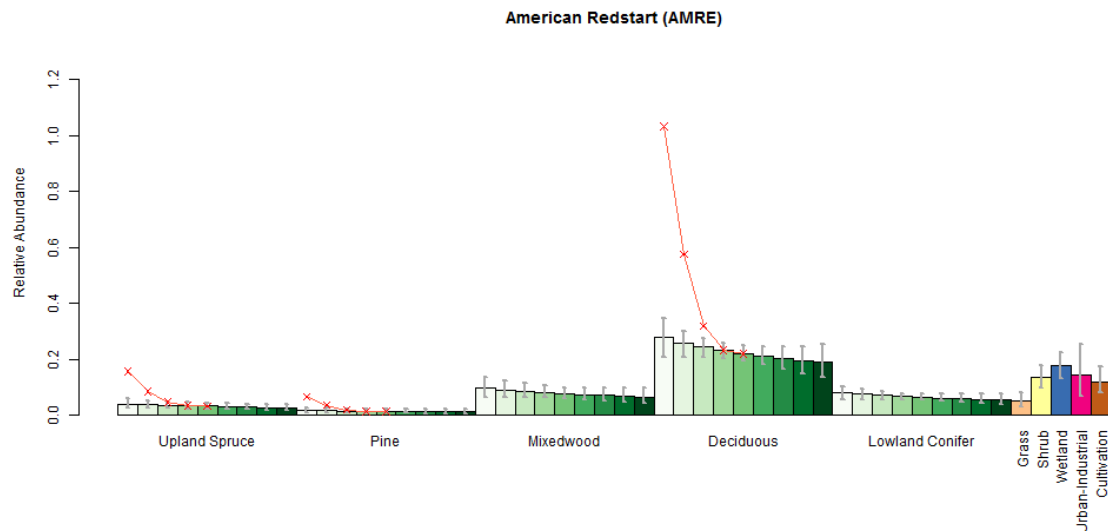


5.4.2 Cross validation

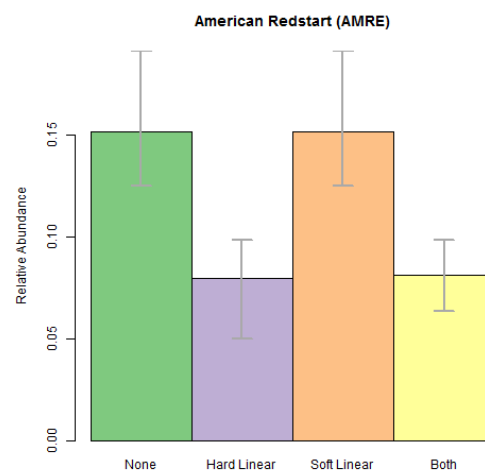
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.4.3 Point level habitat associations

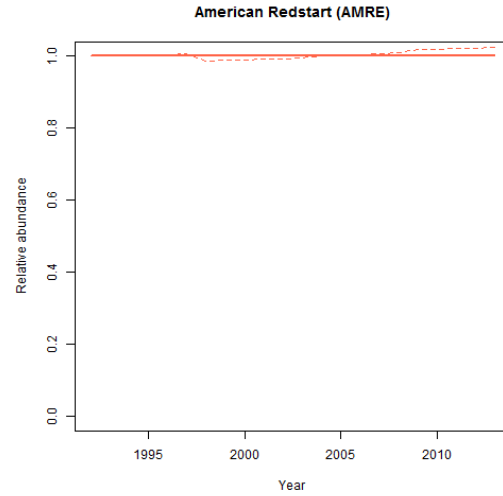


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

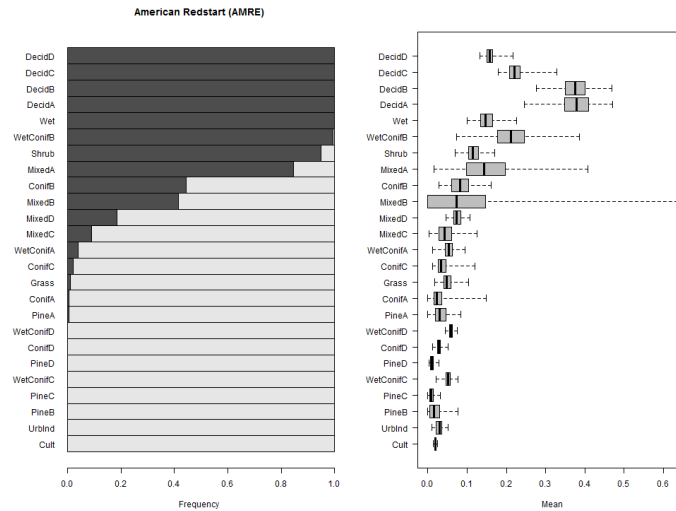


5.4.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



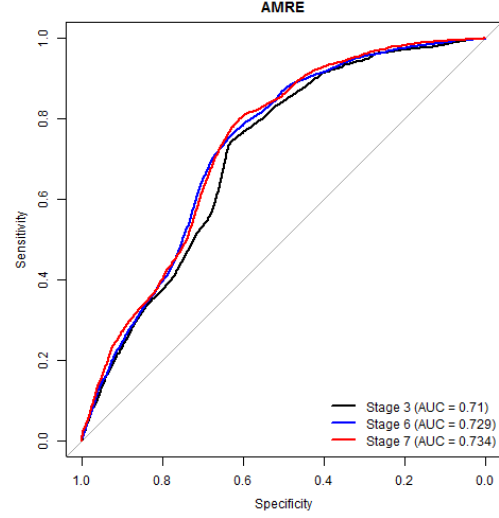
5.4.5 Habitat suitability ranking for patch delineation



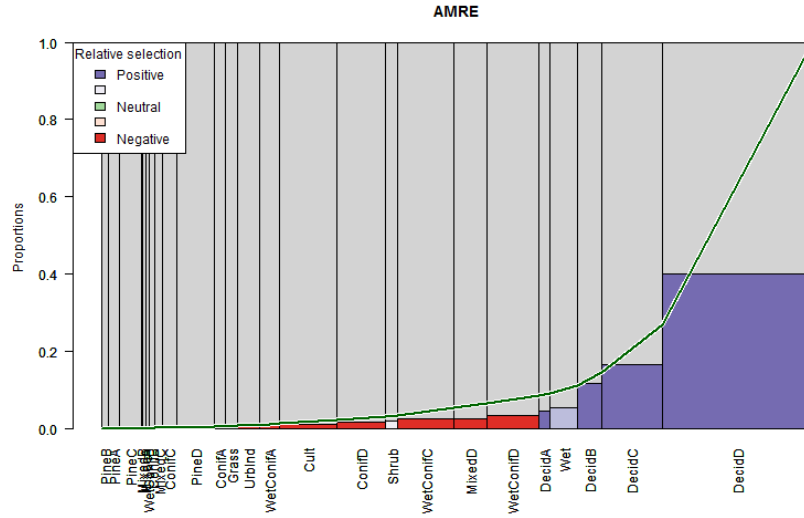
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.4.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

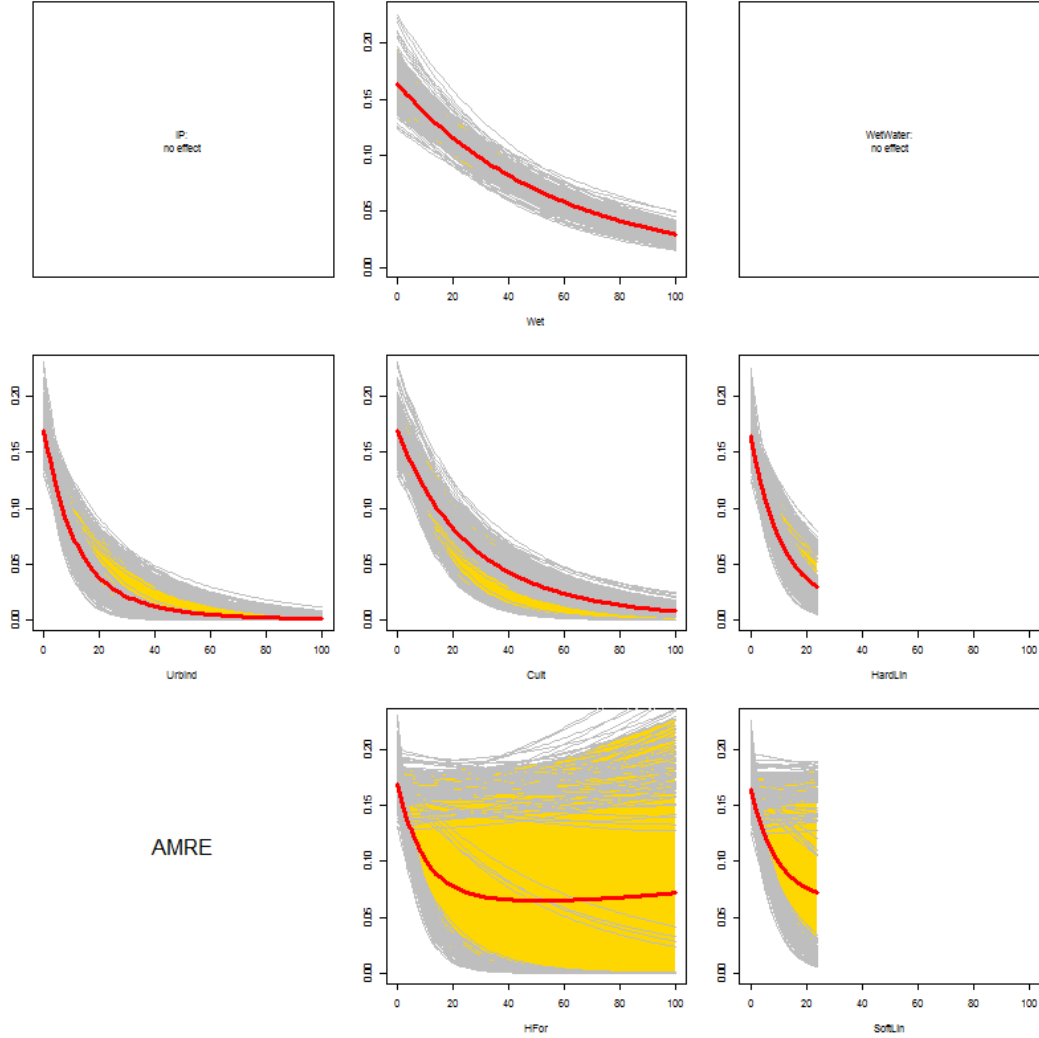


5.4.7 Relative habitat selection



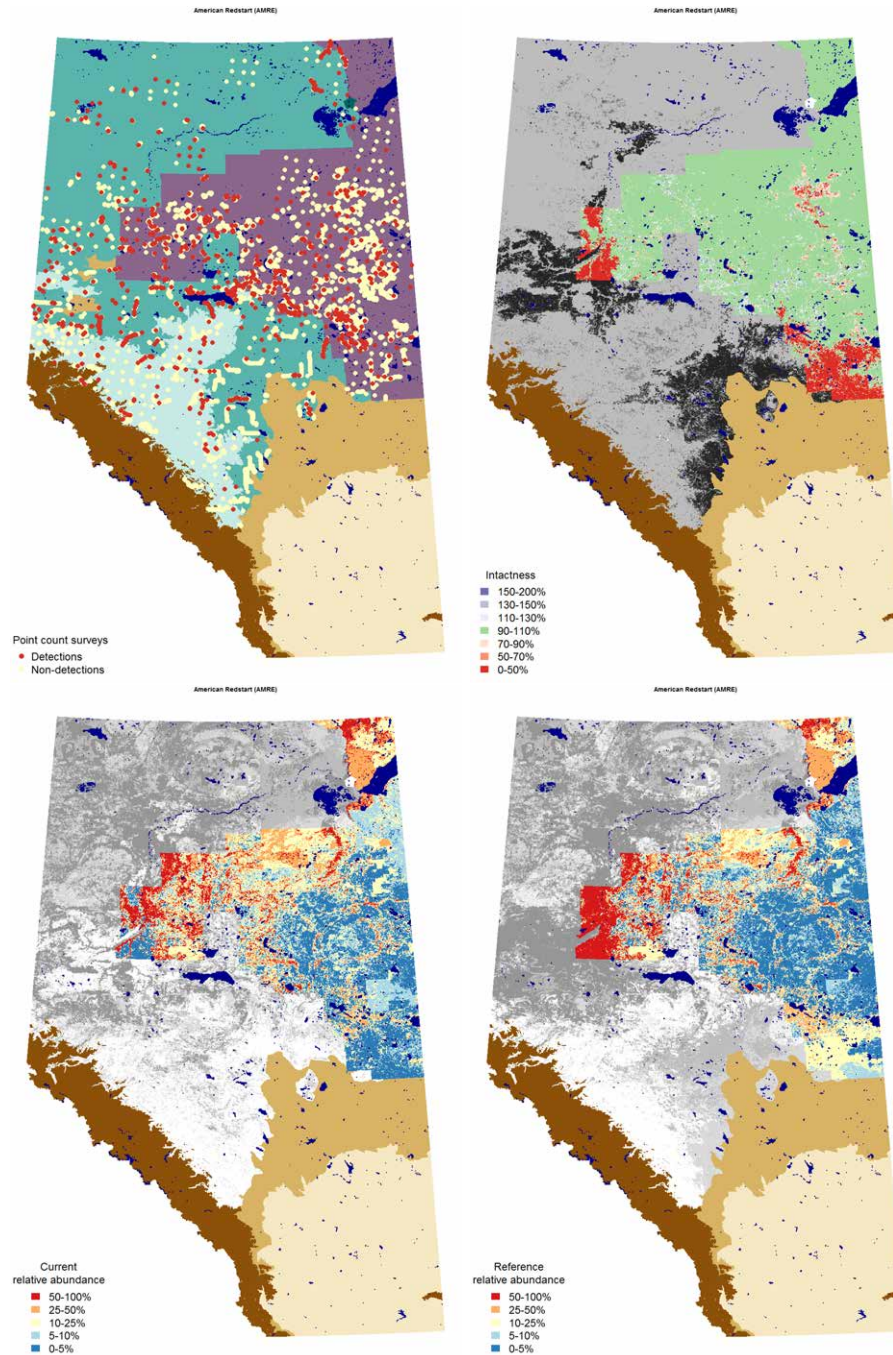
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.4.8 Quarter-section level responses



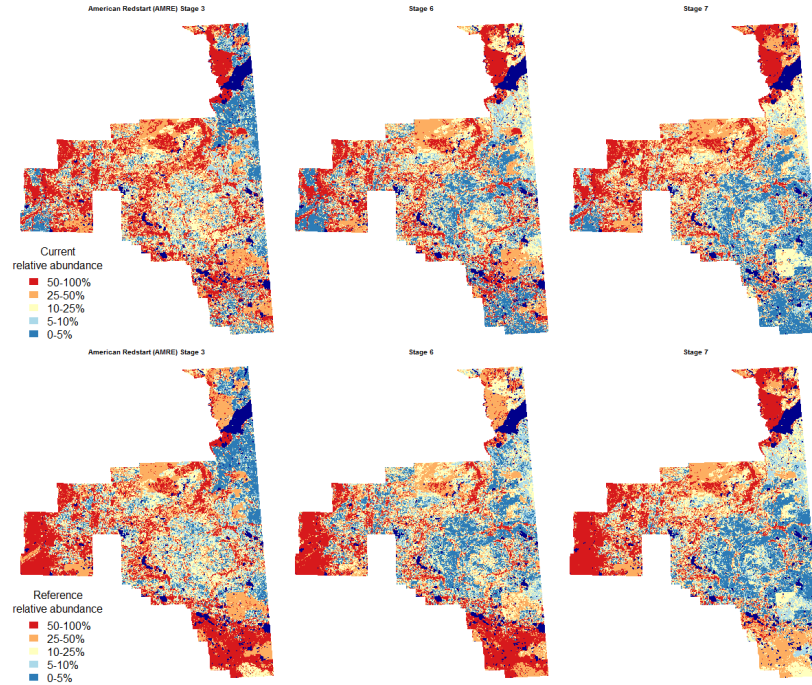
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.4.9 Maps



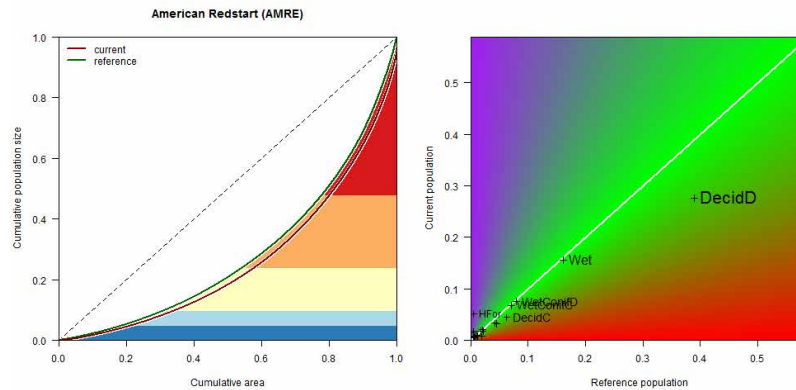
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.4.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.4.11 Population concentration



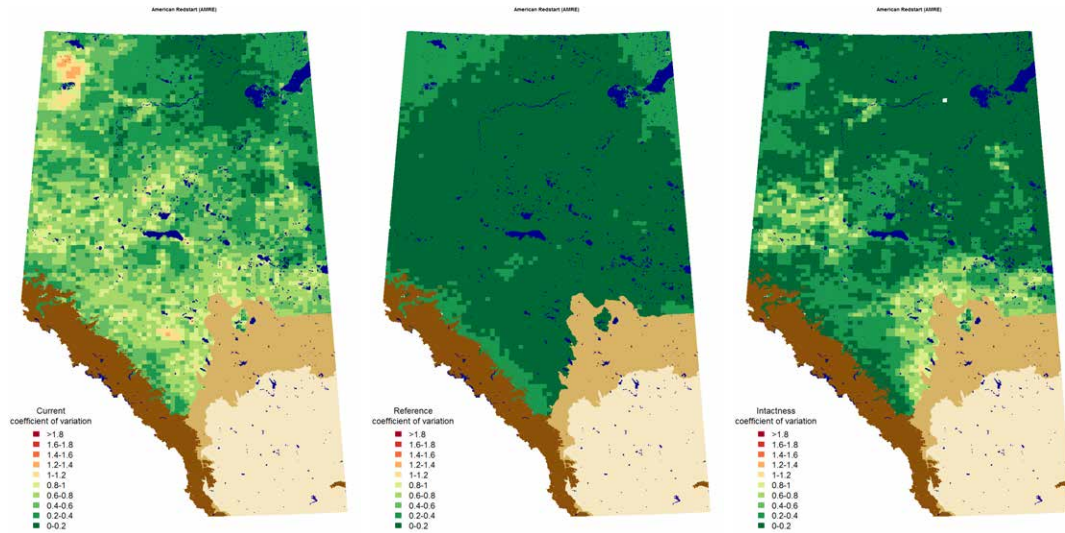
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.4.12 Potential population size

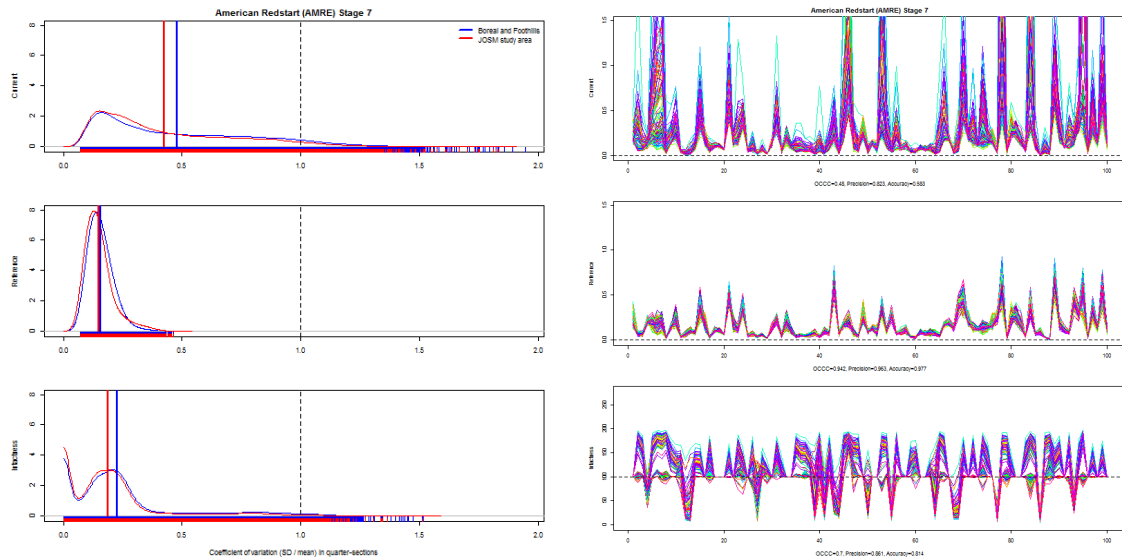
Estimated potential population size of American Redstart in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.4867	0.4330	1.0674	0.6582	0.5776	0.7443
Wet	0.2749	0.2445	0.6028	0.2724	0.2391	0.3081
WetConifD	0.1325	0.1179	0.2905	0.1339	0.1175	0.1514
WetConifC	0.1196	0.1064	0.2624	0.1205	0.1058	0.1363
DecidC	0.0784	0.0698	0.1720	0.1064	0.0933	0.1203
Shrub	0.0576	0.0513	0.1264	0.0773	0.0678	0.0874
DecidB	0.0583	0.0519	0.1278	0.0722	0.0633	0.0816
MixedD	0.0307	0.0273	0.0673	0.0363	0.0318	0.0410
WetConifB	0.0360	0.0320	0.0790	0.0358	0.0314	0.0405
Grass	0.0133	0.0119	0.0292	0.0329	0.0289	0.0372
WetConifA	0.0312	0.0278	0.0684	0.0305	0.0268	0.0345
DecidA	0.0135	0.0120	0.0297	0.0213	0.0187	0.0240
ConifD	0.0159	0.0142	0.0350	0.0185	0.0162	0.0209
ConifC	0.0128	0.0114	0.0280	0.0144	0.0127	0.0163
PineB	0.0132	0.0117	0.0290	0.0128	0.0112	0.0144
ConifA	0.0117	0.0104	0.0256	0.0124	0.0109	0.0140
ConifB	0.0095	0.0084	0.0207	0.0100	0.0087	0.0113
PineC	0.0060	0.0053	0.0131	0.0064	0.0056	0.0072
PineA	0.0050	0.0045	0.0110	0.0049	0.0043	0.0056
PineD	0.0039	0.0035	0.0086	0.0043	0.0038	0.0048
MixedB	0.0034	0.0031	0.0075	0.0037	0.0032	0.0042
MixedA	0.0019	0.0017	0.0042	0.0025	0.0022	0.0028
MixedC	0.0020	0.0018	0.0044	0.0023	0.0020	0.0026
Cult	0.0303	0.0270	0.0665	0.0000	0.0000	0.0000
UrbInd	0.0108	0.0096	0.0238	0.0000	0.0000	0.0000
HardLin	0.0012	0.0011	0.0026	0.0000	0.0000	0.0000
SoftLin	0.0250	0.0223	0.0548	0.0000	0.0000	0.0000
HFor	0.0896	0.0797	0.1965	0.0000	0.0000	0.0000
Total	1.5751	1.4013	3.4544	1.6898	1.4828	1.9108
Loss	0.2156	0.0999	0.2720			
Gain	0.0623	0.0373	1.9798			

5.4.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.4.14 Variable selection frequencies

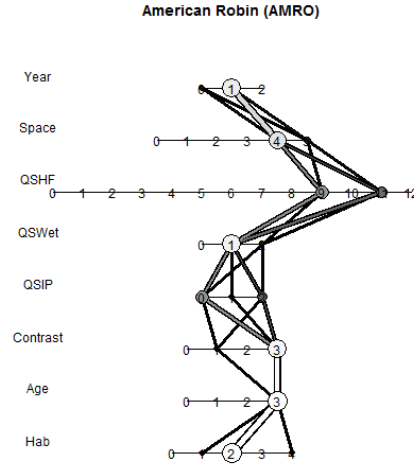
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.3	100.0	200	. + Habitat + isHForC
2.0	45.5	91	NULL
2.1	49.5	99	. + Age
2.2	5.0	10	. + Age + Age2
3.1	67.5	135	. + ROAD
3.3	32.5	65	. + ROAD + SoftLin_PC
4.0	100.0	200	NULL
5.1	100.0	200	. + pWet_QS
6.3	20.5	41	. + Succ_QS + Alien_QS
6.4	6.5	13	. + Succ_QS + Noncult_QS + Cult_QS
6.7	1.5	3	. + Succ_QS + Alien_QS + Succ2_QS
6.8	1.0	2	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	16.5	33	. + Succ_QS + Alien_QS + Alien2_QS
6.10	51.0	102	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.11	0.5	1	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
6.12	2.5	5	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.2	91.0	182	. + xlat + xlong
7.3	9.0	18	. + xlat + xlong + xlat:xlong
8.0	92.0	184	NULL
8.1	4.0	8	. + xYEAR
8.2	4.0	8	. + YR5F

5.5 American Robin (*Turdus migratorius*)

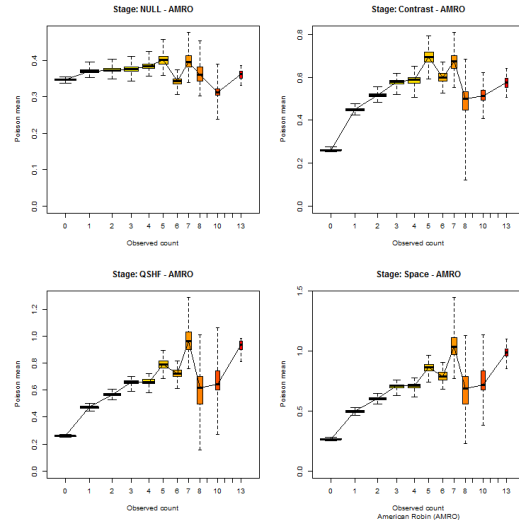
5.5.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

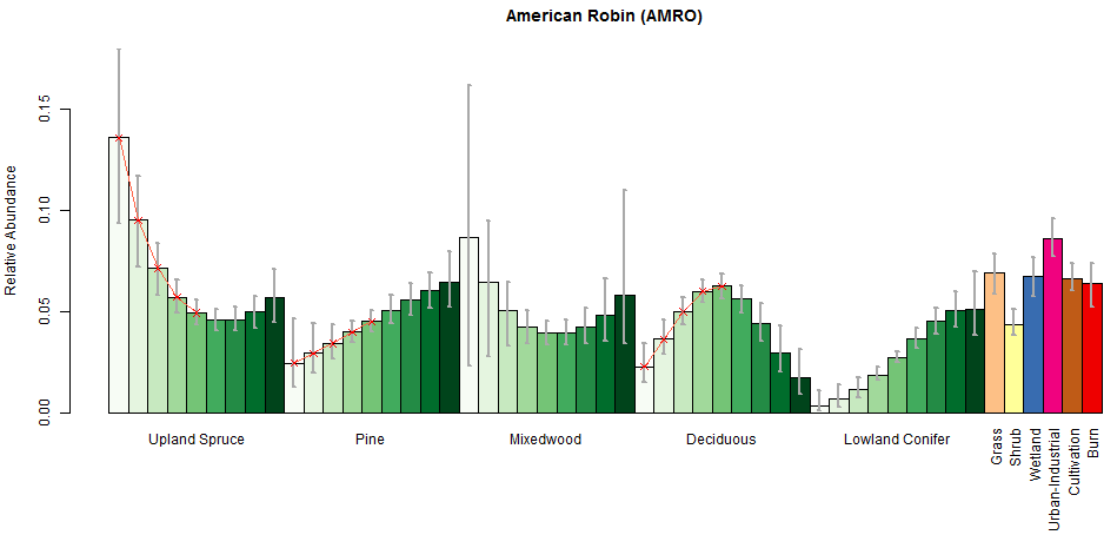


5.5.2 Cross validation

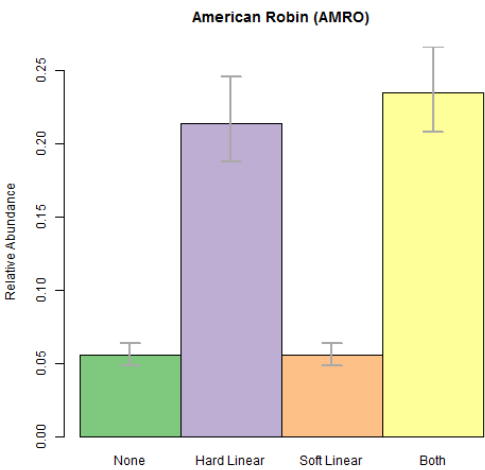
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.5.3 Point level habitat associations

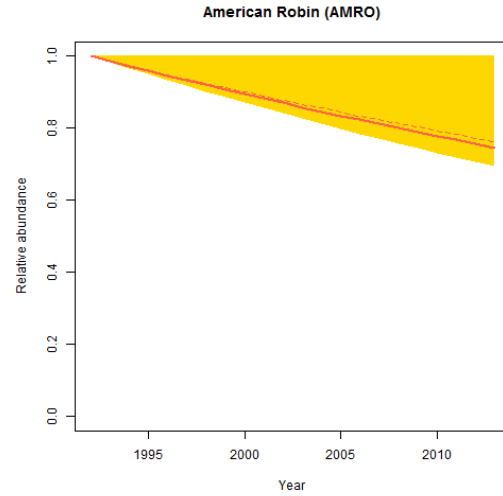


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

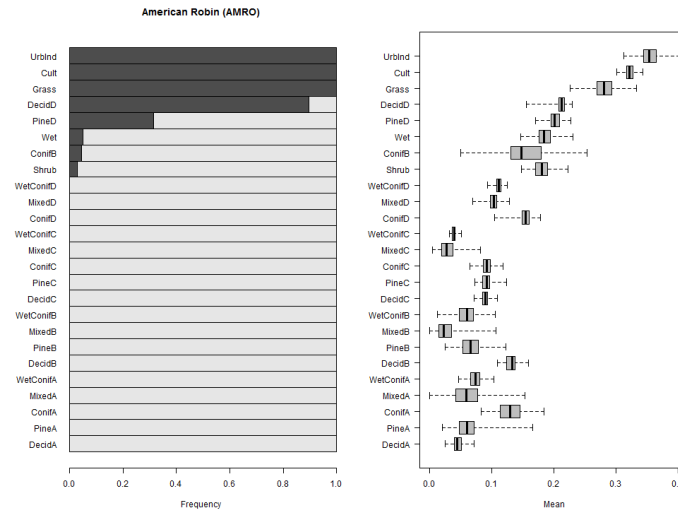


5.5.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



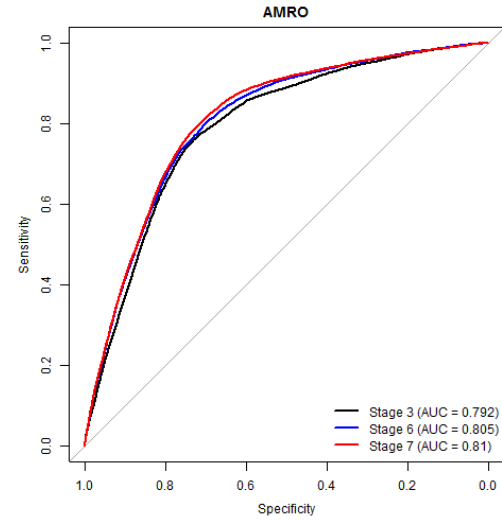
5.5.5 Habitat suitability ranking for patch delineation



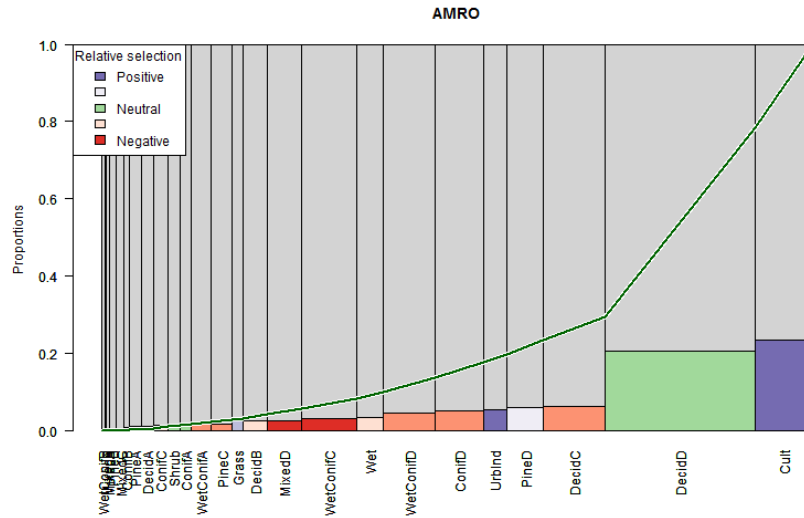
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.5.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

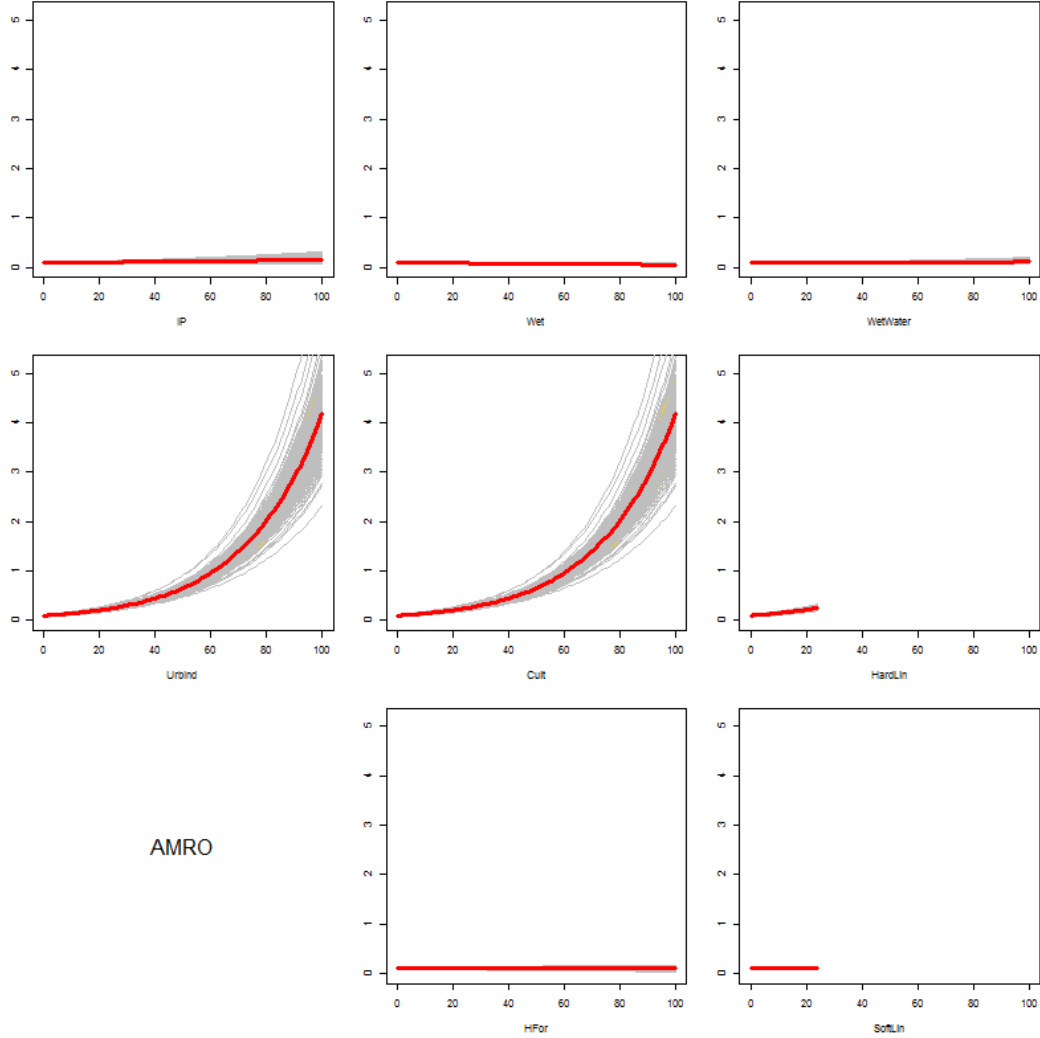


5.5.7 Relative habitat selection



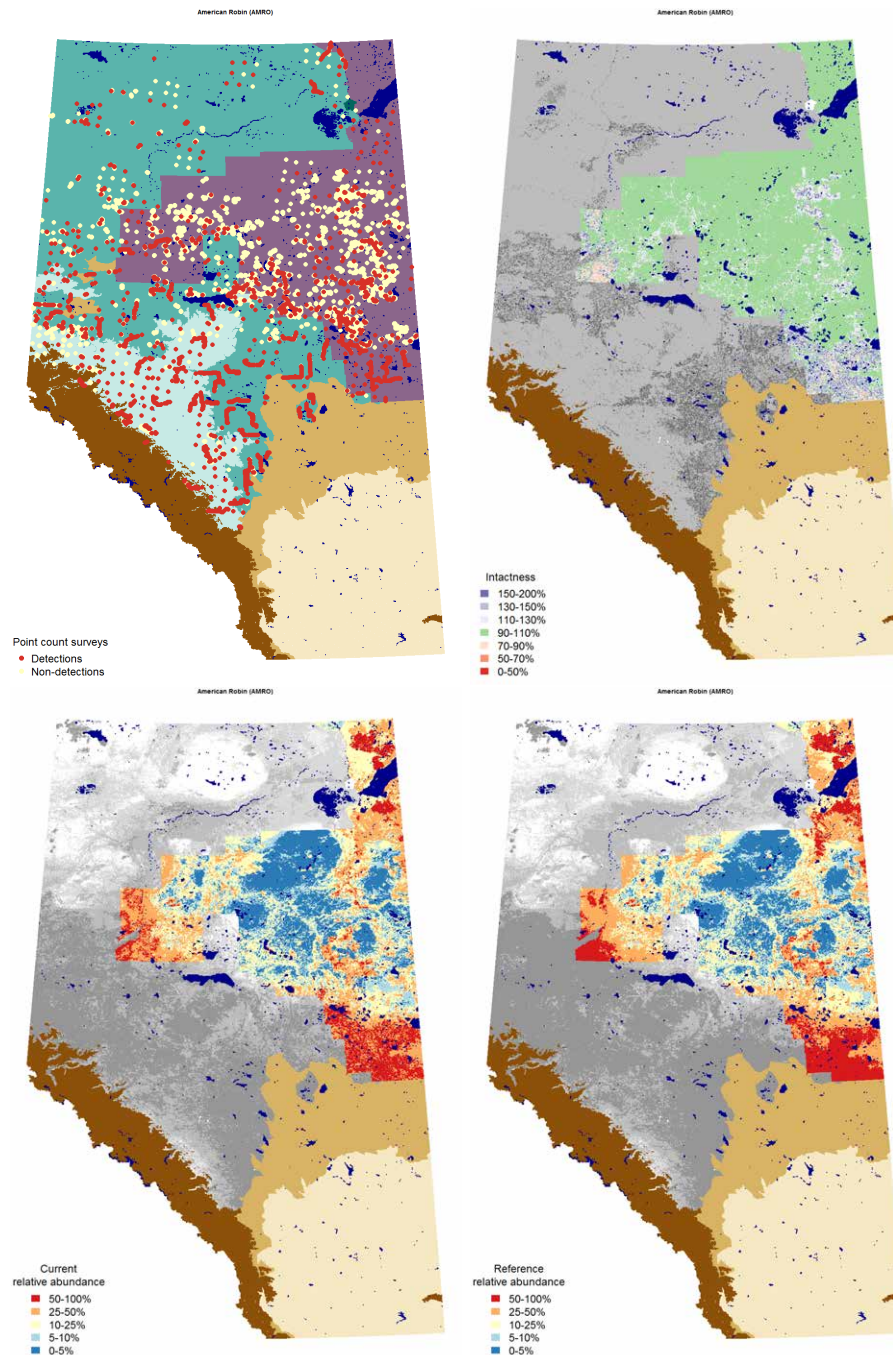
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.5.8 Quarter-section level responses



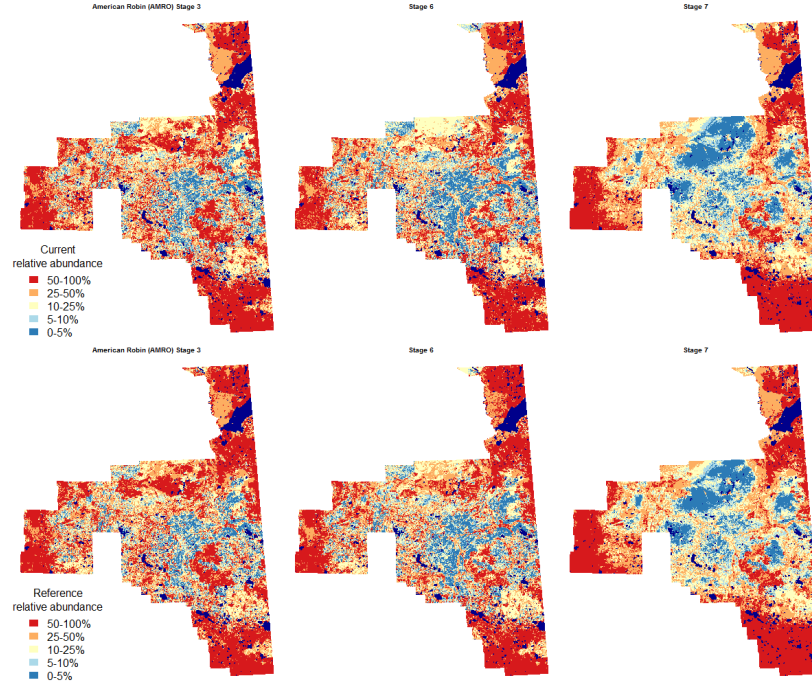
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.5.9 Maps



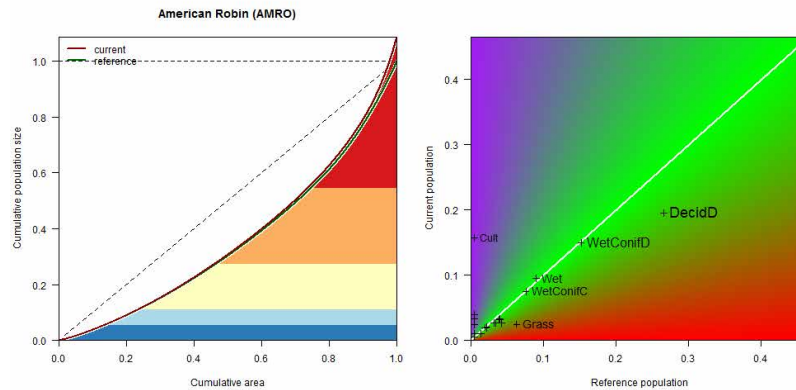
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.5.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.5.11 Population concentration



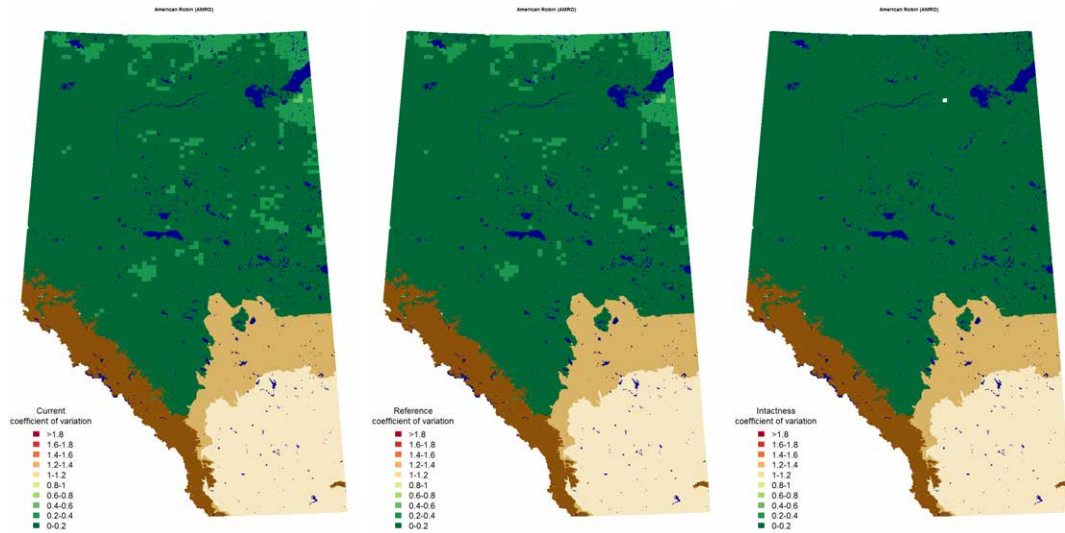
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.5.12 Potential population size

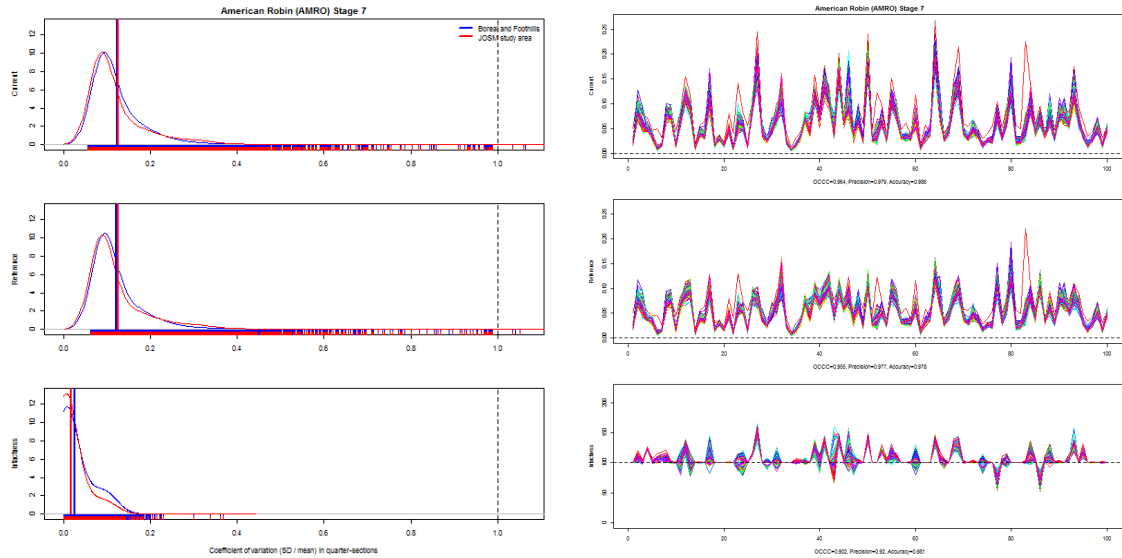
Estimated potential population size of American Robin in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1241	0.1102	0.1336	0.1678	0.1495	0.1826
WetConifD	0.0952	0.0845	0.1025	0.0959	0.0855	0.1044
Wet	0.0602	0.0535	0.0648	0.0571	0.0509	0.0621
WetConifC	0.0477	0.0423	0.0513	0.0480	0.0428	0.0522
Grass	0.0157	0.0140	0.0169	0.0399	0.0356	0.0435
Shrub	0.0169	0.0150	0.0182	0.0269	0.0240	0.0293
MixedD	0.0208	0.0184	0.0223	0.0253	0.0225	0.0275
ConifD	0.0202	0.0179	0.0217	0.0252	0.0225	0.0274
ConifA	0.0205	0.0182	0.0221	0.0243	0.0217	0.0265
DecidC	0.0166	0.0147	0.0178	0.0216	0.0193	0.0235
ConifC	0.0167	0.0148	0.0180	0.0201	0.0180	0.0219
PineC	0.0129	0.0114	0.0139	0.0142	0.0126	0.0154
ConifB	0.0118	0.0104	0.0127	0.0136	0.0121	0.0148
PineD	0.0122	0.0108	0.0131	0.0136	0.0121	0.0148
PineB	0.0124	0.0110	0.0134	0.0125	0.0112	0.0136
DecidB	0.0064	0.0057	0.0069	0.0088	0.0078	0.0095
WetConifB	0.0034	0.0030	0.0037	0.0035	0.0031	0.0038
PineA	0.0031	0.0028	0.0034	0.0032	0.0029	0.0035
DecidA	0.0014	0.0012	0.0015	0.0025	0.0022	0.0027
MixedA	0.0017	0.0015	0.0018	0.0025	0.0022	0.0027
WetConifA	0.0017	0.0015	0.0018	0.0017	0.0016	0.0019
MixedB	0.0014	0.0013	0.0015	0.0017	0.0015	0.0019
MixedC	0.0010	0.0009	0.0011	0.0013	0.0011	0.0014
Cult	0.0999	0.0887	0.1076	0.0000	0.0000	0.0000
UrbInd	0.0150	0.0133	0.0162	0.0000	0.0000	0.0000
HardLin	0.0063	0.0056	0.0068	0.0000	0.0000	0.0000
SoftLin	0.0213	0.0189	0.0229	0.0000	0.0000	0.0000
HFor	0.0248	0.0220	0.0267	0.0000	0.0000	0.0000
Total	0.6914	0.6137	0.7441	0.6313	0.5627	0.6870
Loss	0.0124	0.0057	0.0236			
Gain	0.0684	0.0542	0.0831			

5.5.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.5.14 Variable selection frequencies

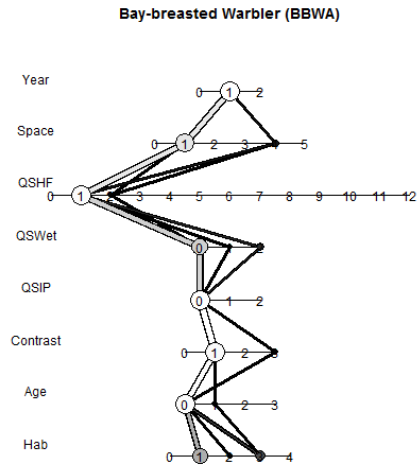
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	0.5	1	. + Habitat
1.2	98.5	197	. + HabitatB
1.4	1.0	2	. + HabitatB + isHForC
2.3	100.0	200	. + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
3.1	3.5	7	. + ROAD
3.3	96.5	193	. + ROAD + SoftLin_PC
4.0	58.0	116	NULL
4.1	4.5	9	. + Remn_QS
4.2	37.5	75	. + Remn_QS + Remn2_QS
5.1	94.5	189	. + pWet_QS
5.2	5.5	11	. + pWetWater_QS
6.9	58.5	117	. + Succ_QS + Alien_QS + Alien2_QS
6.11	41.5	83	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.4	89.5	179	. + xMAP + xPET + xMAT + xCMD
7.5	10.5	21	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	7.0	14	NULL
8.1	93.0	186	. + xYEAR

5.6 Bay-breasted Warbler (*Setophaga castanea*)

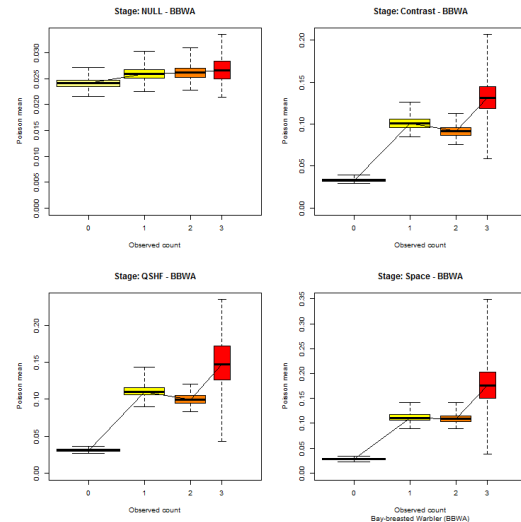
5.6.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

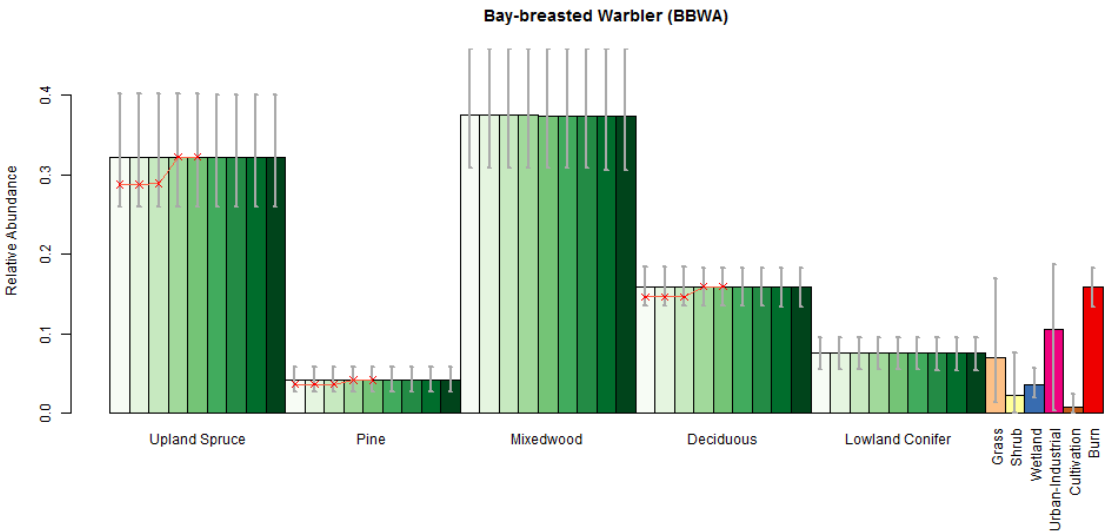


5.6.2 Cross validation

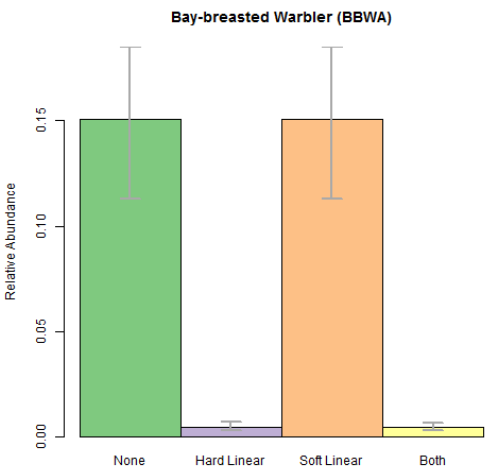
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.6.3 Point level habitat associations

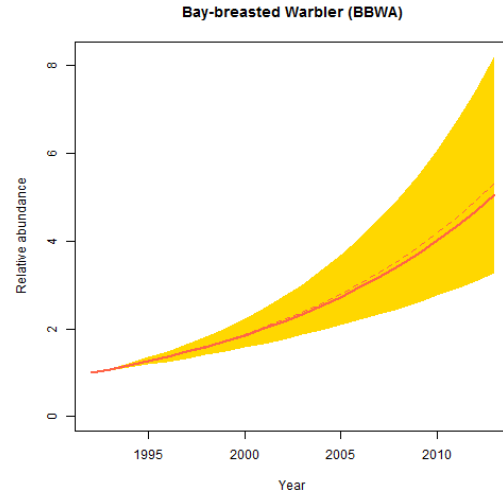


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

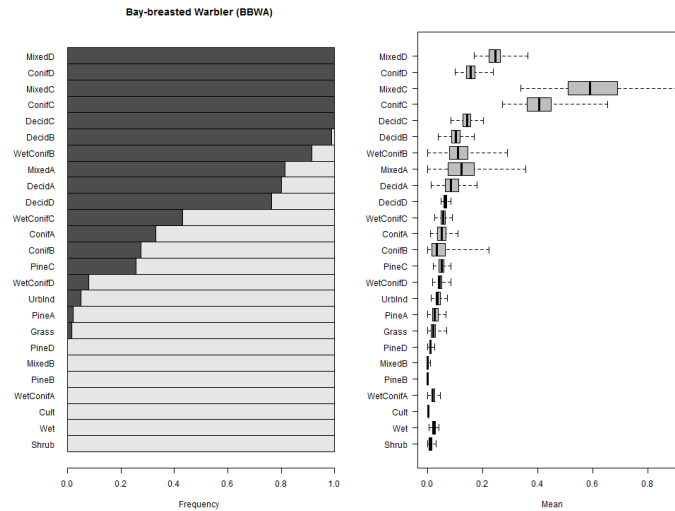


5.6.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).

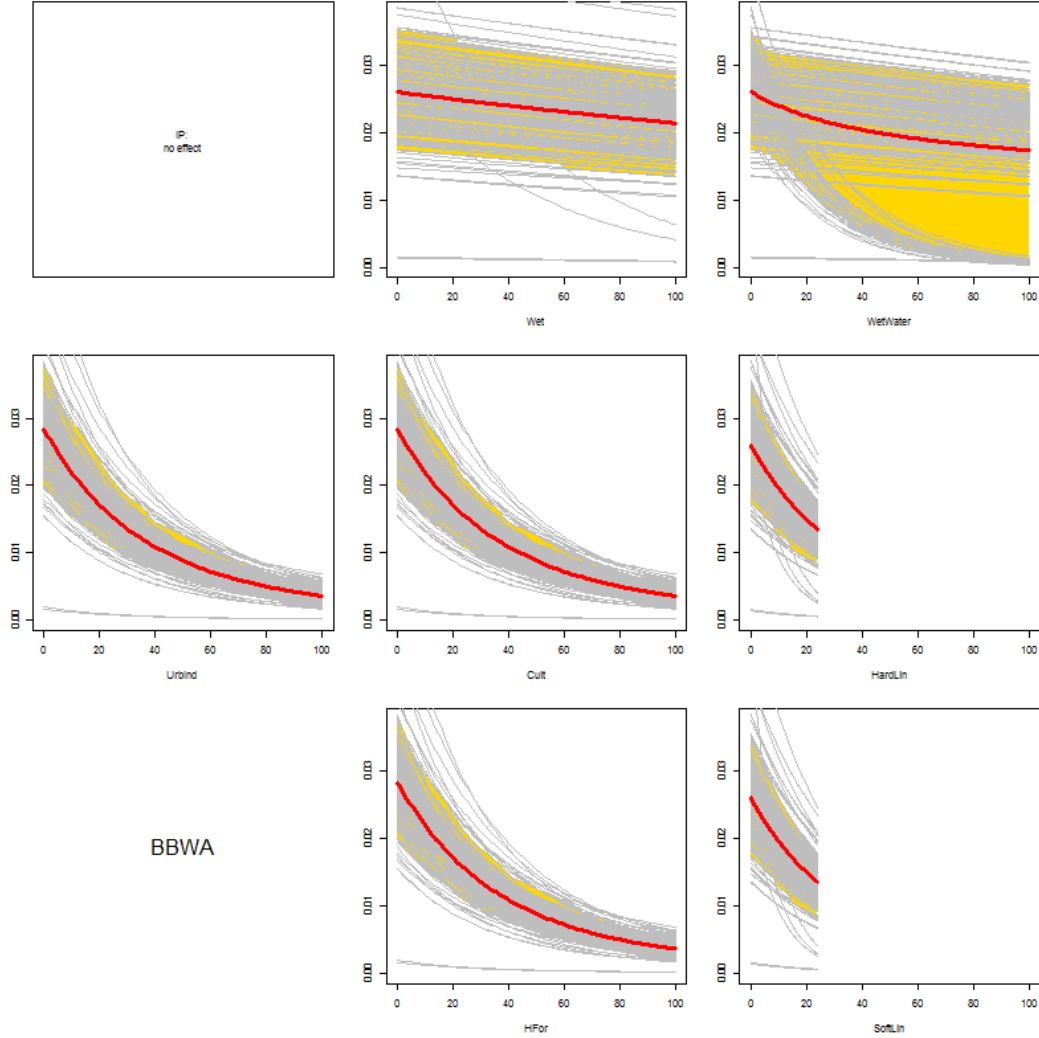


5.6.5 Habitat suitability ranking for patch delineation



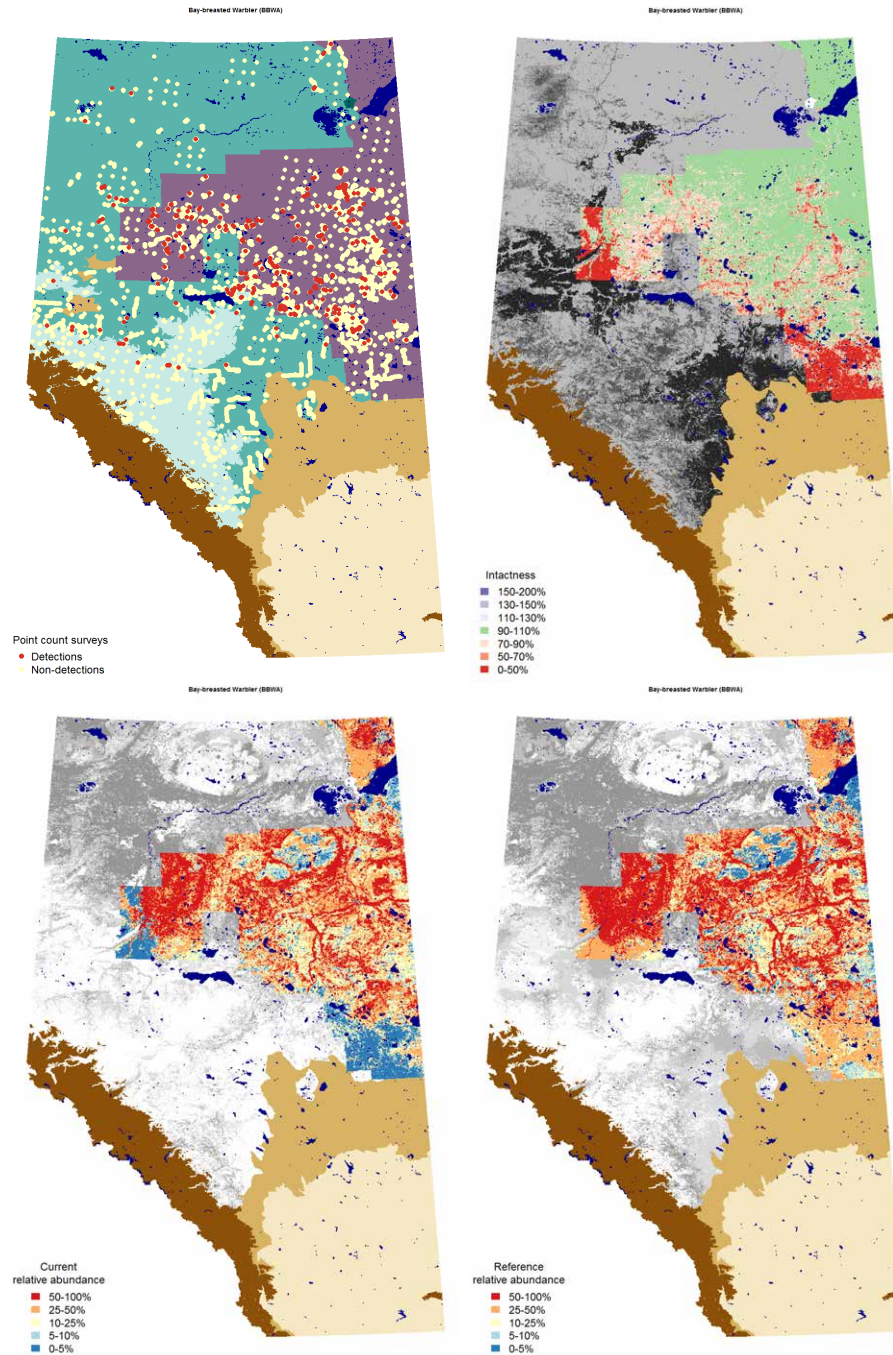
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.6.8 Quarter-section level responses



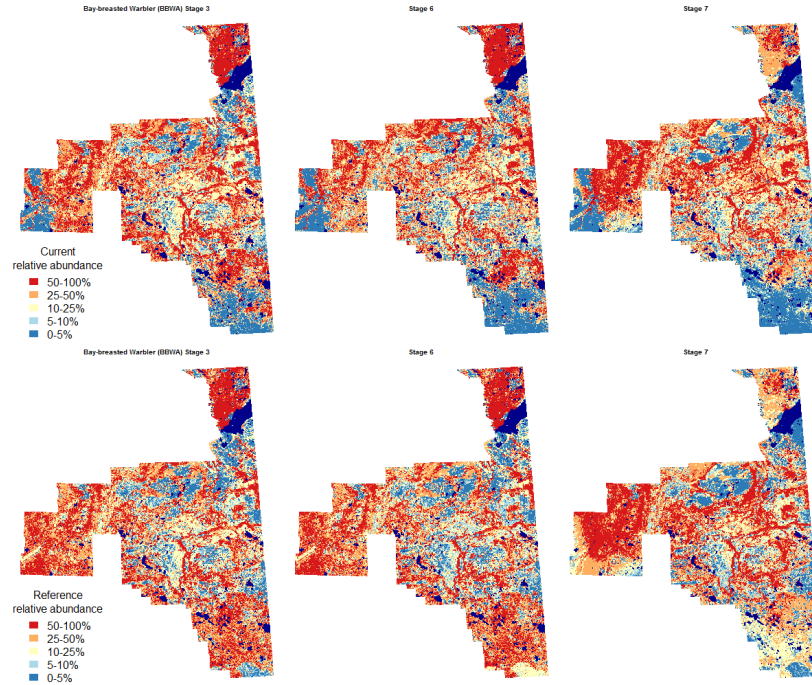
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.6.9 Maps



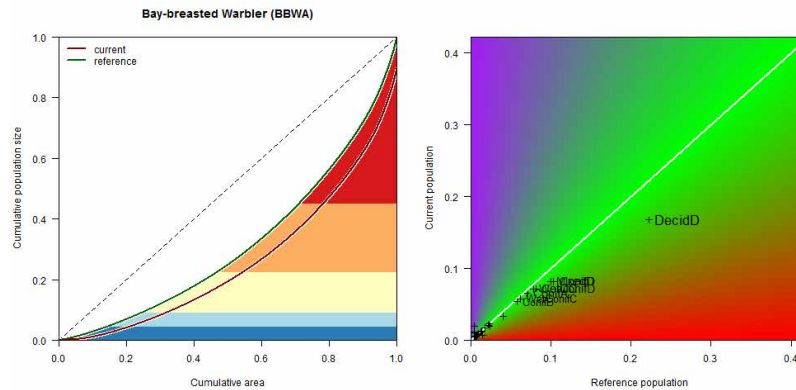
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.6.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.6.11 Population concentration



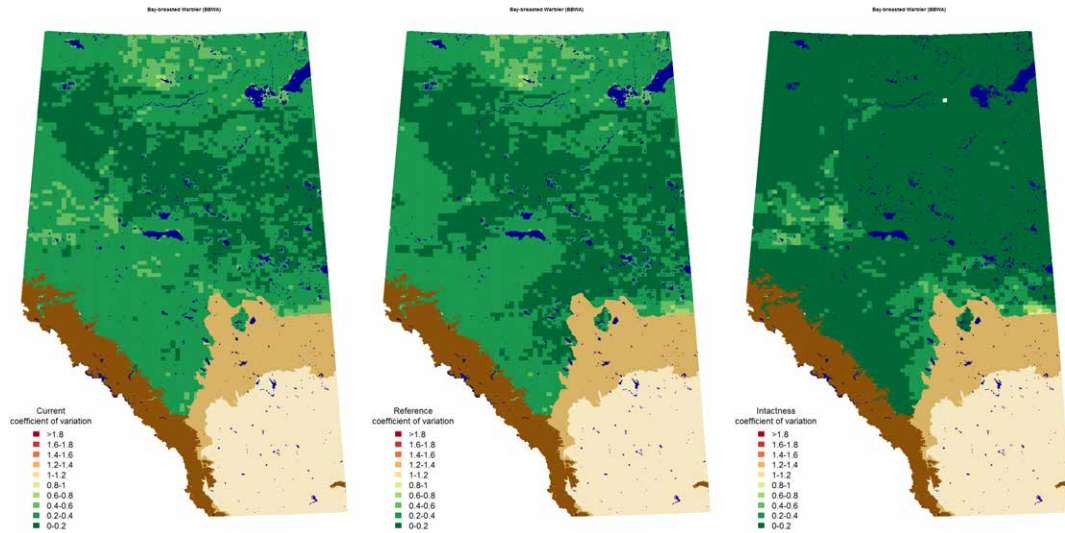
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.6.12 Potential population size

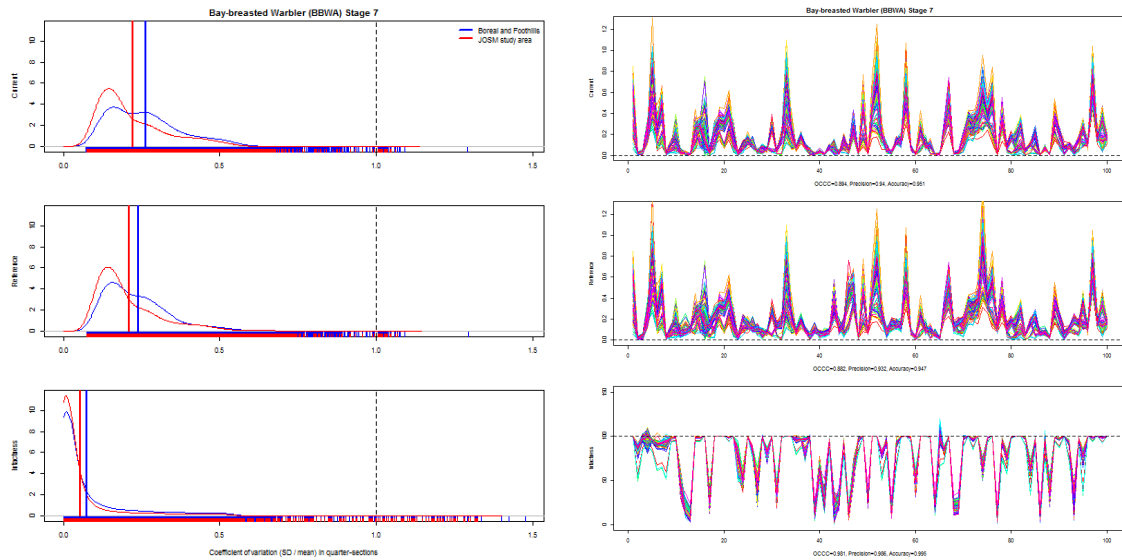
Estimated potential population size of Bay-breasted Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.5088	0.4170	0.5784	0.6691	0.5637	0.7634
ConifD	0.2489	0.2040	0.2829	0.3124	0.2632	0.3565
MixedD	0.2483	0.2035	0.2823	0.3012	0.2538	0.3437
ConifC	0.2179	0.1785	0.2477	0.2452	0.2066	0.2798
WetConifD	0.2173	0.1781	0.2471	0.2366	0.1994	0.2700
ConifA	0.1975	0.1619	0.2246	0.2134	0.1798	0.2435
WetConifC	0.1750	0.1434	0.1989	0.1873	0.1578	0.2137
ConifB	0.1629	0.1335	0.1852	0.1735	0.1461	0.1979
DecidC	0.1022	0.0837	0.1162	0.1216	0.1025	0.1388
DecidB	0.0593	0.0486	0.0675	0.0715	0.0602	0.0816
PineB	0.0685	0.0561	0.0778	0.0686	0.0578	0.0783
Wet	0.0642	0.0526	0.0730	0.0676	0.0570	0.0771
WetConifB	0.0515	0.0422	0.0586	0.0530	0.0447	0.0605
Grass	0.0216	0.0177	0.0245	0.0443	0.0374	0.0506
WetConifA	0.0393	0.0322	0.0447	0.0421	0.0355	0.0480
PineC	0.0358	0.0294	0.0407	0.0383	0.0323	0.0437
MixedB	0.0278	0.0228	0.0316	0.0303	0.0255	0.0346
PineD	0.0270	0.0221	0.0307	0.0293	0.0247	0.0334
PineA	0.0249	0.0204	0.0283	0.0252	0.0213	0.0288
DecidA	0.0154	0.0126	0.0175	0.0220	0.0185	0.0251
MixedA	0.0152	0.0125	0.0173	0.0203	0.0171	0.0231
MixedC	0.0171	0.0141	0.0195	0.0192	0.0162	0.0219
Shrub	0.0152	0.0124	0.0172	0.0182	0.0153	0.0208
Cult	0.0142	0.0116	0.0162	0.0000	0.0000	0.0000
UrbInd	0.0350	0.0287	0.0398	0.0000	0.0000	0.0000
HardLin	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0311	0.0255	0.0353	0.0000	0.0000	0.0000
HFor	0.0612	0.0501	0.0696	0.0000	0.0000	0.0000
Total	2.7033	2.2153	3.0732	3.0102	2.5362	3.4349
Loss	0.3233	0.2687	0.3977			
Gain	0.0027	0.0005	0.0091			

5.6.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.6.14 Variable selection frequencies

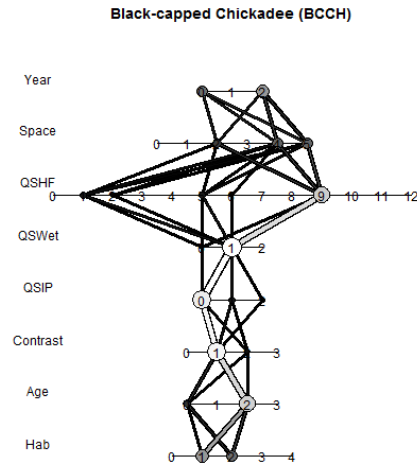
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	68.0	136	. + Habitat
1.2	0.5	1	. + HabitatB
1.3	31.5	63	. + Habitat + isHForC
2.0	99.0	198	NULL
2.1	1.0	2	. + Age
3.1	98.0	196	. + ROAD
3.3	2.0	4	. + ROAD + SoftLin_PC
4.0	100.0	200	NULL
5.0	81.5	163	NULL
5.1	1.0	2	. + pWet_QS
5.2	17.5	35	. + pWetWater_QS
6.1	98.5	197	. + THF_QS
6.2	1.5	3	. + Lin_QS + Nonlin_QS
7.1	90.0	180	. + xlat
7.4	10.0	20	. + xMAP + xPET + xMAT + xCMD
8.1	100.0	200	. + xYEAR

5.7 Black-capped Chickadee (*Poecile atricapillus*)

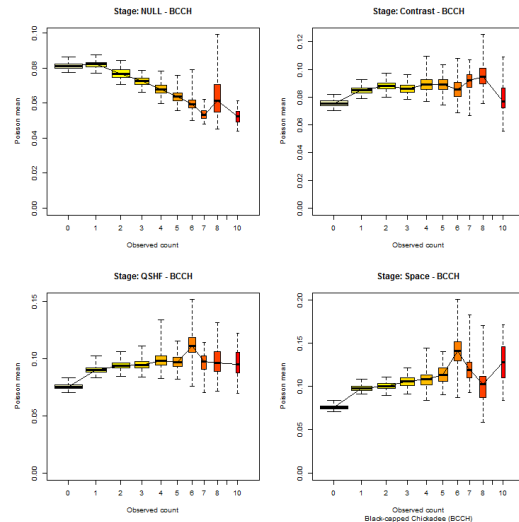
5.7.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

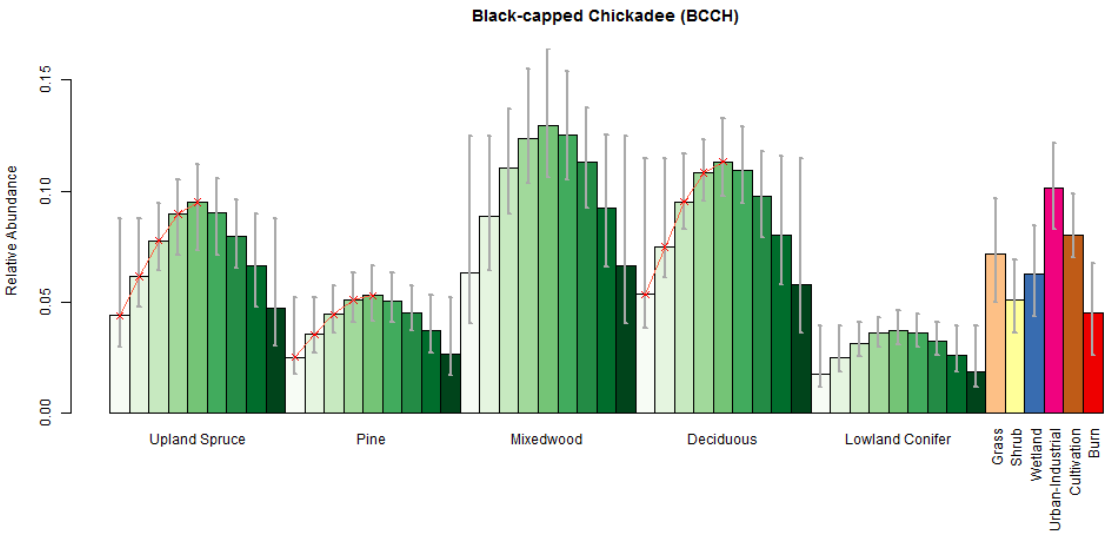


5.7.2 Cross validation

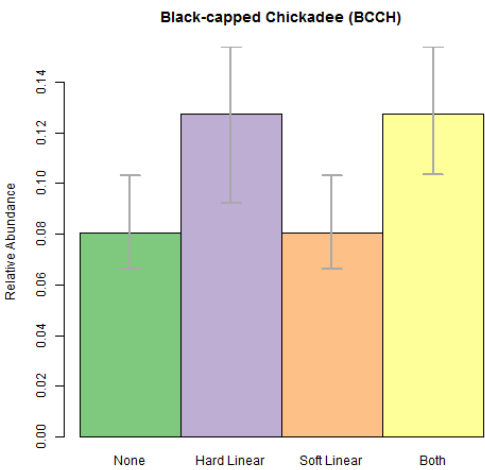
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.7.3 Point level habitat associations

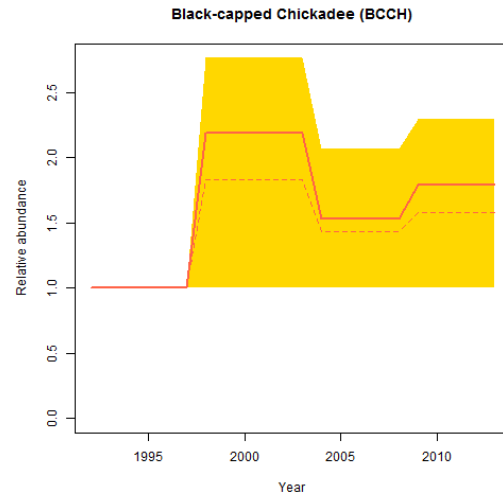


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

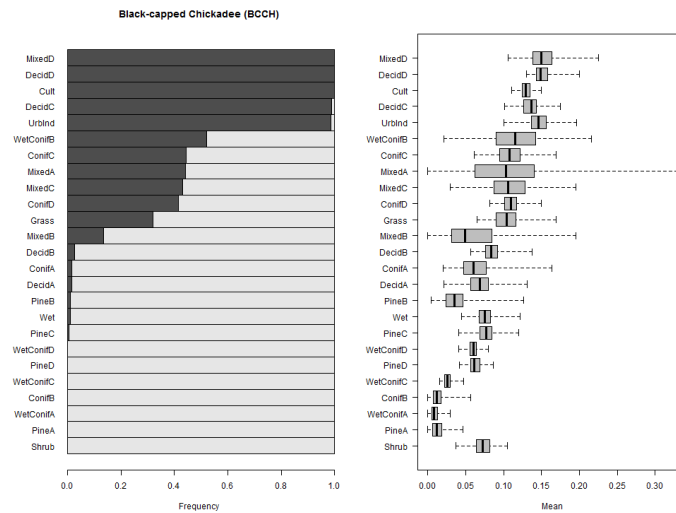


5.7.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



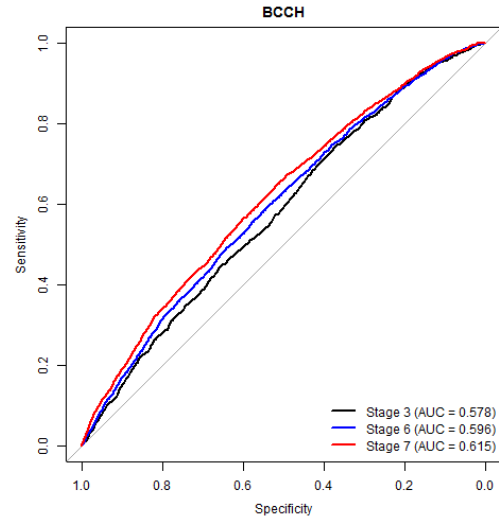
5.7.5 Habitat suitability ranking for patch delineation



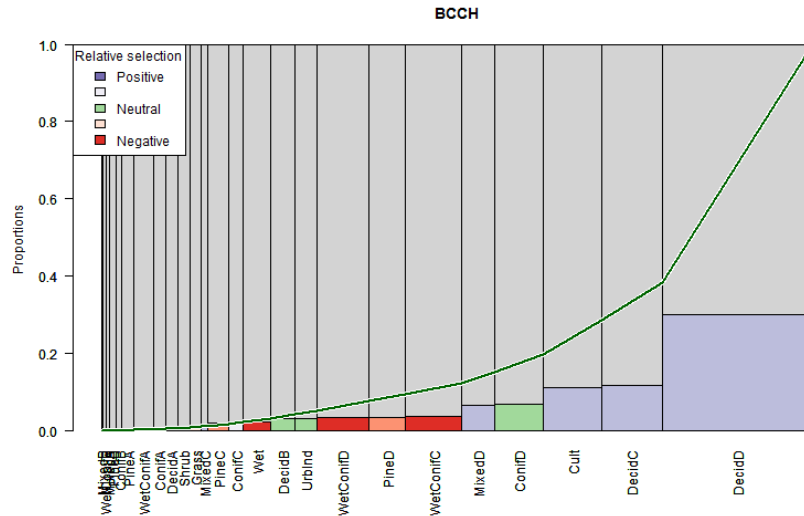
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.7.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

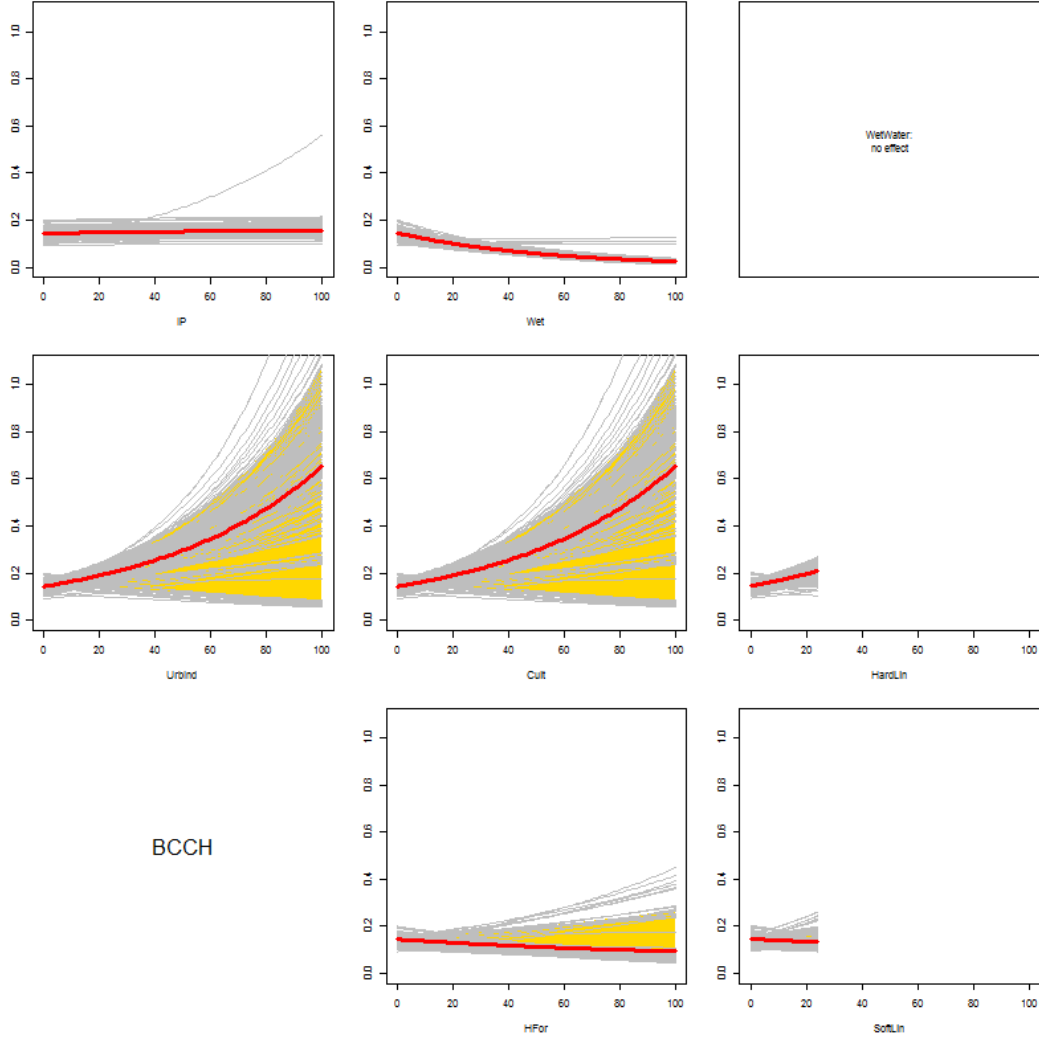


5.7.7 Relative habitat selection



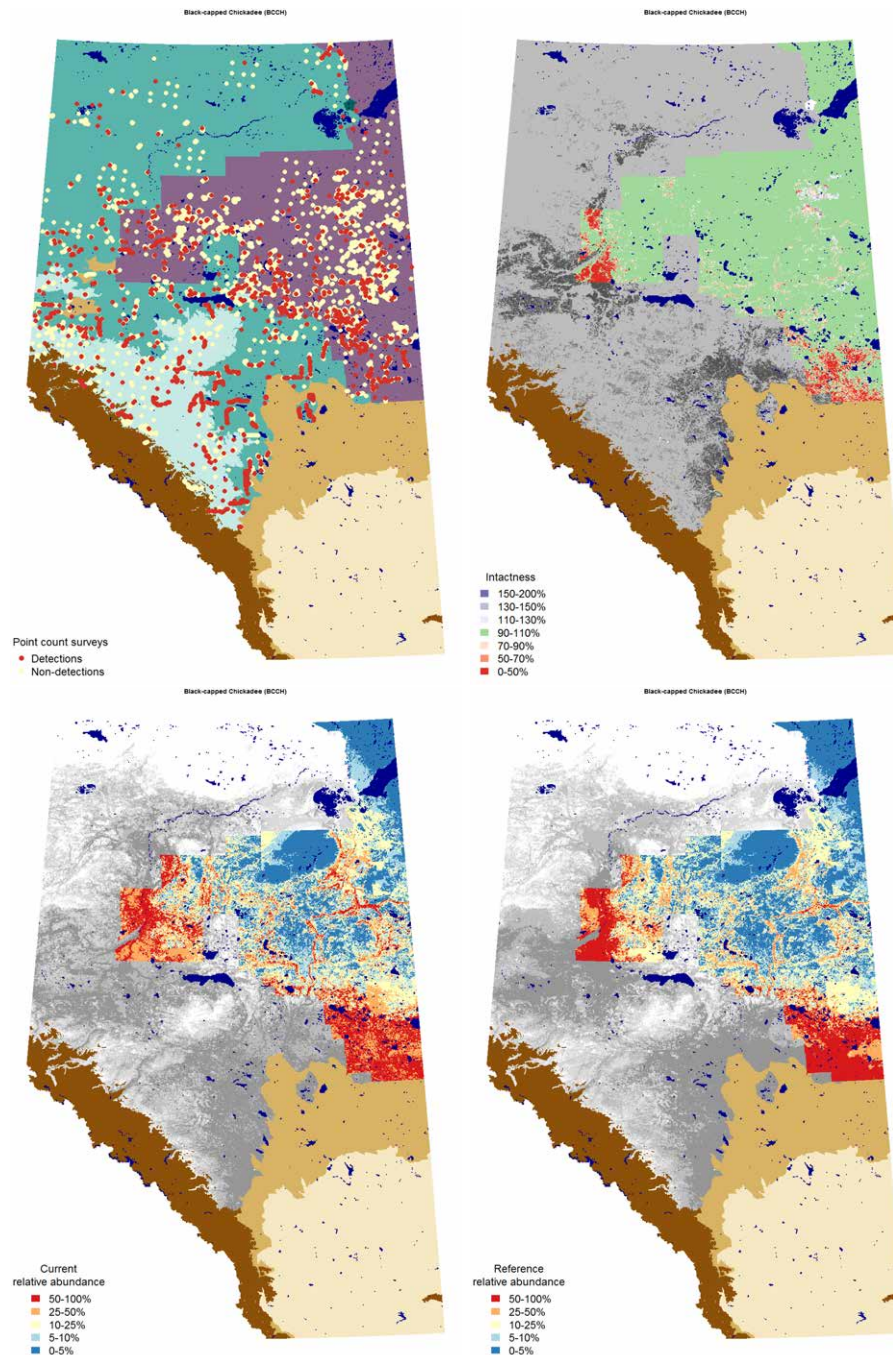
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.7.8 Quarter-section level responses



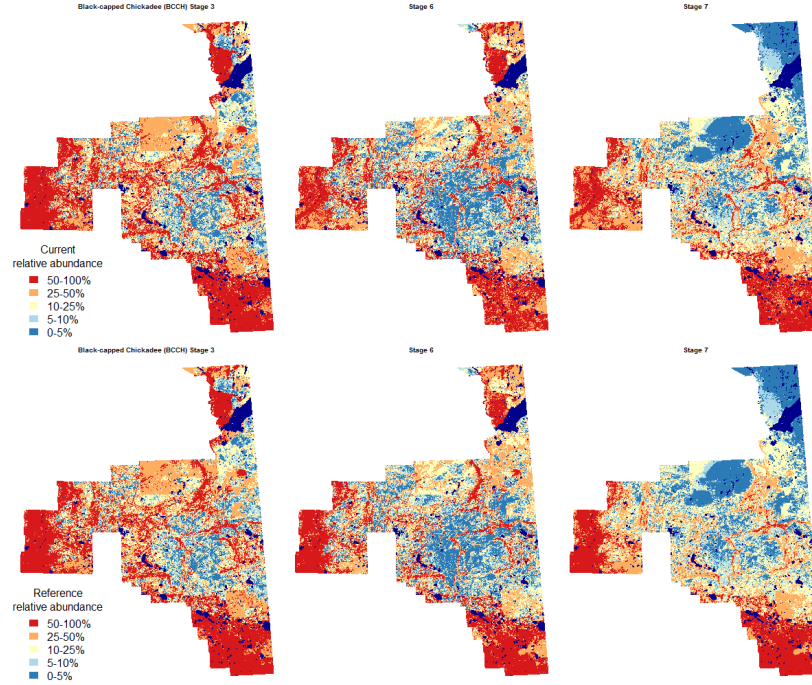
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.7.9 Maps



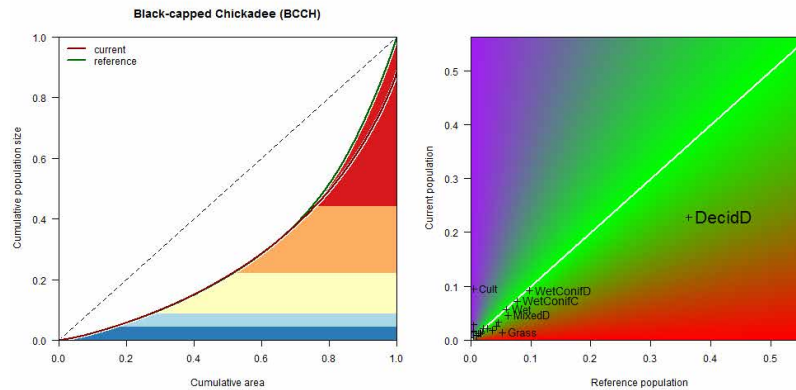
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.7.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.7.11 Population concentration



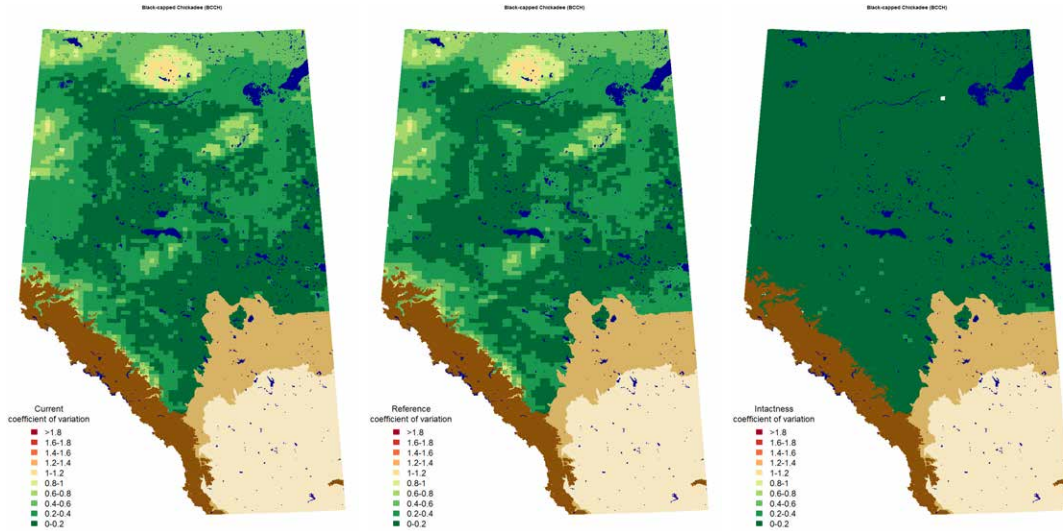
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.7.12 Potential population size

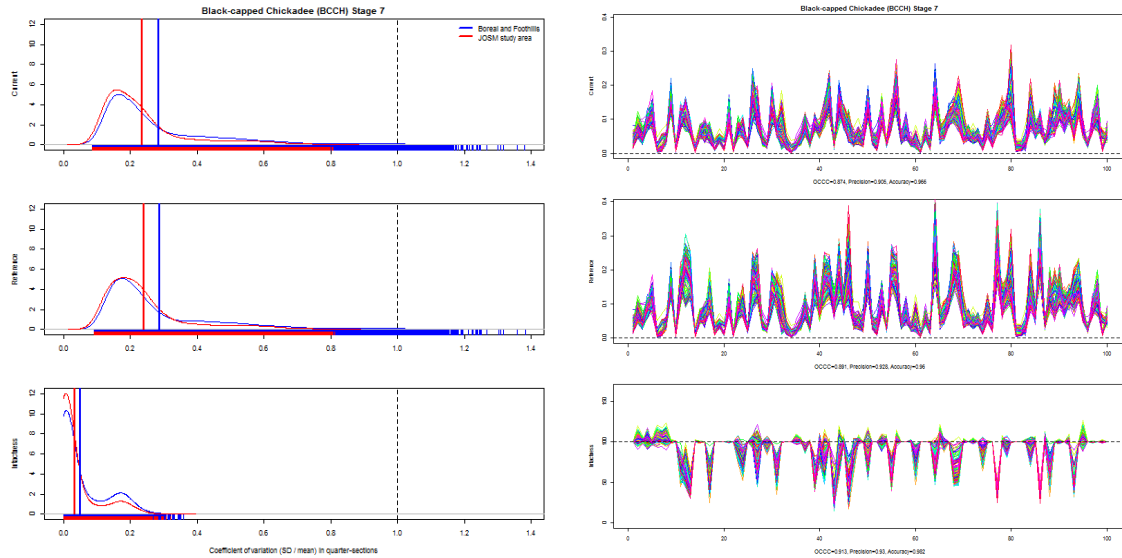
Estimated potential population size of Black-capped Chickadee in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.2448	0.2110	0.2850	0.3856	0.3193	0.4615
WetConifD	0.0987	0.0851	0.1149	0.1040	0.0861	0.1244
WetConifC	0.0778	0.0670	0.0905	0.0821	0.0680	0.0983
MixedD	0.0496	0.0427	0.0577	0.0663	0.0549	0.0793
Wet	0.0616	0.0531	0.0717	0.0634	0.0525	0.0758
Grass	0.0151	0.0131	0.0176	0.0559	0.0463	0.0668
ConifD	0.0355	0.0306	0.0414	0.0493	0.0408	0.0589
DecidC	0.0282	0.0243	0.0329	0.0457	0.0378	0.0546
Shrub	0.0199	0.0172	0.0232	0.0387	0.0320	0.0463
ConifC	0.0228	0.0197	0.0266	0.0301	0.0249	0.0361
PineB	0.0229	0.0198	0.0267	0.0230	0.0190	0.0275
PineC	0.0173	0.0149	0.0201	0.0204	0.0169	0.0244
DecidB	0.0129	0.0112	0.0151	0.0188	0.0156	0.0225
PineD	0.0140	0.0120	0.0163	0.0168	0.0139	0.0201
WetConifB	0.0129	0.0111	0.0150	0.0134	0.0111	0.0160
ConifB	0.0092	0.0079	0.0107	0.0107	0.0088	0.0128
ConifA	0.0086	0.0074	0.0100	0.0103	0.0085	0.0123
WetConifA	0.0098	0.0084	0.0114	0.0101	0.0084	0.0121
PineA	0.0056	0.0048	0.0065	0.0057	0.0047	0.0069
DecidA	0.0025	0.0021	0.0029	0.0051	0.0042	0.0061
MixedB	0.0021	0.0018	0.0025	0.0027	0.0022	0.0032
MixedC	0.0018	0.0015	0.0021	0.0025	0.0021	0.0030
MixedA	0.0015	0.0013	0.0017	0.0023	0.0019	0.0027
Cult	0.1027	0.0885	0.1195	0.0000	0.0000	0.0000
UrbInd	0.0169	0.0146	0.0197	0.0000	0.0000	0.0000
HardLin	0.0027	0.0023	0.0031	0.0000	0.0000	0.0000
SoftLin	0.0182	0.0157	0.0212	0.0000	0.0000	0.0000
HFor	0.0308	0.0266	0.0359	0.0000	0.0000	0.0000
Total	0.9465	0.8157	1.1018	1.0627	0.8800	1.2717
Loss	0.1281	0.0690	0.1876			
Gain	0.0098	0.0024	0.0291			

5.7.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.7.14 Variable selection frequencies

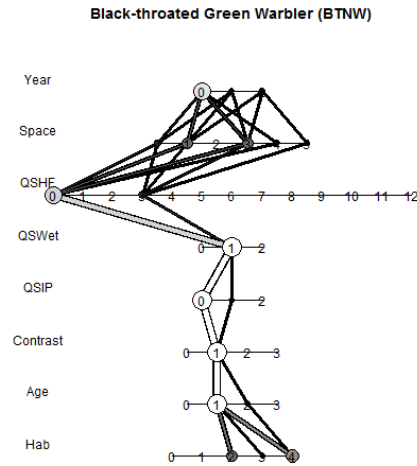
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	58.0	116	. + Habitat
1.2	42.0	84	. + HabitatB
2.0	19.5	39	NULL
2.2	80.5	161	. + Age + Age2
3.1	94.0	188	. + ROAD
3.2	6.0	12	. + SoftLin_PC
4.0	91.0	182	NULL
4.1	8.5	17	. + Remn_QS
4.2	0.5	1	. + Remn_QS + Remn2_QS
5.0	2.0	4	NULL
5.1	98.0	196	. + pWet_QS
6.1	9.5	19	. + THF_QS
6.2	1.5	3	. + Lin_QS + Nonlin_QS
6.5	9.5	19	. + THF_QS + THF2_QS
6.6	1.0	2	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.9	78.5	157	. + Succ_QS + Alien_QS + Alien2_QS
7.2	24.0	48	. + xlat + xlong
7.4	37.5	75	. + xMAP + xPET + xMAT + xCMD
7.5	38.5	77	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	42.0	84	NULL
8.2	58.0	116	. + YR5F

5.8 Black-throated Green Warbler (*Setophaga virens*)

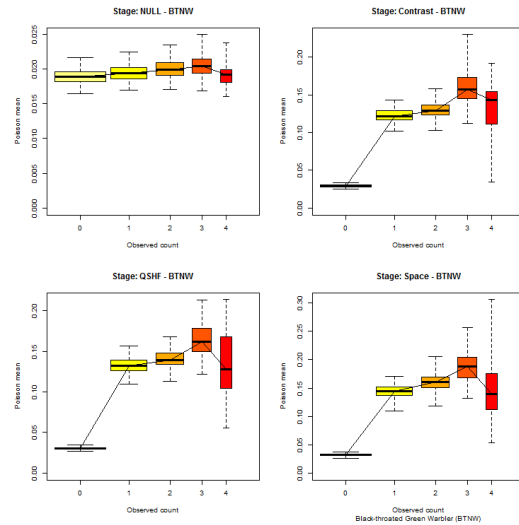
5.8.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

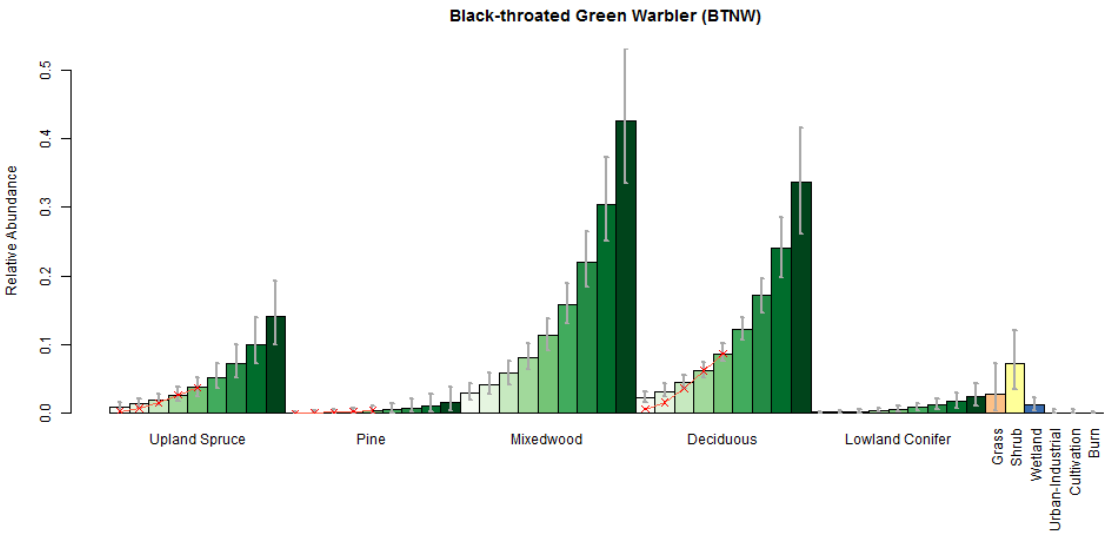


5.8.2 Cross validation

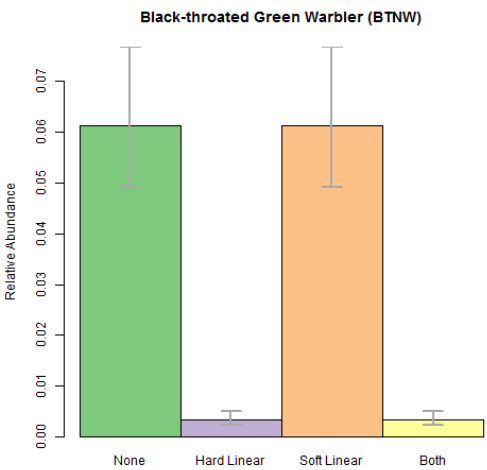
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.8.3 Point level habitat associations

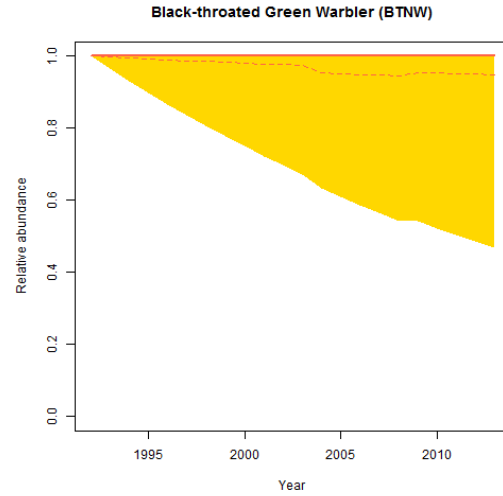


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

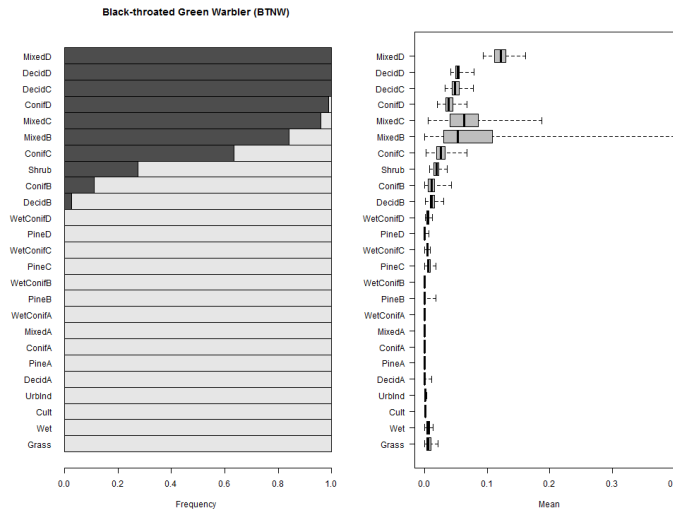


5.8.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



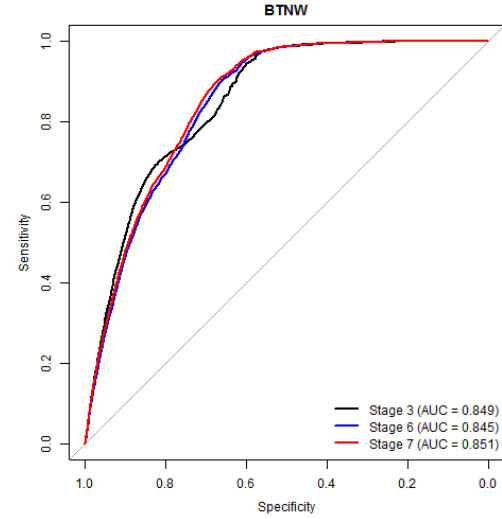
5.8.5 Habitat suitability ranking for patch delineation



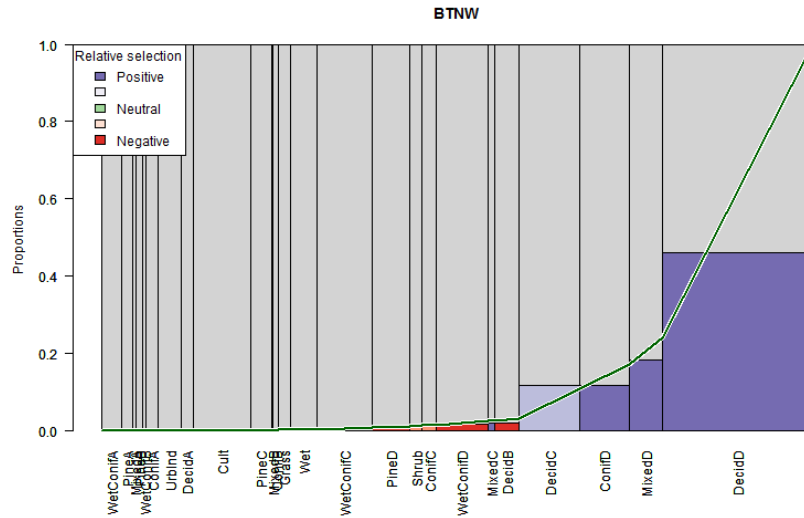
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.8.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

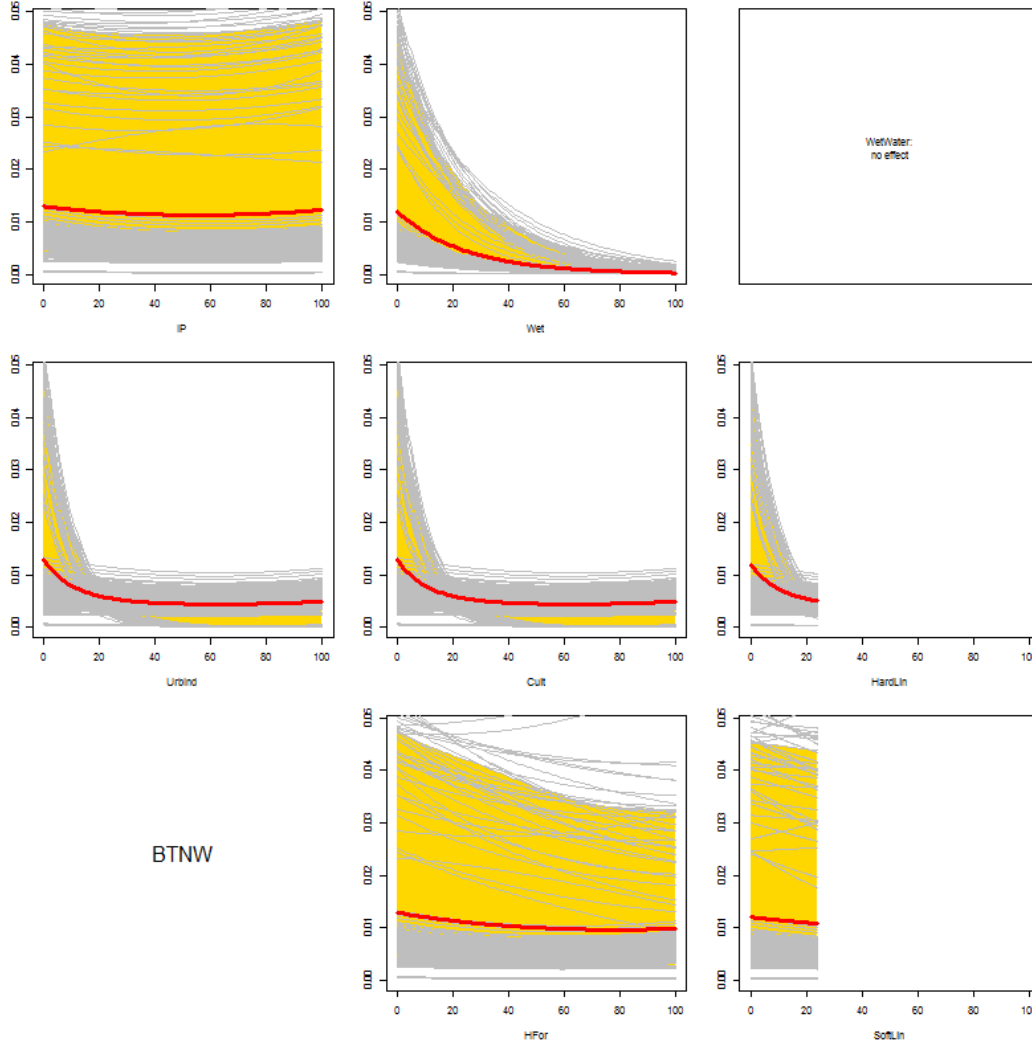


5.8.7 Relative habitat selection



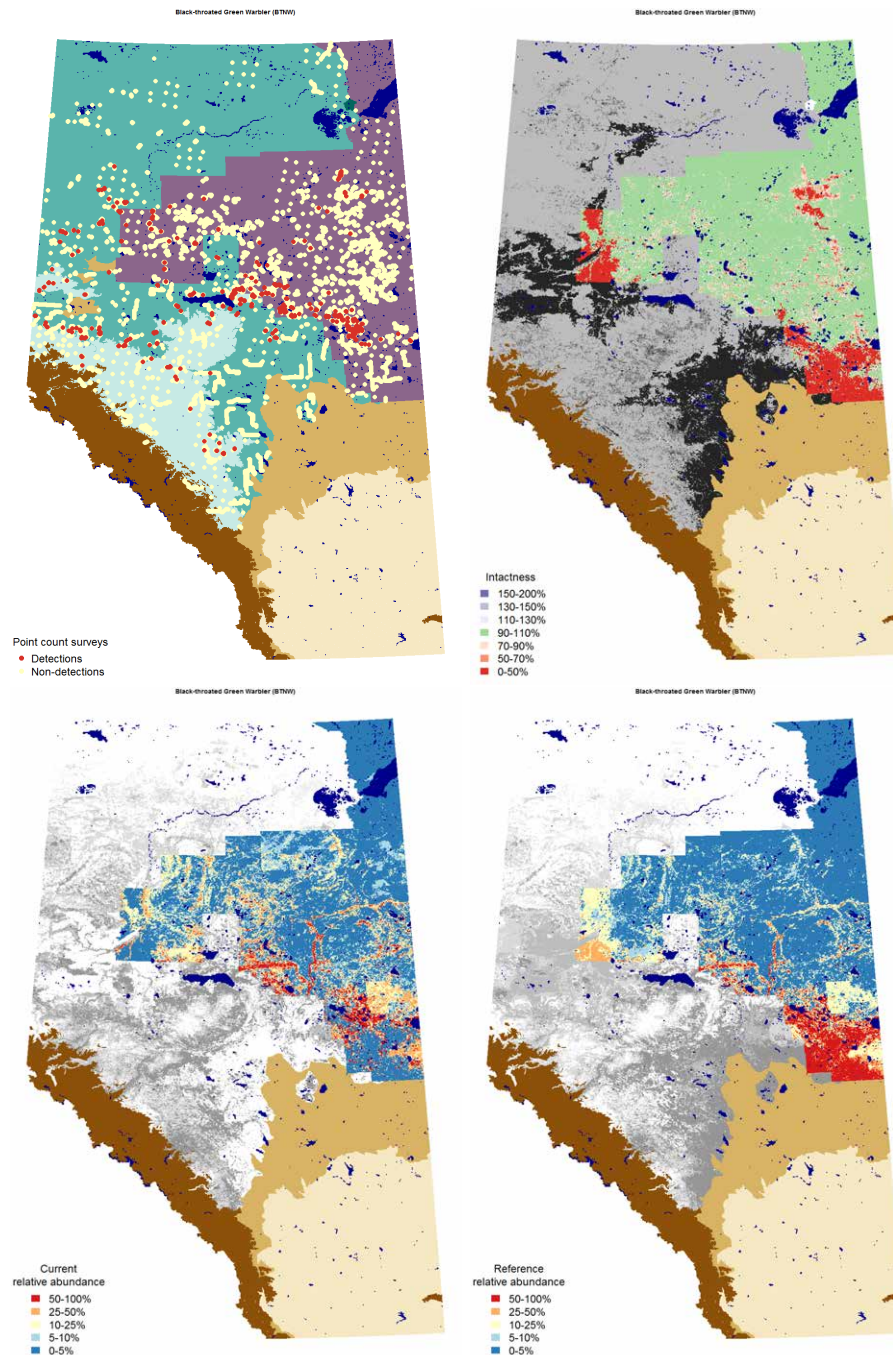
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.8.8 Quarter-section level responses



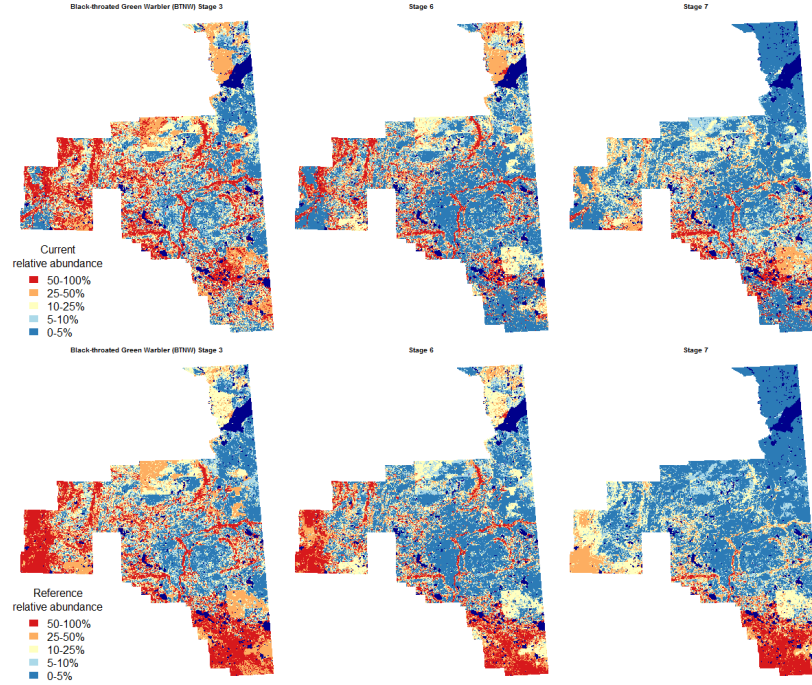
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.8.9 Maps



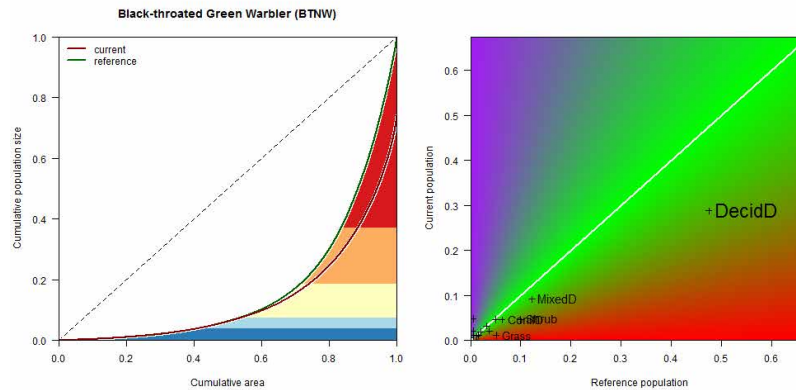
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.8.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.8.11 Population concentration



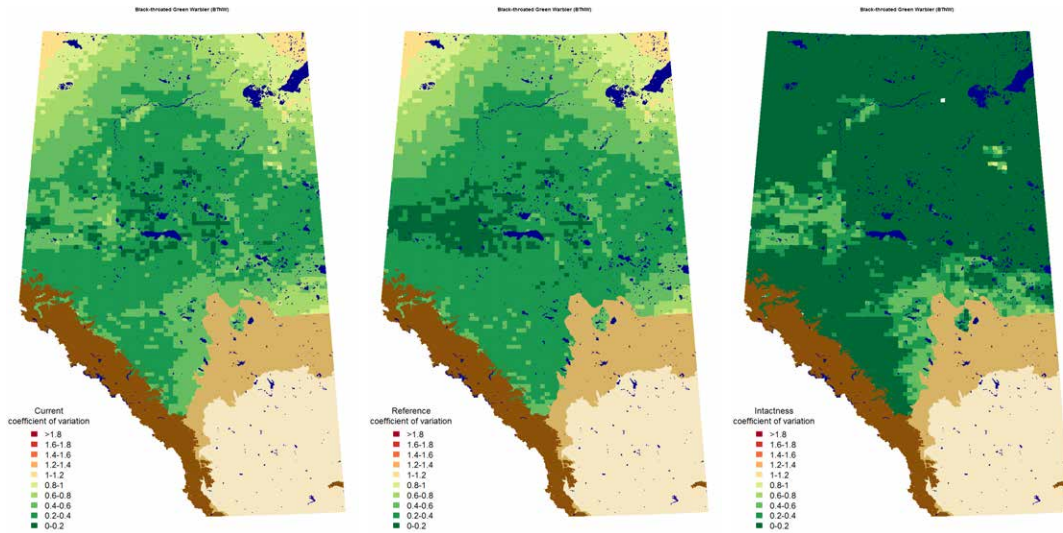
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.8.12 Potential population size

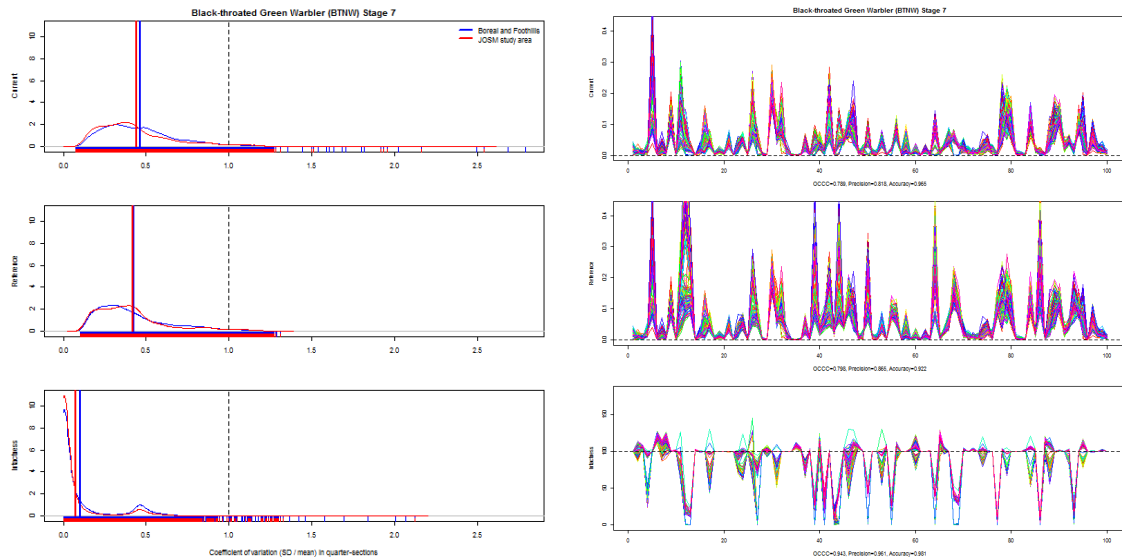
Estimated potential population size of Black-throated Green Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1576	0.1292	0.1884	0.2473	0.1916	0.3818
MixedD	0.0500	0.0410	0.0598	0.0638	0.0494	0.0985
Shrub	0.0254	0.0208	0.0304	0.0516	0.0400	0.0797
ConifD	0.0247	0.0203	0.0296	0.0326	0.0253	0.0503
Grass	0.0059	0.0048	0.0070	0.0266	0.0206	0.0411
WetConifD	0.0252	0.0207	0.0302	0.0258	0.0200	0.0398
DecidC	0.0116	0.0095	0.0139	0.0192	0.0149	0.0297
Wet	0.0175	0.0144	0.0210	0.0167	0.0130	0.0258
WetConifC	0.0106	0.0087	0.0126	0.0106	0.0082	0.0164
ConifC	0.0058	0.0048	0.0070	0.0079	0.0062	0.0123
DecidB	0.0046	0.0038	0.0055	0.0064	0.0050	0.0099
ConifB	0.0017	0.0014	0.0020	0.0019	0.0014	0.0029
ConifA	0.0013	0.0011	0.0016	0.0016	0.0012	0.0024
DecidA	0.0006	0.0005	0.0007	0.0014	0.0011	0.0022
WetConifB	0.0014	0.0011	0.0016	0.0013	0.0010	0.0021
MixedC	0.0008	0.0007	0.0010	0.0012	0.0009	0.0018
MixedB	0.0008	0.0007	0.0010	0.0010	0.0008	0.0015
PineD	0.0007	0.0006	0.0009	0.0009	0.0007	0.0014
WetConifA	0.0008	0.0006	0.0009	0.0007	0.0006	0.0012
MixedA	0.0005	0.0004	0.0006	0.0007	0.0006	0.0011
PineC	0.0005	0.0004	0.0006	0.0007	0.0005	0.0010
PineB	0.0006	0.0005	0.0007	0.0005	0.0004	0.0008
PineA	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Cult	0.0058	0.0047	0.0069	0.0000	0.0000	0.0000
UrbInd	0.0007	0.0006	0.0008	0.0000	0.0000	0.0000
HardLin	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0112	0.0092	0.0134	0.0000	0.0000	0.0000
HFor	0.0264	0.0217	0.0316	0.0000	0.0000	0.0000
Total	0.3930	0.3222	0.4699	0.5208	0.4035	0.8040
Loss	0.1416	0.0861	0.4005			
Gain	0.0131	0.0061	0.0166			

5.8.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.8.14 Variable selection frequencies

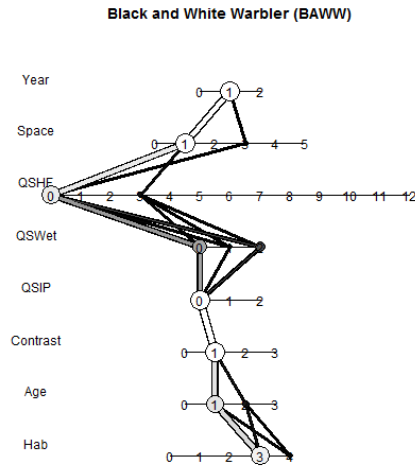
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	43.0	86	. + HabitatB
1.3	0.5	1	. + Habitat + isHForC
1.4	56.5	113	. + HabitatB + isHForC
2.1	99.5	199	. + Age
2.2	0.5	1	. + Age + Age2
3.1	100.0	200	. + ROAD
4.0	99.5	199	NULL
4.1	0.5	1	. + Remn_QS
5.1	100.0	200	. + pWet_QS
6.0	83.0	166	NULL
6.3	17.0	34	. + Succ_QS + Alien_QS
7.0	15.0	30	NULL
7.1	42.0	84	. + xlat
7.3	41.5	83	. + xlat + xlong + xlat:xlong
7.4	1.0	2	. + xMAP + xPET + xMAT + xCMD
7.5	0.5	1	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	89.5	179	NULL
8.1	8.0	16	. + xYEAR
8.2	2.5	5	. + YR5F

5.9 Black and White Warbler (*Mniotilta varia*)

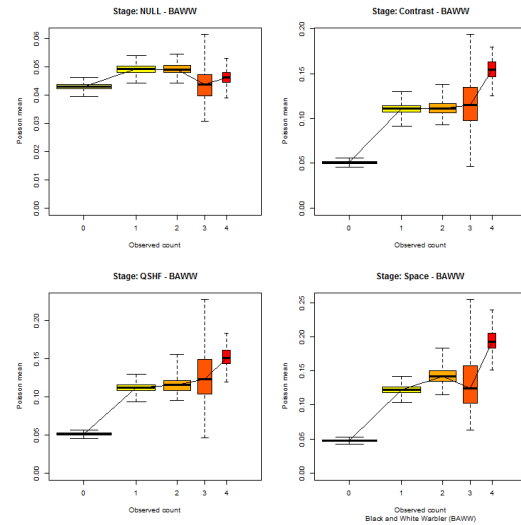
5.9.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

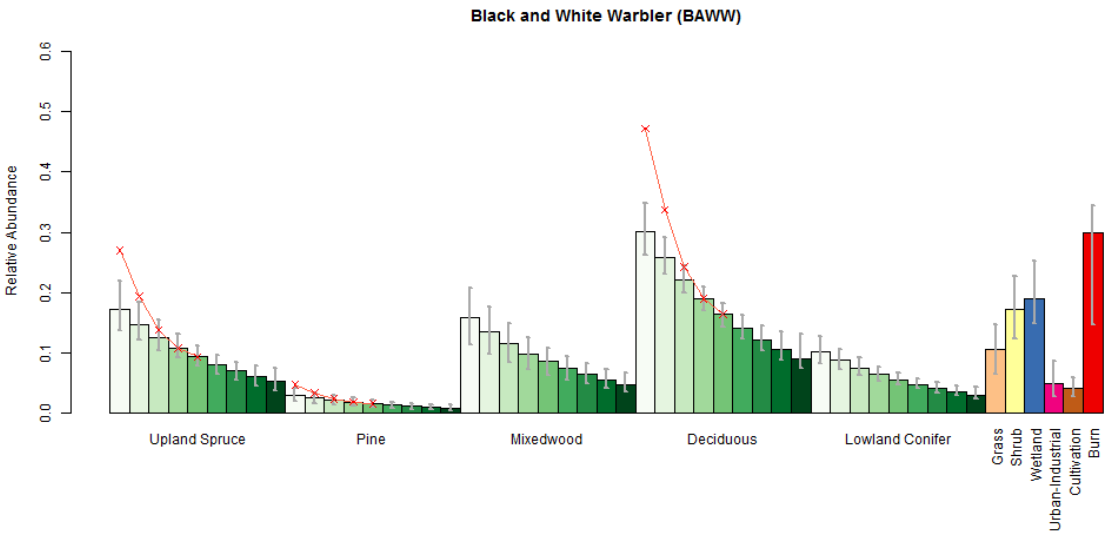


5.9.2 Cross validation

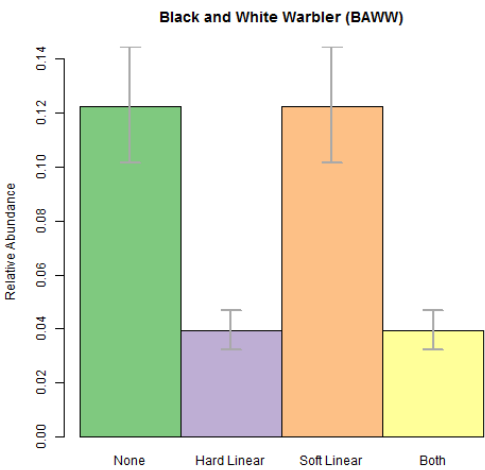
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.9.3 Point level habitat associations

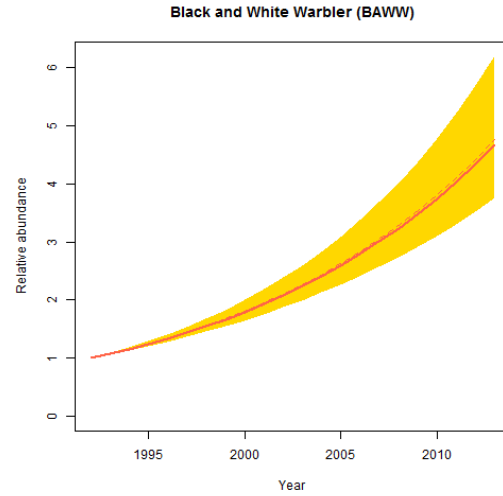


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

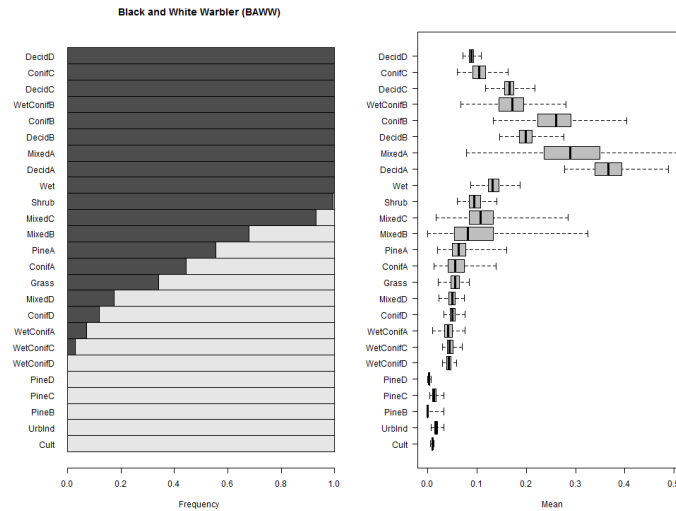


5.9.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



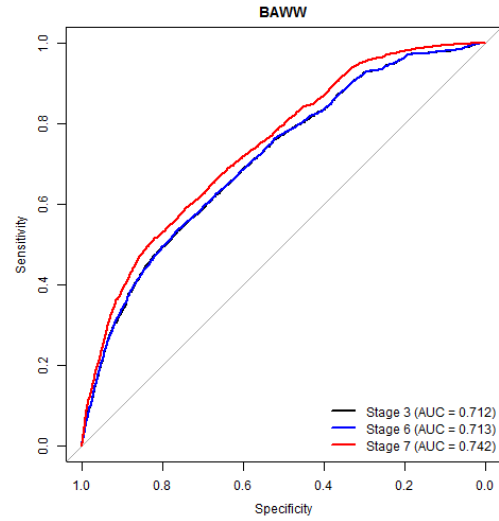
5.9.5 Habitat suitability ranking for patch delineation



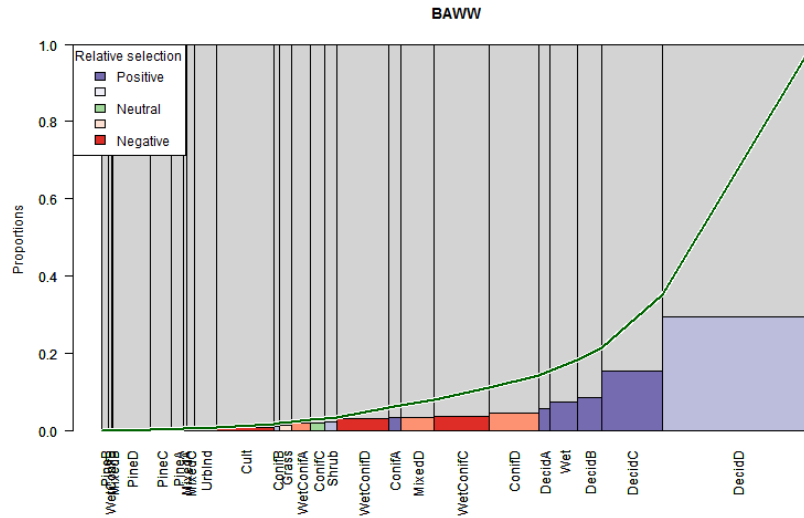
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.9.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

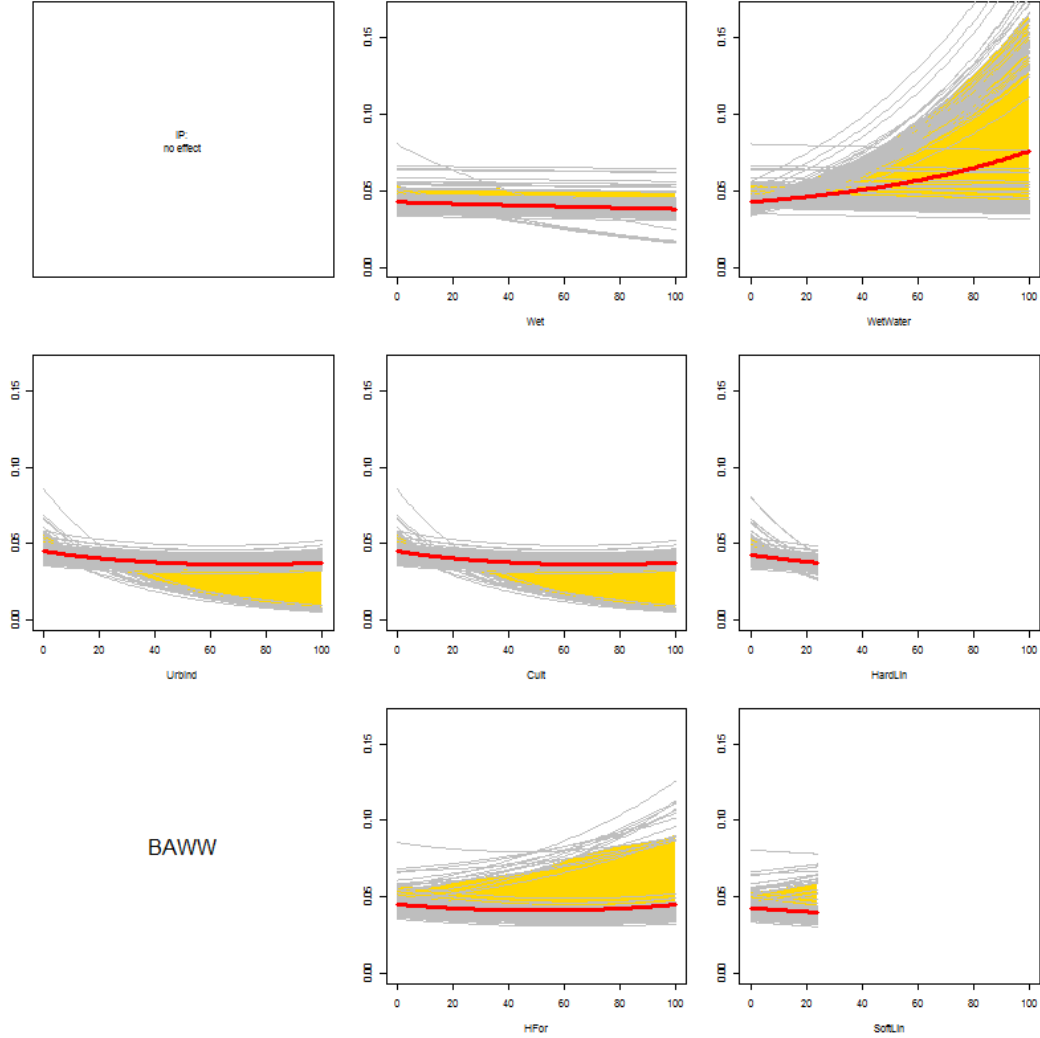


5.9.7 Relative habitat selection



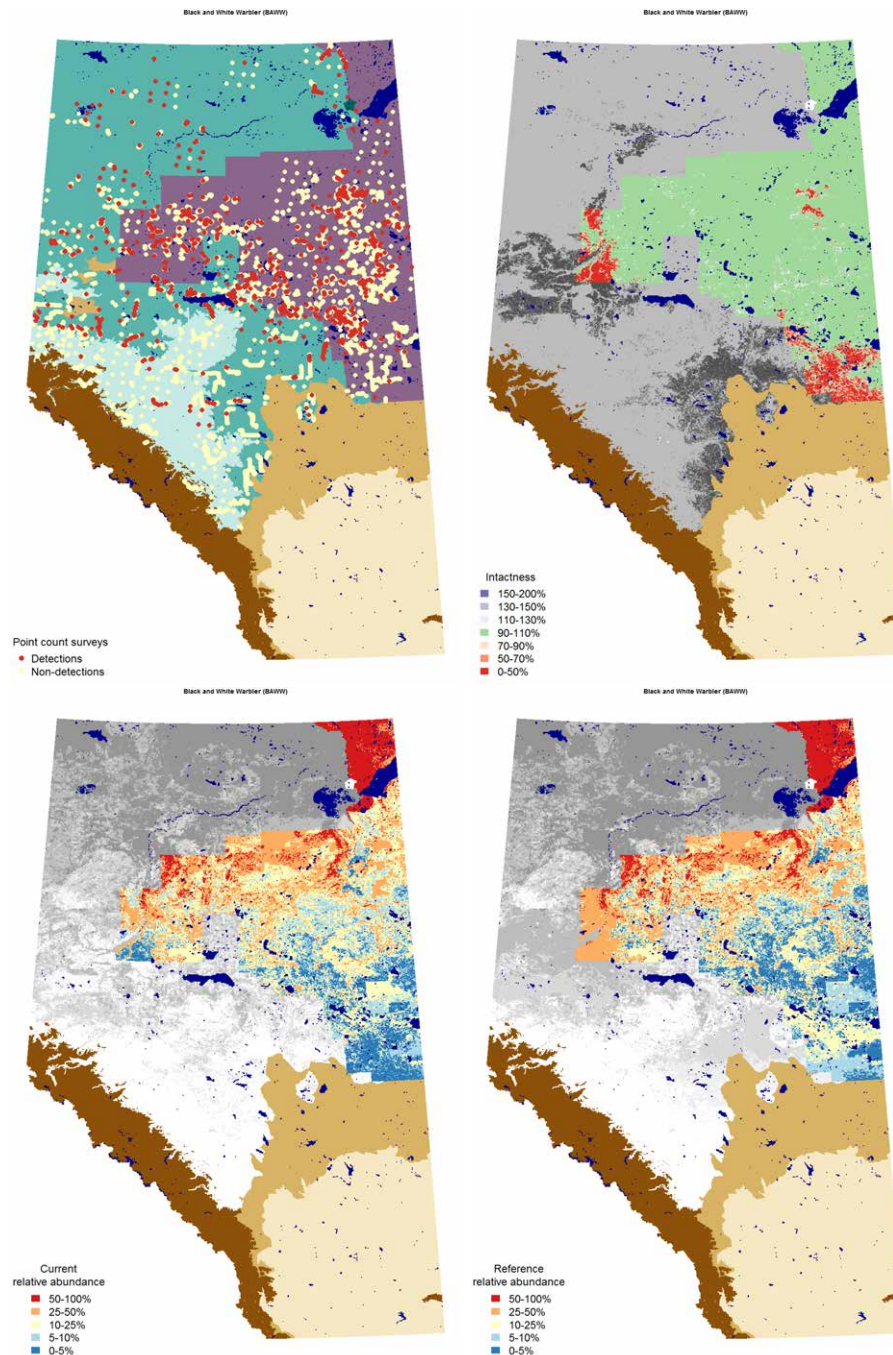
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.9.8 Quarter-section level responses



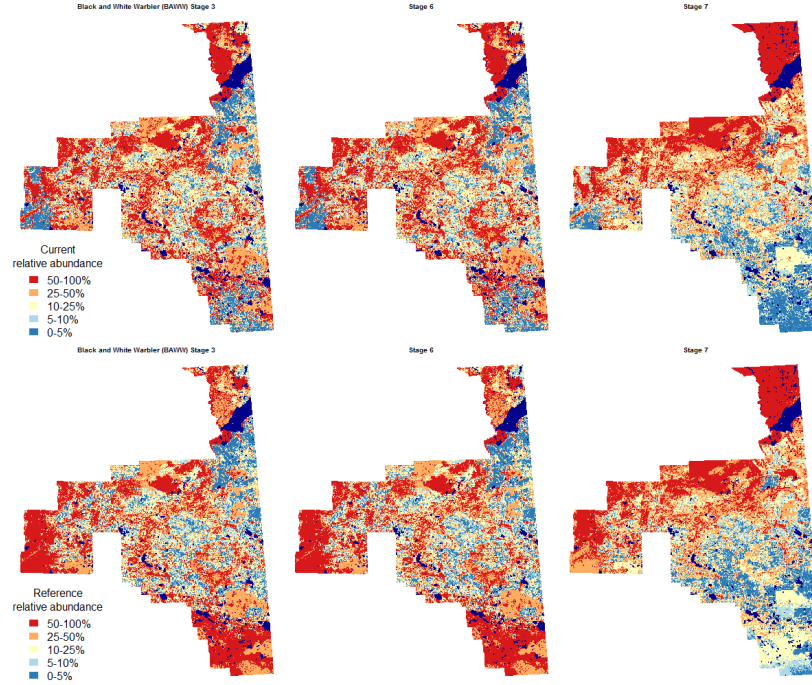
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.9.9 Maps



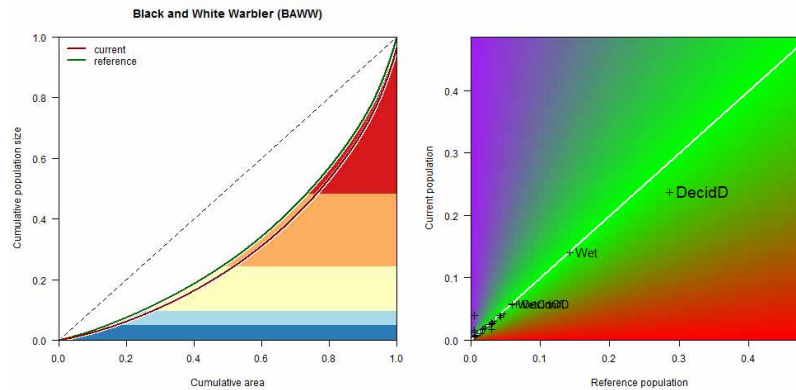
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.9.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.9.11 Population concentration



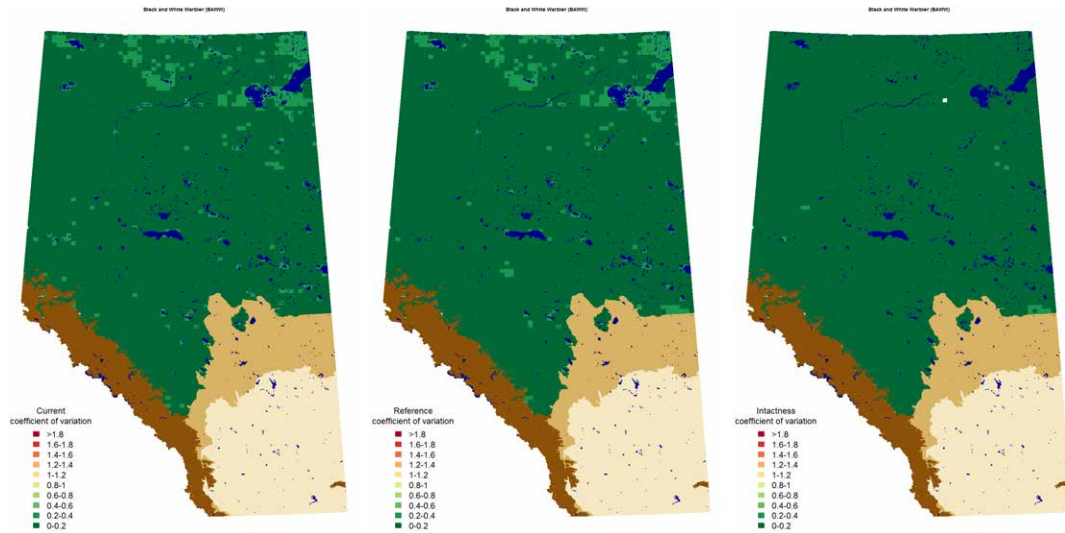
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.9.12 Potential population size

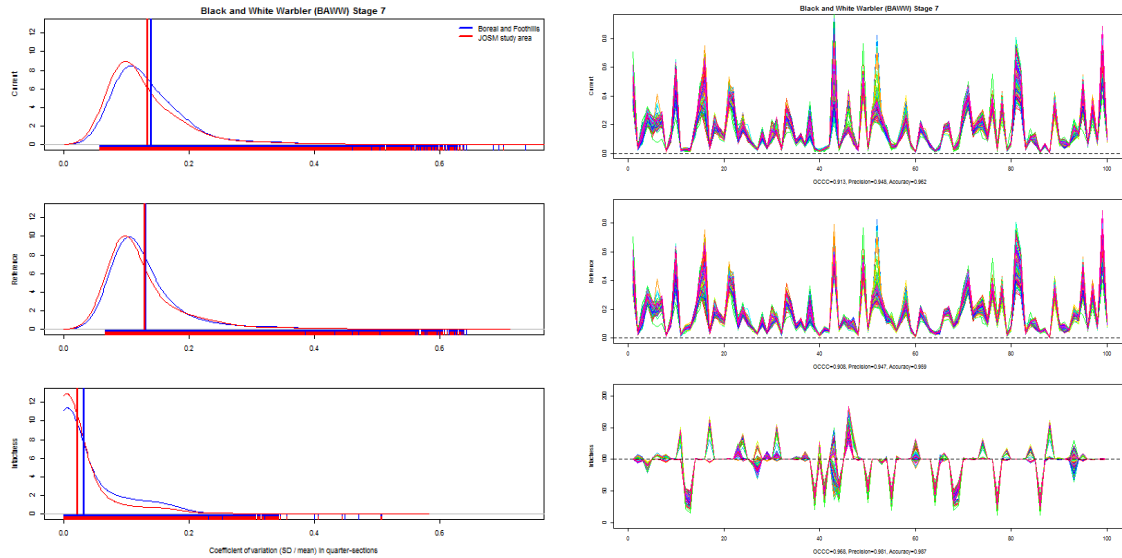
Estimated potential population size of Black and White Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.5207	0.4625	0.6062	0.6283	0.5517	0.7315
Wet	0.3075	0.2731	0.3580	0.3125	0.2744	0.3638
DecidC	0.1273	0.1131	0.1482	0.1440	0.1264	0.1676
WetConifC	0.1269	0.1127	0.1478	0.1316	0.1155	0.1531
WetConifD	0.1255	0.1115	0.1461	0.1300	0.1141	0.1513
Shrub	0.0923	0.0820	0.1074	0.1043	0.0916	0.1214
DecidB	0.0806	0.0716	0.0938	0.0940	0.0825	0.1094
ConifA	0.0862	0.0766	0.1004	0.0919	0.0807	0.1070
ConifC	0.0675	0.0600	0.0786	0.0733	0.0644	0.0854
ConifD	0.0594	0.0527	0.0691	0.0680	0.0597	0.0792
Grass	0.0382	0.0339	0.0444	0.0656	0.0576	0.0764
ConifB	0.0617	0.0548	0.0718	0.0654	0.0574	0.0761
MixedD	0.0541	0.0480	0.0629	0.0612	0.0537	0.0712
WetConifB	0.0458	0.0406	0.0533	0.0467	0.0410	0.0544
WetConifA	0.0408	0.0363	0.0475	0.0420	0.0368	0.0488
PineB	0.0381	0.0338	0.0443	0.0382	0.0336	0.0445
DecidA	0.0245	0.0218	0.0286	0.0332	0.0291	0.0386
PineC	0.0164	0.0146	0.0192	0.0172	0.0151	0.0200
PineA	0.0160	0.0142	0.0187	0.0162	0.0143	0.0189
PineD	0.0102	0.0091	0.0119	0.0107	0.0094	0.0125
MixedB	0.0087	0.0077	0.0101	0.0093	0.0082	0.0108
MixedA	0.0053	0.0047	0.0062	0.0067	0.0059	0.0078
MixedC	0.0048	0.0042	0.0056	0.0052	0.0045	0.0060
Cult	0.0345	0.0307	0.0402	0.0000	0.0000	0.0000
UrbInd	0.0079	0.0071	0.0092	0.0000	0.0000	0.0000
HardLin	0.0011	0.0010	0.0013	0.0000	0.0000	0.0000
SoftLin	0.0286	0.0254	0.0333	0.0000	0.0000	0.0000
HFor	0.0867	0.0770	0.1010	0.0000	0.0000	0.0000
Total	2.1172	1.8807	2.4651	2.1954	1.9277	2.5559
Loss	0.1006	0.0834	0.1204			
Gain	0.0220	0.0143	0.0588			

5.9.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.9.14 Variable selection frequencies

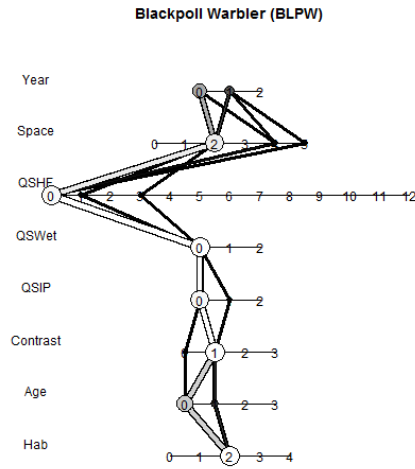
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.3	94.5	189	. + Habitat + isHForC
1.4	5.5	11	. + HabitatB + isHForC
2.1	89.5	179	. + Age
2.2	10.5	21	. + Age + Age2
3.1	100.0	200	. + ROAD
4.0	100.0	200	NULL
5.0	64.5	129	NULL
5.1	3.5	7	. + pWet_QS
5.2	32.0	64	. + pWetWater_QS
6.0	92.5	185	NULL
6.3	7.5	15	. + Succ_QS + Alien_QS
7.1	99.5	199	. + xlat
7.3	0.5	1	. + xlat + xlong + xlat:xlong
8.1	100.0	200	. + xYEAR

5.10 Blackpoll Warbler (*Setophaga striata*)

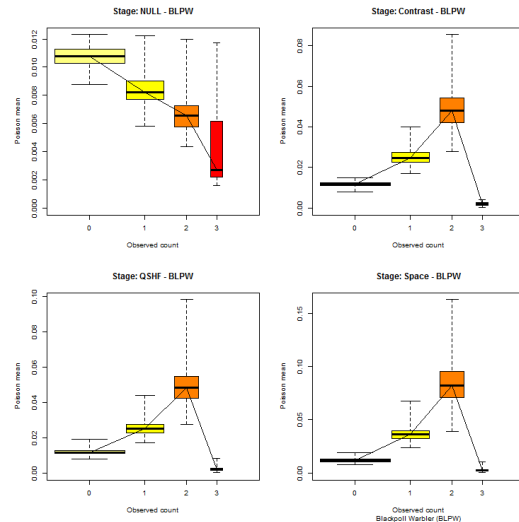
5.10.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

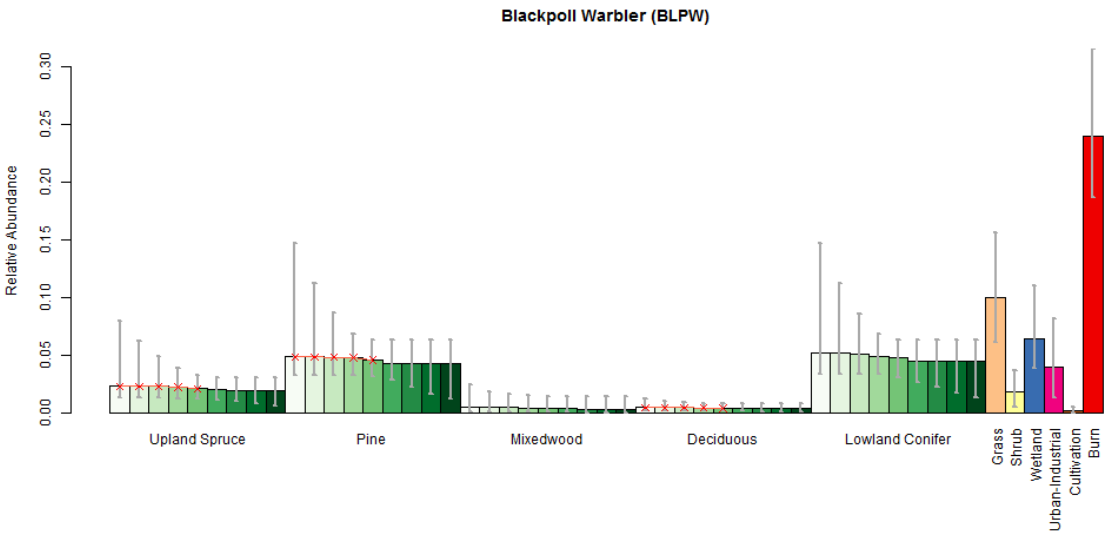


5.10.2 Cross validation

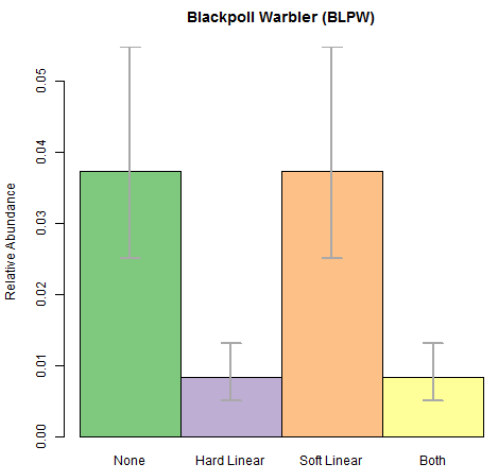
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.10.3 Point level habitat associations

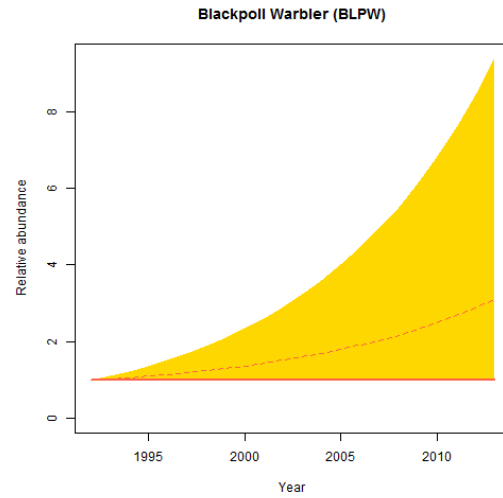


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

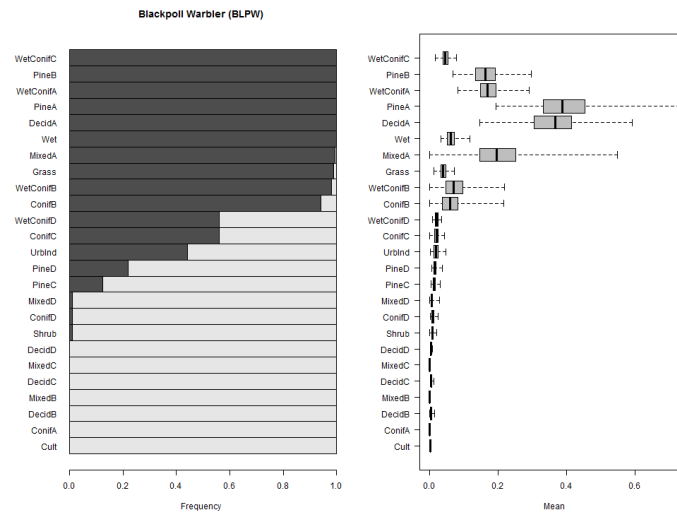


5.10.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



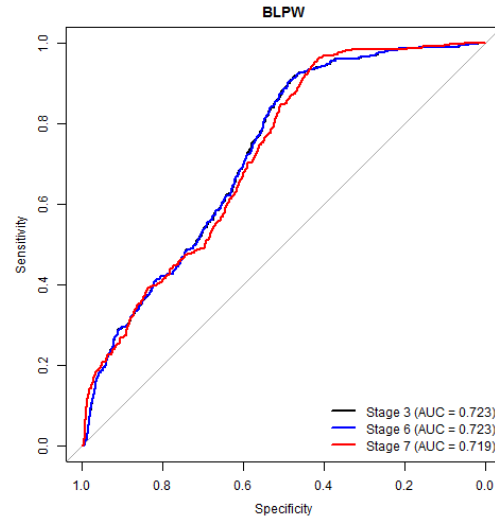
5.10.5 Habitat suitability ranking for patch delineation



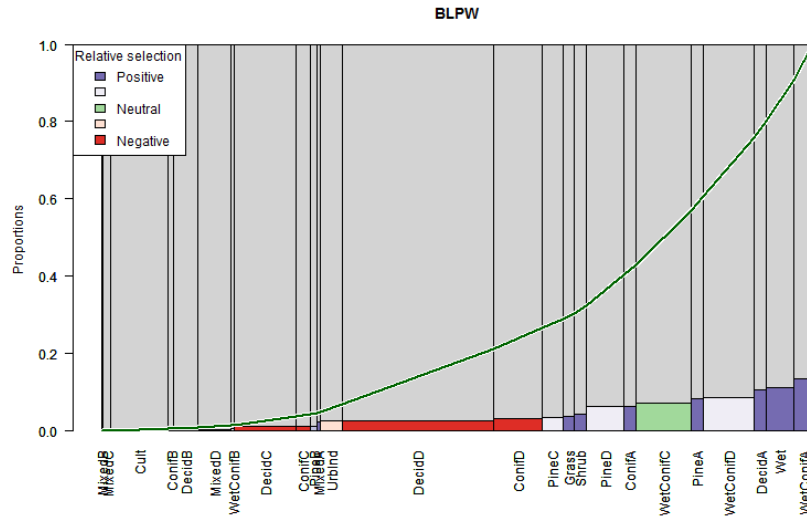
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.10.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

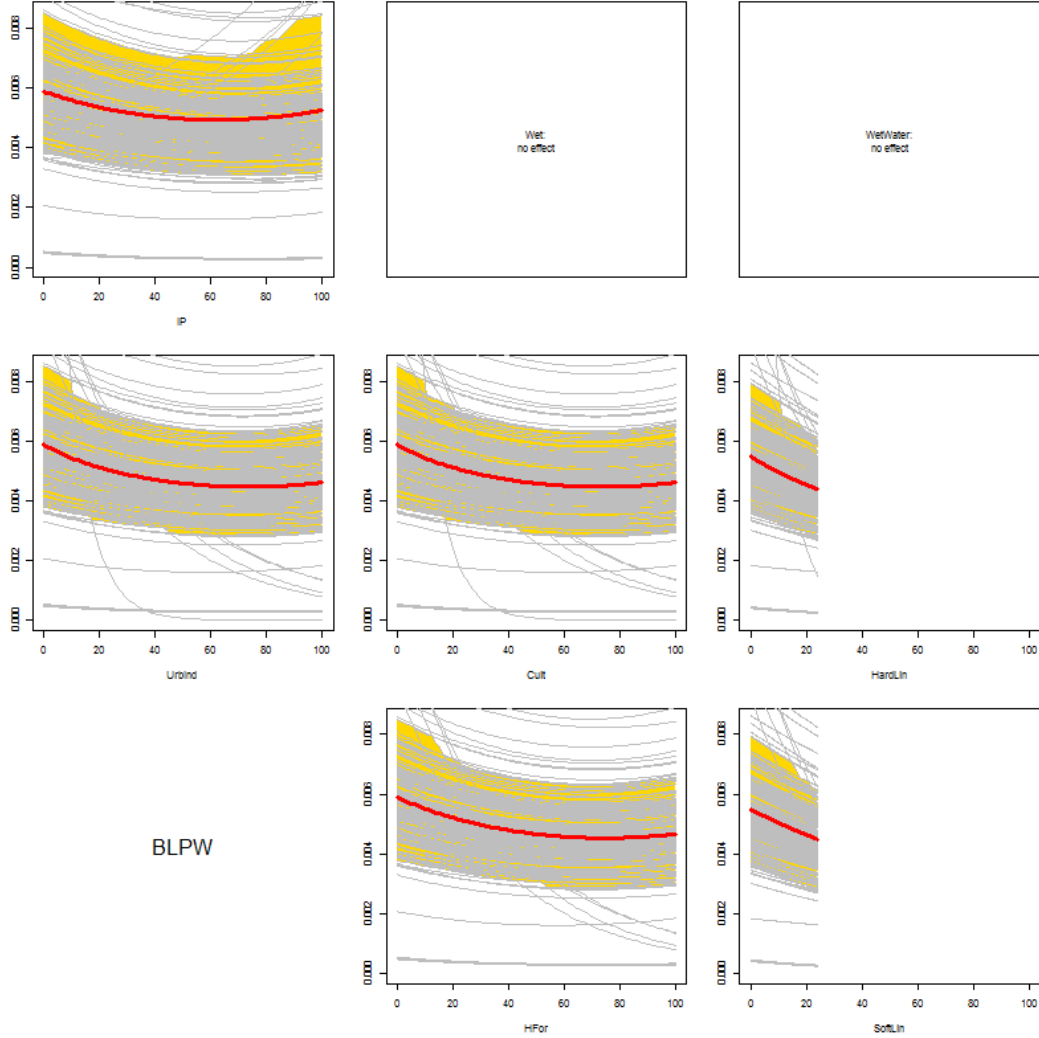


5.10.7 Relative habitat selection



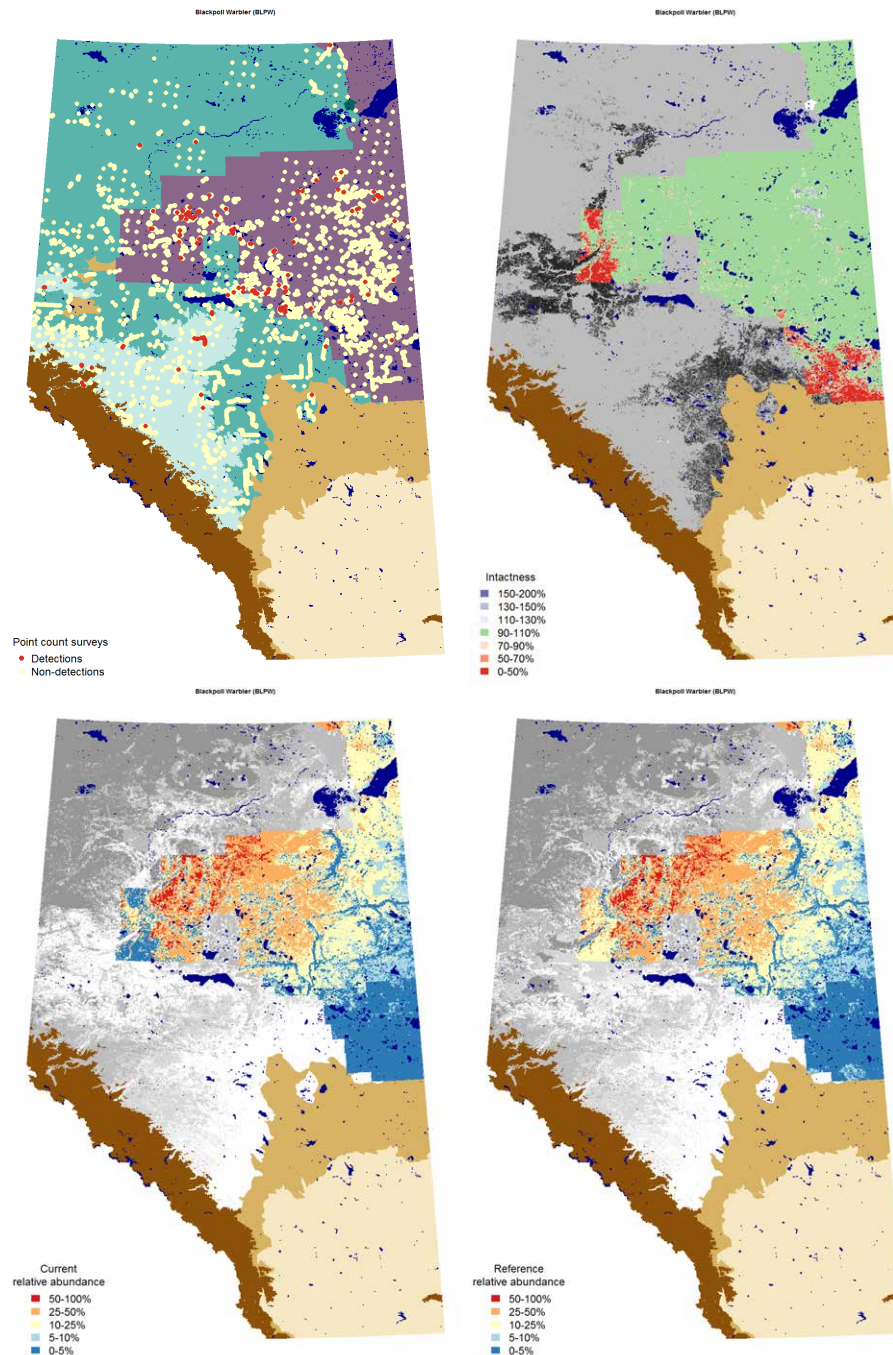
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.10.8 Quarter-section level responses



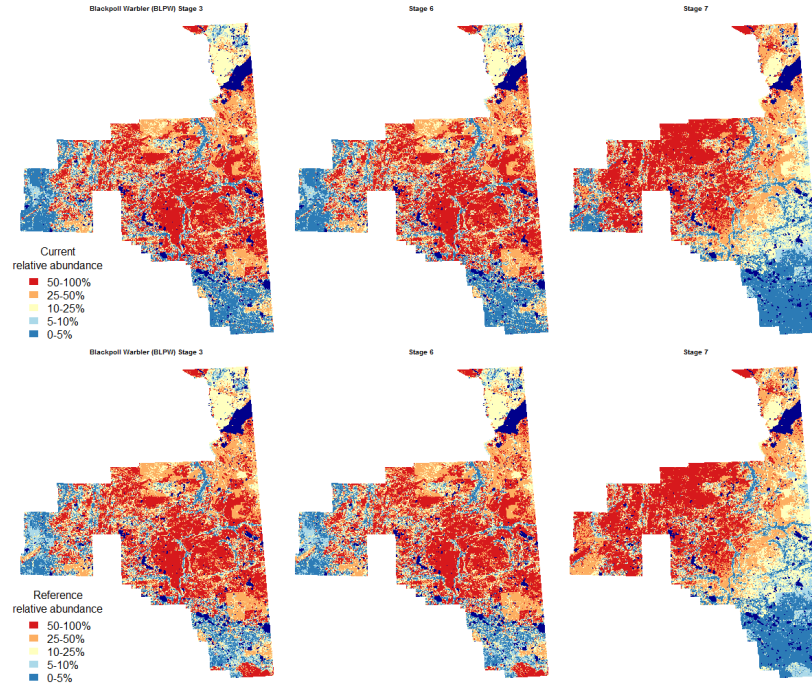
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.10.9 Maps



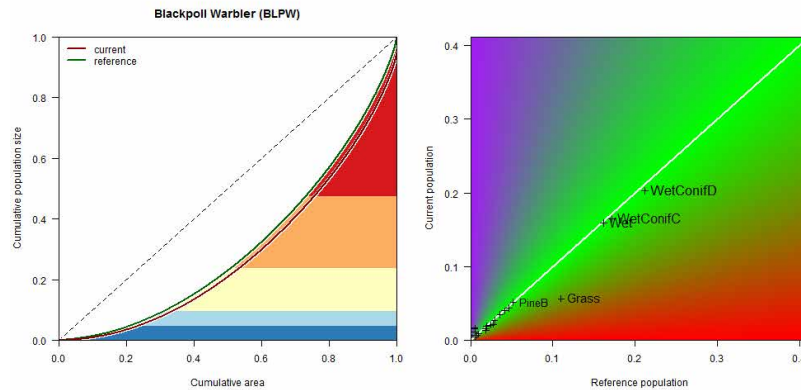
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.10.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.10.11 Population concentration



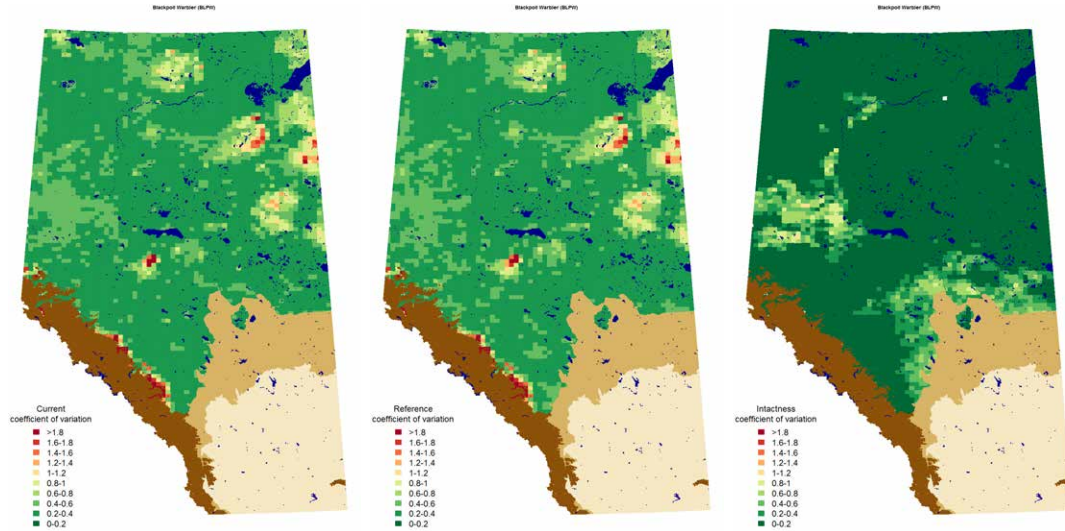
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.10.12 Potential population size

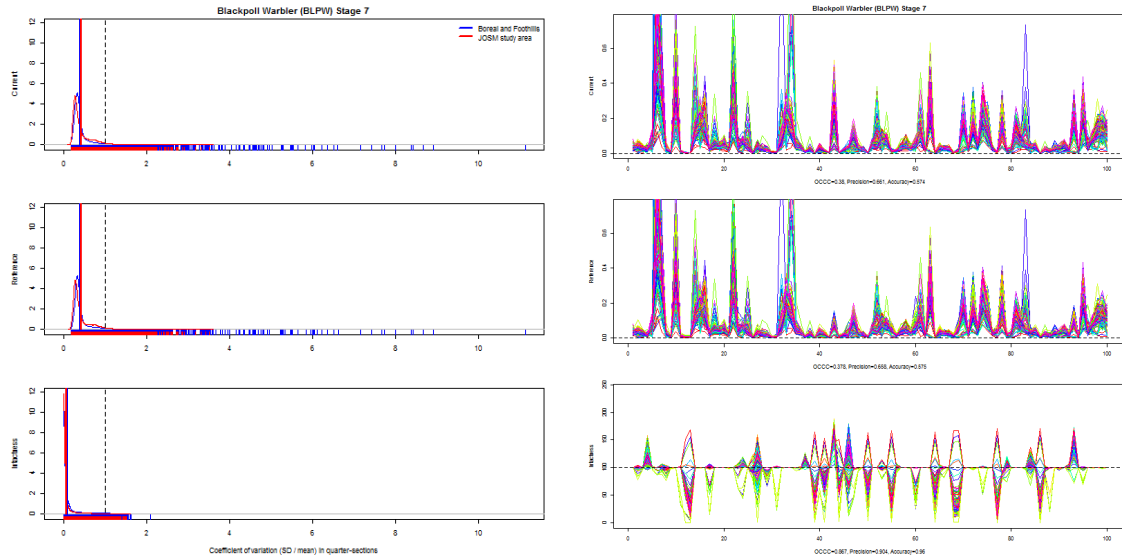
Estimated potential population size of Blackpoll Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.1155	0.0796	0.1825	0.1212	0.0833	0.2036
WetConifC	0.0938	0.0647	0.1483	0.0983	0.0676	0.1652
Wet	0.0904	0.0623	0.1429	0.0928	0.0638	0.1559
Grass	0.0321	0.0221	0.0507	0.0631	0.0434	0.1060
PineB	0.0292	0.0201	0.0462	0.0297	0.0204	0.0499
PineC	0.0247	0.0170	0.0390	0.0268	0.0184	0.0450
WetConifB	0.0227	0.0157	0.0359	0.0239	0.0165	0.0402
WetConifA	0.0198	0.0137	0.0313	0.0206	0.0142	0.0346
PineD	0.0152	0.0105	0.0240	0.0166	0.0115	0.0280
DecidD	0.0124	0.0085	0.0196	0.0159	0.0110	0.0268
ConifD	0.0118	0.0081	0.0187	0.0141	0.0097	0.0237
PineA	0.0109	0.0075	0.0172	0.0112	0.0077	0.0188
ConifC	0.0092	0.0063	0.0145	0.0105	0.0072	0.0177
Shrub	0.0079	0.0055	0.0125	0.0105	0.0072	0.0176
ConifA	0.0049	0.0034	0.0077	0.0056	0.0039	0.0094
ConifB	0.0037	0.0026	0.0059	0.0044	0.0030	0.0073
MixedD	0.0020	0.0014	0.0031	0.0023	0.0016	0.0038
DecidC	0.0018	0.0012	0.0028	0.0023	0.0016	0.0038
DecidB	0.0012	0.0009	0.0020	0.0016	0.0011	0.0027
DecidA	0.0003	0.0002	0.0005	0.0004	0.0003	0.0007
MixedB	0.0002	0.0001	0.0003	0.0002	0.0001	0.0003
MixedC	0.0001	0.0001	0.0002	0.0002	0.0001	0.0003
MixedA	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002
Cult	0.0038	0.0026	0.0060	0.0000	0.0000	0.0000
UrbInd	0.0091	0.0063	0.0143	0.0000	0.0000	0.0000
HardLin	0.0002	0.0001	0.0003	0.0000	0.0000	0.0000
SoftLin	0.0094	0.0065	0.0148	0.0000	0.0000	0.0000
HFor	0.0061	0.0042	0.0097	0.0000	0.0000	0.0000
Total	0.5384	0.3712	0.8510	0.5721	0.3935	0.9614
Loss	0.0328	0.0108	0.0577			
Gain	0.0037	0.0008	0.0113			

5.10.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.10.14 Variable selection frequencies

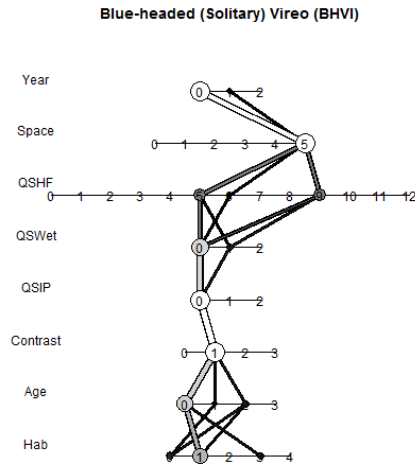
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	100.0	200	. + HabitatB
2.0	80.0	160	NULL
2.1	20.0	40	. + Age
3.0	0.5	1	NULL
3.1	99.5	199	. + ROAD
4.0	97.0	194	NULL
4.1	3.0	6	. + Remn_QS
5.0	100.0	200	NULL
6.0	97.5	195	NULL
6.1	2.0	4	. + THF_QS
6.3	0.5	1	. + Succ_QS + Alien_QS
7.2	93.0	186	. + xlat + xlong
7.4	6.0	12	. + xMAP + xPET + xMAT + xCMD
7.5	1.0	2	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	66.0	132	NULL
8.1	34.0	68	. + xYEAR

5.11 Blue-headed (Solitary) Vireo (*Vireo solitarius*)

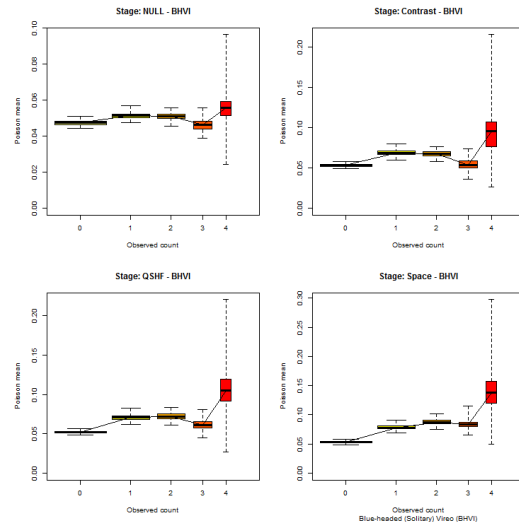
5.11.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

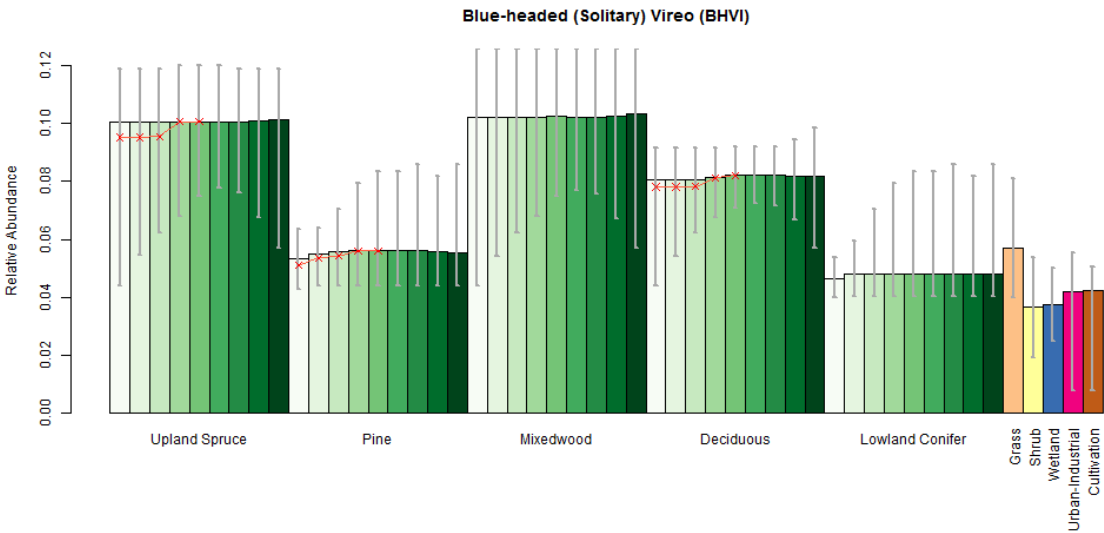


5.11.2 Cross validation

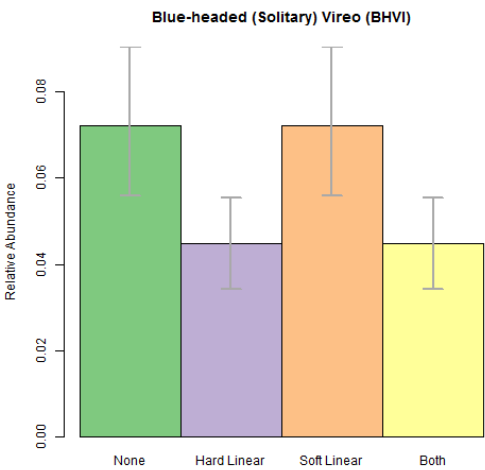
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.11.3 Point level habitat associations

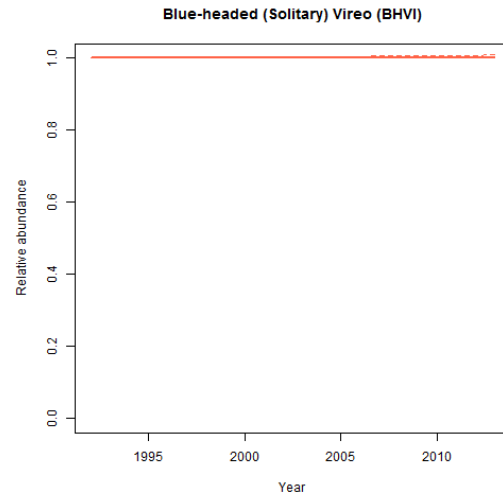


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

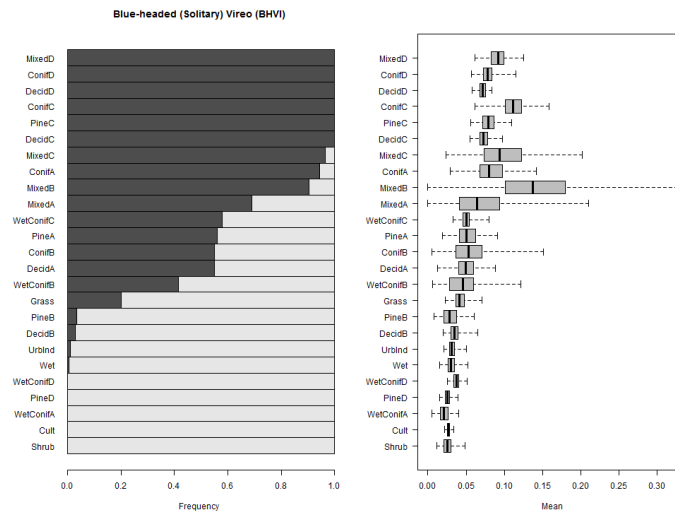


5.11.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



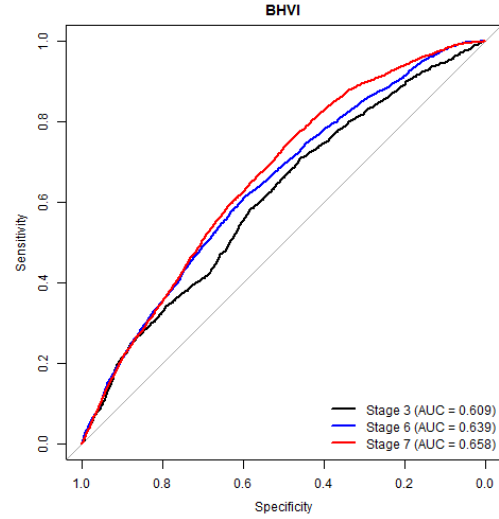
5.11.5 Habitat suitability ranking for patch delineation



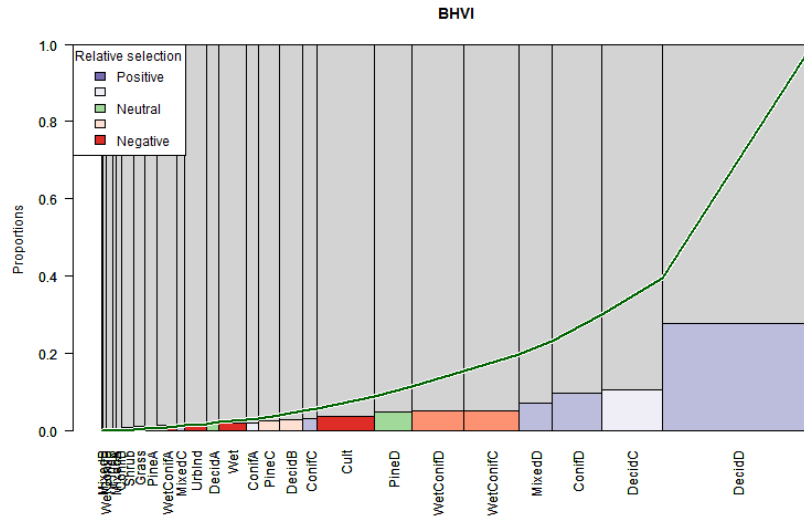
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.11.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

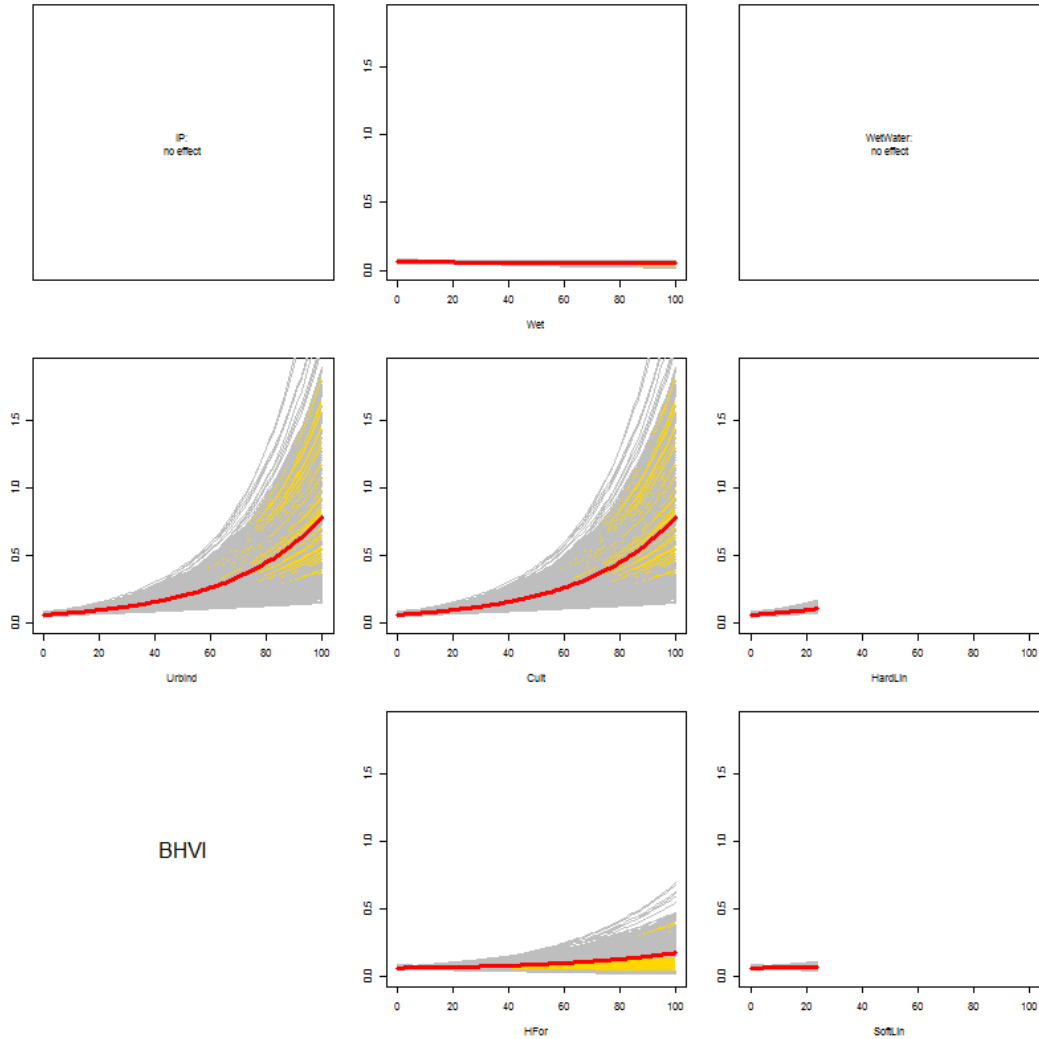


5.11.7 Relative habitat selection



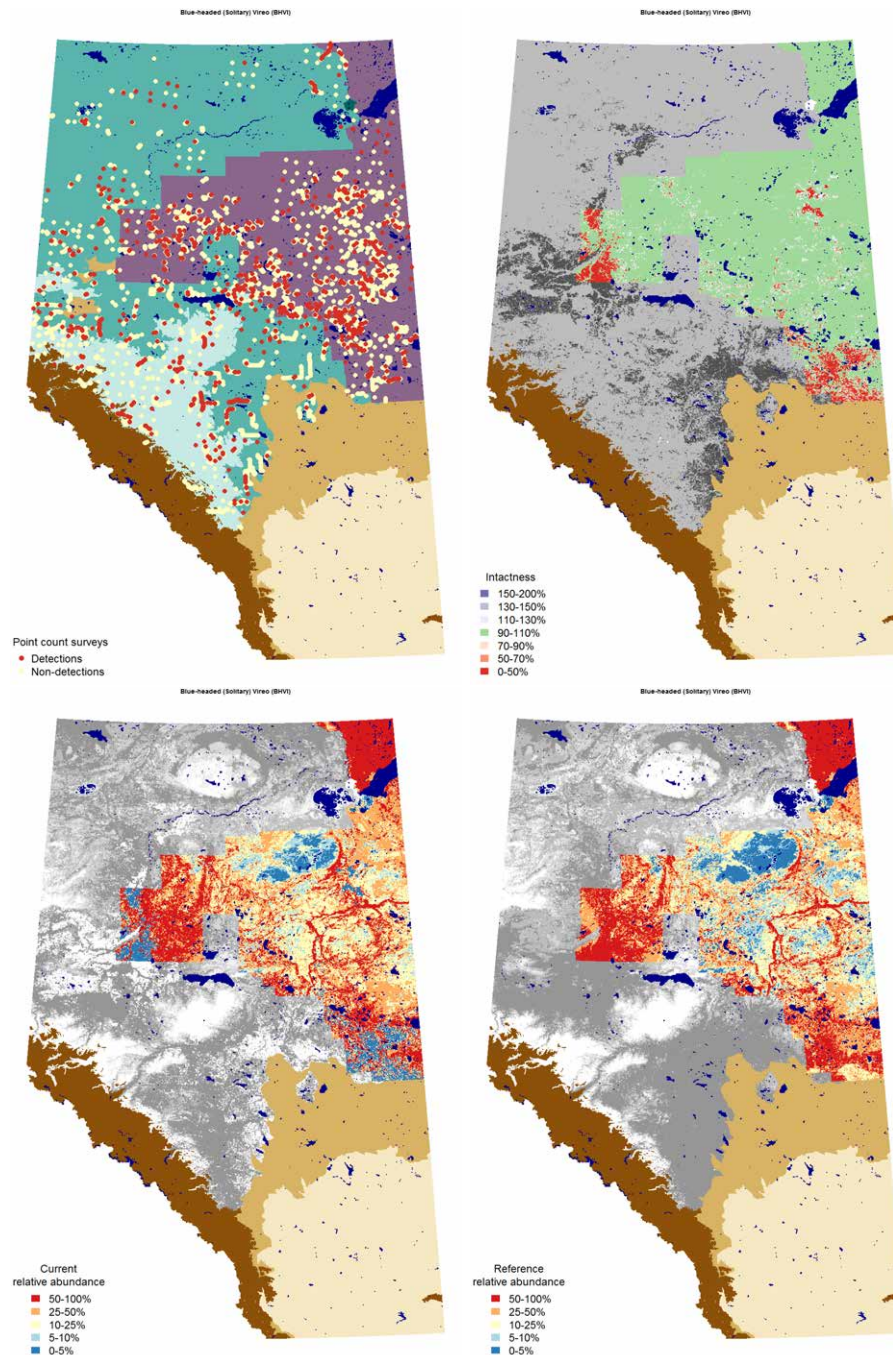
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.11.8 Quarter-section level responses



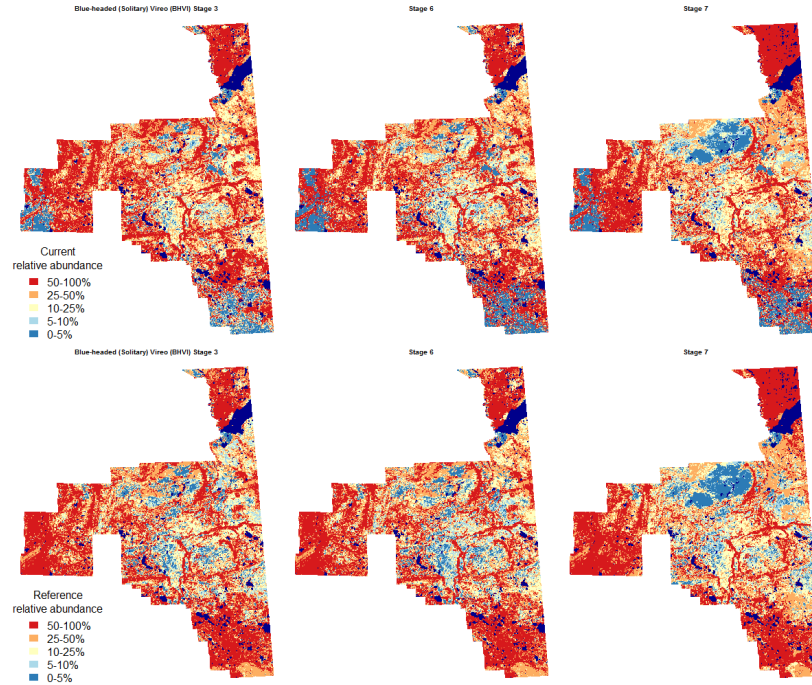
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.11.9 Maps



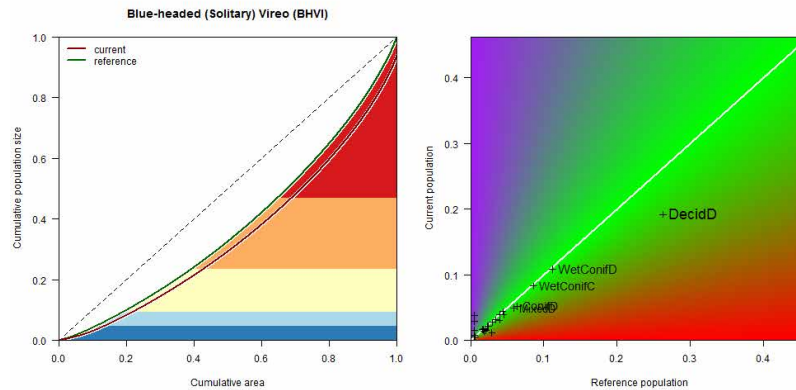
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase (>100%) and decrease (<100%). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.11.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.11.11 Population concentration



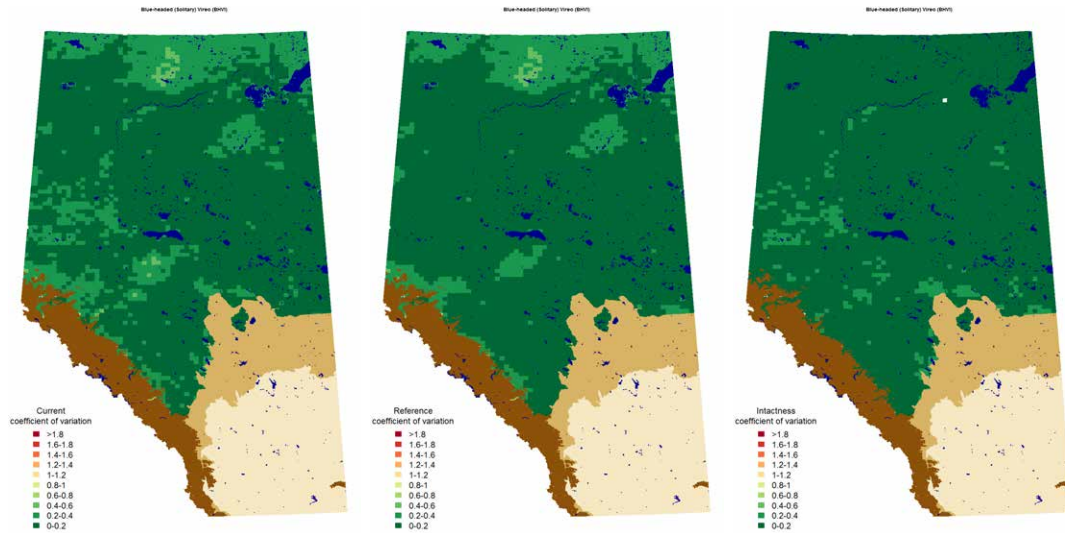
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.11.12 Potential population size

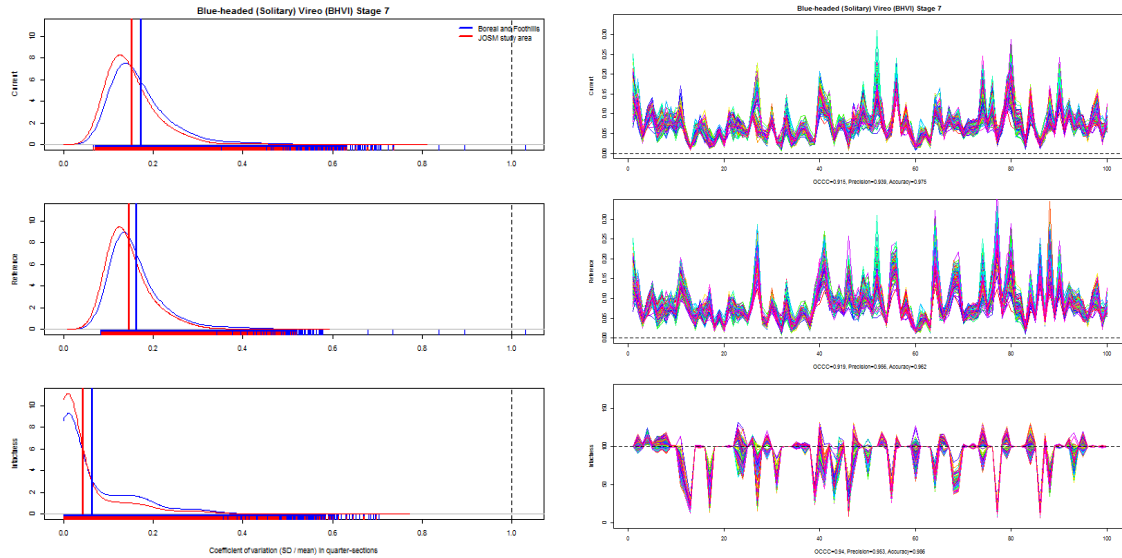
Estimated potential population size of Blue-headed (Solitary) Vireo in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.2096	0.1882	0.2380	0.2866	0.2511	0.3305
WetConifD	0.1184	0.1064	0.1345	0.1225	0.1073	0.1412
WetConifC	0.0902	0.0810	0.1025	0.0938	0.0822	0.1081
ConifD	0.0567	0.0510	0.0645	0.0691	0.0606	0.0797
MixedD	0.0533	0.0479	0.0605	0.0641	0.0561	0.0739
ConifC	0.0429	0.0385	0.0487	0.0491	0.0430	0.0566
PineB	0.0476	0.0427	0.0540	0.0479	0.0420	0.0552
Wet	0.0431	0.0387	0.0489	0.0436	0.0382	0.0502
DecidC	0.0336	0.0302	0.0382	0.0431	0.0377	0.0497
ConifA	0.0340	0.0305	0.0386	0.0370	0.0325	0.0427
PineC	0.0297	0.0267	0.0337	0.0324	0.0284	0.0373
Grass	0.0124	0.0111	0.0141	0.0319	0.0279	0.0368
ConifB	0.0237	0.0213	0.0270	0.0262	0.0230	0.0302
PineD	0.0234	0.0210	0.0266	0.0256	0.0224	0.0295
Shrub	0.0167	0.0150	0.0190	0.0233	0.0204	0.0268
DecidB	0.0155	0.0140	0.0176	0.0203	0.0178	0.0234
WetConifB	0.0188	0.0169	0.0213	0.0195	0.0171	0.0224
WetConifA	0.0181	0.0162	0.0205	0.0187	0.0164	0.0216
PineA	0.0176	0.0158	0.0200	0.0179	0.0157	0.0207
DecidA	0.0043	0.0039	0.0049	0.0068	0.0060	0.0079
MixedB	0.0040	0.0036	0.0045	0.0044	0.0039	0.0051
MixedA	0.0028	0.0025	0.0032	0.0037	0.0033	0.0043
MixedC	0.0029	0.0026	0.0033	0.0034	0.0029	0.0039
Cult	0.0415	0.0373	0.0471	0.0000	0.0000	0.0000
UrbInd	0.0090	0.0081	0.0102	0.0000	0.0000	0.0000
HardLin	0.0005	0.0005	0.0006	0.0000	0.0000	0.0000
SoftLin	0.0163	0.0146	0.0185	0.0000	0.0000	0.0000
HFor	0.0320	0.0287	0.0363	0.0000	0.0000	0.0000
Total	1.0185	0.9149	1.1568	1.0908	0.9556	1.2577
Loss	0.0894	0.0604	0.1296			
Gain	0.0211	0.0080	0.0522			

5.11.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.11.14 Variable selection frequencies

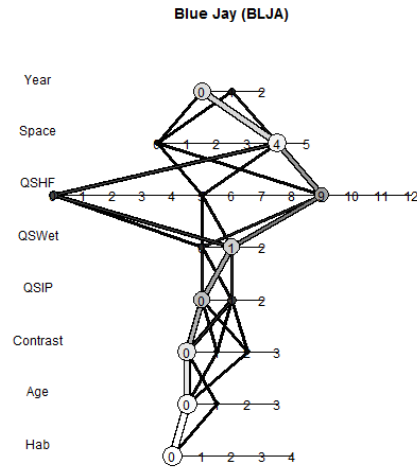
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	17.5	35	NULL
1.1	70.0	140	. + Habitat
1.3	12.5	25	. + Habitat + isHForC
2.0	82.0	164	NULL
2.1	5.5	11	. + Age
2.2	12.5	25	. + Age + Age2
3.1	100.0	200	. + ROAD
4.0	100.0	200	NULL
5.0	84.5	169	NULL
5.1	15.5	31	. + pWet_QS
6.5	49.0	98	. + THF_QS + THF2_QS
6.6	1.5	3	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.9	49.5	99	. + Succ_QS + Alien_QS + Alien2_QS
7.5	100.0	200	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	99.0	198	NULL
8.1	1.0	2	. + xYEAR

5.12 Blue Jay (*Cyanocitta cristata*)

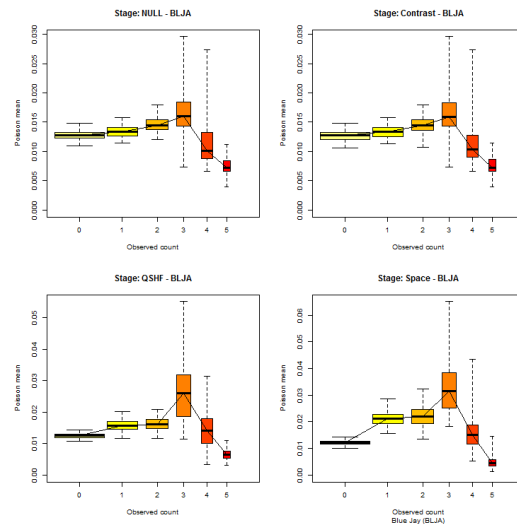
5.12.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

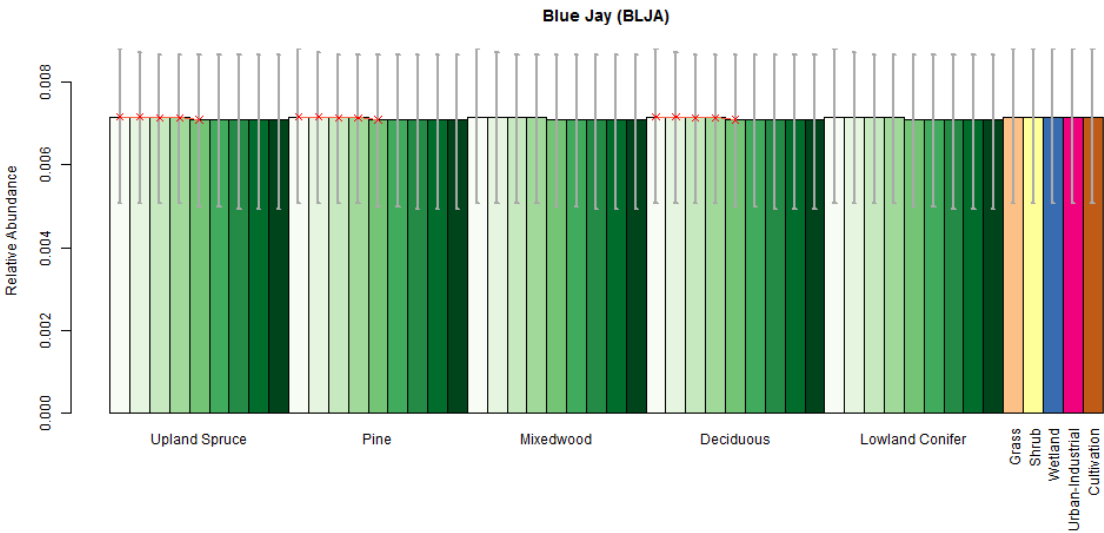


5.12.2 Cross validation

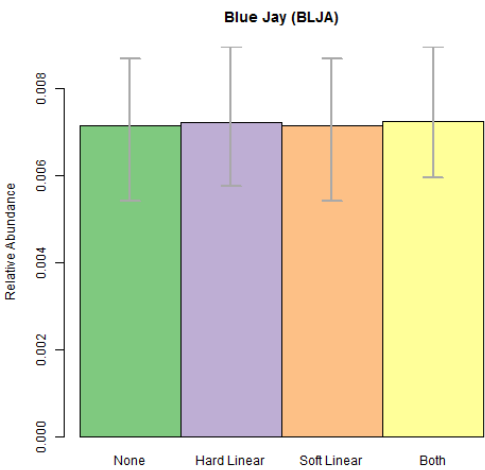
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.12.3 Point level habitat associations

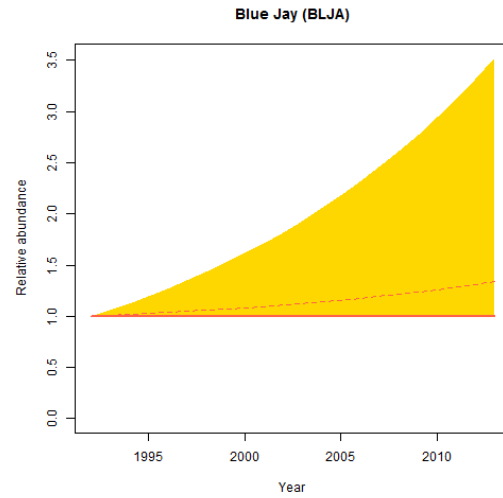


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

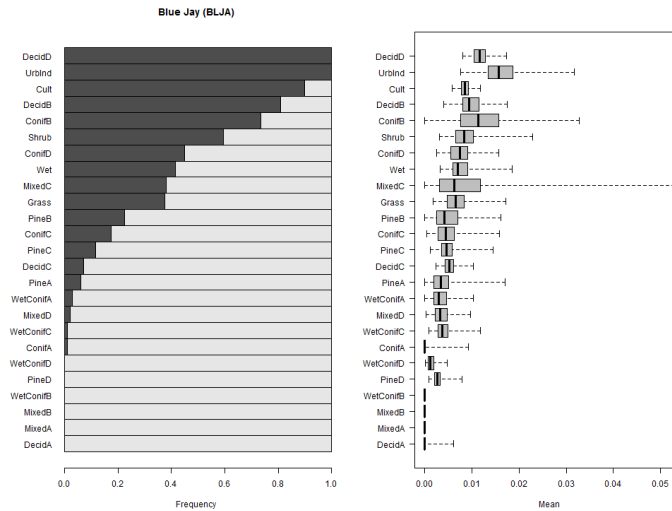


5.12.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



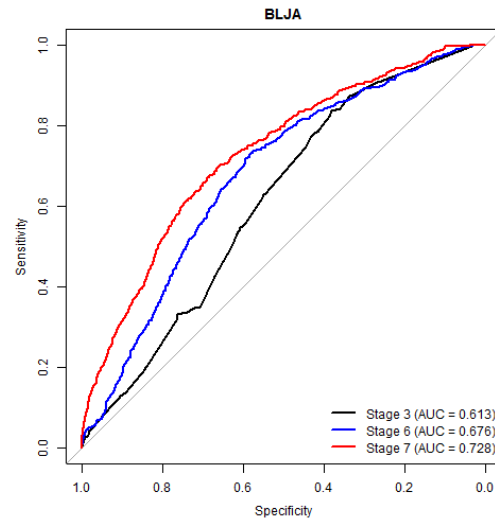
5.12.5 Habitat suitability ranking for patch delineation



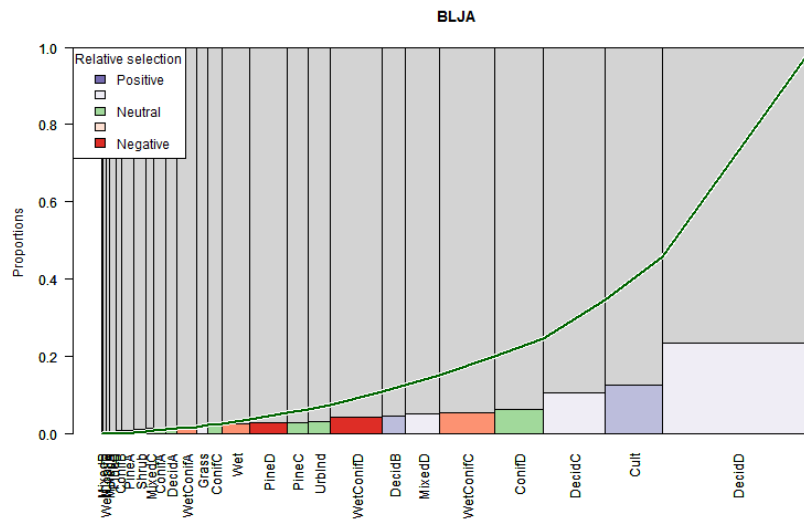
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.12.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

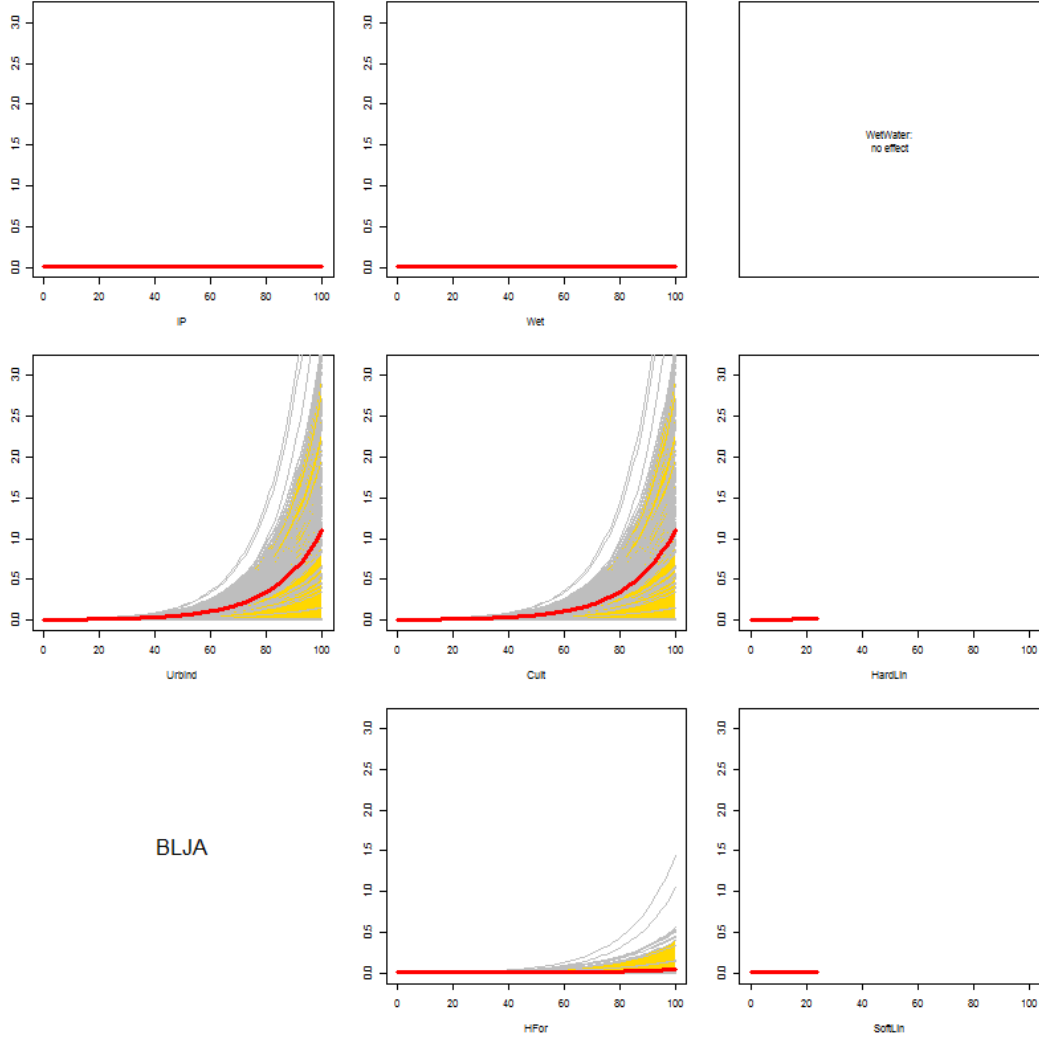


5.12.7 Relative habitat selection



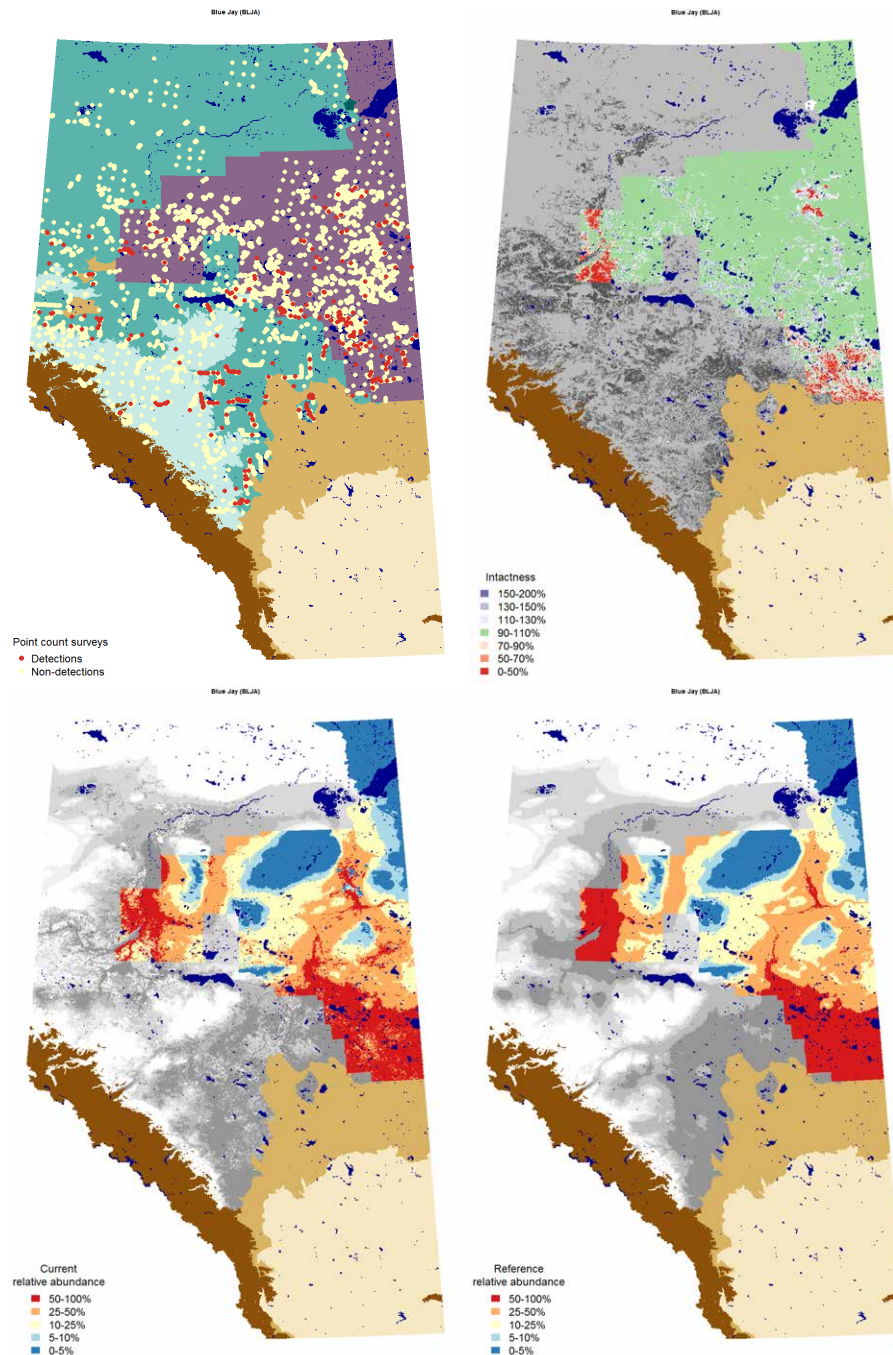
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.12.8 Quarter-section level responses



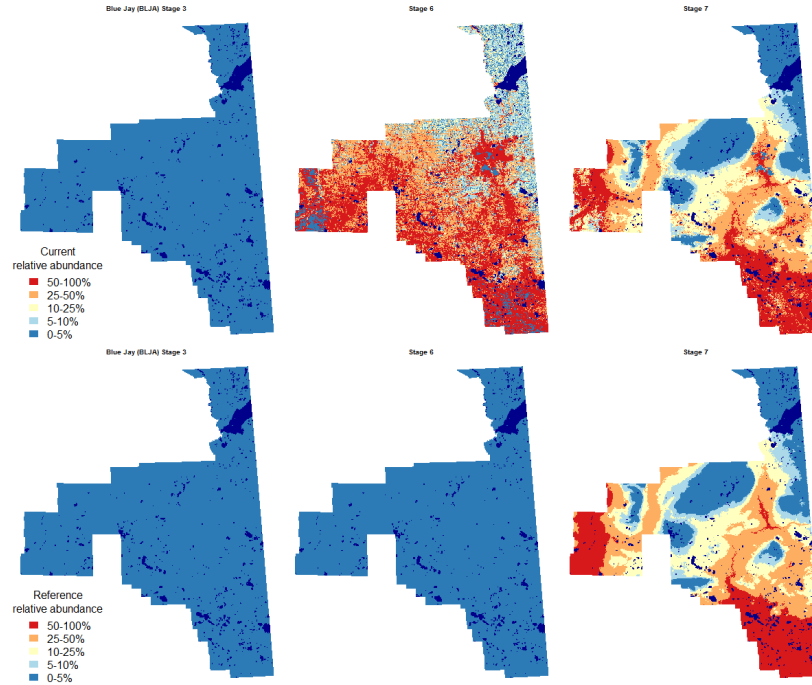
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.12.9 Maps



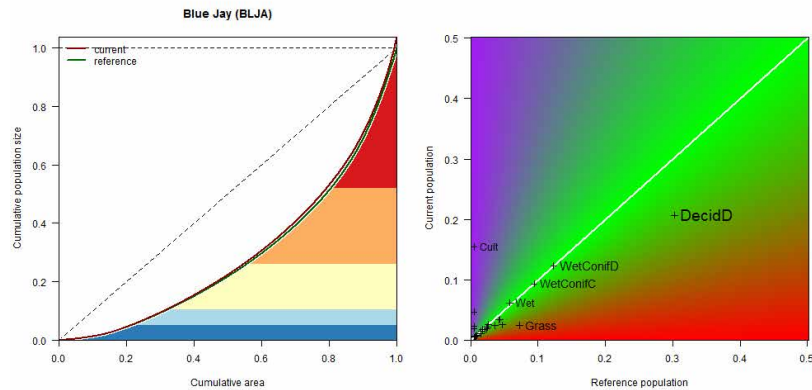
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.12.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.12.11 Population concentration



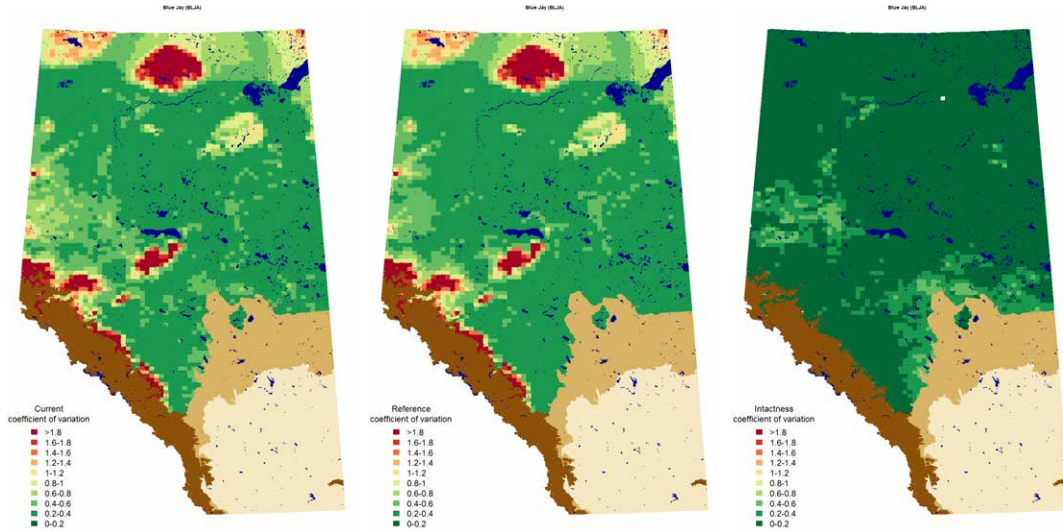
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.12.12 Potential population size

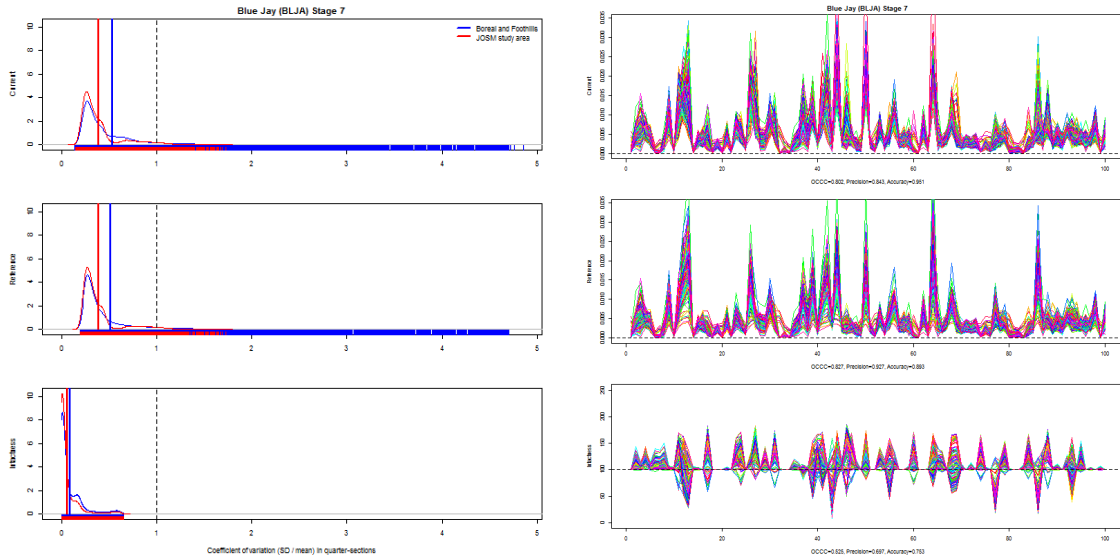
Estimated potential population size of Blue Jay in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0150	0.0118	0.0193	0.0217	0.0148	0.0288
WetConifD	0.0089	0.0070	0.0114	0.0089	0.0061	0.0118
WetConifC	0.0068	0.0053	0.0087	0.0068	0.0046	0.0090
Grass	0.0018	0.0014	0.0023	0.0052	0.0036	0.0069
Wet	0.0045	0.0035	0.0058	0.0042	0.0028	0.0055
Shrub	0.0019	0.0015	0.0024	0.0034	0.0023	0.0045
MixedD	0.0025	0.0020	0.0032	0.0031	0.0021	0.0042
ConifD	0.0024	0.0019	0.0031	0.0030	0.0021	0.0040
DecidC	0.0018	0.0014	0.0023	0.0026	0.0018	0.0034
PineB	0.0019	0.0015	0.0024	0.0019	0.0013	0.0025
PineC	0.0016	0.0012	0.0020	0.0018	0.0012	0.0024
ConifC	0.0014	0.0011	0.0018	0.0017	0.0012	0.0023
PineD	0.0013	0.0010	0.0017	0.0015	0.0010	0.0020
WetConifA	0.0013	0.0010	0.0016	0.0013	0.0009	0.0017
WetConifB	0.0011	0.0009	0.0014	0.0011	0.0008	0.0015
DecidB	0.0008	0.0006	0.0010	0.0011	0.0008	0.0015
ConifA	0.0006	0.0005	0.0008	0.0007	0.0005	0.0009
ConifB	0.0005	0.0004	0.0006	0.0006	0.0004	0.0007
PineA	0.0005	0.0004	0.0006	0.0005	0.0003	0.0007
DecidA	0.0002	0.0001	0.0002	0.0004	0.0003	0.0005
MixedA	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
MixedC	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
MixedB	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cult	0.0112	0.0088	0.0144	0.0000	0.0000	0.0000
UrbInd	0.0014	0.0011	0.0018	0.0000	0.0000	0.0000
HardLin	0.0003	0.0002	0.0003	0.0000	0.0000	0.0000
SoftLin	0.0017	0.0013	0.0021	0.0000	0.0000	0.0000
HFor	0.0034	0.0027	0.0044	0.0000	0.0000	0.0000
Total	0.0748	0.0588	0.0960	0.0718	0.0491	0.0953
Loss	0.0032	0.0001	0.0110			
Gain	0.0077	0.0006	0.0162			

5.12.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.12.14 Variable selection frequencies

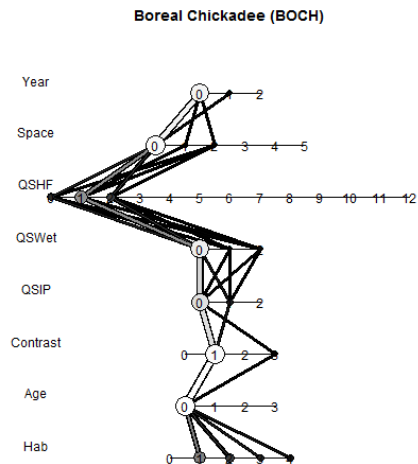
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	200	NULL
2.0	98.0	196	NULL
2.1	2.0	4	. + Age
3.0	91.0	182	NULL
3.1	5.0	10	. + ROAD
3.2	4.0	8	. + SoftLin_PC
4.0	76.0	152	NULL
4.1	24.0	48	. + Remn_QS
5.0	18.5	37	NULL
5.1	81.5	163	. + pWet_QS
6.0	29.5	59	NULL
6.5	7.0	14	. + THF_QS + THF2_QS
6.9	63.5	127	. + Succ_QS + Alien_QS + Alien2_QS
7.0	4.5	9	NULL
7.4	95.5	191	. + xMAP + xPET + xMAT + xCMD
8.0	87.0	174	NULL
8.1	13.0	26	. + xYEAR

5.13 Boreal Chickadee (*Poecile hudsonicus*)

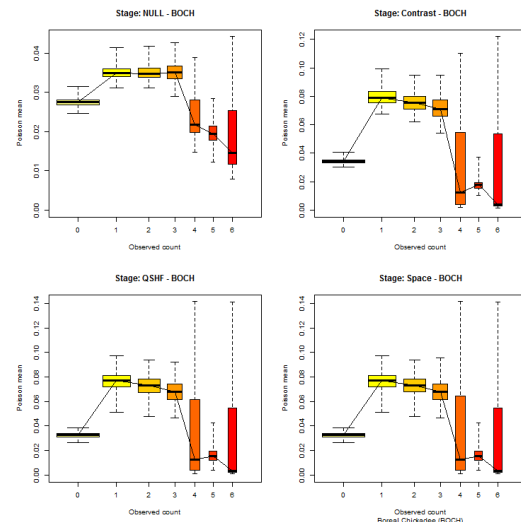
5.13.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

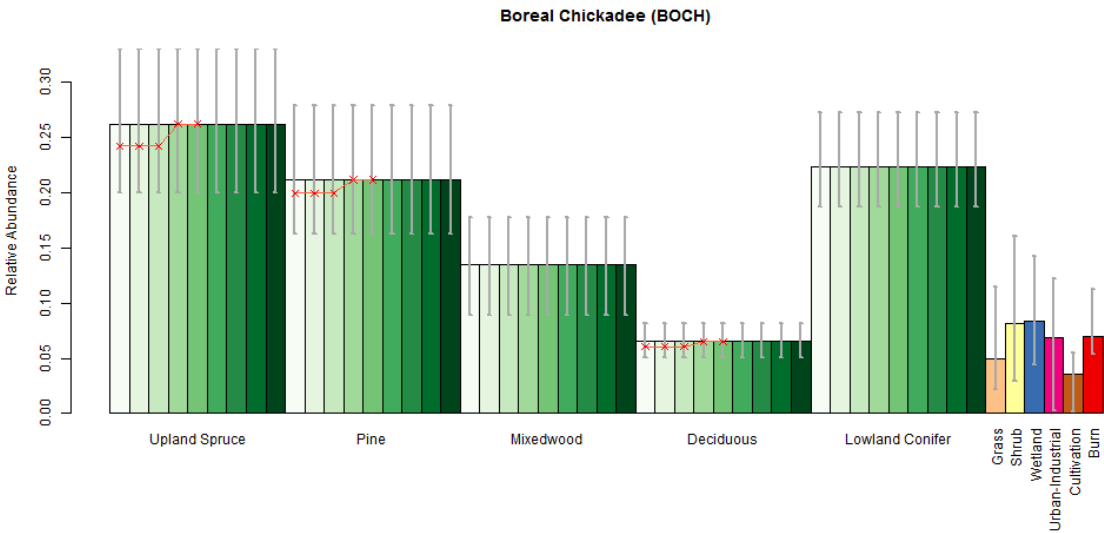


5.13.2 Cross validation

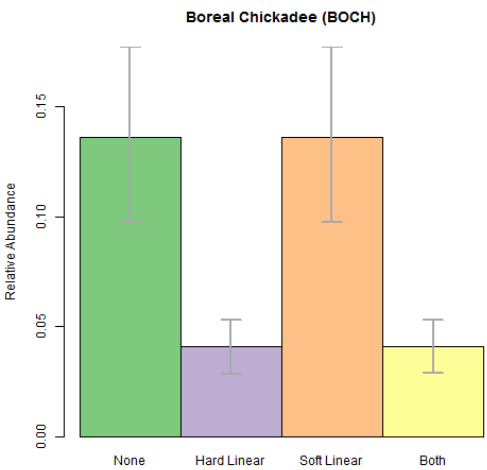
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.13.3 Point level habitat associations

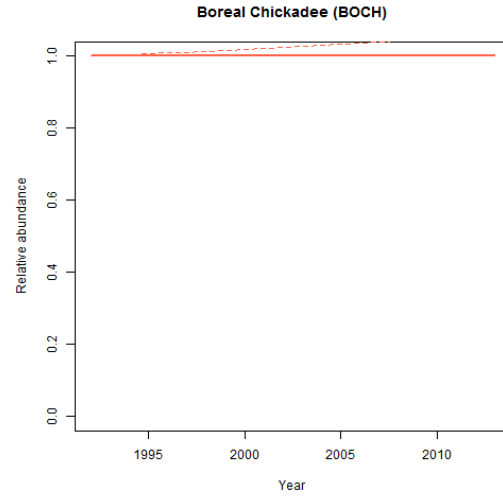


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

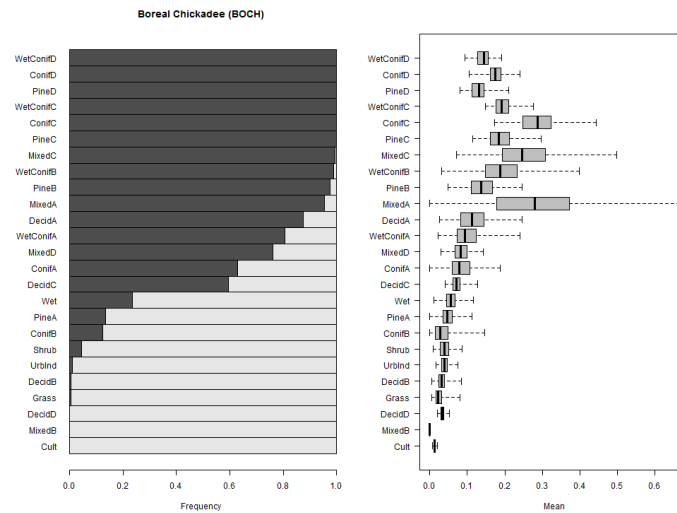


5.13.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



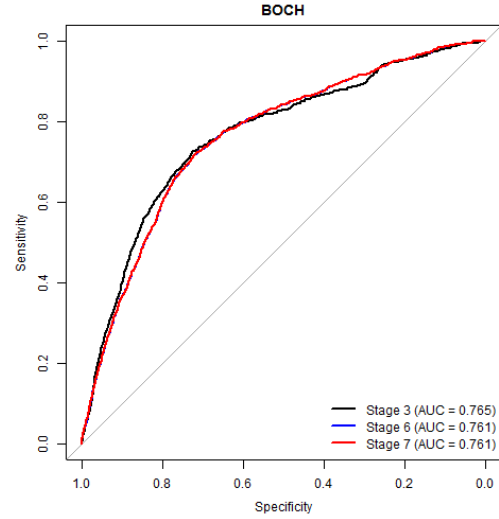
5.13.5 Habitat suitability ranking for patch delineation



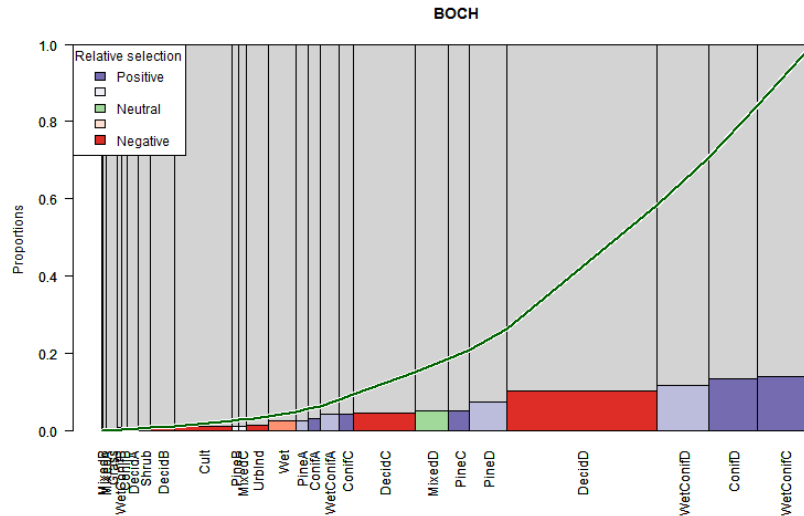
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.13.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

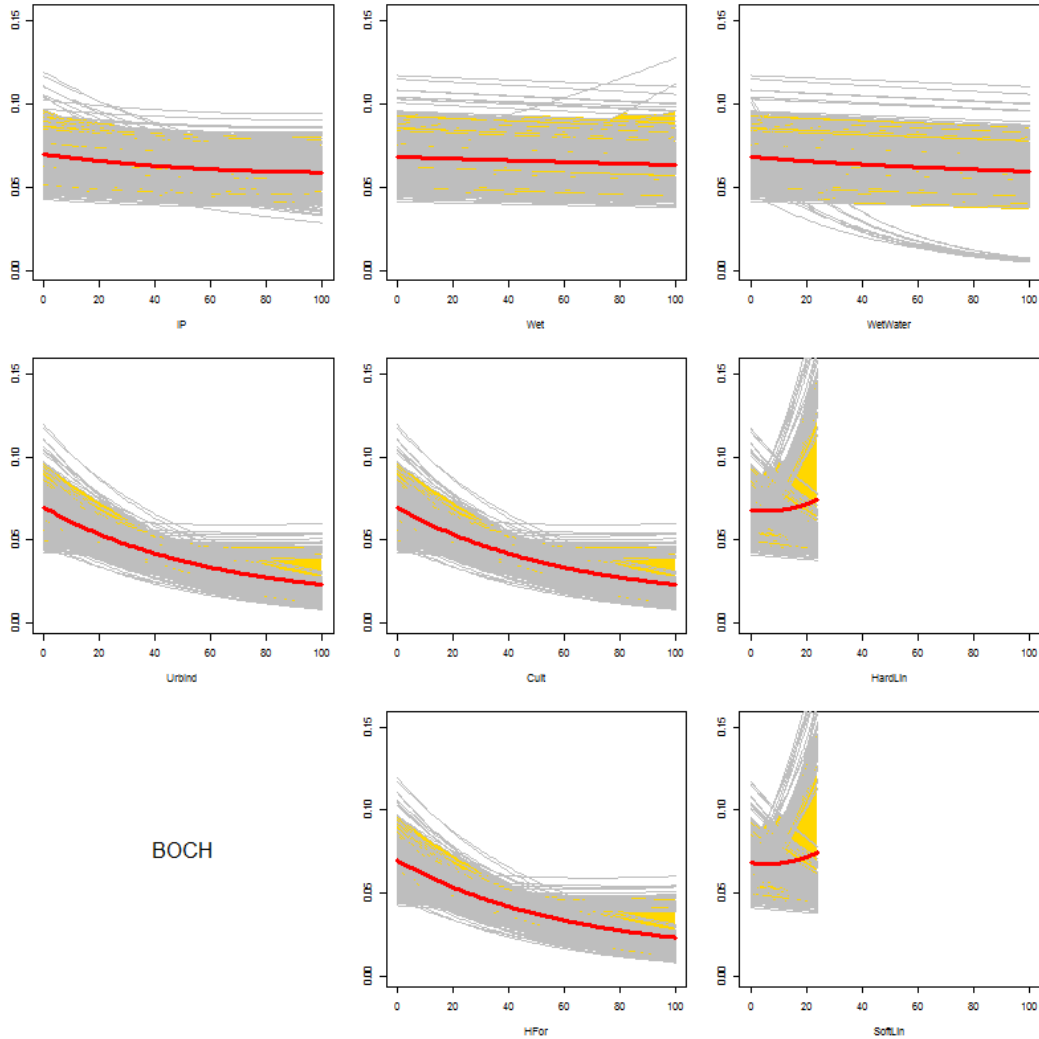


5.13.7 Relative habitat selection



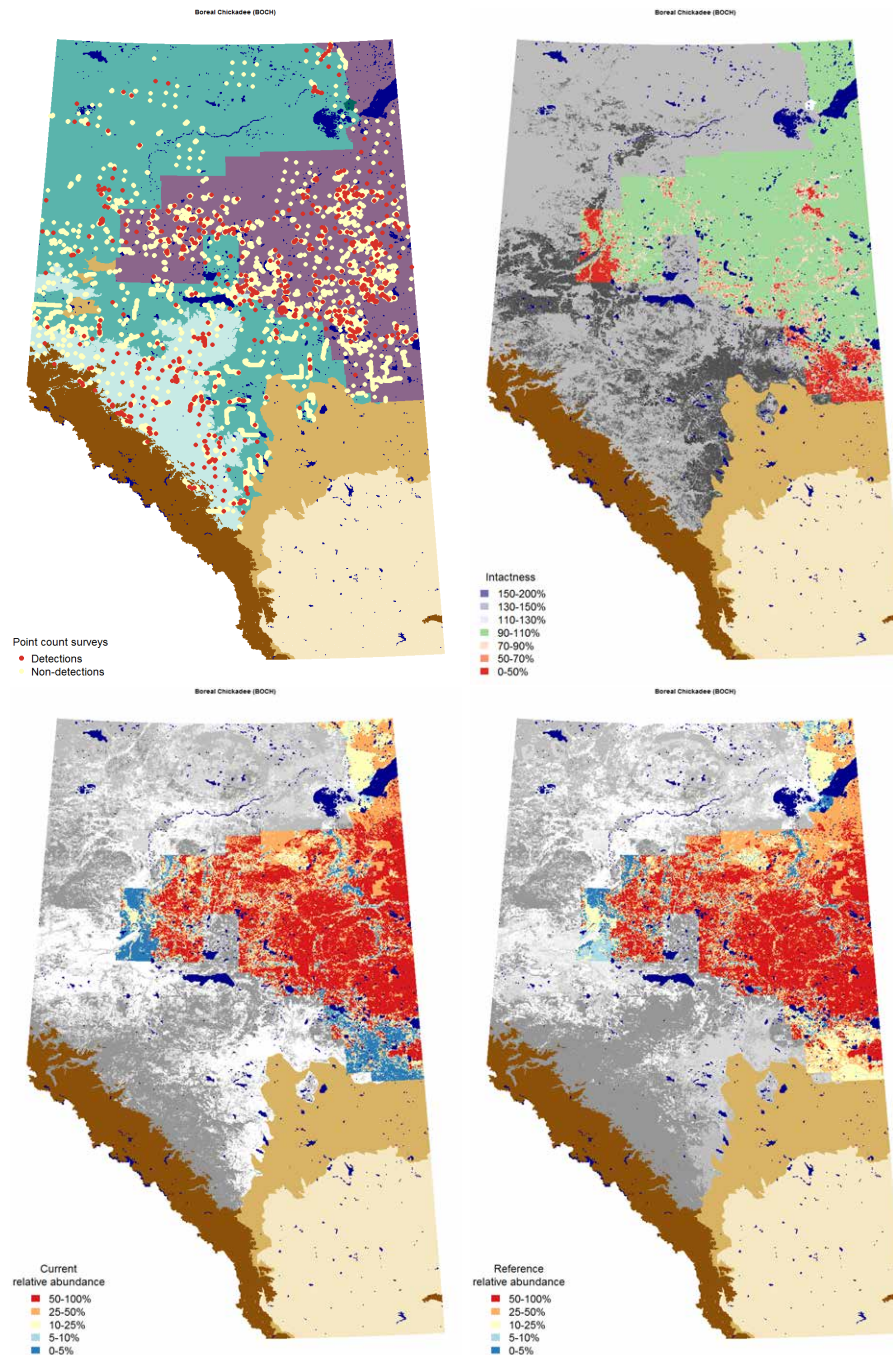
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.13.8 Quarter-section level responses



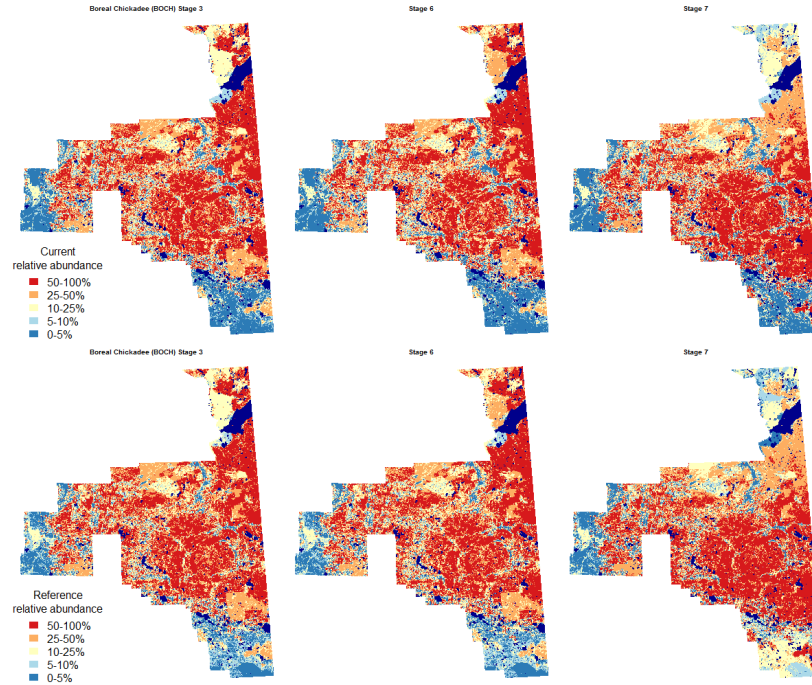
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.13.9 Maps



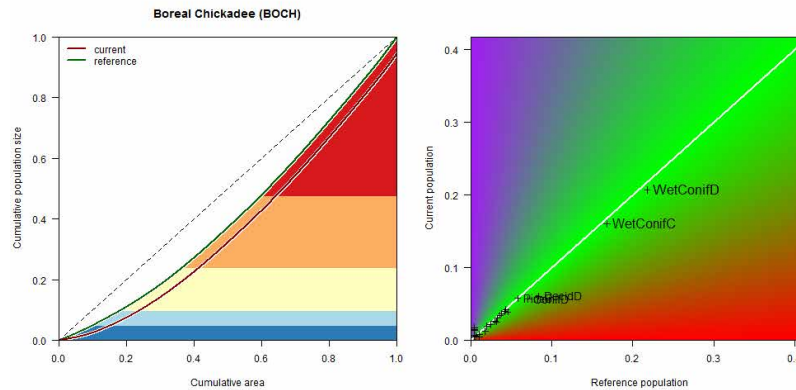
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.13.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.13.11 Population concentration



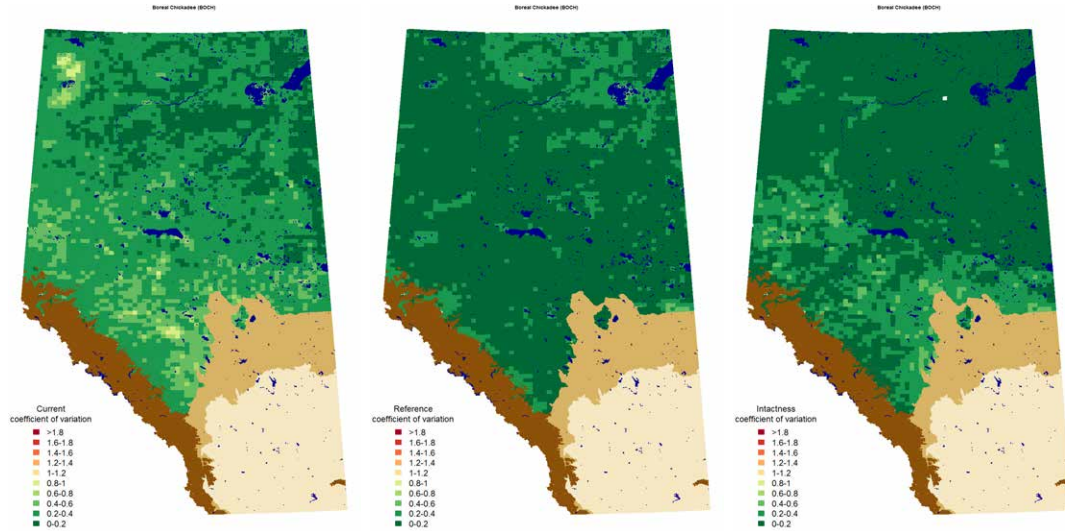
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.13.12 Potential population size

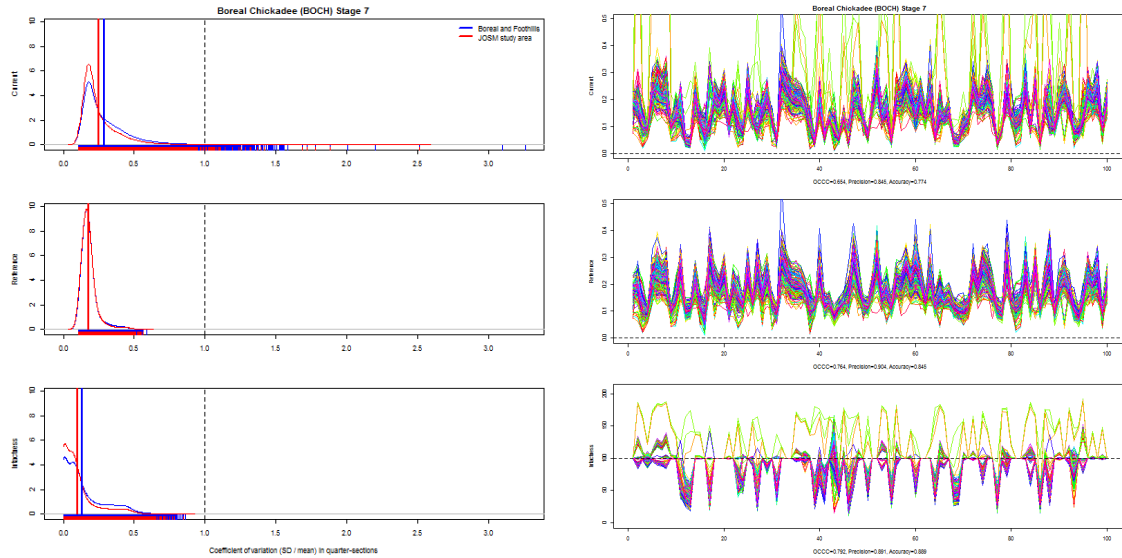
Estimated potential population size of Boreal Chickadee in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.5632	0.4771	0.7130	0.5950	0.4818	0.7403
WetConifC	0.4360	0.3693	0.5520	0.4603	0.3728	0.5728
DecidD	0.1655	0.1402	0.2095	0.2293	0.1856	0.2853
ConifD	0.1533	0.1299	0.1941	0.1934	0.1566	0.2406
PineB	0.1566	0.1327	0.1983	0.1588	0.1286	0.1976
ConifC	0.1066	0.0903	0.1349	0.1252	0.1014	0.1558
Wet	0.1147	0.0972	0.1452	0.1193	0.0966	0.1485
PineC	0.1068	0.0905	0.1353	0.1166	0.0944	0.1451
WetConifB	0.1006	0.0852	0.1274	0.1045	0.0846	0.1300
WetConifA	0.0944	0.0800	0.1195	0.0996	0.0806	0.1239
PineD	0.0822	0.0696	0.1040	0.0913	0.0739	0.1136
MixedD	0.0697	0.0590	0.0882	0.0867	0.0702	0.1079
ConifA	0.0708	0.0600	0.0897	0.0823	0.0666	0.1024
ConifB	0.0599	0.0507	0.0758	0.0671	0.0543	0.0835
PineA	0.0531	0.0450	0.0672	0.0551	0.0446	0.0686
Shrub	0.0348	0.0294	0.0440	0.0497	0.0402	0.0618
DecidC	0.0221	0.0187	0.0280	0.0303	0.0246	0.0377
Grass	0.0114	0.0097	0.0145	0.0298	0.0242	0.0371
DecidB	0.0148	0.0126	0.0188	0.0189	0.0153	0.0235
DecidA	0.0039	0.0033	0.0049	0.0063	0.0051	0.0078
MixedB	0.0050	0.0043	0.0064	0.0058	0.0047	0.0072
MixedA	0.0036	0.0030	0.0045	0.0052	0.0042	0.0065
MixedC	0.0031	0.0027	0.0040	0.0039	0.0031	0.0048
Cult	0.0394	0.0334	0.0499	0.0000	0.0000	0.0000
UrbInd	0.0177	0.0150	0.0224	0.0000	0.0000	0.0000
HardLin	0.0007	0.0006	0.0009	0.0000	0.0000	0.0000
SoftLin	0.0388	0.0328	0.0491	0.0000	0.0000	0.0000
HFor	0.0471	0.0399	0.0597	0.0000	0.0000	0.0000
Total	2.5758	2.1820	3.2612	2.7343	2.2140	3.4022
Loss	0.1977	0.0684	0.2978			
Gain	0.0011	0.0001	0.1413			

5.13.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.13.14 Variable selection frequencies

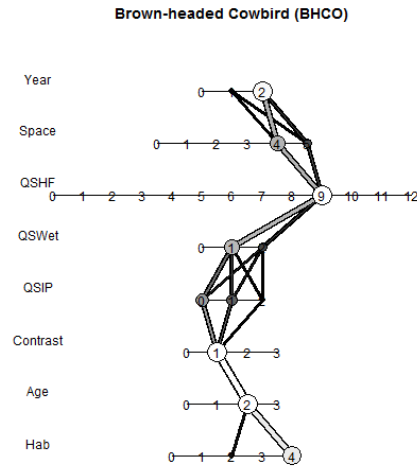
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	50.5	101	. + Habitat
1.2	25.0	50	. + HabitatB
1.3	15.5	31	. + Habitat + isHForC
1.4	9.0	18	. + HabitatB + isHForC
2.0	100.0	200	NULL
3.1	98.0	196	. + ROAD
3.3	2.0	4	. + ROAD + SoftLin_PC
4.0	87.5	175	NULL
4.1	12.5	25	. + Remn_QS
5.0	93.5	187	NULL
5.1	1.5	3	. + pWet_QS
5.2	5.0	10	. + pWetWater_QS
6.0	17.5	35	NULL
6.1	57.0	114	. + THF_QS
6.2	25.5	51	. + Lin_QS + Nonlin_QS
7.0	98.0	196	NULL
7.1	0.5	1	. + xlat
7.2	1.5	3	. + xlat + xlong
8.0	95.5	191	NULL
8.1	4.5	9	. + xYEAR

5.14 Brown-headed Cowbird (*Molothrus ater*)

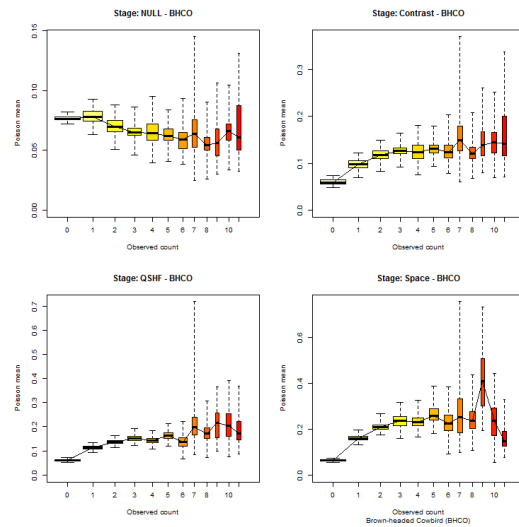
5.14.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

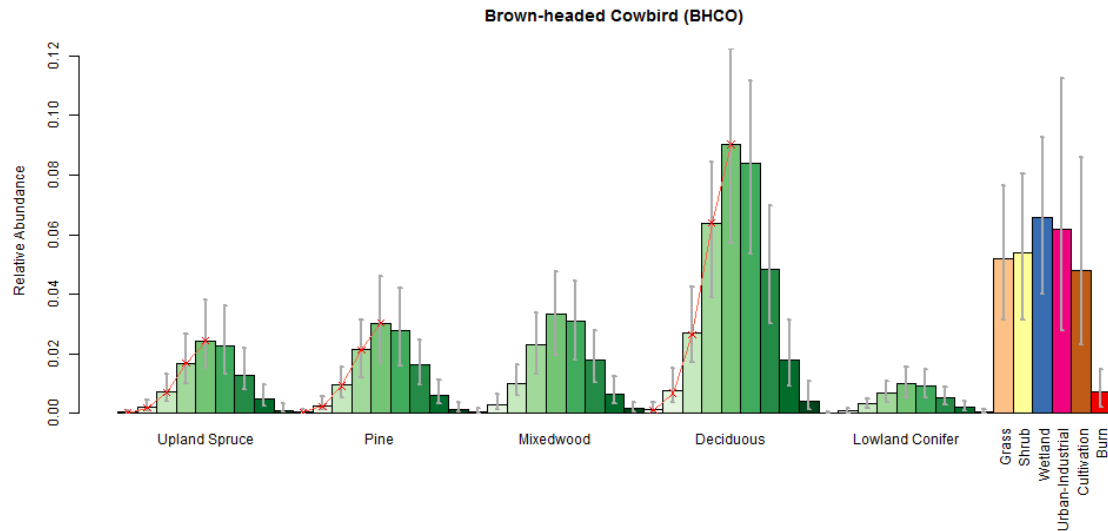


5.14.2 Cross validation

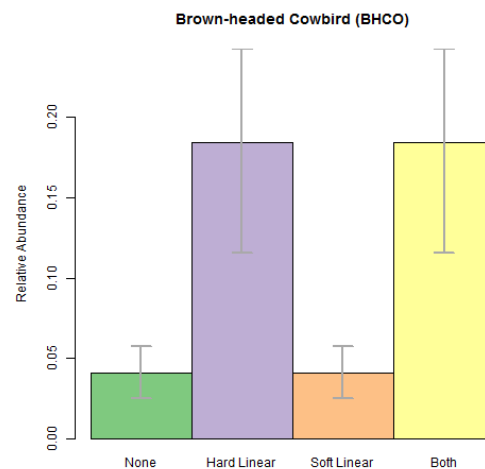
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.14.3 Point level habitat associations

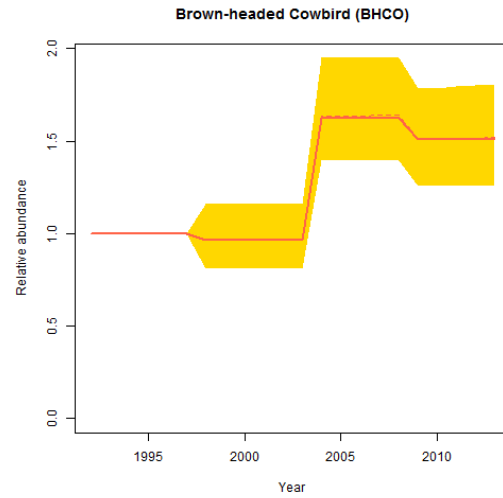


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

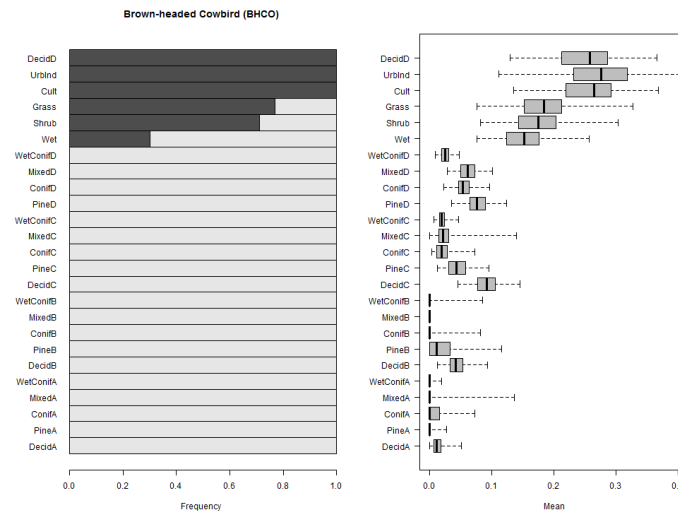


5.14.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



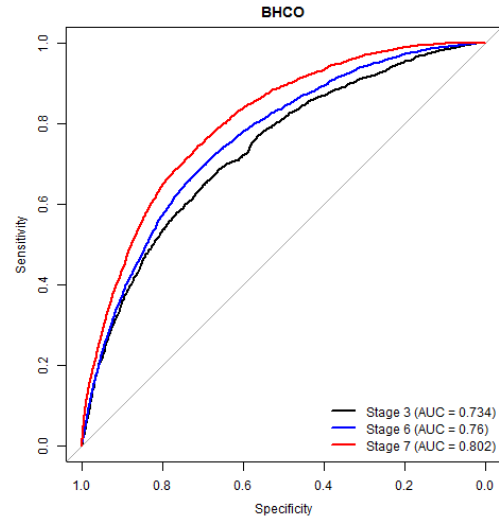
5.14.5 Habitat suitability ranking for patch delineation



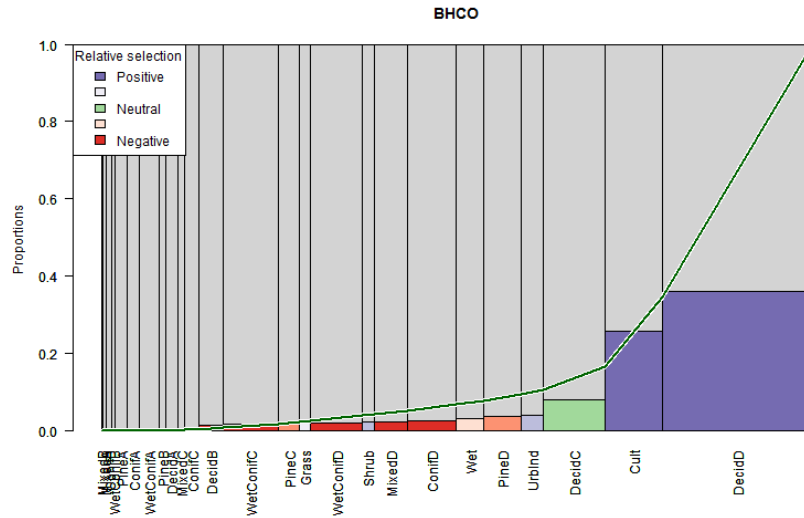
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.14.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

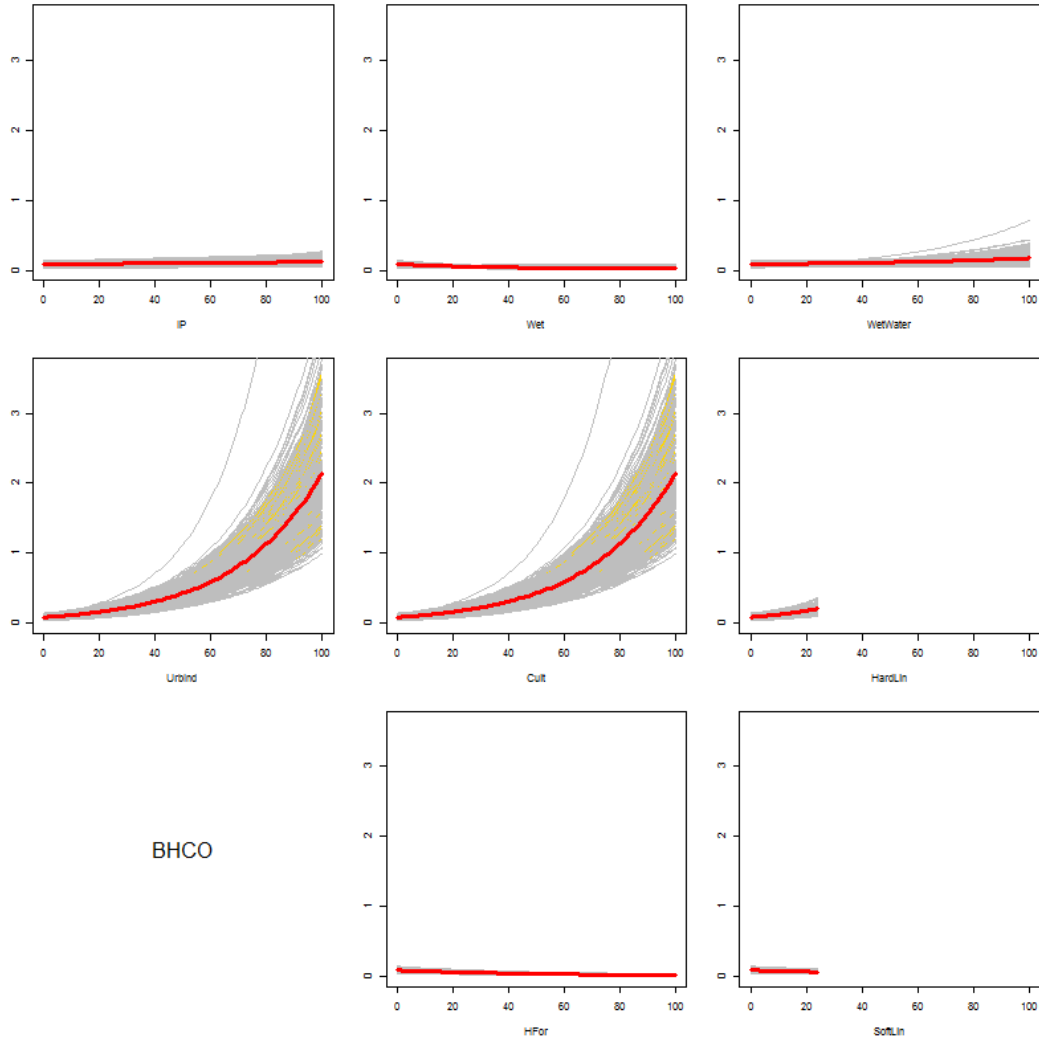


5.14.7 Relative habitat selection



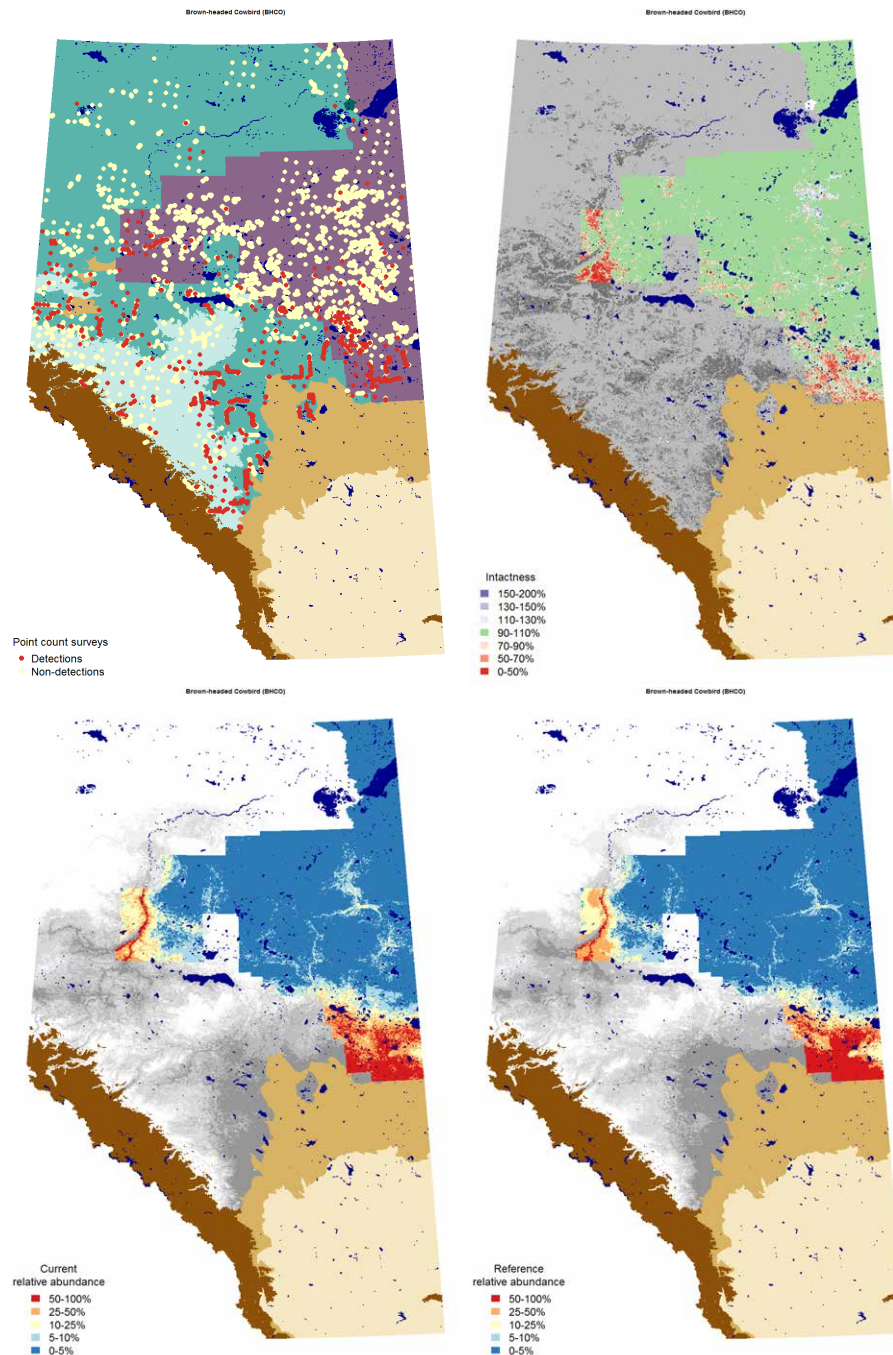
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.14.8 Quarter-section level responses



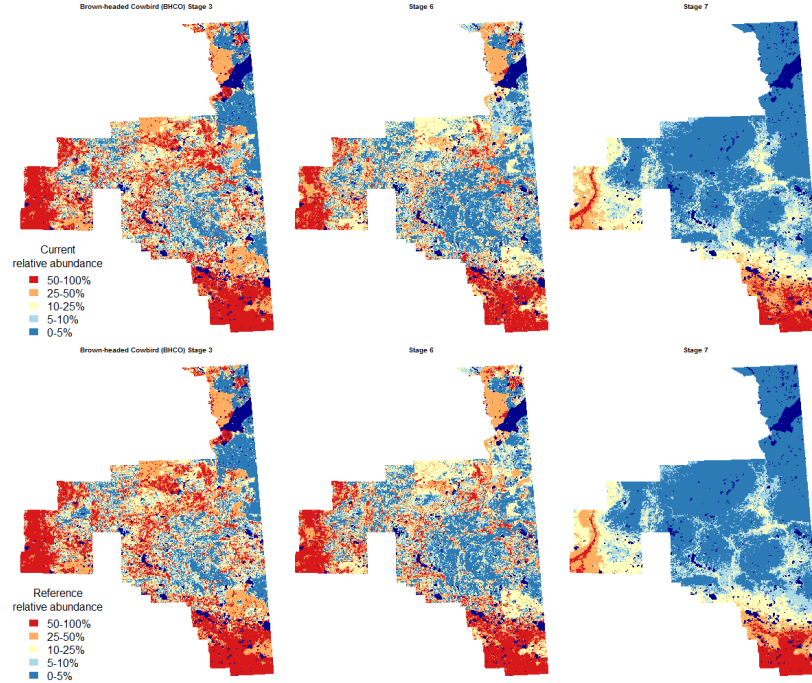
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.14.9 Maps



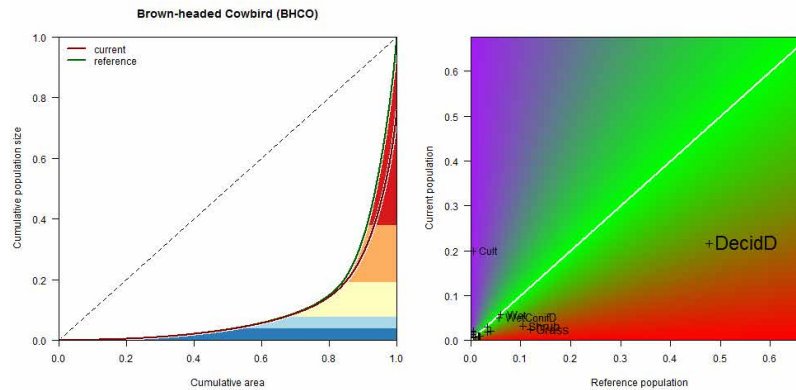
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.14.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.14.11 Population concentration



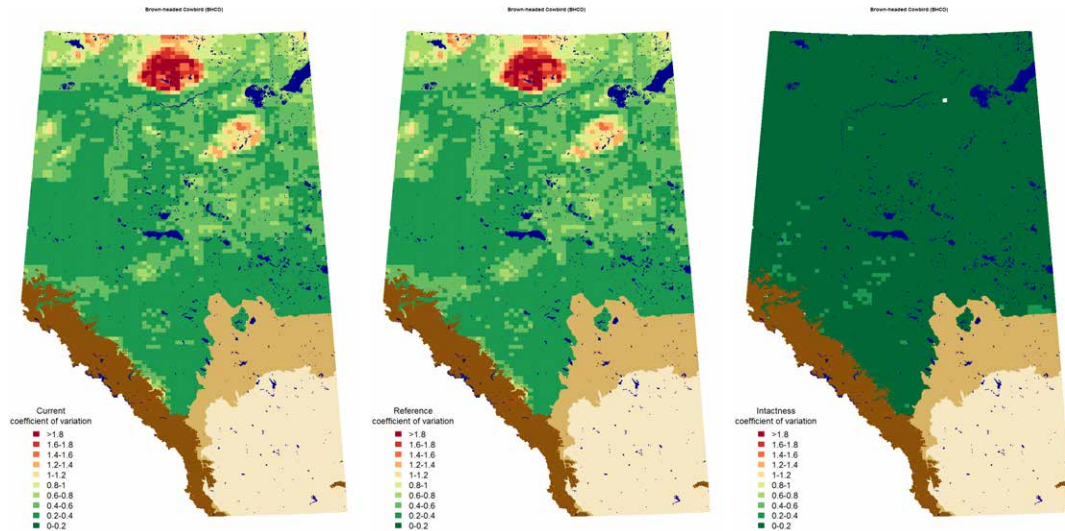
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.14.12 Potential population size

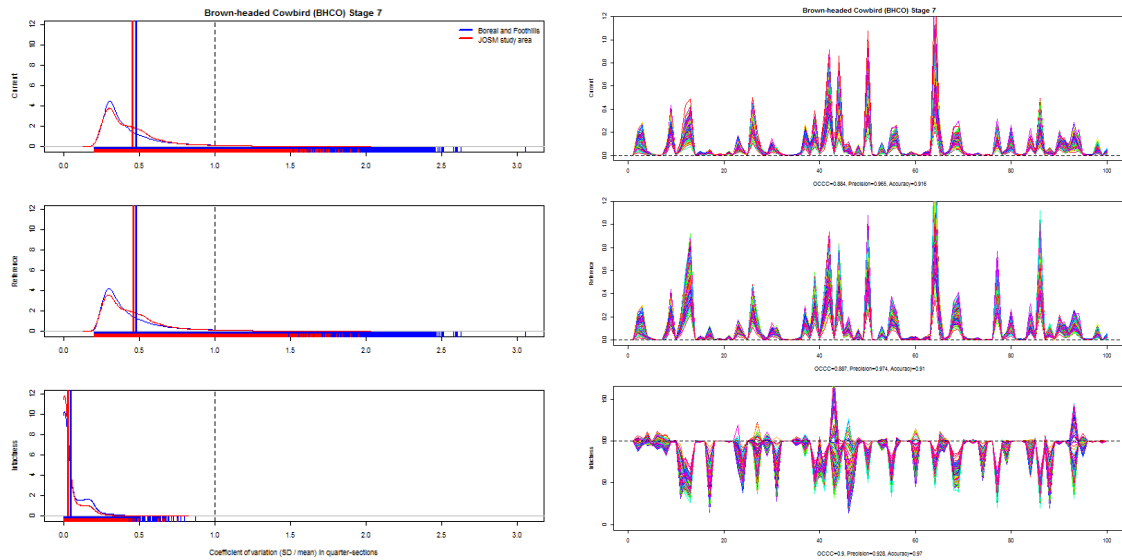
Estimated potential population size of Brown-headed Cowbird in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1796	0.1036	0.2528	0.3835	0.2219	0.5529
Grass	0.0195	0.0113	0.0275	0.0958	0.0554	0.1381
Shrub	0.0258	0.0149	0.0363	0.0837	0.0484	0.1207
Wet	0.0472	0.0272	0.0664	0.0488	0.0283	0.0704
WetConifD	0.0418	0.0241	0.0589	0.0463	0.0268	0.0668
DecidC	0.0169	0.0098	0.0238	0.0327	0.0189	0.0472
MixedD	0.0147	0.0085	0.0207	0.0273	0.0158	0.0394
WetConifC	0.0249	0.0144	0.0351	0.0273	0.0158	0.0393
ConifD	0.0075	0.0043	0.0105	0.0151	0.0088	0.0218
PineD	0.0081	0.0046	0.0113	0.0135	0.0078	0.0195
PineC	0.0075	0.0043	0.0106	0.0128	0.0074	0.0184
ConifC	0.0040	0.0023	0.0057	0.0074	0.0043	0.0107
DecidB	0.0023	0.0013	0.0032	0.0041	0.0024	0.0059
PineB	0.0019	0.0011	0.0026	0.0019	0.0011	0.0028
WetConifB	0.0009	0.0005	0.0012	0.0009	0.0005	0.0013
MixedC	0.0003	0.0002	0.0004	0.0006	0.0004	0.0009
WetConifA	0.0004	0.0002	0.0006	0.0004	0.0003	0.0006
DecidA	0.0001	0.0001	0.0002	0.0004	0.0003	0.0006
ConifB	0.0002	0.0001	0.0003	0.0004	0.0002	0.0005
PineA	0.0002	0.0001	0.0003	0.0002	0.0001	0.0003
ConifA	0.0001	0.0001	0.0002	0.0002	0.0001	0.0003
MixedB	0.0001	0.0000	0.0001	0.0001	0.0001	0.0002
MixedA	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
Cult	0.1653	0.0954	0.2327	0.0000	0.0000	0.0000
UrbInd	0.0153	0.0088	0.0215	0.0000	0.0000	0.0000
HardLin	0.0055	0.0032	0.0078	0.0000	0.0000	0.0000
SoftLin	0.0167	0.0096	0.0235	0.0000	0.0000	0.0000
HFor	0.0111	0.0064	0.0156	0.0000	0.0000	0.0000
Total	0.6180	0.3566	0.8698	0.8037	0.4650	1.1588
Loss	0.1921	0.0921	0.3372			
Gain	0.0022	0.0007	0.0103			

5.14.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.14.14 Variable selection frequencies

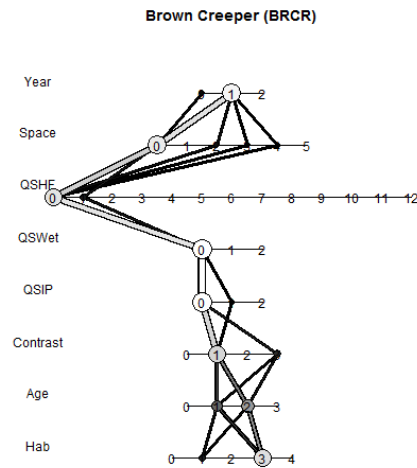
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	8.0	16	. + HabitatB
1.4	92.0	184	. + HabitatB + isHForC
2.2	100.0	200	. + Age + Age2
3.1	100.0	200	. + ROAD
4.0	59.5	119	NULL
4.1	38.5	77	. + Remn_QS
4.2	2.0	4	. + Remn_QS + Remn2_QS
5.1	72.0	144	. + pWet_QS
5.2	28.0	56	. + pWetWater_QS
6.9	100.0	200	. + Succ_QS + Alien_QS + Alien2_QS
7.4	70.0	140	. + xMAP + xPET + xMAT + xCMD
7.5	30.0	60	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	2.5	5	. + xYEAR
8.2	97.5	195	. + YR5F

5.15 Brown Creeper (*Certhia americana*)

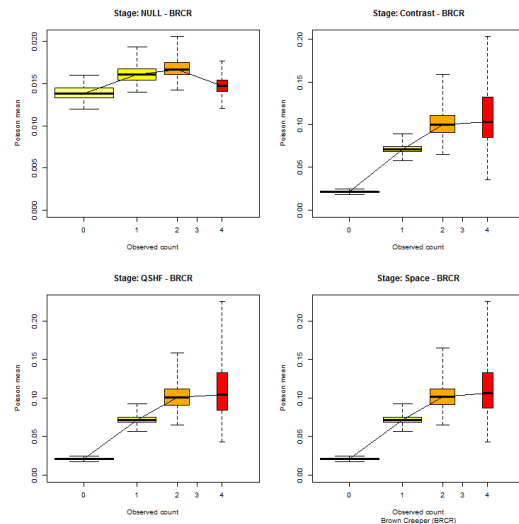
5.15.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

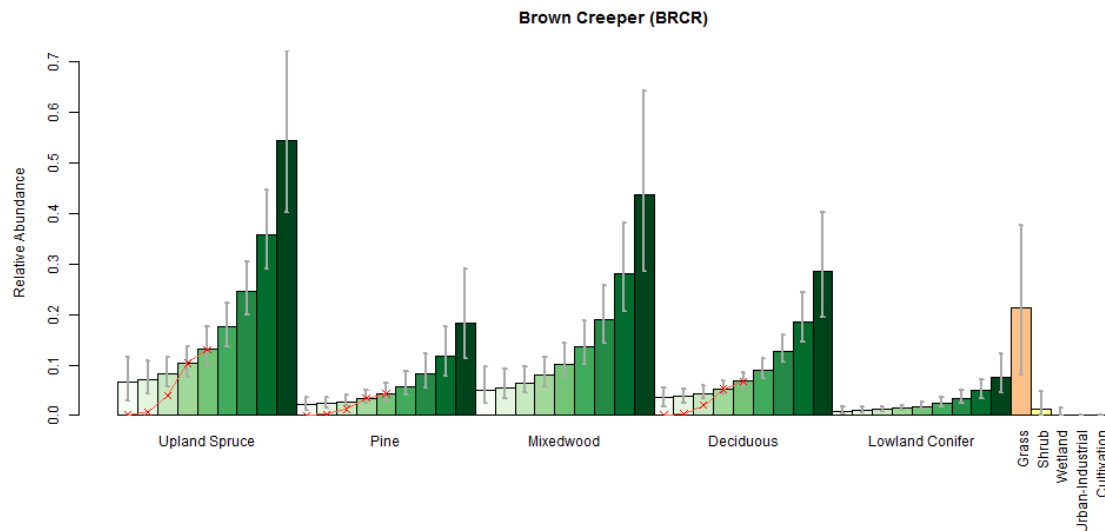


5.15.2 Cross validation

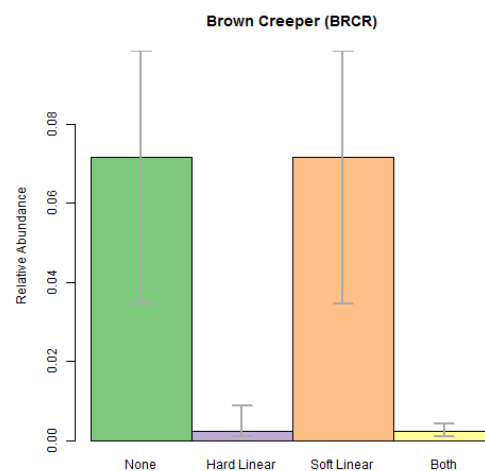
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.15.3 Point level habitat associations

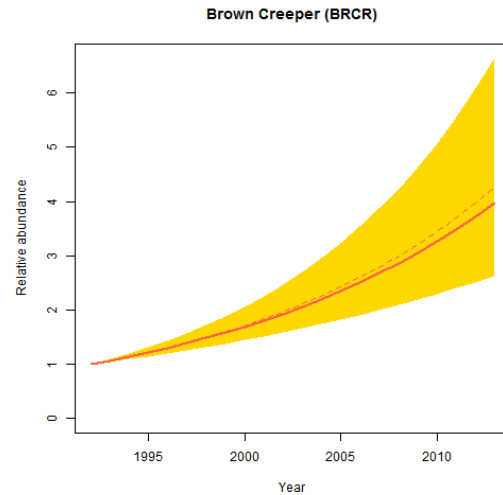


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

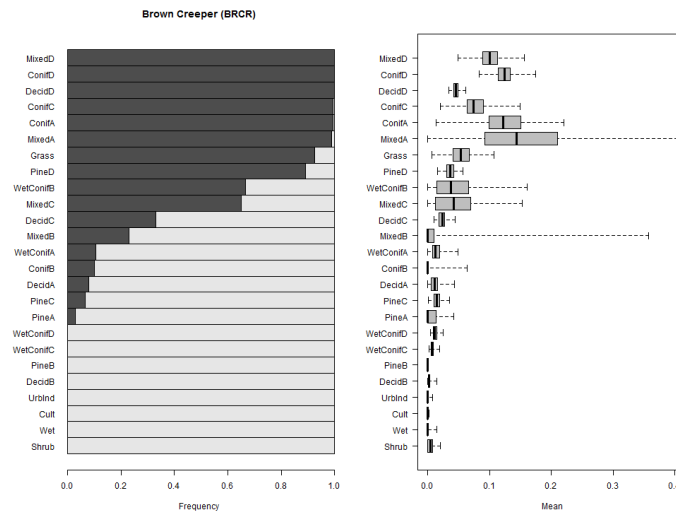


5.15.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



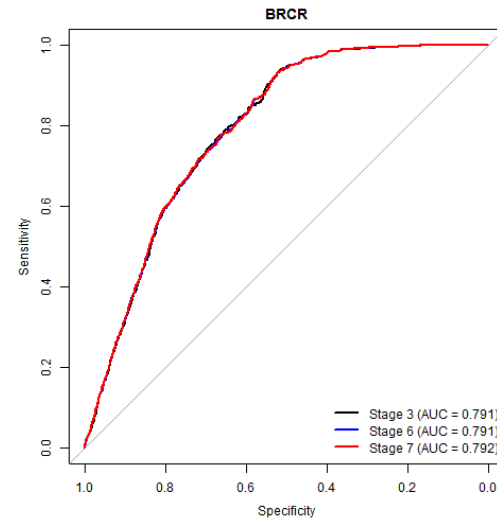
5.15.5 Habitat suitability ranking for patch delineation



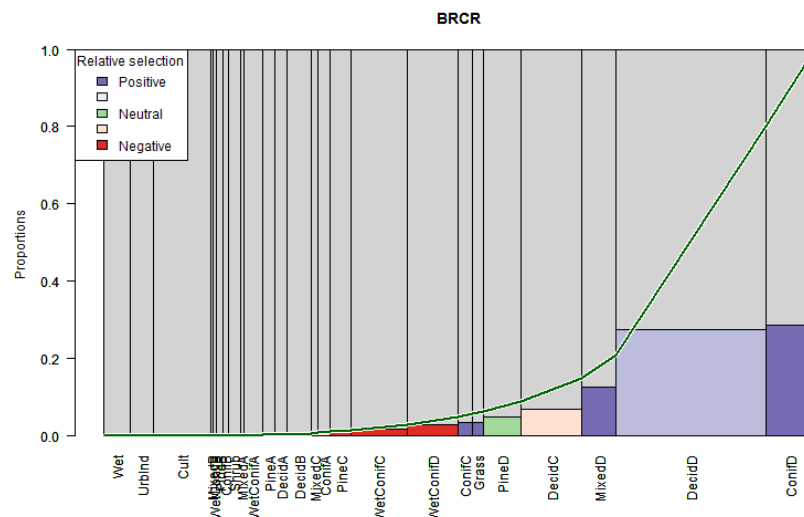
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.15.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

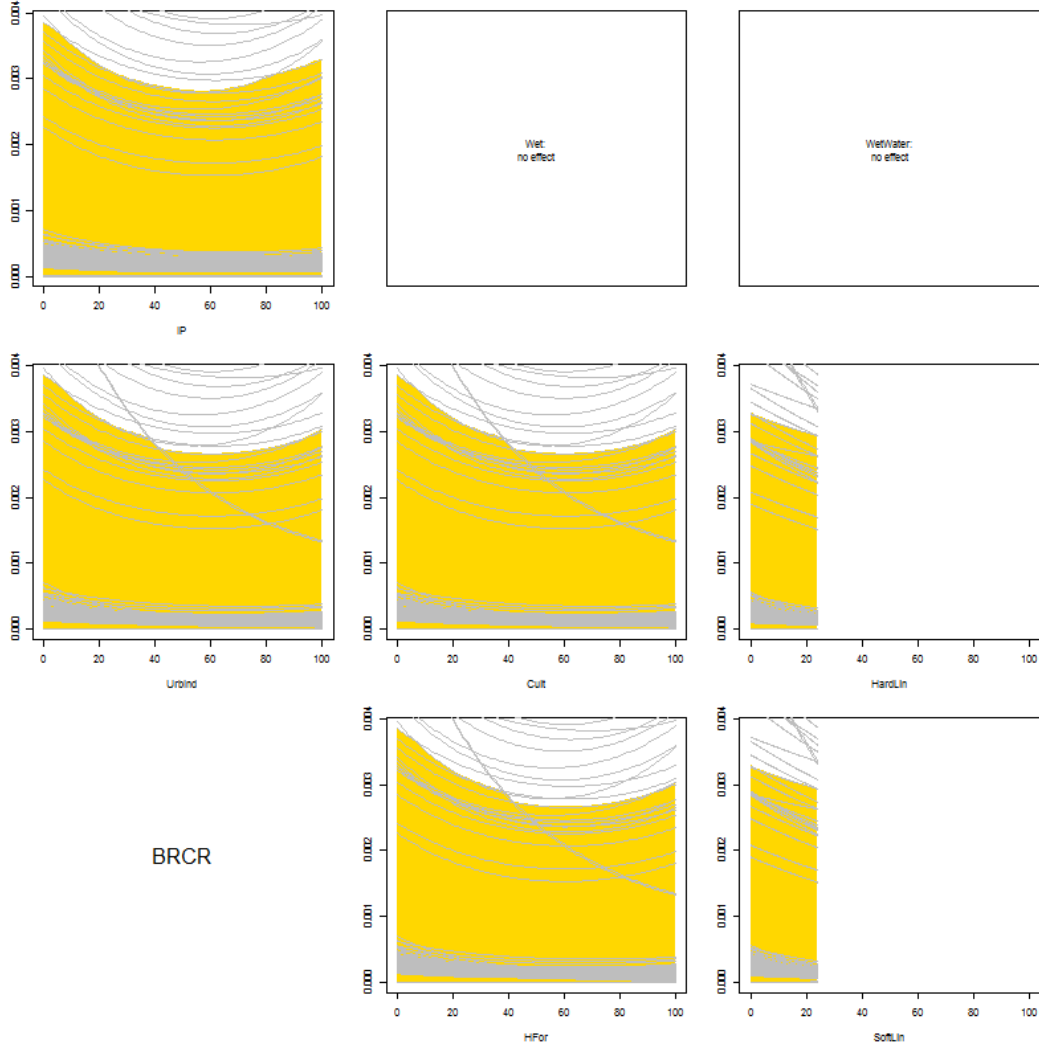


5.15.7 Relative habitat selection



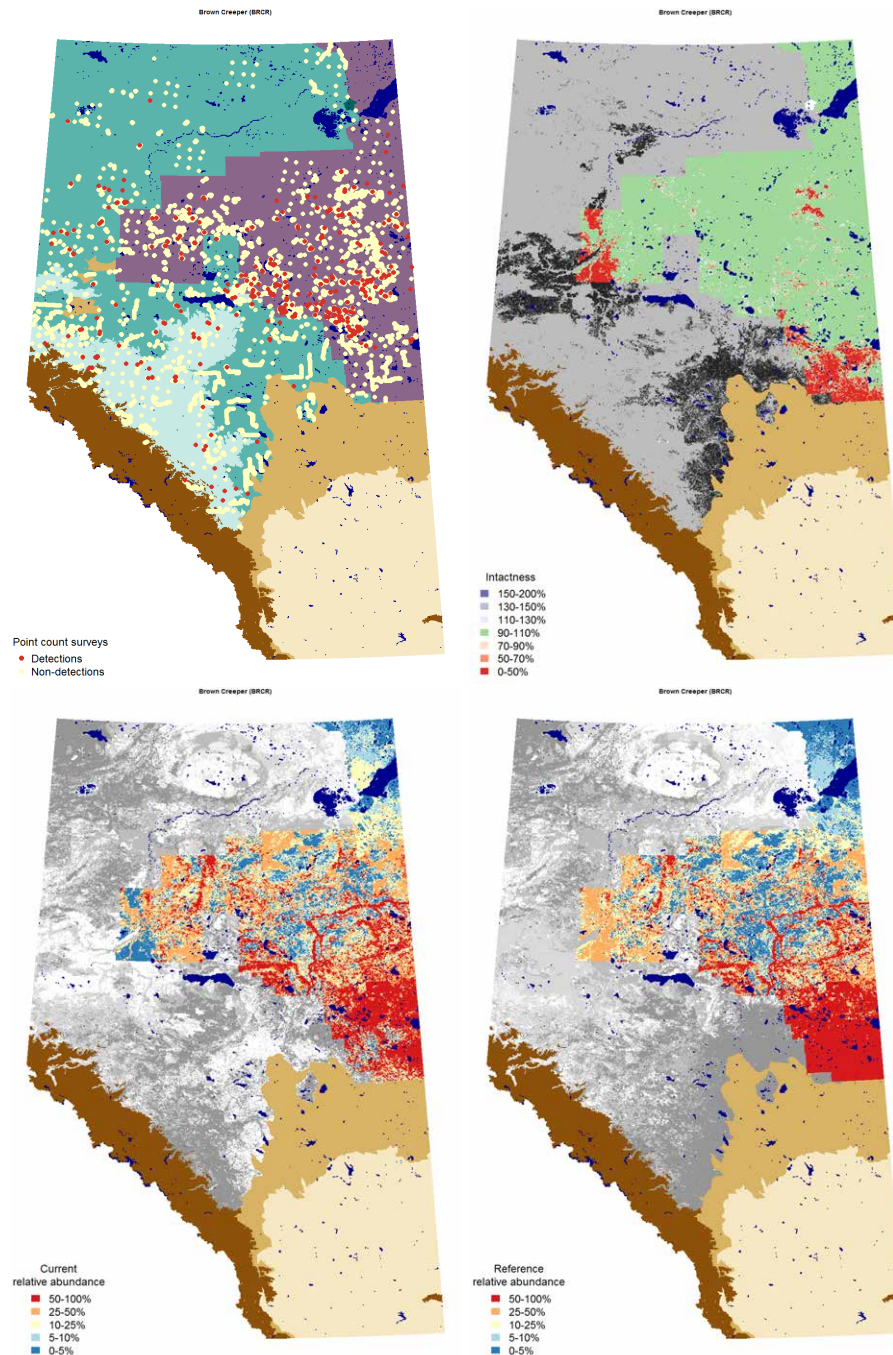
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.15.8 Quarter-section level responses



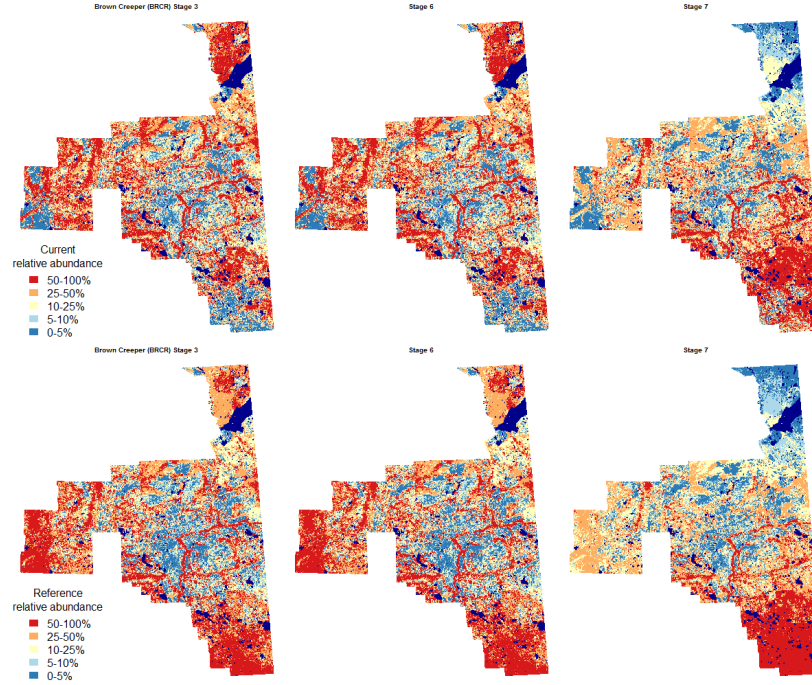
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.15.9 Maps



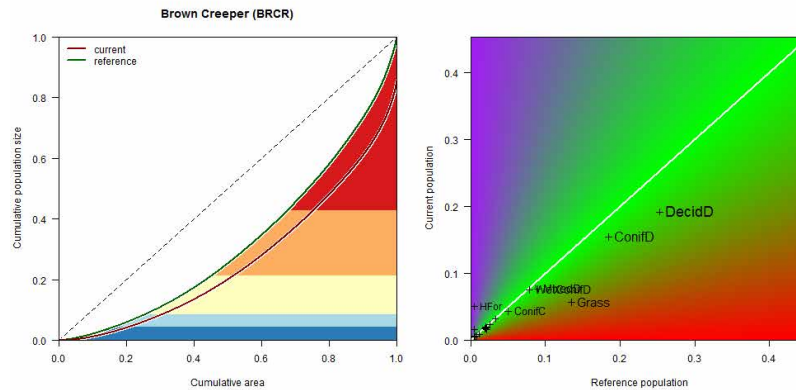
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on "Space" stage of the variable selection procedure (no year effect).

5.15.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.15.11 Population concentration



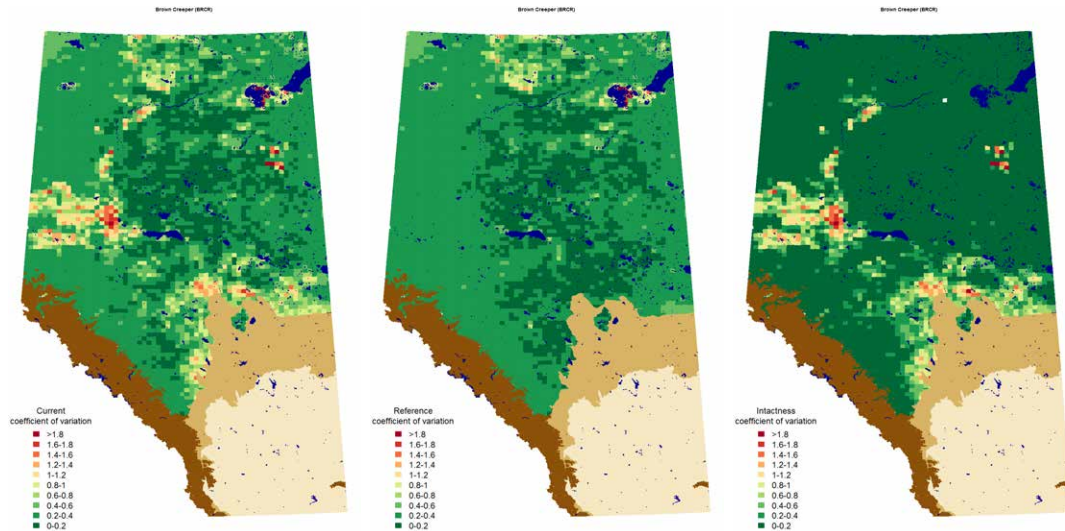
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.15.12 Potential population size

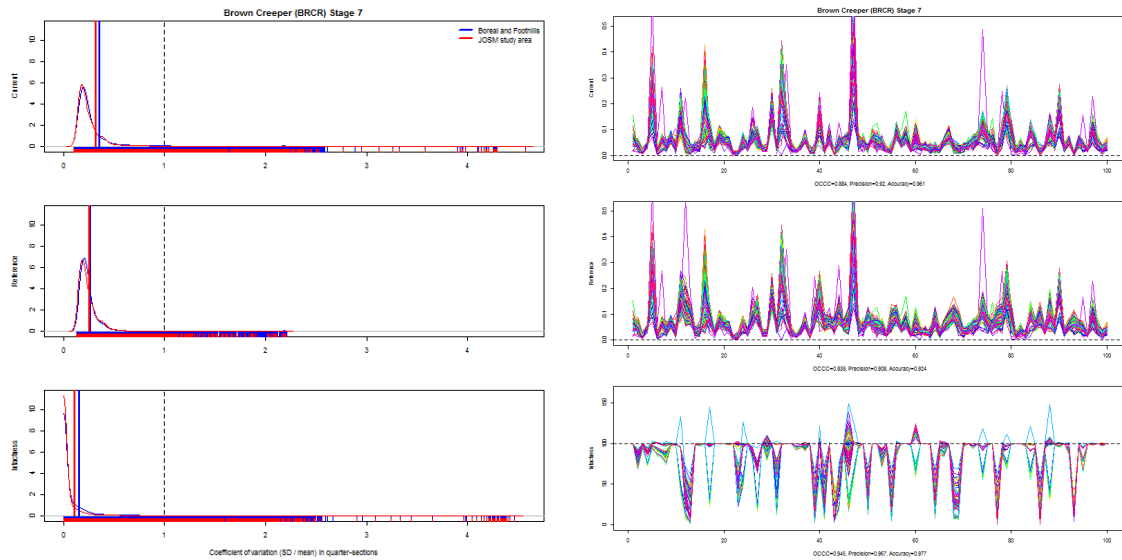
Estimated potential population size of Brown Creeper in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1681	0.1442	0.2153	0.2193	0.1868	0.2899
ConifD	0.1351	0.1159	0.1730	0.1601	0.1364	0.2117
Grass	0.0498	0.0427	0.0638	0.1171	0.0997	0.1547
MixedD	0.0671	0.0576	0.0859	0.0781	0.0666	0.1033
WetConifD	0.0661	0.0567	0.0846	0.0685	0.0584	0.0906
ConifC	0.0382	0.0328	0.0490	0.0438	0.0373	0.0579
WetConifC	0.0277	0.0238	0.0355	0.0287	0.0244	0.0379
PineD	0.0207	0.0178	0.0265	0.0224	0.0191	0.0296
ConifA	0.0168	0.0144	0.0216	0.0190	0.0161	0.0251
DecidC	0.0144	0.0124	0.0185	0.0187	0.0160	0.0248
PineC	0.0164	0.0141	0.0211	0.0174	0.0148	0.0230
PineB	0.0174	0.0149	0.0222	0.0173	0.0147	0.0229
ConifB	0.0150	0.0129	0.0193	0.0164	0.0140	0.0217
DecidB	0.0080	0.0068	0.0102	0.0100	0.0085	0.0132
Shrub	0.0054	0.0047	0.0069	0.0072	0.0061	0.0095
PineA	0.0052	0.0045	0.0067	0.0053	0.0045	0.0070
WetConifB	0.0047	0.0040	0.0060	0.0048	0.0041	0.0063
WetConifA	0.0039	0.0033	0.0050	0.0040	0.0034	0.0053
DecidA	0.0020	0.0017	0.0026	0.0032	0.0027	0.0042
MixedB	0.0020	0.0017	0.0025	0.0022	0.0019	0.0029
MixedA	0.0013	0.0011	0.0017	0.0018	0.0016	0.0024
MixedC	0.0015	0.0013	0.0019	0.0018	0.0015	0.0023
Wet	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
UrbInd	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HardLin	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0146	0.0125	0.0187	0.0000	0.0000	0.0000
HFor	0.0439	0.0377	0.0562	0.0000	0.0000	0.0000
Total	0.7456	0.6396	0.9547	0.8671	0.7386	1.1462
Loss	0.1287	0.0826	0.2344			
Gain	0.0095	0.0004	0.0128			

5.15.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.15.14 Variable selection frequencies

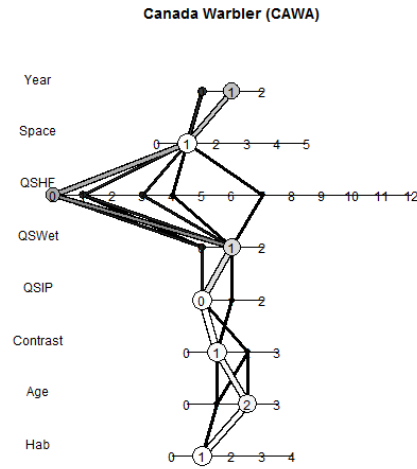
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	12.5	25	. + Habitat
1.3	87.5	175	. + Habitat + isHForC
2.1	40.0	80	. + Age
2.2	60.0	120	. + Age + Age2
3.1	83.5	167	. + ROAD
3.3	16.5	33	. + ROAD + SoftLin_PC
4.0	99.5	199	NULL
4.1	0.5	1	. + Remn_QS
5.0	100.0	200	NULL
6.0	89.5	179	NULL
6.1	10.5	21	. + THF_QS
7.0	92.0	184	NULL
7.2	6.5	13	. + xlat + xlong
7.3	1.0	2	. + xlat + xlong + xlat:xlong
7.4	0.5	1	. + xMAP + xPET + xMAT + xCMD
8.0	4.0	8	NULL
8.1	96.0	192	. + xYEAR

5.16 Canada Warbler (*Cardellina canadensis*)

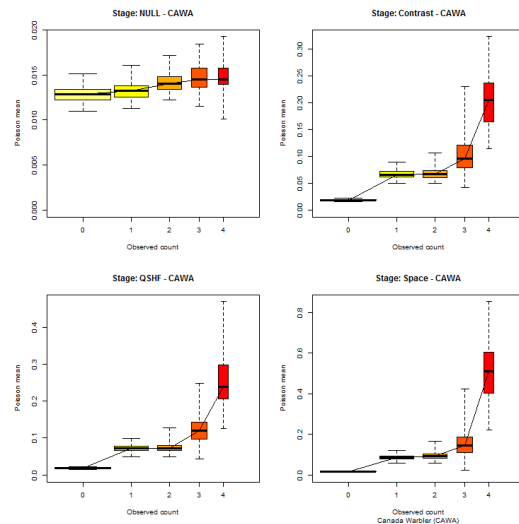
5.16.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

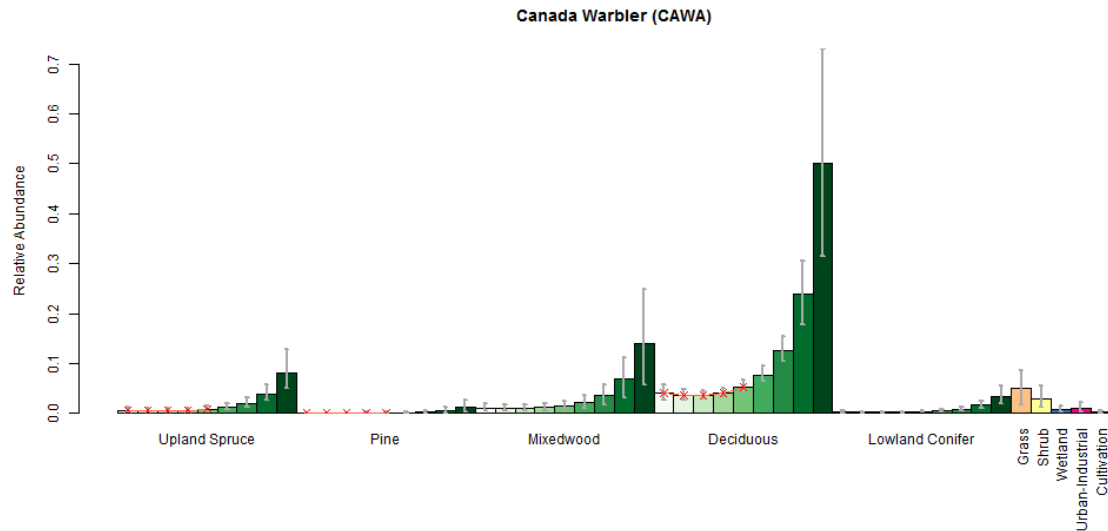


5.16.2 Cross validation

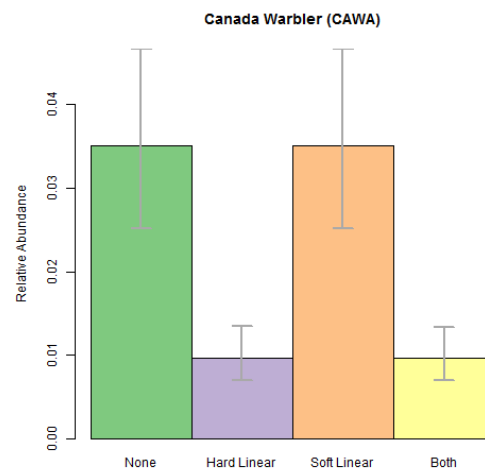
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.16.3 Point level habitat associations

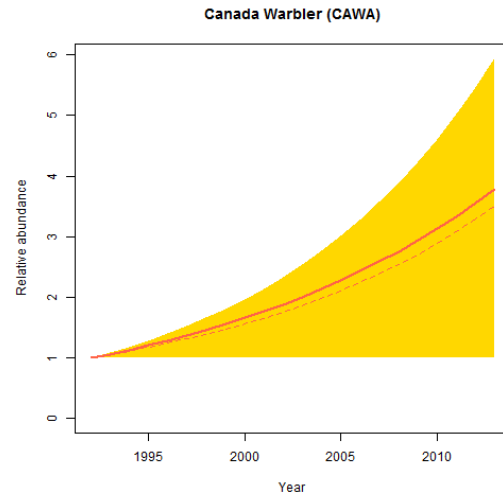


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

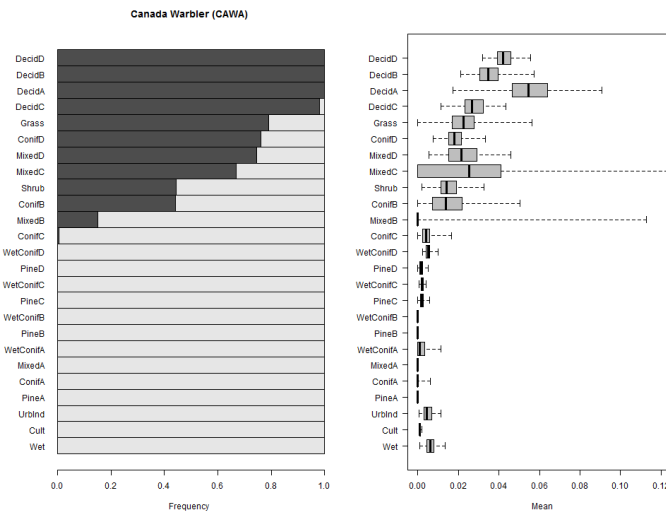


5.16.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



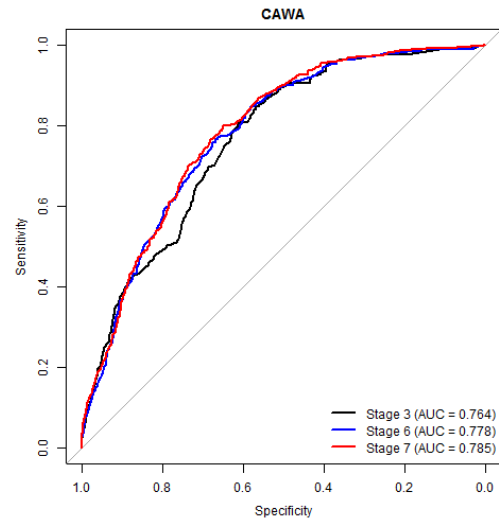
5.16.5 Habitat suitability ranking for patch delineation



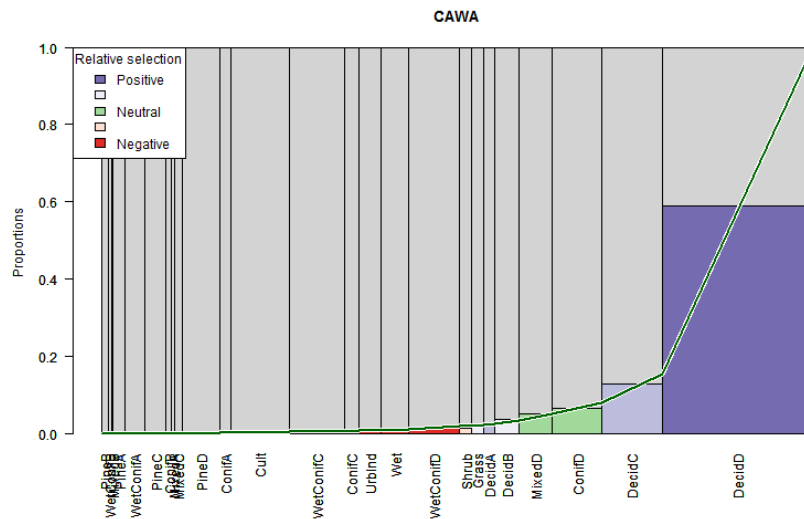
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.16.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

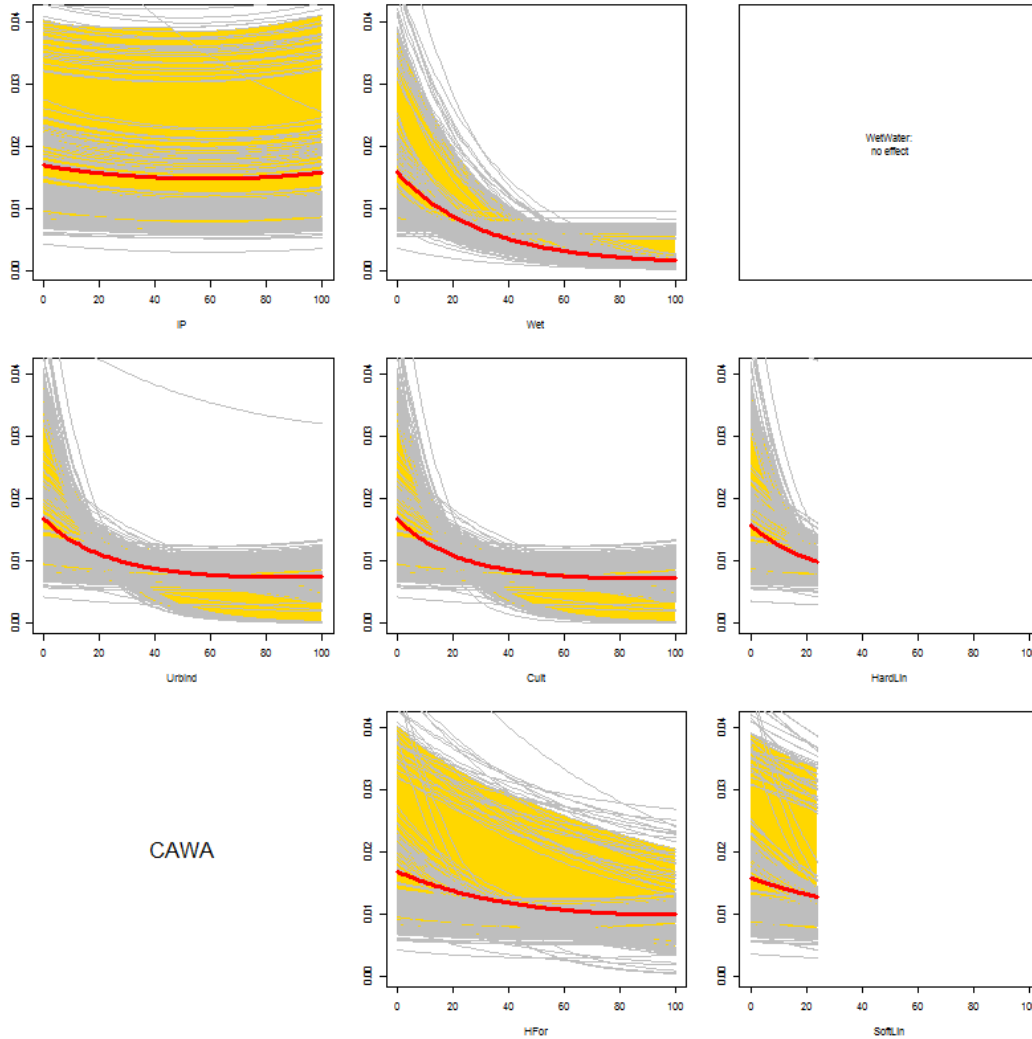


5.16.7 Relative habitat selection



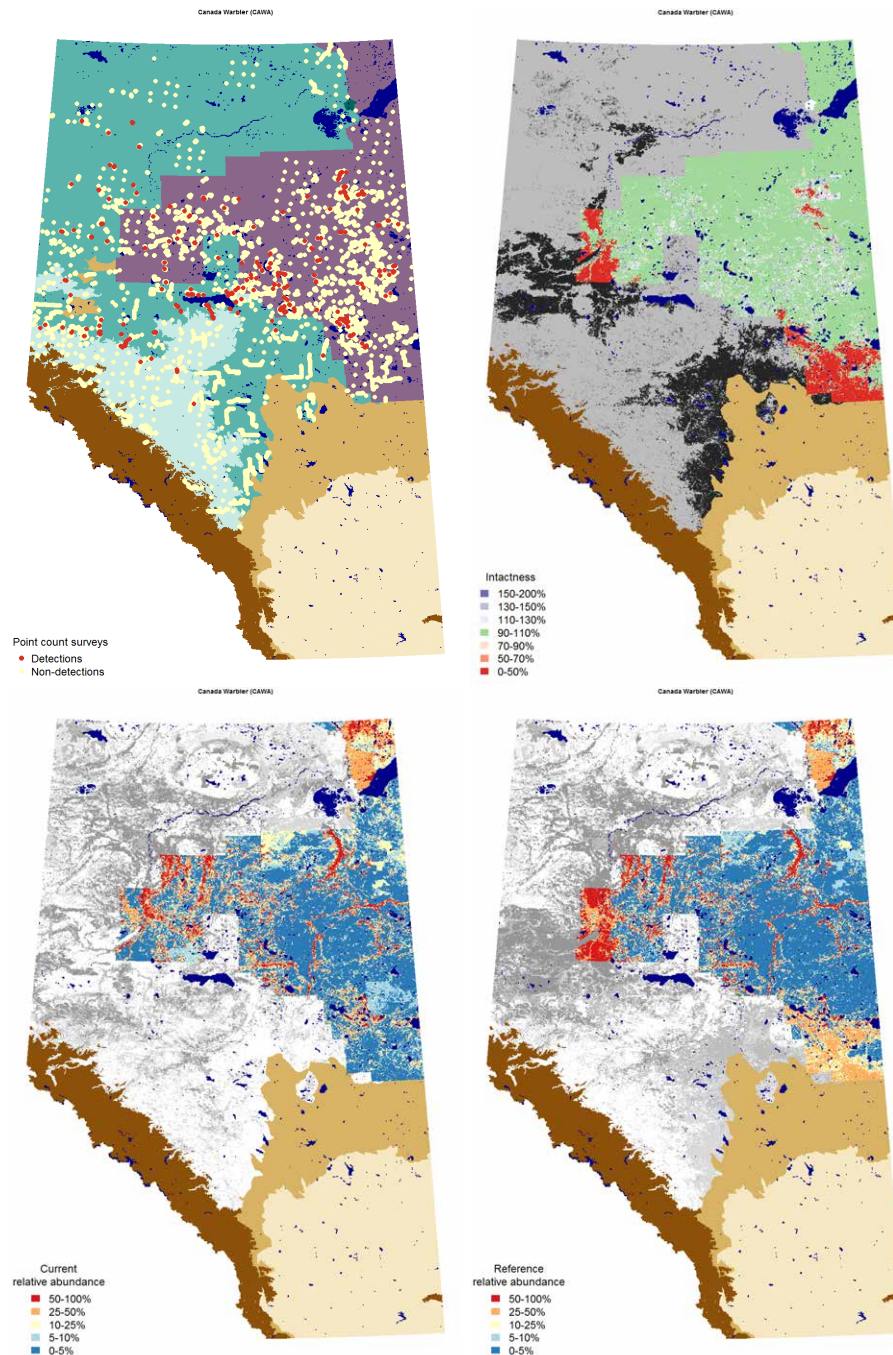
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.16.8 Quarter-section level responses



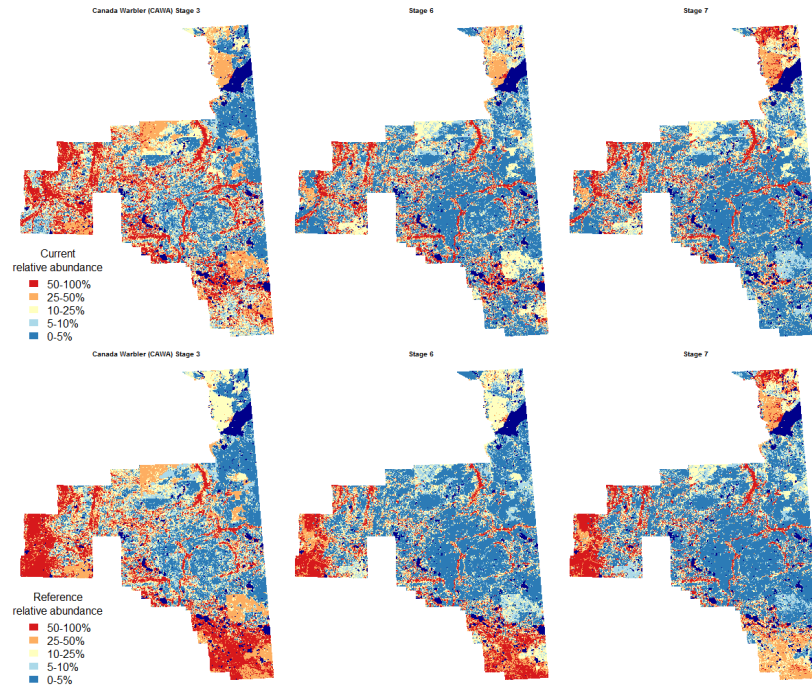
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.16.9 Maps



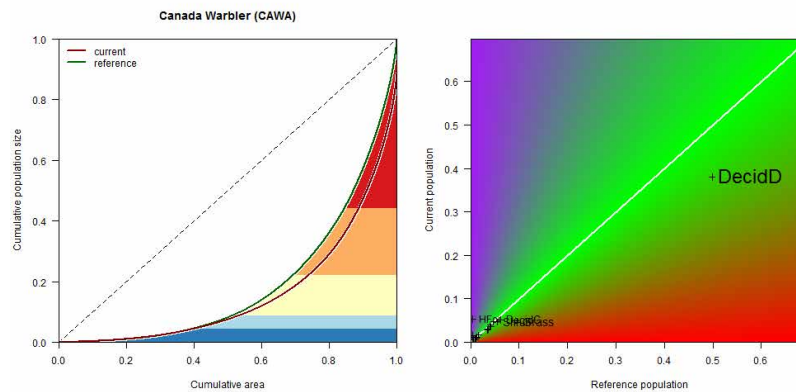
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.16.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.16.11 Population concentration



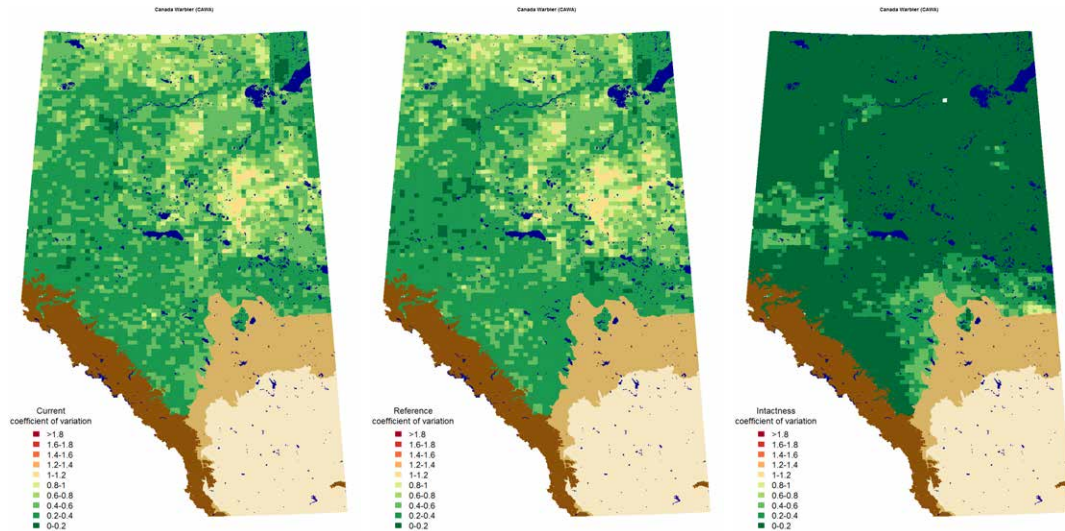
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.16.12 Potential population size

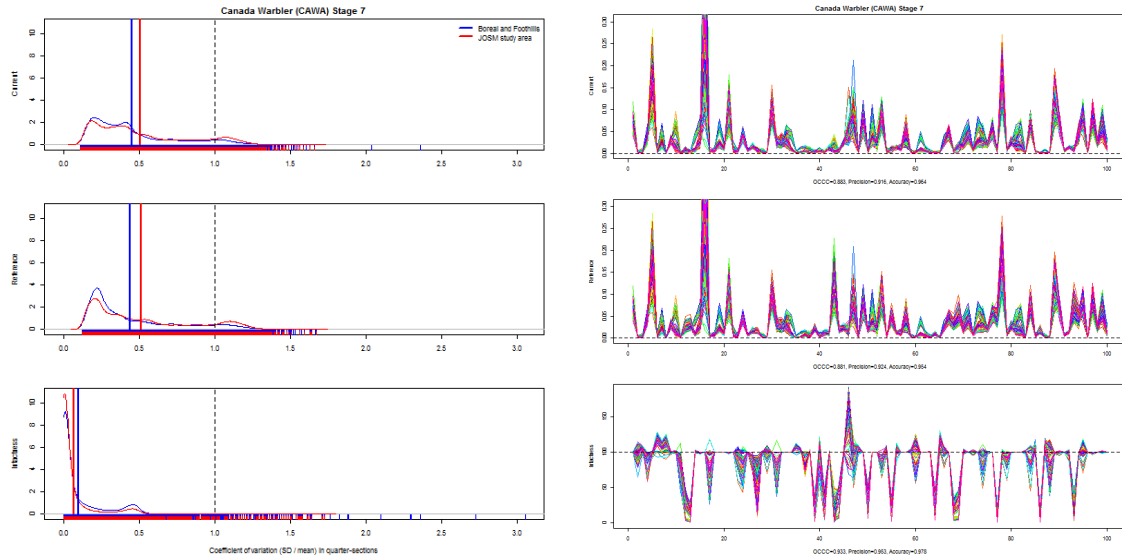
Estimated potential population size of Canada Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1400	0.1152	0.1715	0.1806	0.1468	0.2254
Grass	0.0170	0.0140	0.0208	0.0346	0.0282	0.0432
DecidC	0.0190	0.0156	0.0232	0.0223	0.0181	0.0278
Shrub	0.0172	0.0141	0.0210	0.0200	0.0163	0.0250
Wet	0.0174	0.0143	0.0213	0.0172	0.0140	0.0214
ConifD	0.0130	0.0107	0.0159	0.0152	0.0124	0.0190
WetConifD	0.0144	0.0119	0.0177	0.0147	0.0120	0.0184
MixedD	0.0114	0.0094	0.0140	0.0129	0.0105	0.0161
DecidB	0.0107	0.0088	0.0131	0.0125	0.0101	0.0156
WetConifC	0.0060	0.0049	0.0074	0.0061	0.0050	0.0076
ConifA	0.0045	0.0037	0.0055	0.0047	0.0038	0.0059
ConifC	0.0036	0.0030	0.0044	0.0040	0.0032	0.0050
ConifB	0.0037	0.0031	0.0046	0.0038	0.0031	0.0048
DecidA	0.0024	0.0020	0.0029	0.0035	0.0028	0.0044
PineB	0.0024	0.0020	0.0030	0.0024	0.0020	0.0030
WetConifB	0.0018	0.0015	0.0022	0.0018	0.0015	0.0022
WetConifA	0.0013	0.0011	0.0016	0.0013	0.0011	0.0016
PineD	0.0011	0.0009	0.0014	0.0012	0.0010	0.0015
PineA	0.0010	0.0008	0.0012	0.0009	0.0008	0.0012
PineC	0.0009	0.0007	0.0010	0.0009	0.0007	0.0011
MixedB	0.0008	0.0006	0.0010	0.0008	0.0007	0.0010
MixedA	0.0004	0.0003	0.0005	0.0005	0.0004	0.0006
MixedC	0.0004	0.0003	0.0005	0.0004	0.0004	0.0006
Cult	0.0042	0.0034	0.0051	0.0000	0.0000	0.0000
UrbInd	0.0023	0.0019	0.0028	0.0000	0.0000	0.0000
HardLin	0.0003	0.0003	0.0004	0.0000	0.0000	0.0000
SoftLin	0.0055	0.0045	0.0068	0.0000	0.0000	0.0000
HFor	0.0197	0.0162	0.0241	0.0000	0.0000	0.0000
Total	0.3223	0.2652	0.3950	0.3624	0.2947	0.4524
Loss	0.0479	0.0311	0.0928			
Gain	0.0101	0.0025	0.0135			

5.16.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.16.14 Variable selection frequencies

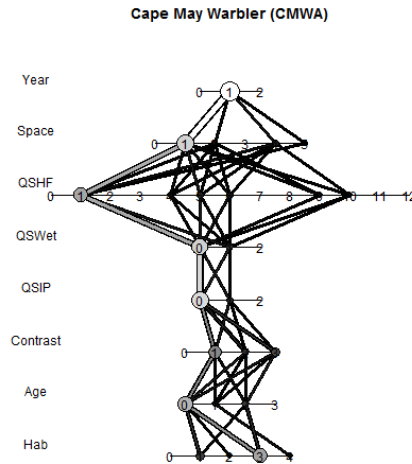
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	100.0	200	. + Habitat
2.1	4.0	8	. + Age
2.2	96.0	192	. + Age + Age2
3.1	97.5	195	. + ROAD
3.2	2.5	5	. + SoftLin_PC
4.0	99.5	199	NULL
4.1	0.5	1	. + Remn_QS
5.0	14.0	28	NULL
5.1	86.0	172	. + pWet_QS
6.0	67.0	134	NULL
6.1	18.5	37	. + THF_QS
6.3	12.5	25	. + Succ_QS + Alien_QS
6.4	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS
6.7	1.5	3	. + Succ_QS + Alien_QS + Succ2_QS
7.1	100.0	200	. + xlat
8.0	23.5	47	NULL
8.1	76.5	153	. + xYEAR

5.17 Cape May Warbler (*Setophaga tigrina*)

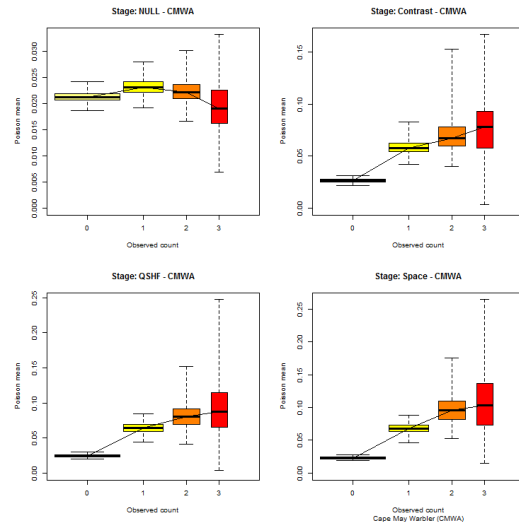
5.17.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

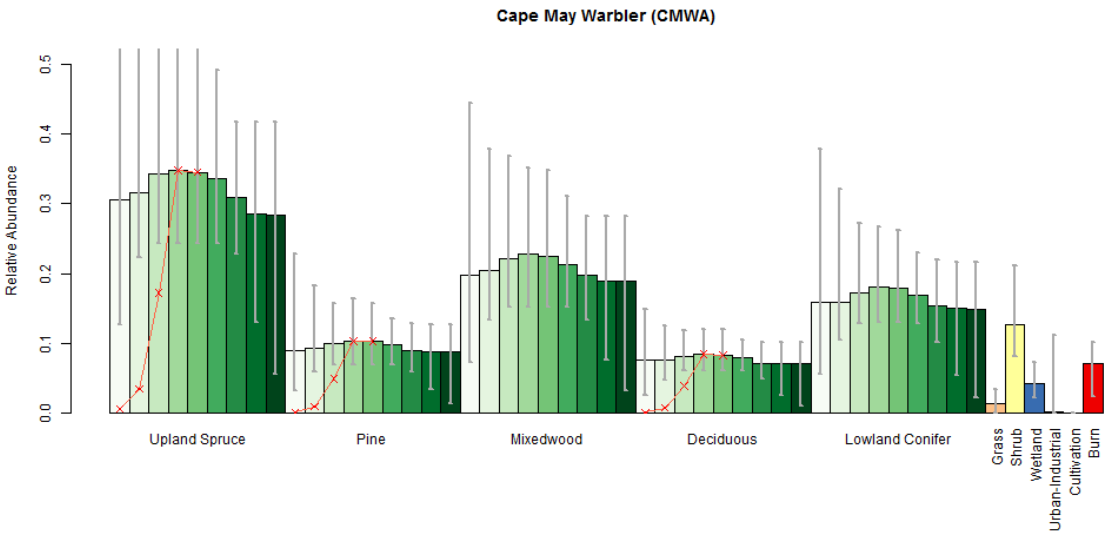


5.17.2 Cross validation

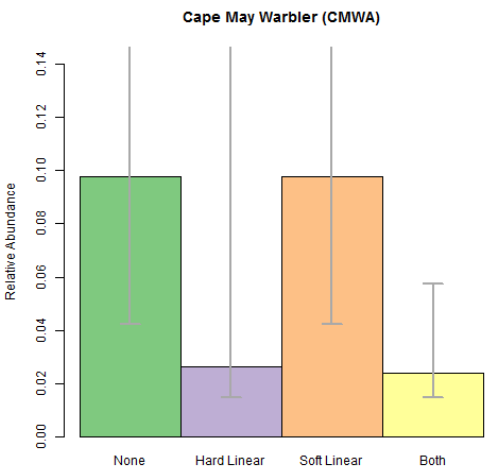
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.17.3 Point level habitat associations

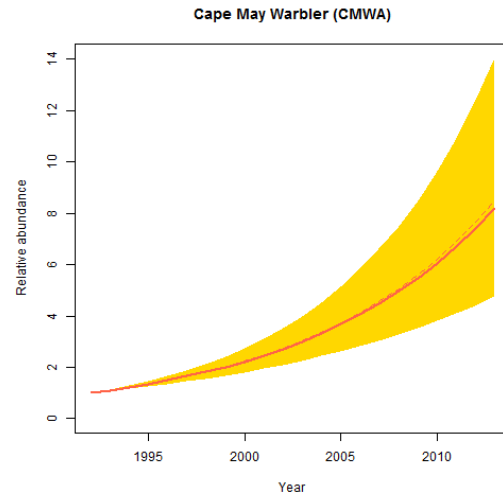


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

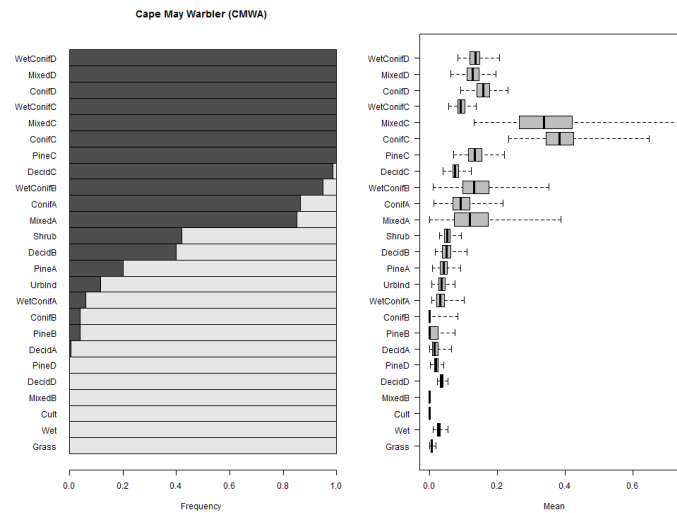


5.17.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



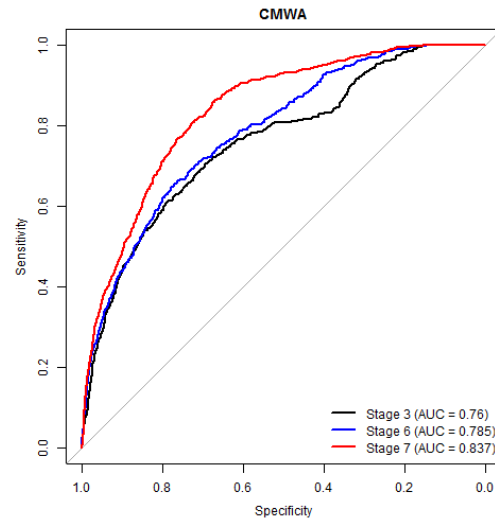
5.17.5 Habitat suitability ranking for patch delineation



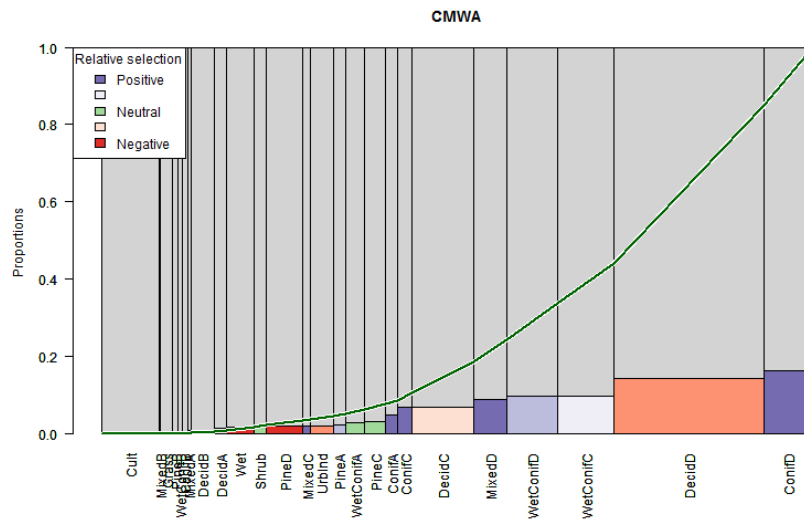
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.17.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

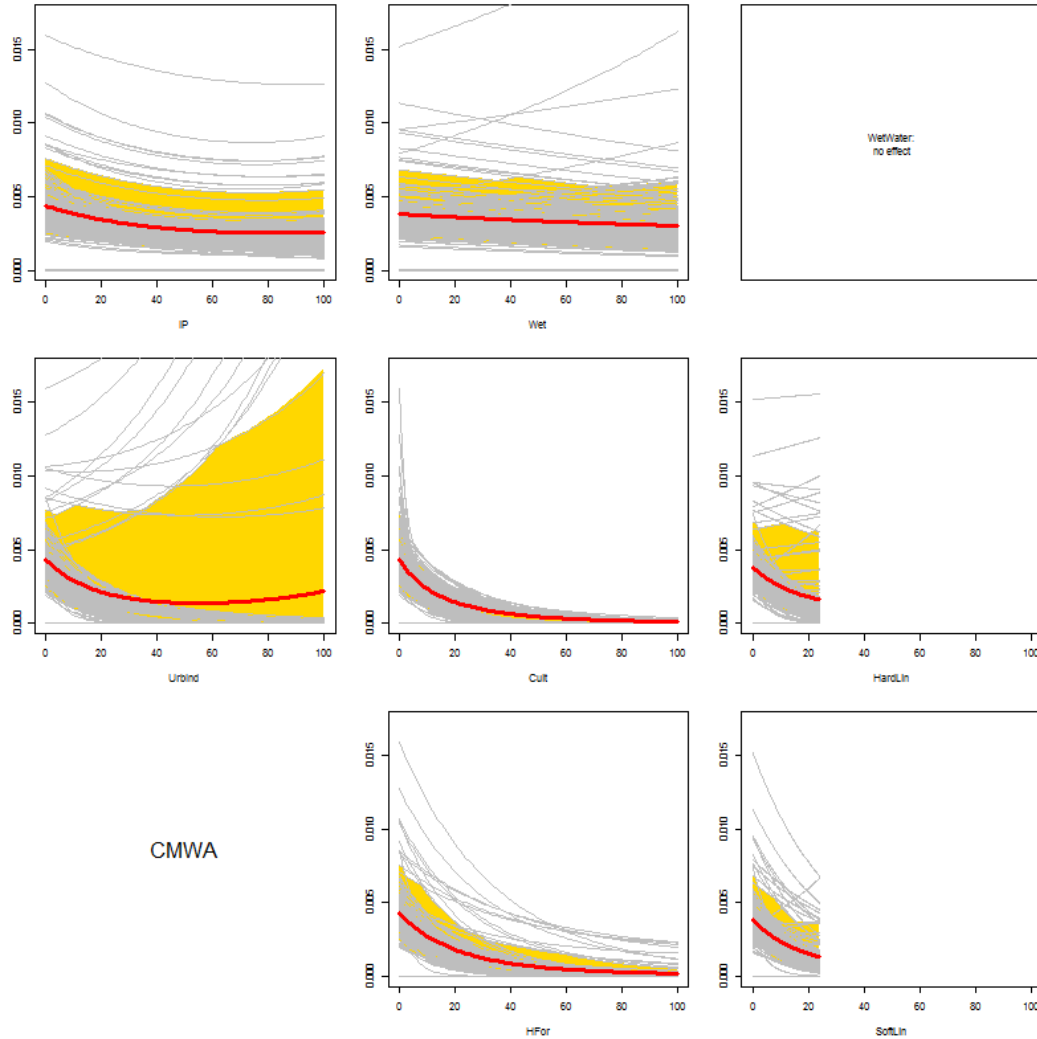


5.17.7 Relative habitat selection



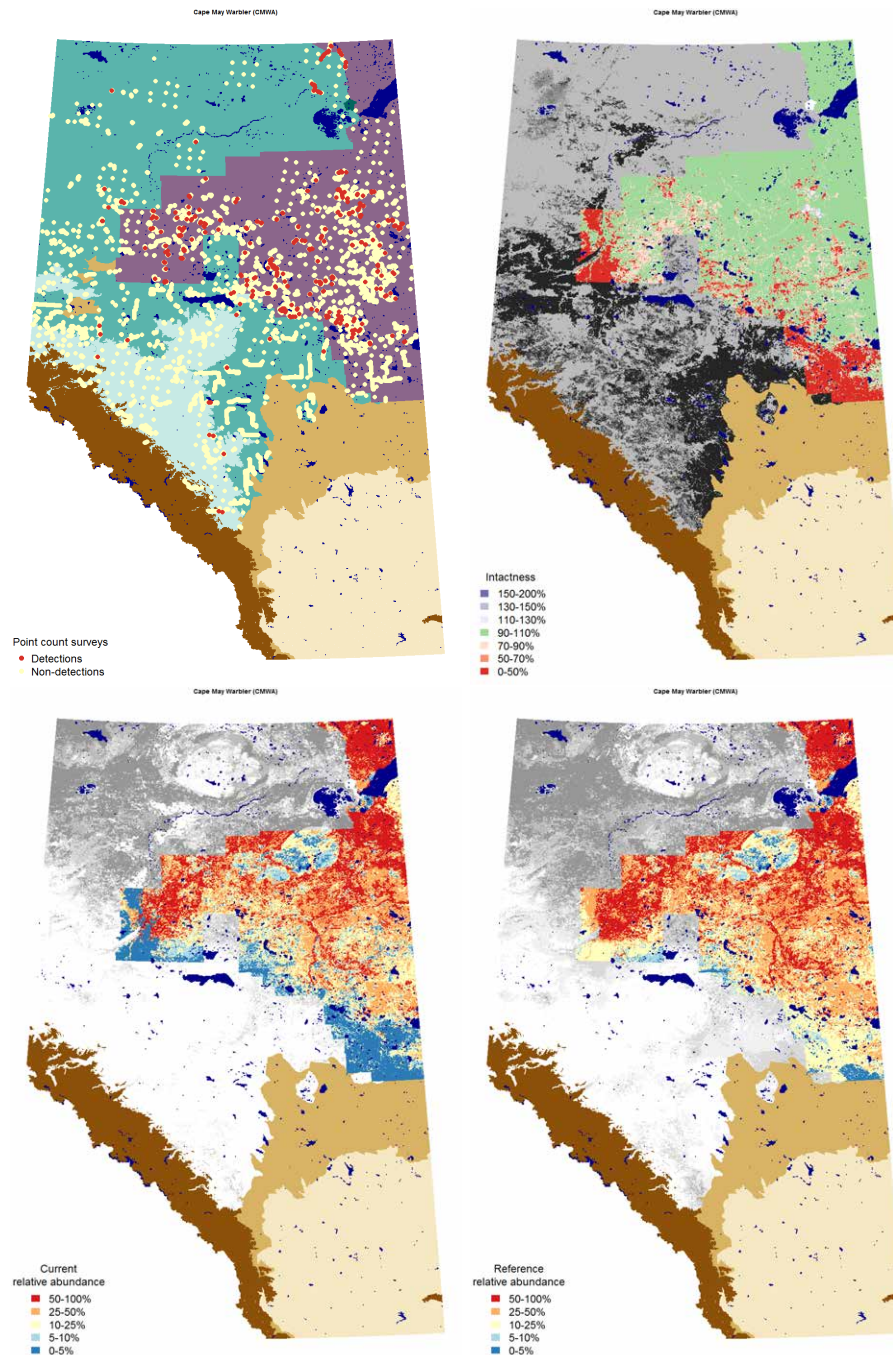
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.17.8 Quarter-section level responses



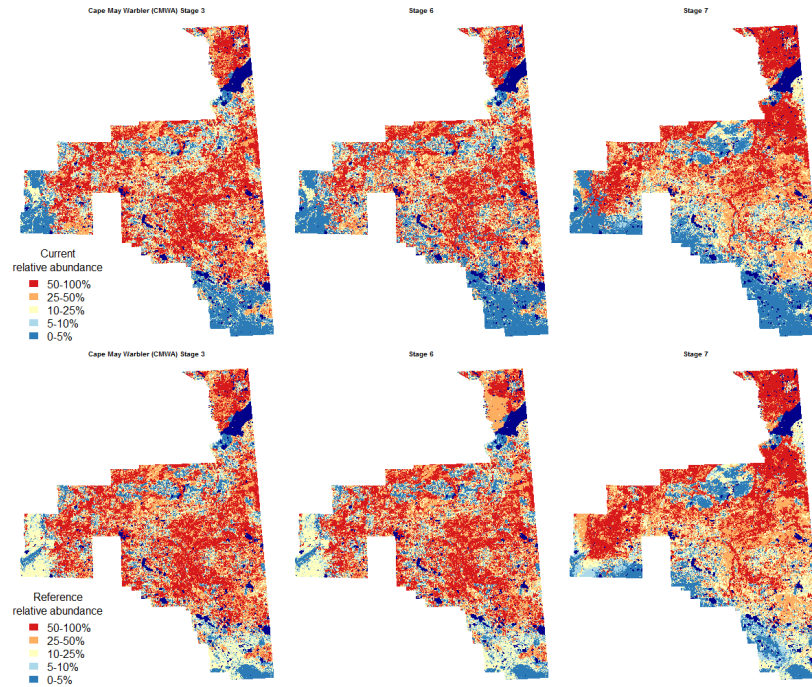
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.17.9 Maps



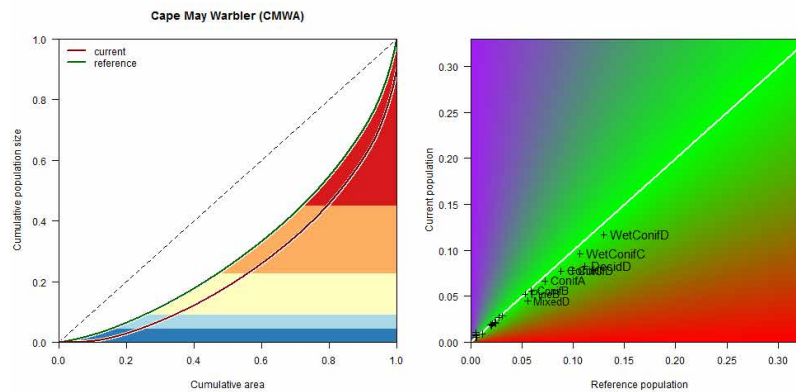
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.17.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.17.11 Population concentration



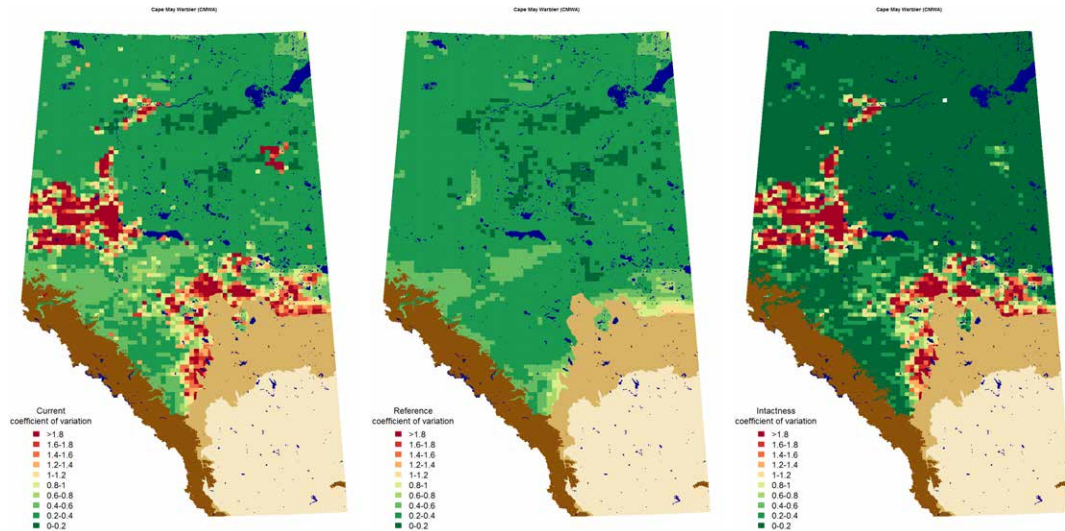
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.17.12 Potential population size

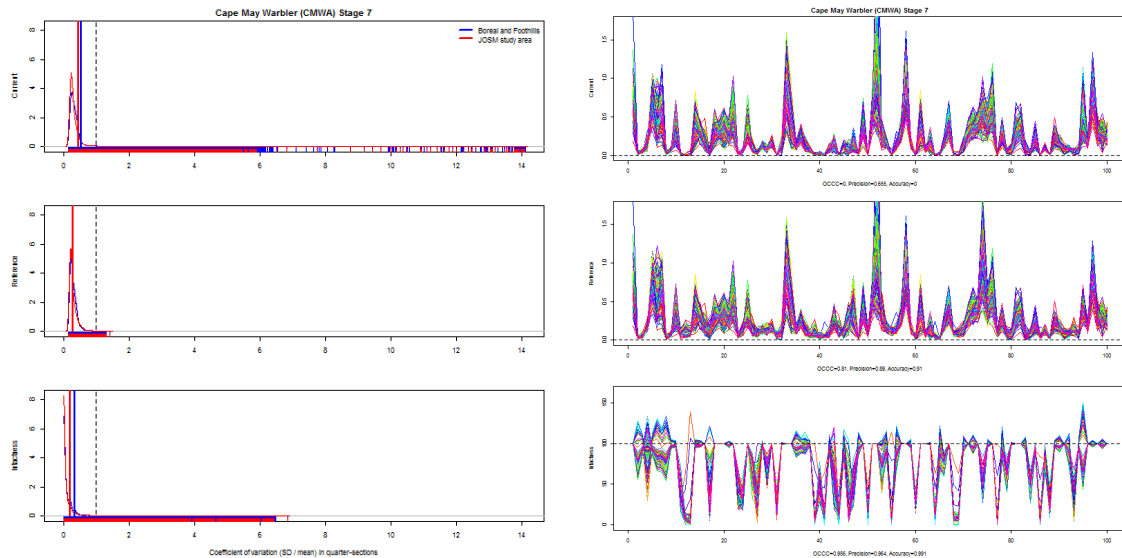
Estimated potential population size of Cape May Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.4098	0.3353	0.5633	0.4586	0.3710	0.6130
DecidD	0.2895	0.2369	0.3979	0.3934	0.3182	0.5258
WetConifC	0.3376	0.2763	0.4641	0.3766	0.3047	0.5033
ConifD	0.2728	0.2232	0.3750	0.3492	0.2825	0.4667
ConifC	0.2713	0.2220	0.3730	0.3116	0.2521	0.4165
ConifA	0.2333	0.1909	0.3207	0.2550	0.2063	0.3409
ConifB	0.1953	0.1598	0.2685	0.2095	0.1695	0.2800
MixedD	0.1574	0.1288	0.2164	0.1972	0.1596	0.2636
PineB	0.1845	0.1510	0.2536	0.1870	0.1513	0.2500
PineC	0.0996	0.0815	0.1370	0.1088	0.0880	0.1454
WetConifB	0.0941	0.0770	0.1293	0.0984	0.0796	0.1315
Shrub	0.0718	0.0588	0.0987	0.0872	0.0706	0.1166
PineD	0.0763	0.0625	0.1049	0.0851	0.0689	0.1138
WetConifA	0.0749	0.0612	0.1029	0.0823	0.0666	0.1100
Wet	0.0706	0.0577	0.0970	0.0755	0.0611	0.1010
DecidC	0.0618	0.0506	0.0850	0.0735	0.0595	0.0983
PineA	0.0668	0.0546	0.0918	0.0687	0.0556	0.0919
DecidB	0.0325	0.0266	0.0447	0.0399	0.0323	0.0533
MixedB	0.0182	0.0149	0.0251	0.0198	0.0160	0.0264
MixedC	0.0115	0.0094	0.0158	0.0130	0.0105	0.0173
DecidA	0.0088	0.0072	0.0120	0.0125	0.0101	0.0167
MixedA	0.0092	0.0075	0.0126	0.0123	0.0099	0.0164
Grass	0.0060	0.0049	0.0083	0.0119	0.0096	0.0159
Cult	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
UrbInd	0.0284	0.0232	0.0390	0.0000	0.0000	0.0000
HardLin	0.0003	0.0002	0.0004	0.0000	0.0000	0.0000
SoftLin	0.0254	0.0208	0.0349	0.0000	0.0000	0.0000
HFor	0.0368	0.0301	0.0506	0.0000	0.0000	0.0000
Total	3.1446	2.5730	4.3224	3.5268	2.8533	4.7143
Loss	0.3525	0.2397	0.5561			
Gain	0.0010	0.0001	0.1067			

5.17.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.17.14 Variable selection frequencies

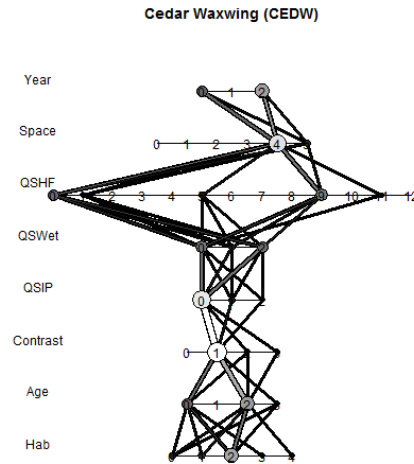
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	26.0	52	. + Habitat
1.2	2.0	4	. + HabitatB
1.3	64.5	129	. + Habitat + isHForC
1.4	7.5	15	. + HabitatB + isHForC
2.0	70.5	141	NULL
2.1	7.5	15	. + Age
2.2	22.0	44	. + Age + Age2
3.1	53.5	107	. + ROAD
3.2	17.5	35	. + SoftLin_PC
3.3	29.0	58	. + ROAD + SoftLin_PC
4.0	86.0	172	NULL
4.1	14.0	28	. + Remn_QS
5.0	81.5	163	NULL
5.1	18.5	37	. + pWet_QS
6.1	65.0	130	. + THF_QS
6.4	7.0	14	. + Succ_QS + Noncult_QS + Cult_QS
6.5	14.0	28	. + THF_QS + THF2_QS
6.6	8.5	17	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.9	4.0	8	. + Succ_QS + Alien_QS + Alien2_QS
6.10	1.5	3	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
7.1	82.5	165	. + xlat
7.2	5.0	10	. + xlat + xlong
7.4	12.0	24	. + xMAP + xPET + xMAT + xCMD
7.5	0.5	1	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	100.0	200	. + xYEAR

5.18 Cedar Waxwing (*Bombycilla cedrorum*)

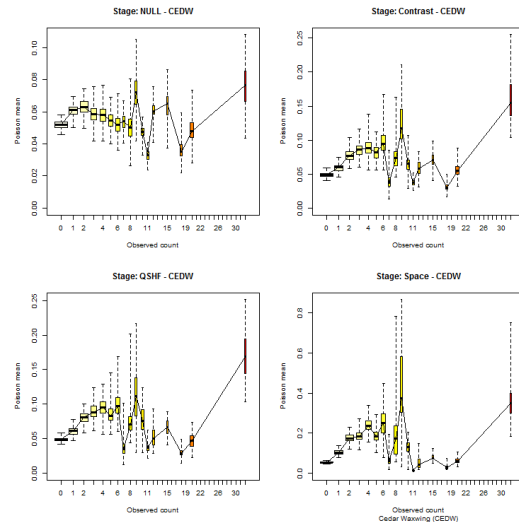
5.18.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

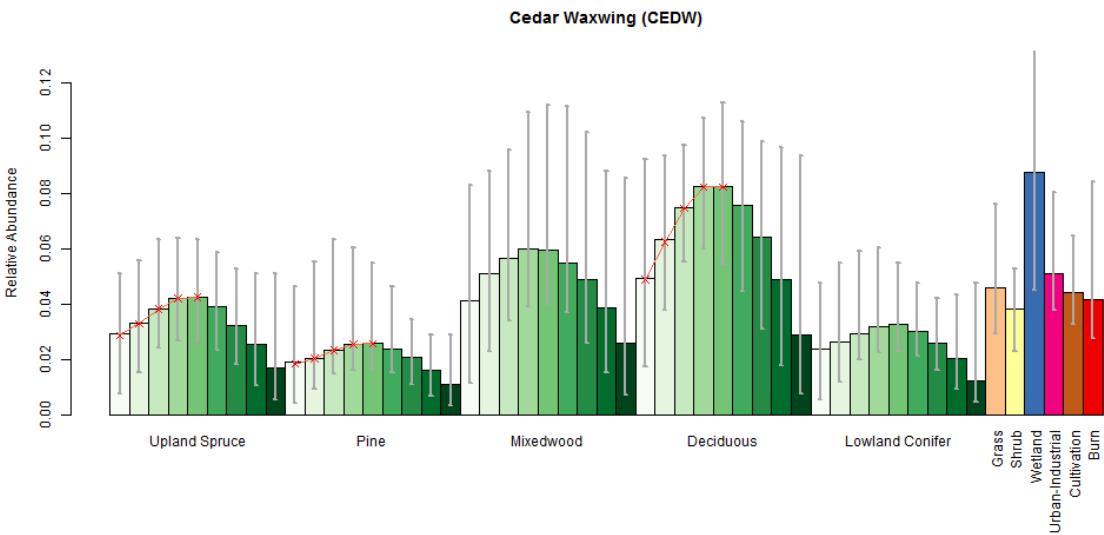


5.18.2 Cross validation

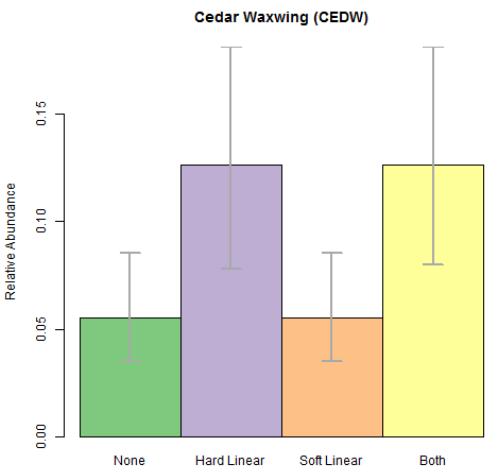
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.18.3 Point level habitat associations

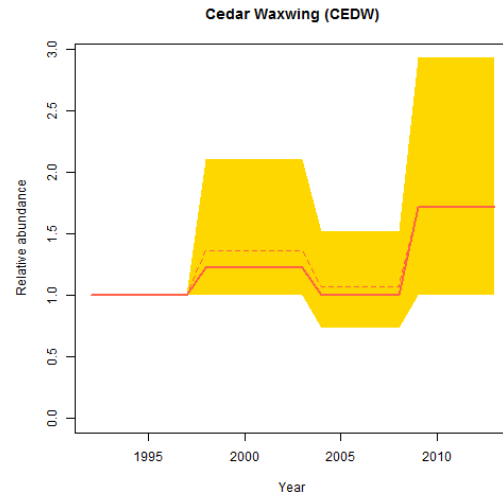


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

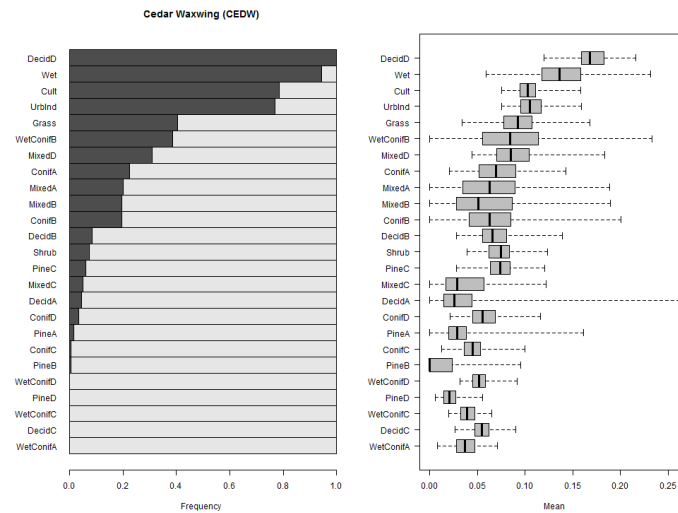


5.18.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



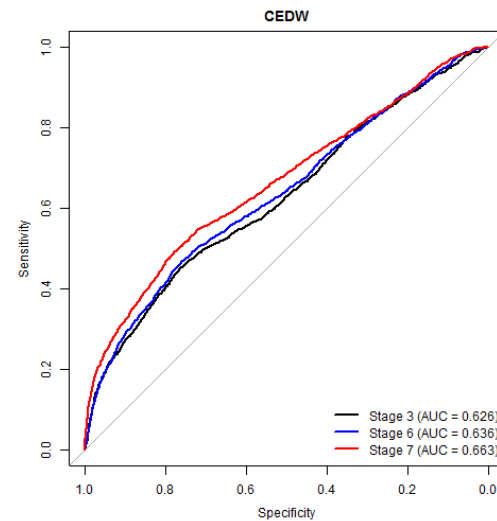
5.18.5 Habitat suitability ranking for patch delineation



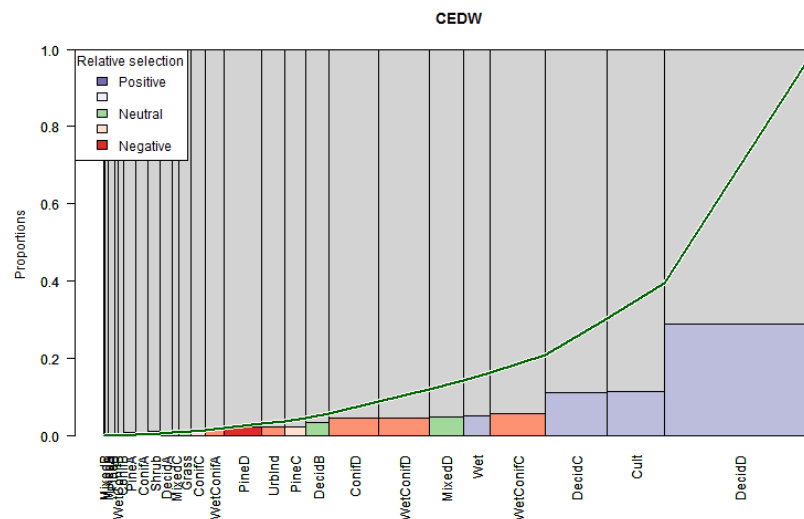
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.18.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

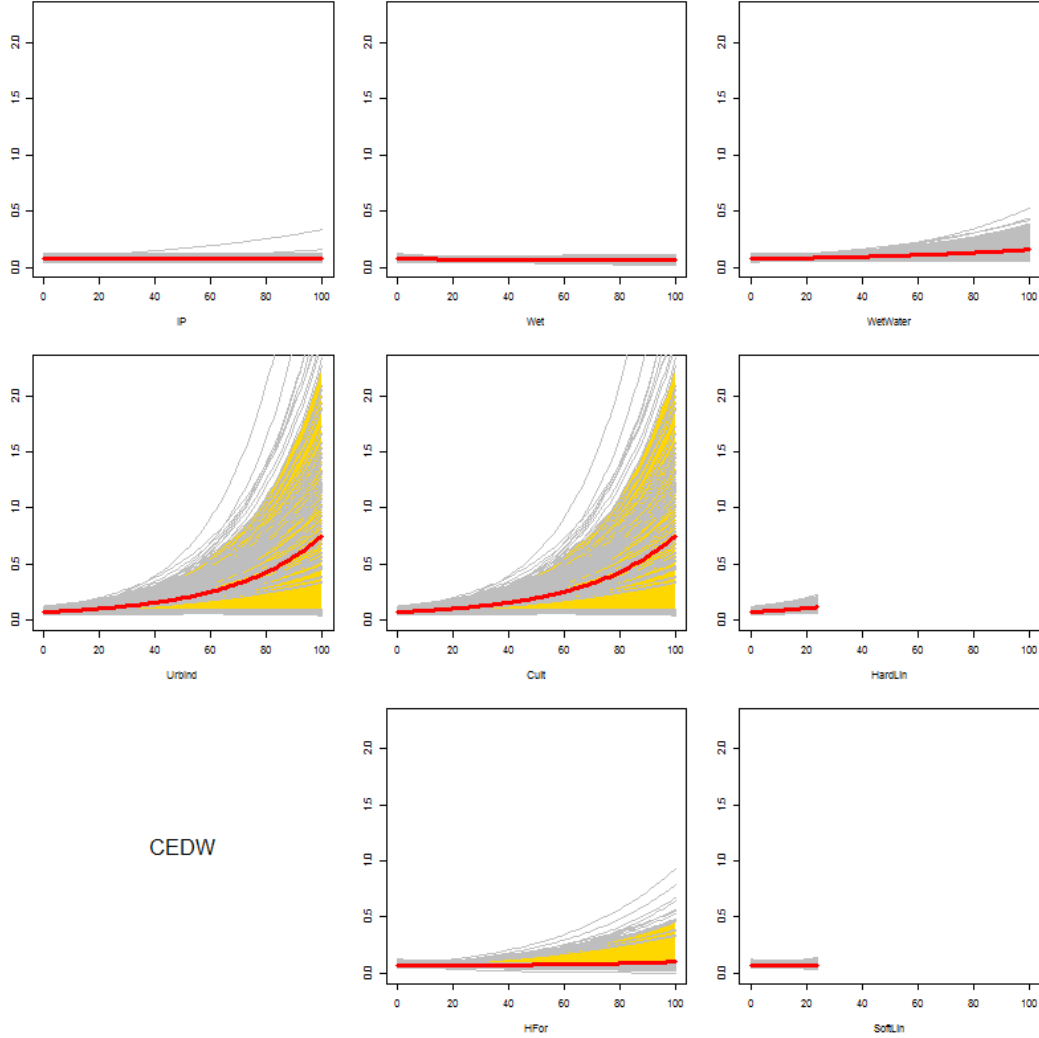


5.18.7 Relative habitat selection



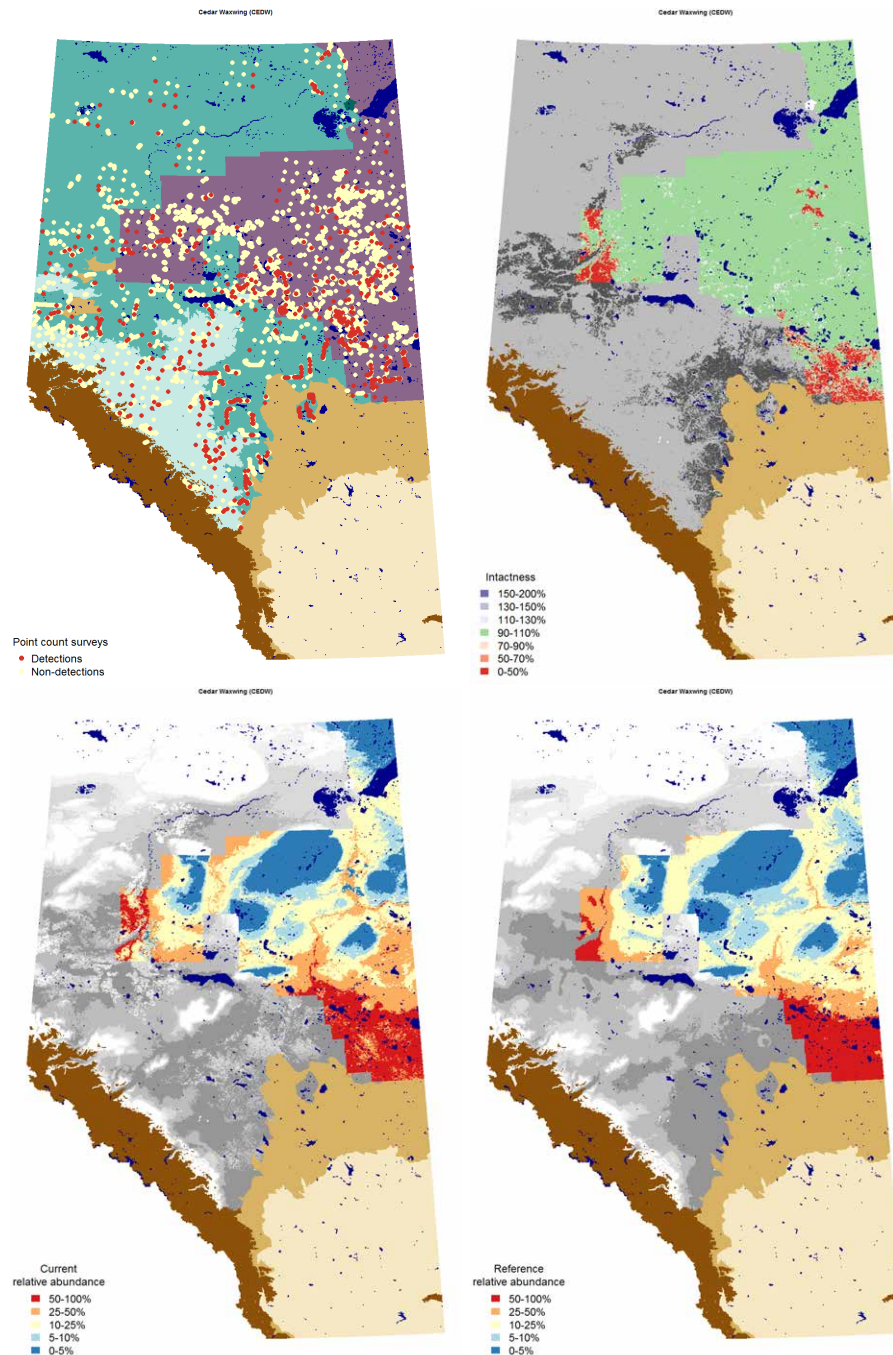
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.18.8 Quarter-section level responses



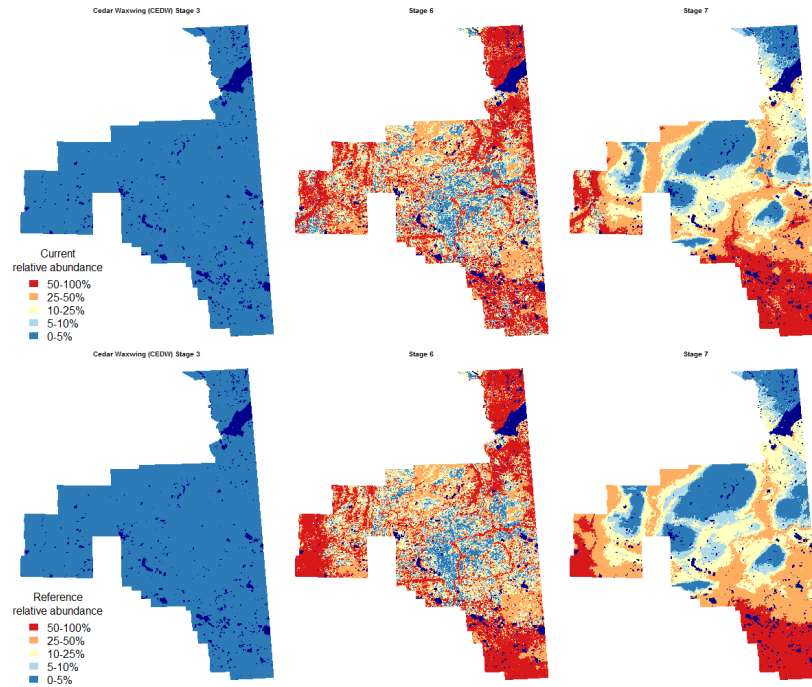
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.18.9 Maps



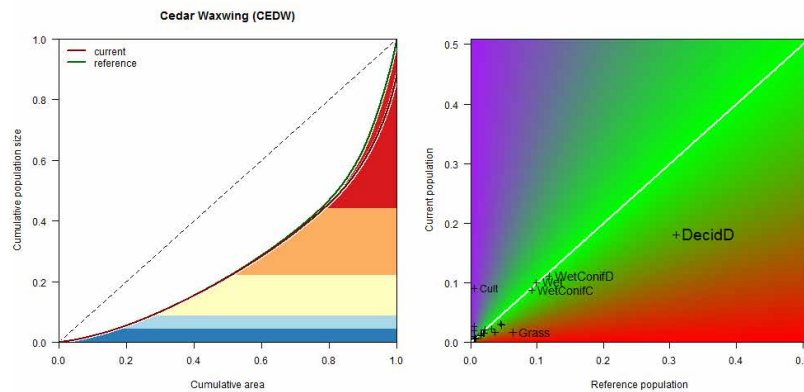
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.18.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.18.11 Population concentration



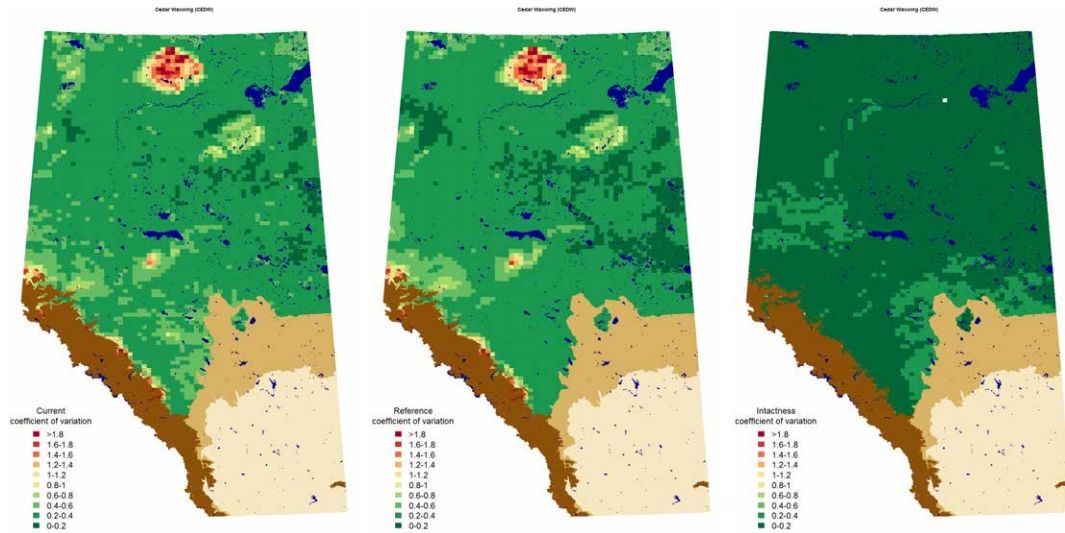
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.18.12 Potential population size

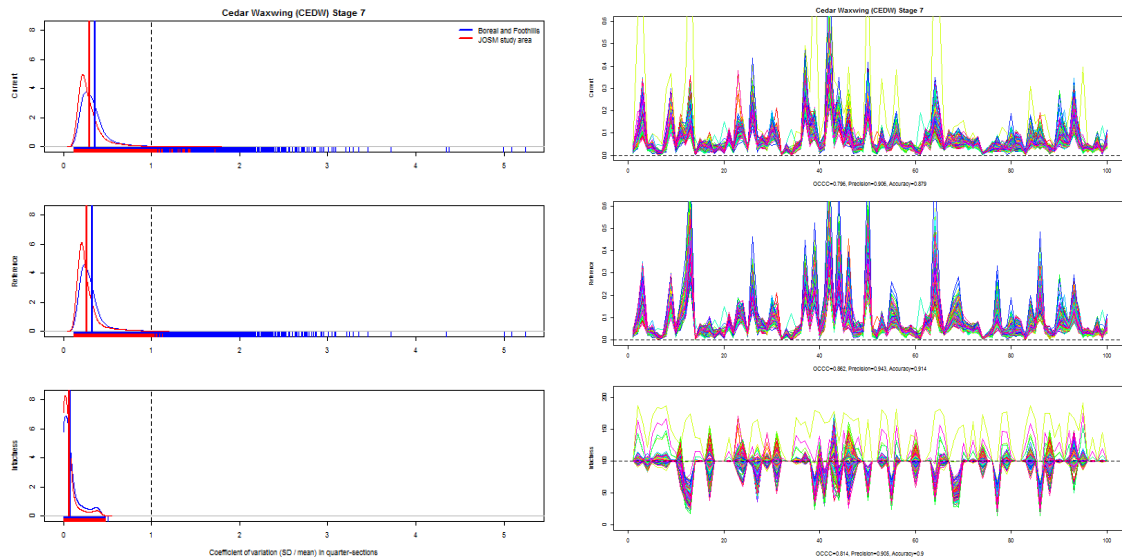
Estimated potential population size of Cedar Waxwing in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1887	0.1534	0.2285	0.3217	0.2628	0.4091
WetConifD	0.1165	0.0947	0.1411	0.1225	0.1000	0.1557
Wet	0.1050	0.0853	0.1272	0.1031	0.0842	0.1311
WetConifC	0.0913	0.0742	0.1106	0.0963	0.0787	0.1225
Grass	0.0171	0.0139	0.0207	0.0662	0.0540	0.0841
DecidC	0.0308	0.0251	0.0374	0.0487	0.0398	0.0620
MixedD	0.0327	0.0265	0.0396	0.0468	0.0383	0.0596
Shrub	0.0170	0.0138	0.0205	0.0376	0.0307	0.0478
ConifD	0.0235	0.0191	0.0285	0.0333	0.0272	0.0424
PineB	0.0222	0.0180	0.0268	0.0223	0.0183	0.0284
ConifC	0.0155	0.0126	0.0188	0.0215	0.0176	0.0273
PineC	0.0161	0.0131	0.0195	0.0196	0.0160	0.0249
WetConifB	0.0166	0.0135	0.0201	0.0171	0.0139	0.0217
WetConifA	0.0162	0.0131	0.0196	0.0167	0.0136	0.0212
PineD	0.0131	0.0107	0.0159	0.0162	0.0132	0.0206
DecidB	0.0112	0.0091	0.0136	0.0161	0.0132	0.0205
ConifA	0.0072	0.0058	0.0087	0.0087	0.0071	0.0111
ConifB	0.0064	0.0052	0.0078	0.0075	0.0061	0.0095
PineA	0.0065	0.0053	0.0079	0.0068	0.0055	0.0086
DecidA	0.0025	0.0021	0.0031	0.0049	0.0040	0.0063
MixedC	0.0014	0.0011	0.0016	0.0020	0.0017	0.0026
MixedA	0.0013	0.0010	0.0015	0.0019	0.0016	0.0024
MixedB	0.0014	0.0011	0.0017	0.0017	0.0014	0.0022
Cult	0.0947	0.0770	0.1147	0.0000	0.0000	0.0000
UrbInd	0.0103	0.0084	0.0125	0.0000	0.0000	0.0000
HardLin	0.0041	0.0033	0.0050	0.0000	0.0000	0.0000
SoftLin	0.0204	0.0166	0.0247	0.0000	0.0000	0.0000
HFor	0.0276	0.0224	0.0334	0.0000	0.0000	0.0000
Total	0.9170	0.7455	1.1108	1.0393	0.8490	1.3216
Loss	0.1240	0.0649	0.2754			
Gain	0.0054	0.0010	0.0270			

5.18.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.18.14 Variable selection frequencies

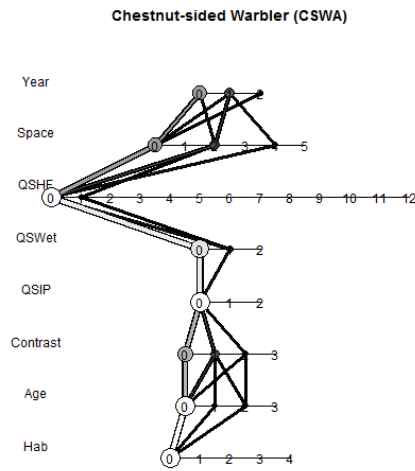
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	11.5	23	NULL
1.1	19.5	39	. + Habitat
1.2	64.0	128	. + HabitatB
1.3	3.0	6	. + Habitat + isHForC
1.4	2.0	4	. + HabitatB + isHForC
2.0	39.0	78	NULL
2.2	59.5	119	. + Age + Age2
2.3	1.5	3	. + Age + Age2 + Age:isMix + Age:isPine
			+ Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
3.1	97.5	195	. + ROAD
3.2	2.0	4	. + SoftLin_PC
3.3	0.5	1	. + ROAD + SoftLin_PC
4.0	88.5	177	NULL
4.1	10.5	21	. + Remn_QS
4.2	1.0	2	. + Remn_QS + Remn2_QS
5.0	45.5	91	NULL
5.1	12.5	25	. + pWet_QS
5.2	42.0	84	. + pWetWater_QS
6.0	41.0	82	NULL
6.1	2.0	4	. + THF_QS
6.5	9.5	19	. + THF_QS + THF2_QS
6.9	47.0	94	. + Succ_QS + Alien_QS + Alien2_QS
6.11	0.5	1	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.4	85.5	171	. + xMAP + xPET + xMAT + xCMD
7.5	14.5	29	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	38.5	77	NULL
8.2	61.5	123	. + YR5F

5.19 Chestnut-sided Warbler (*Setophaga pensylvanica*)

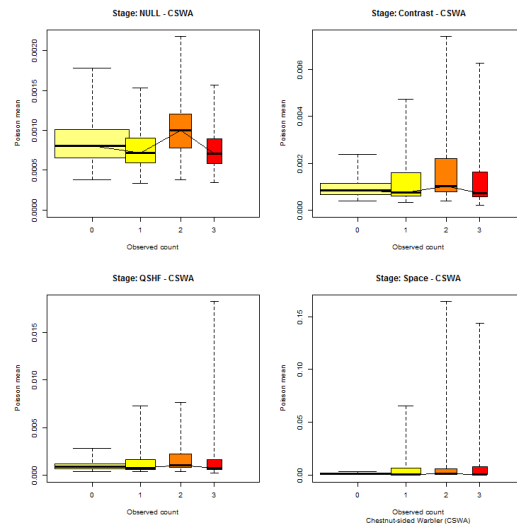
5.19.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

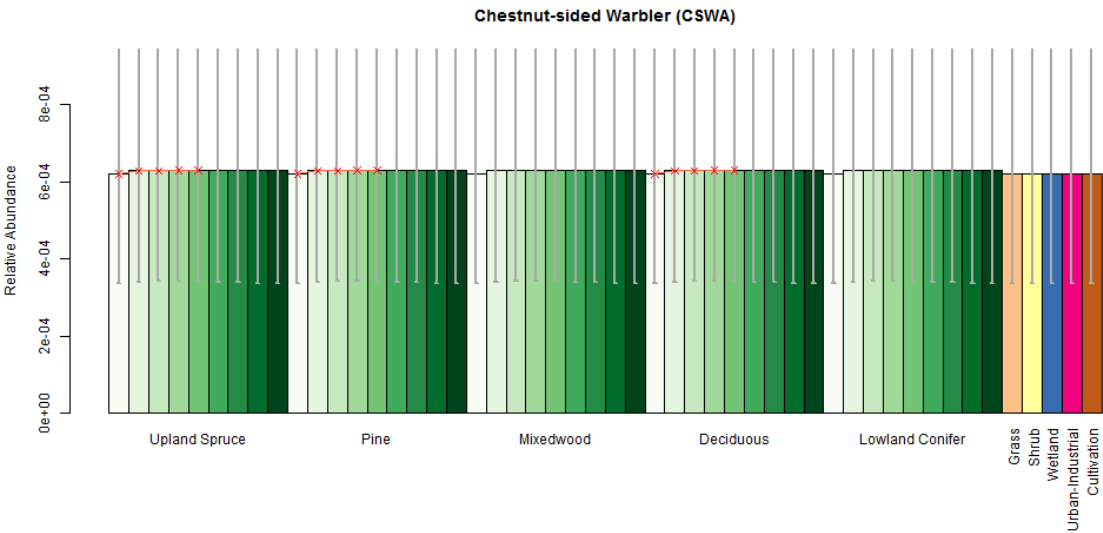


5.19.2 Cross validation

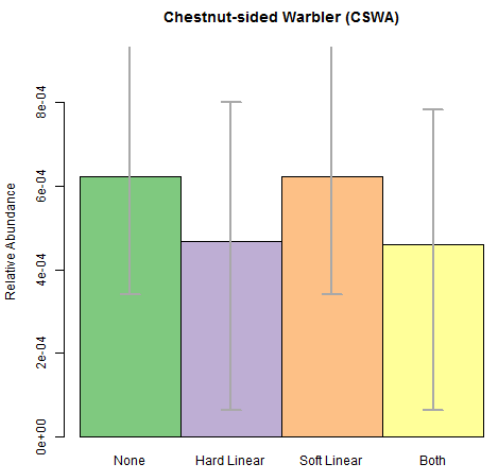
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.19.3 Point level habitat associations

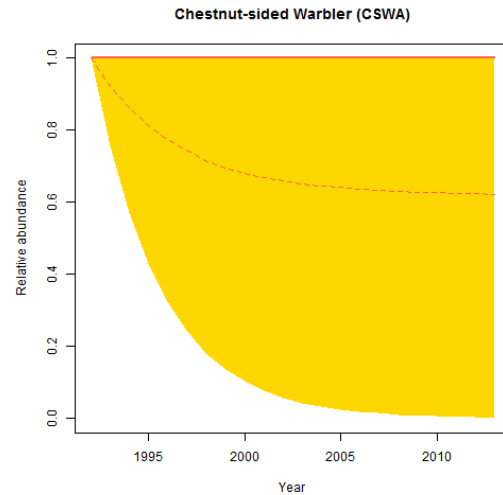


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

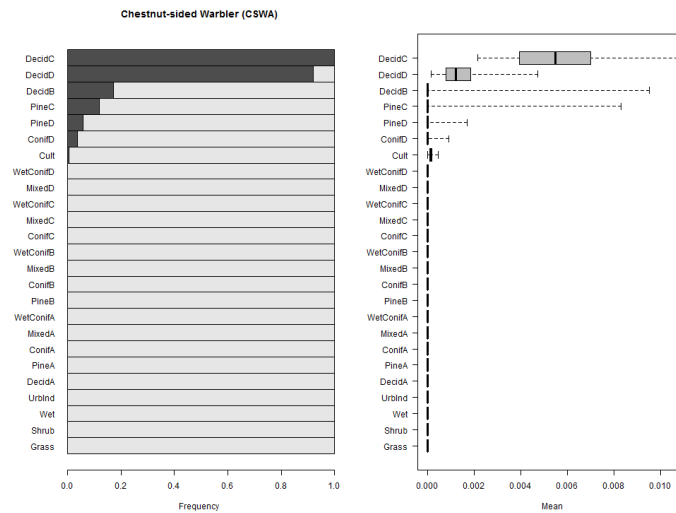


5.19.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



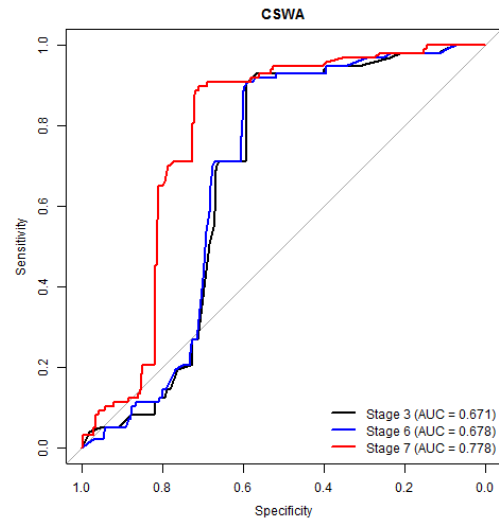
5.19.5 Habitat suitability ranking for patch delineation



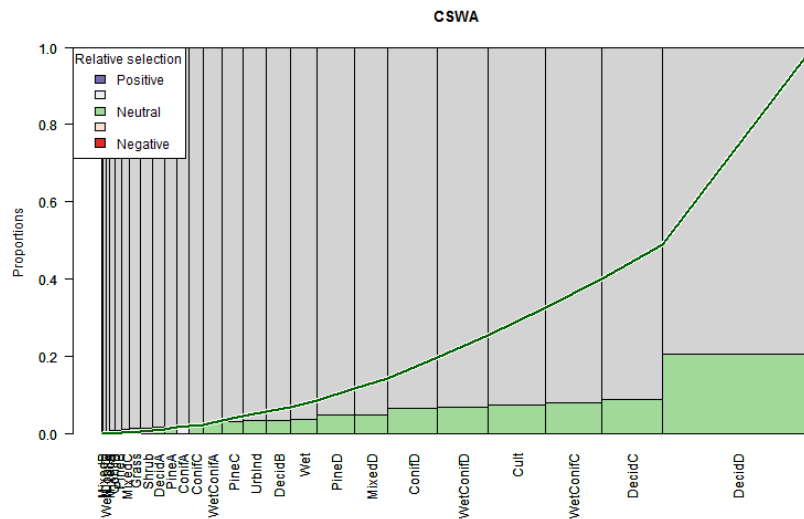
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.19.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

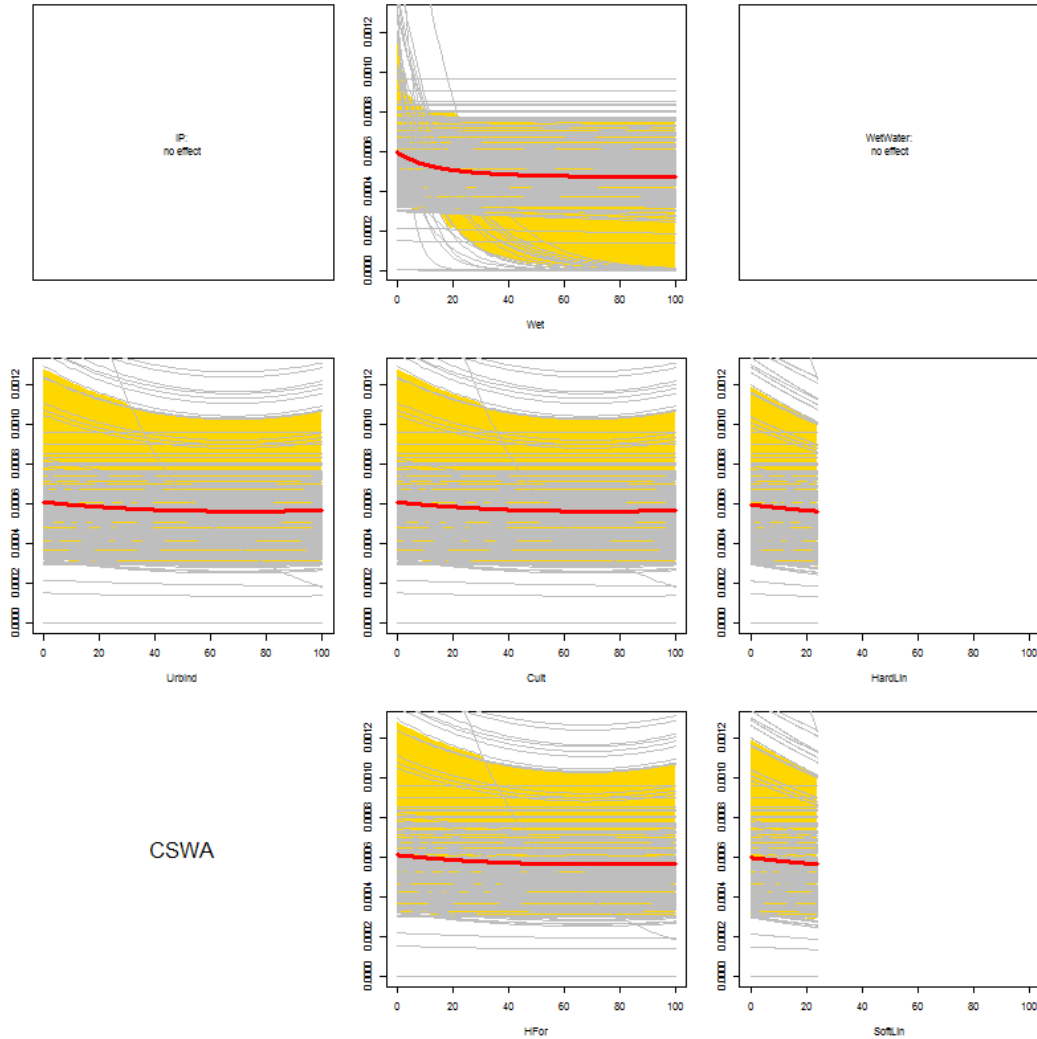


5.19.7 Relative habitat selection



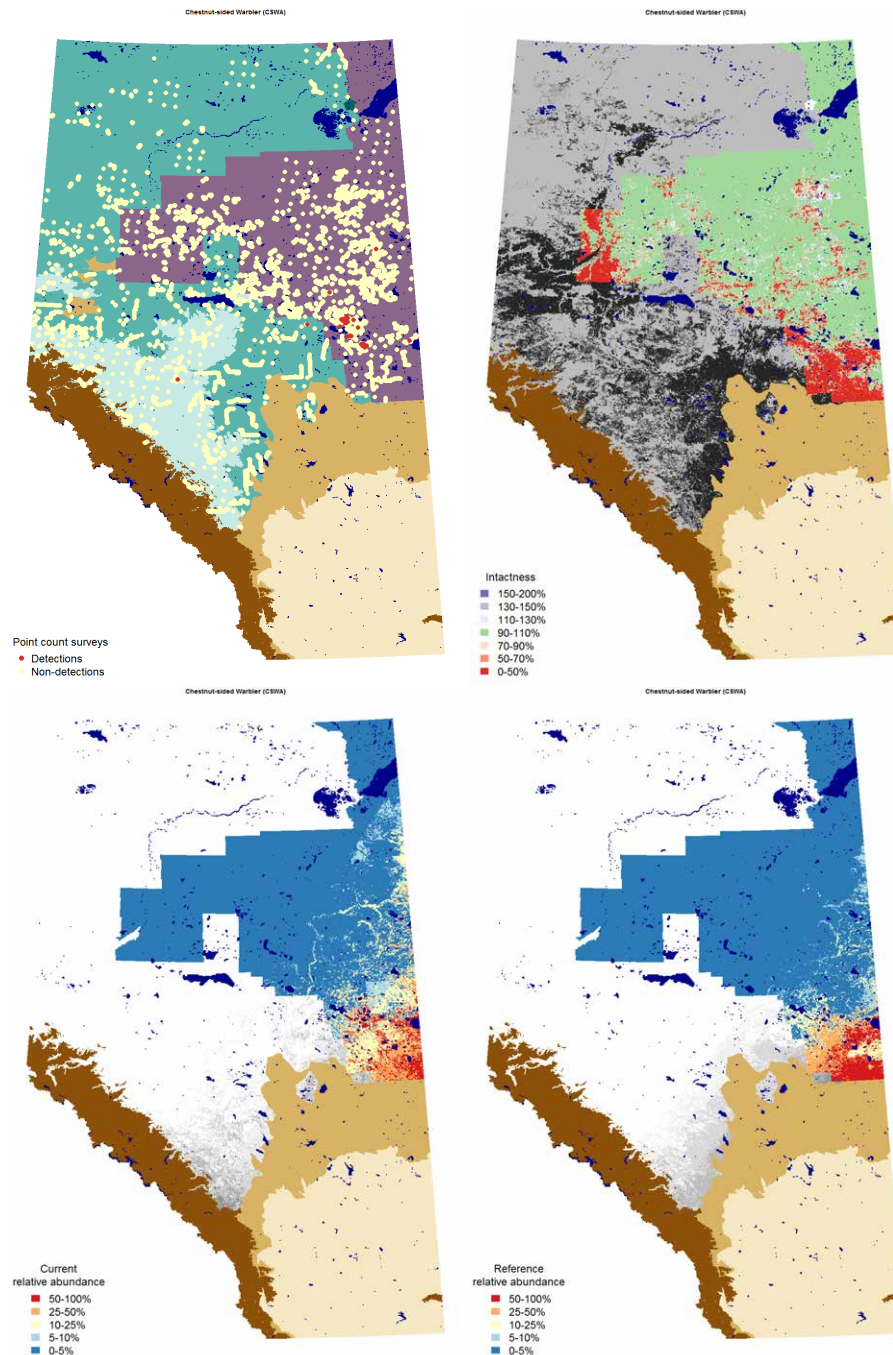
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.19.8 Quarter-section level responses



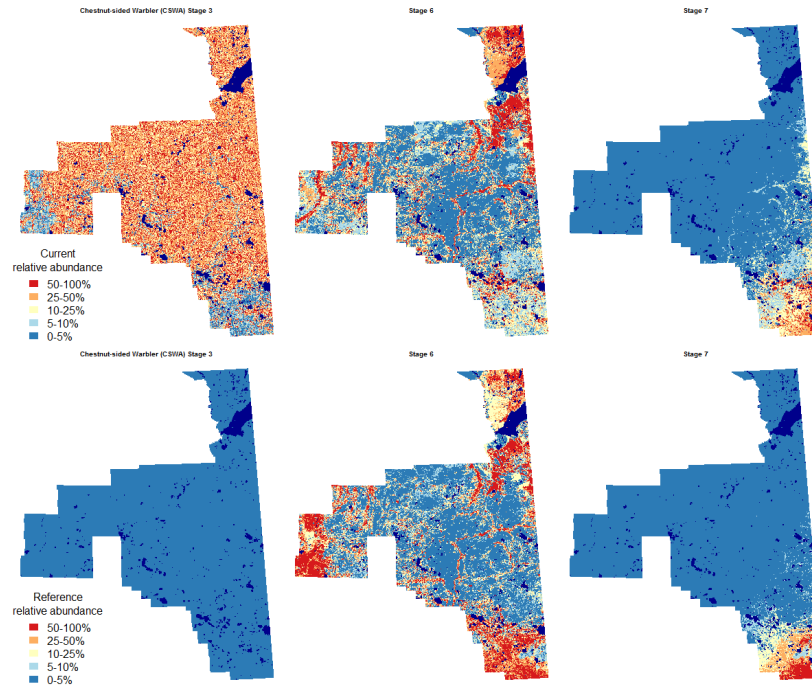
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.19.9 Maps



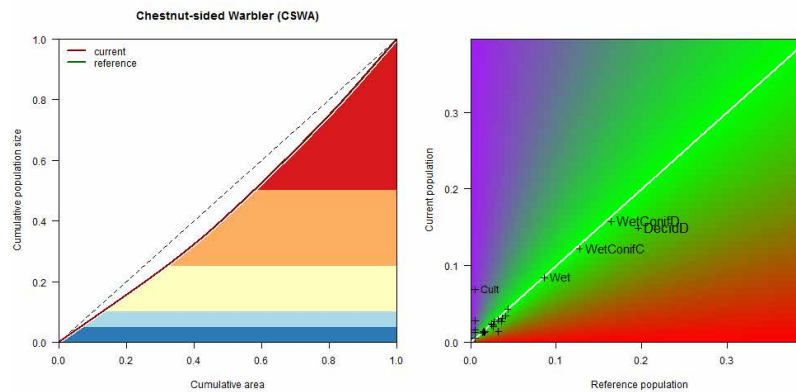
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.19.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.19.11 Population concentration



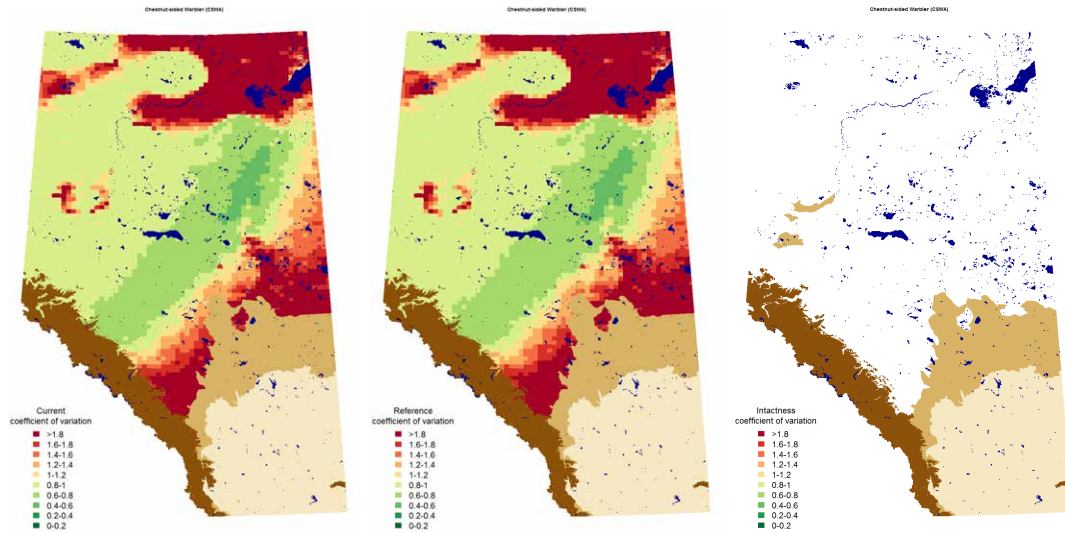
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.19.12 Potential population size

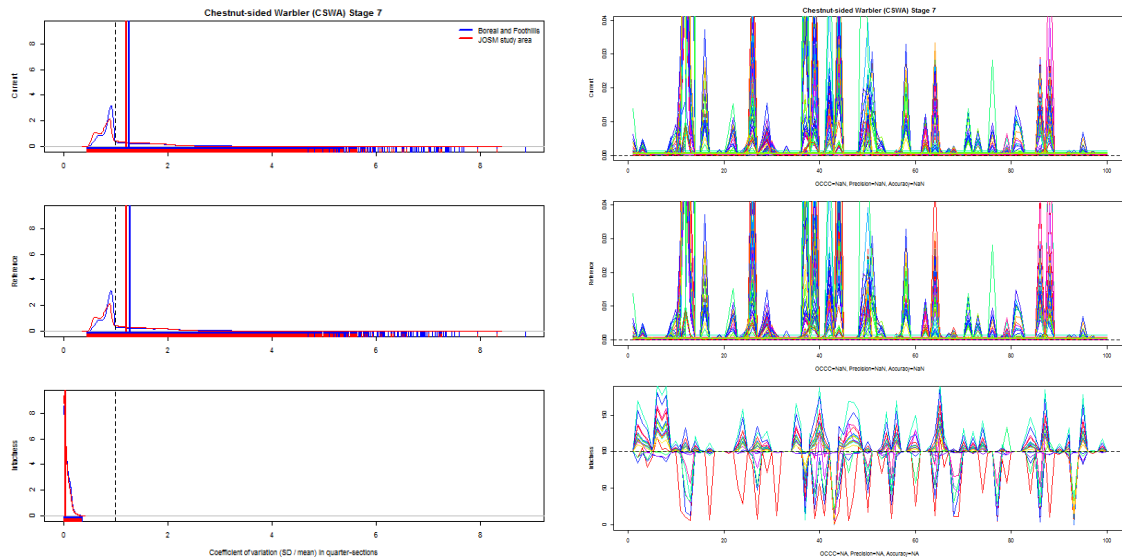
Estimated potential population size of Chestnut-sided Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0015	0.0008	0.0172	0.0020	0.0011	0.0231
WetConifD	0.0016	0.0009	0.0181	0.0017	0.0009	0.0194
WetConifC	0.0012	0.0007	0.0140	0.0013	0.0007	0.0150
Wet	0.0009	0.0005	0.0097	0.0009	0.0005	0.0102
PineB	0.0004	0.0002	0.0050	0.0004	0.0002	0.0051
ConifD	0.0003	0.0002	0.0039	0.0004	0.0002	0.0048
MixedD	0.0003	0.0002	0.0036	0.0004	0.0002	0.0044
Shrub	0.0003	0.0002	0.0031	0.0004	0.0002	0.0043
Grass	0.0001	0.0001	0.0016	0.0003	0.0002	0.0039
PineC	0.0003	0.0002	0.0034	0.0003	0.0002	0.0038
WetConifB	0.0003	0.0001	0.0031	0.0003	0.0002	0.0033
ConifC	0.0002	0.0001	0.0026	0.0003	0.0001	0.0031
DecidC	0.0002	0.0001	0.0023	0.0003	0.0001	0.0031
PineD	0.0002	0.0001	0.0026	0.0003	0.0001	0.0029
WetConifA	0.0002	0.0001	0.0027	0.0003	0.0001	0.0029
ConifA	0.0001	0.0001	0.0016	0.0002	0.0001	0.0020
DecidB	0.0001	0.0001	0.0015	0.0002	0.0001	0.0019
PineA	0.0001	0.0001	0.0016	0.0001	0.0001	0.0017
ConifB	0.0001	0.0001	0.0014	0.0001	0.0001	0.0016
DecidA	0.0000	0.0000	0.0004	0.0001	0.0000	0.0006
MixedB	0.0000	0.0000	0.0002	0.0000	0.0000	0.0003
MixedA	0.0000	0.0000	0.0002	0.0000	0.0000	0.0003
MixedC	0.0000	0.0000	0.0002	0.0000	0.0000	0.0002
Cult	0.0007	0.0004	0.0079	0.0000	0.0000	0.0000
UrbInd	0.0001	0.0001	0.0015	0.0000	0.0000	0.0000
HardLin	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0002	0.0001	0.0019	0.0000	0.0000	0.0000
HFor	0.0003	0.0002	0.0032	0.0000	0.0000	0.0000
Total	0.0102	0.0055	0.1148	0.0102	0.0055	0.1180
Loss	0.0000	0.0000	0.0040			
Gain	0.0000	0.0000	0.0048			

5.19.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.19.14 Variable selection frequencies

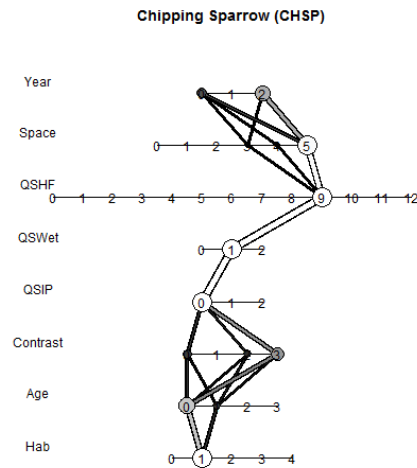
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	186	NULL
2.0	97.3	181	NULL
2.1	1.6	3	. + Age
2.2	1.1	2	. + Age + Age2
3.0	69.3	129	NULL
3.1	29.0	54	. + ROAD
3.2	1.6	3	. + SoftLin_PC
4.0	100.0	186	NULL
5.0	90.3	168	NULL
5.1	9.7	18	. + pWet_QS
6.0	99.5	185	NULL
6.1	0.5	1	. + THF_QS
7.0	61.3	114	NULL
7.2	30.6	57	. + xlat + xlong
7.4	8.1	15	. + xMAP + xPET + xMAT + xCMD
8.0	61.8	115	NULL
8.1	37.6	70	. + xYEAR
8.2	0.5	1	. + YR5F

5.20 Chipping Sparrow (*Spizella passerina*)

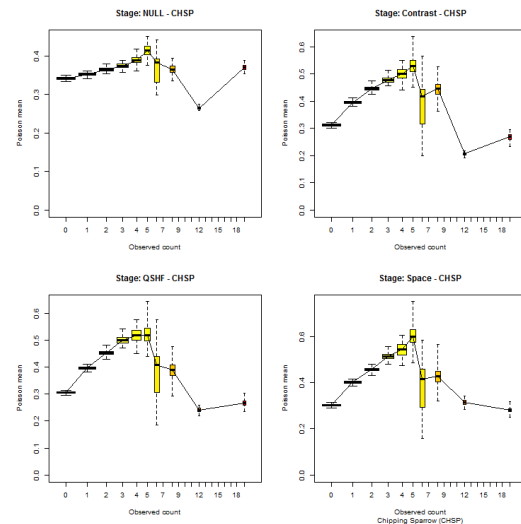
5.20.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

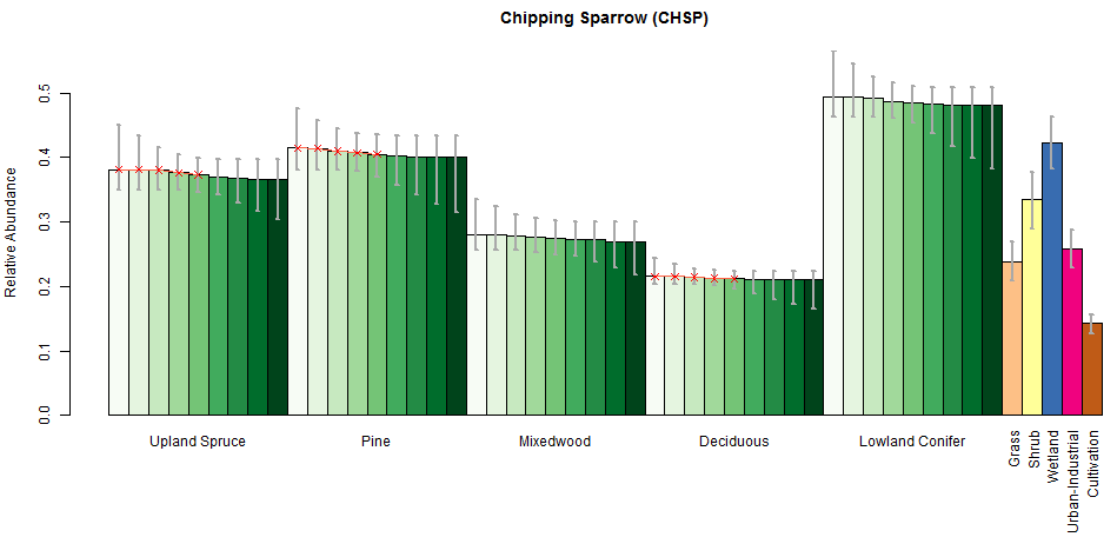


5.20.2 Cross validation

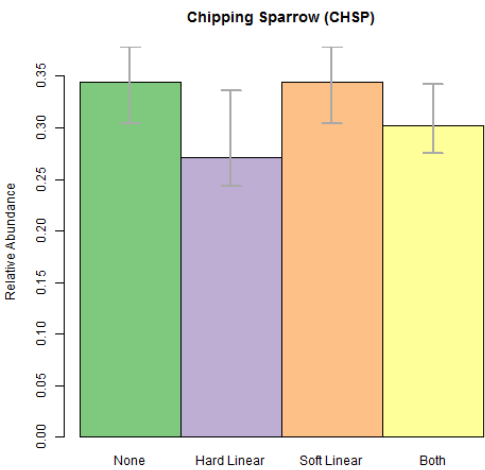
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.20.3 Point level habitat associations

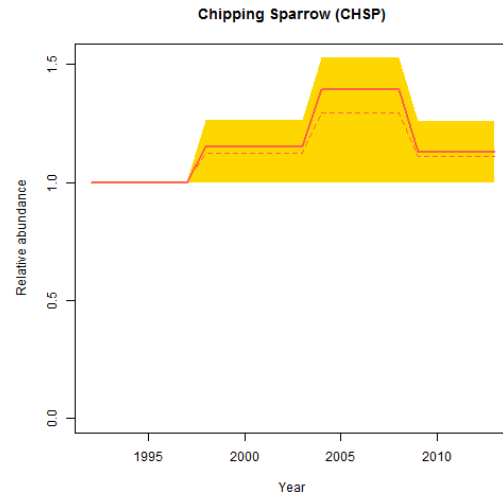


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

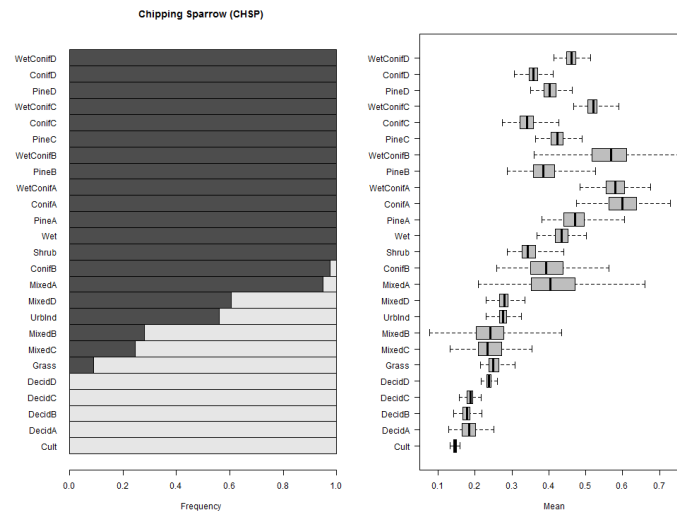


5.20.4 Year effect

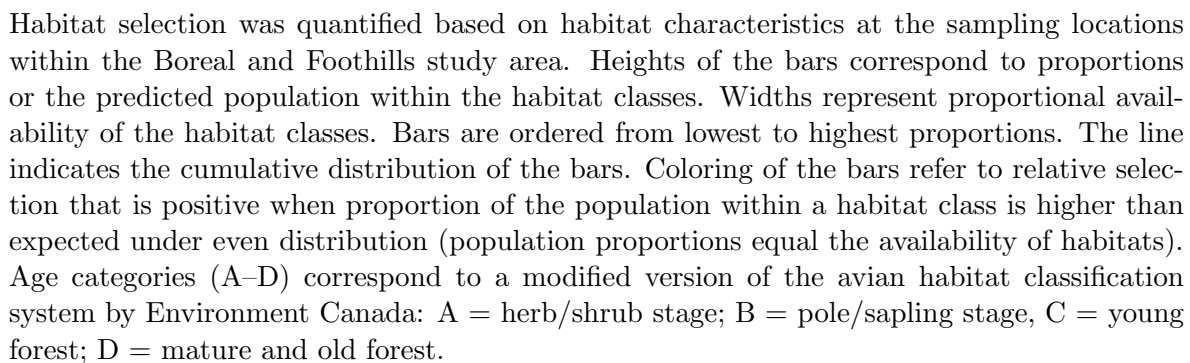
Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



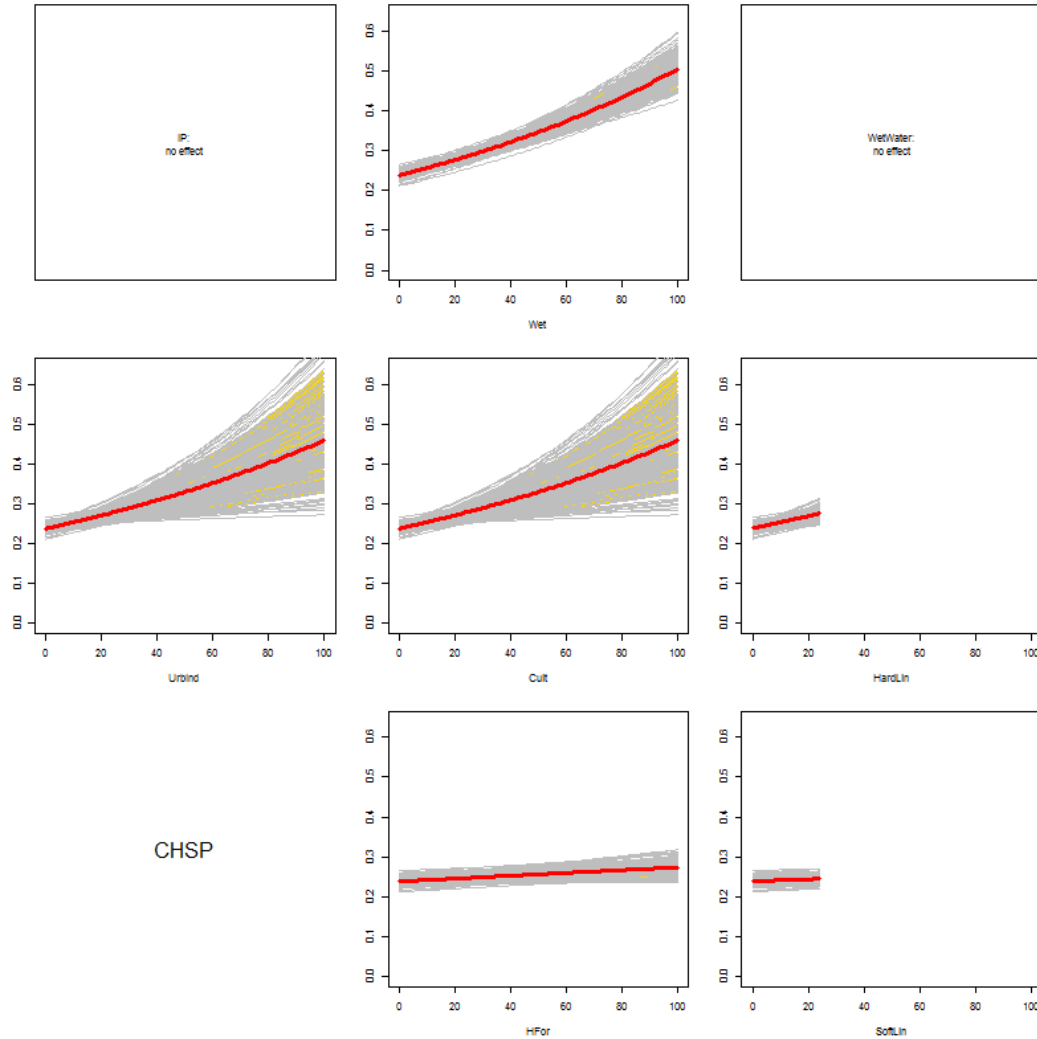
5.20.5 Habitat suitability ranking for patch delineation



Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

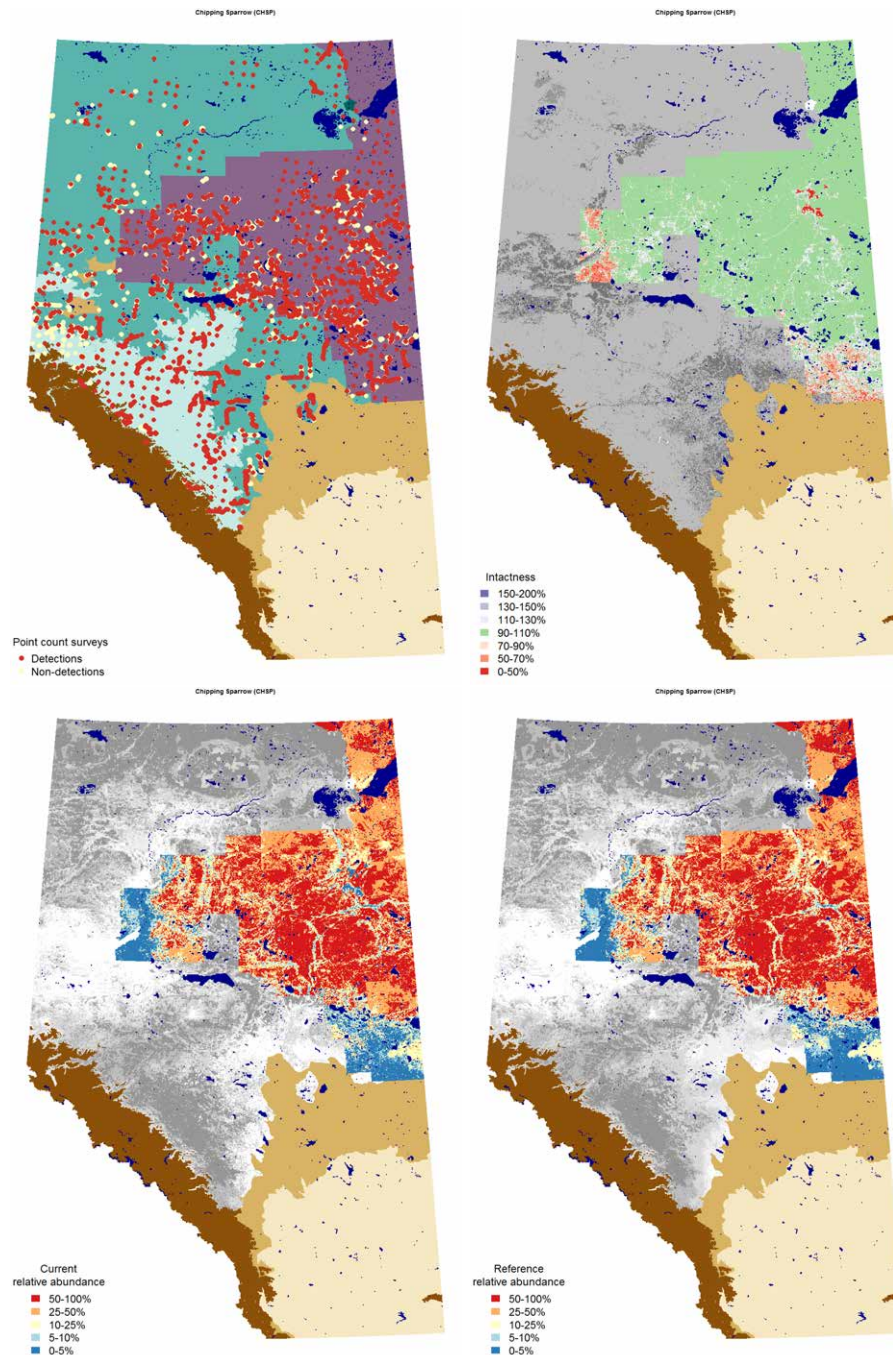


5.20.8 Quarter-section level responses



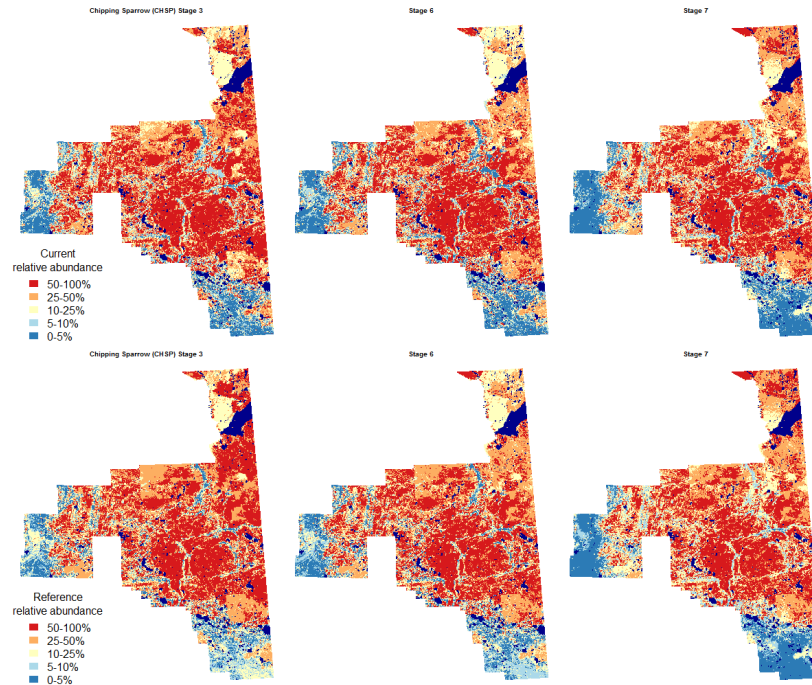
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.20.9 Maps



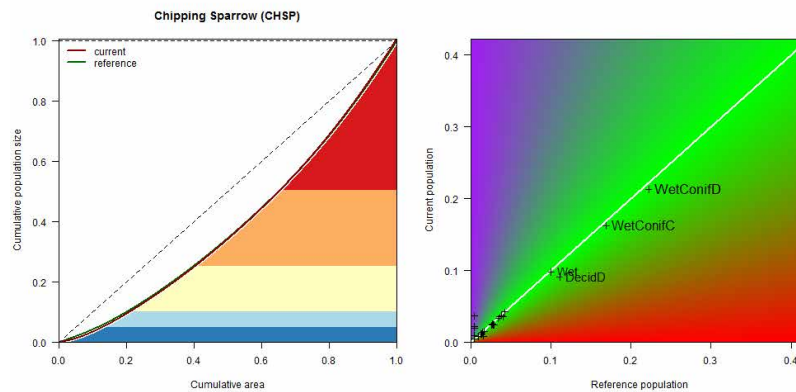
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.20.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.20.11 Population concentration



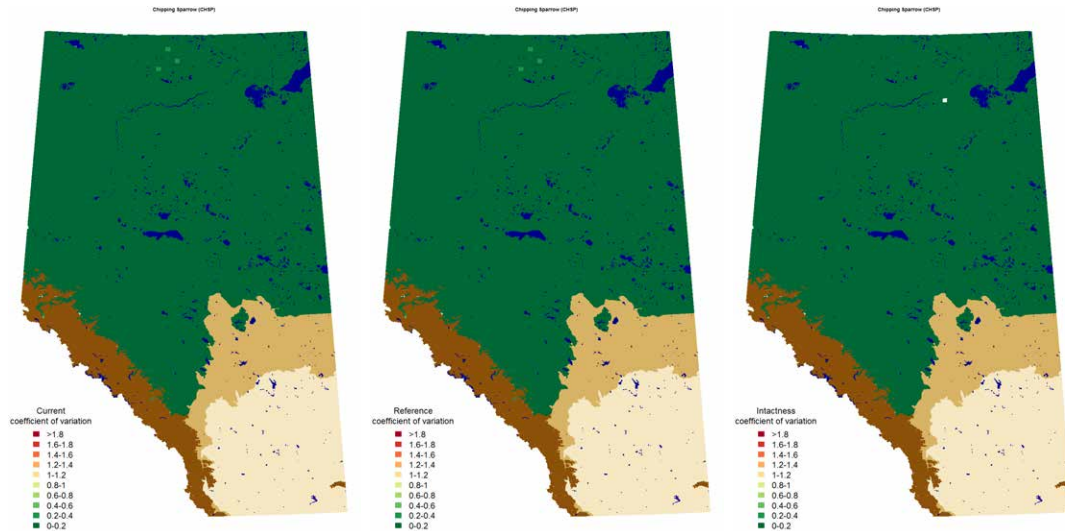
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.20.12 Potential population size

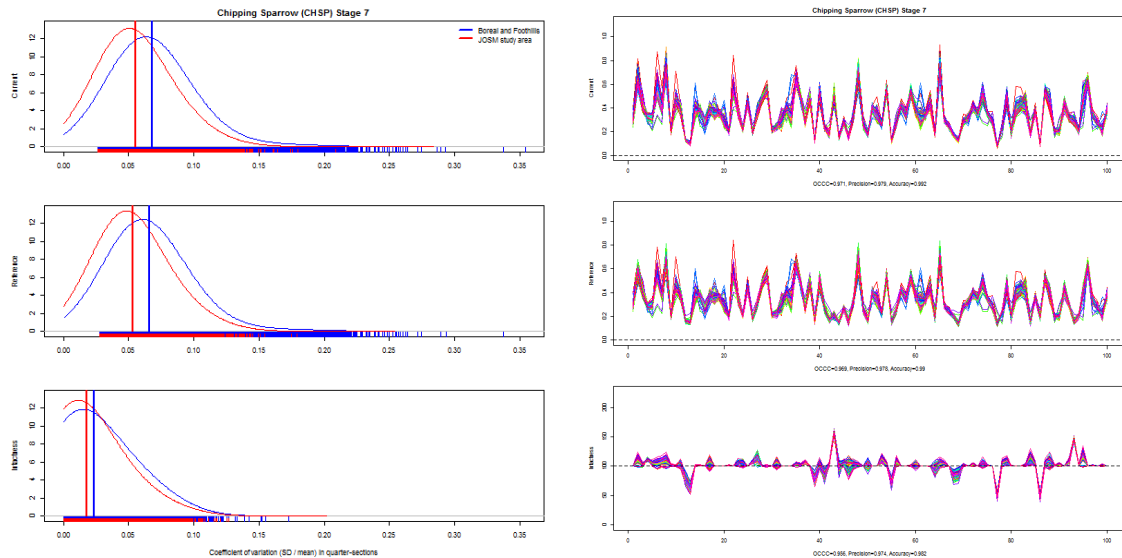
Estimated potential population size of Chipping Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	1.2735	1.2179	1.3335	1.3319	1.2675	1.3858
WetConifC	0.9705	0.9281	1.0162	1.0145	0.9654	1.0556
DecidD	0.5445	0.5207	0.5702	0.6657	0.6335	0.6926
Wet	0.5867	0.5611	0.6144	0.6030	0.5739	0.6275
PineB	0.2522	0.2412	0.2641	0.2554	0.2430	0.2657
ConifD	0.2105	0.2013	0.2204	0.2454	0.2336	0.2554
WetConifA	0.2237	0.2139	0.2342	0.2334	0.2221	0.2428
WetConifB	0.2109	0.2017	0.2209	0.2182	0.2077	0.2271
PineC	0.1968	0.1882	0.2061	0.2086	0.1985	0.2171
Shrub	0.1426	0.1364	0.1494	0.1740	0.1656	0.1810
MixedD	0.1459	0.1396	0.1528	0.1670	0.1590	0.1738
PineD	0.1532	0.1465	0.1604	0.1637	0.1558	0.1704
ConifC	0.1414	0.1352	0.1481	0.1595	0.1518	0.1660
ConifA	0.0884	0.0845	0.0926	0.1017	0.0968	0.1058
Grass	0.0518	0.0495	0.0542	0.0951	0.0905	0.0989
PineA	0.0834	0.0797	0.0873	0.0863	0.0821	0.0898
DecidC	0.0694	0.0663	0.0726	0.0856	0.0815	0.0891
ConifB	0.0678	0.0648	0.0710	0.0763	0.0726	0.0794
DecidB	0.0482	0.0461	0.0505	0.0592	0.0563	0.0616
DecidA	0.0149	0.0143	0.0156	0.0220	0.0210	0.0229
MixedA	0.0079	0.0076	0.0083	0.0109	0.0104	0.0114
MixedB	0.0095	0.0091	0.0100	0.0109	0.0103	0.0113
MixedC	0.0063	0.0060	0.0066	0.0072	0.0069	0.0075
Cult	0.1206	0.1154	0.1263	0.0000	0.0000	0.0000
UrbInd	0.0542	0.0518	0.0568	0.0000	0.0000	0.0000
HardLin	0.0051	0.0049	0.0054	0.0000	0.0000	0.0000
SoftLin	0.2182	0.2087	0.2285	0.0000	0.0000	0.0000
HFor	0.1294	0.1238	0.1355	0.0000	0.0000	0.0000
Total	6.0278	5.7643	6.3118	5.9956	5.7057	6.2385
Loss	0.0832	0.0653	0.1287			
Gain	0.1326	0.0271	0.2357			

5.20.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.20.14 Variable selection frequencies

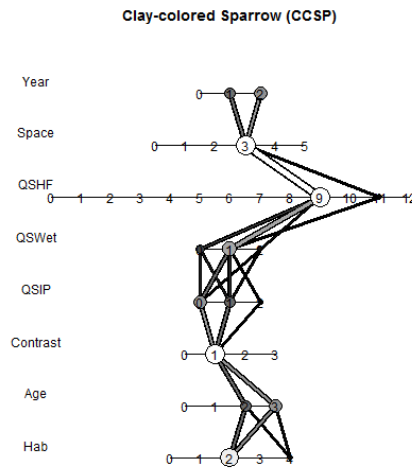
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	100.0	200	. + Habitat
2.0	78.0	156	NULL
2.1	22.0	44	. + Age
3.0	23.0	46	NULL
3.2	18.0	36	. + SoftLin_PC
3.3	59.0	118	. + ROAD + SoftLin_PC
4.0	100.0	200	NULL
5.1	100.0	200	. + pWet_QS
6.9	100.0	200	. + Succ_QS + Alien_QS + Alien2_QS
7.3	1.0	2	. + xlat + xlong + xlat:xlong
7.4	1.0	2	. + xMAP + xPET + xMAT + xCMD
7.5	98.0	196	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	31.5	63	NULL
8.2	68.5	137	. + YR5F

5.21 Clay-colored Sparrow (*Spizella pallida*)

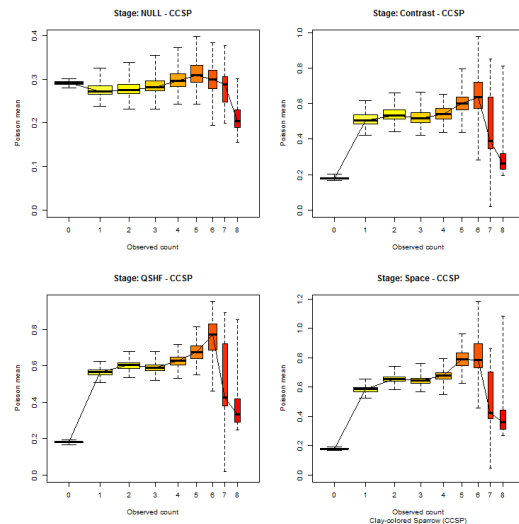
5.21.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

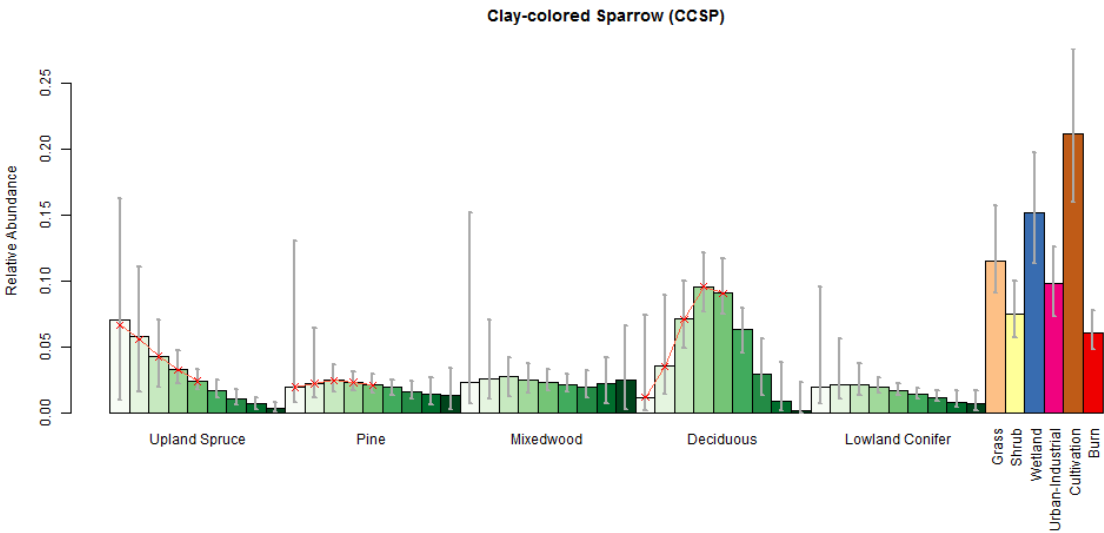


5.21.2 Cross validation

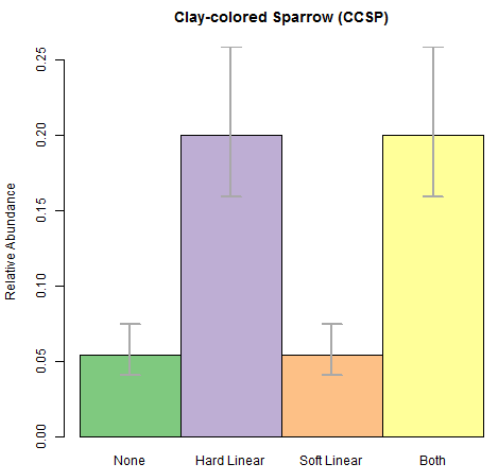
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.21.3 Point level habitat associations

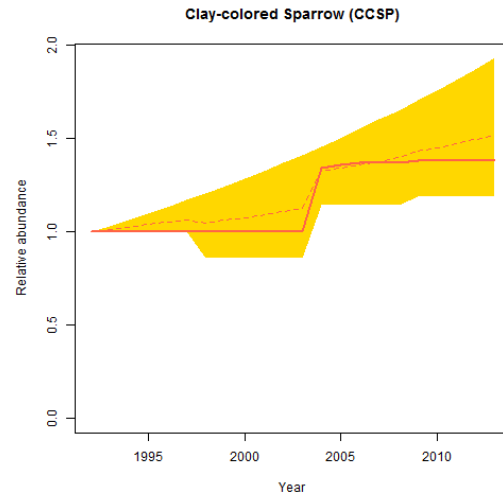


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

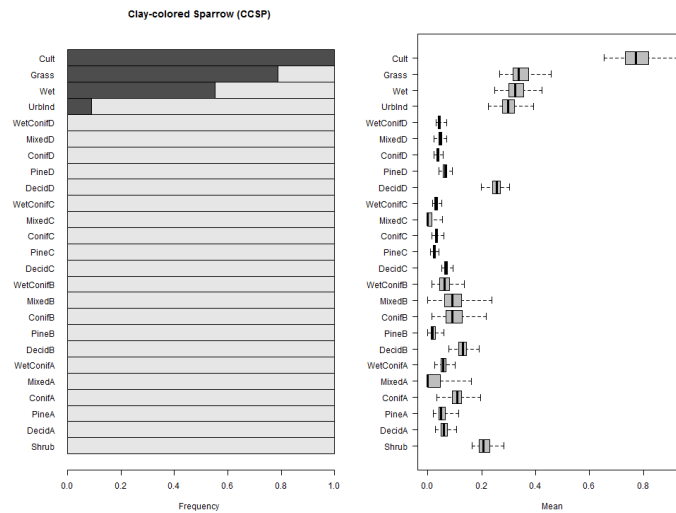


5.21.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



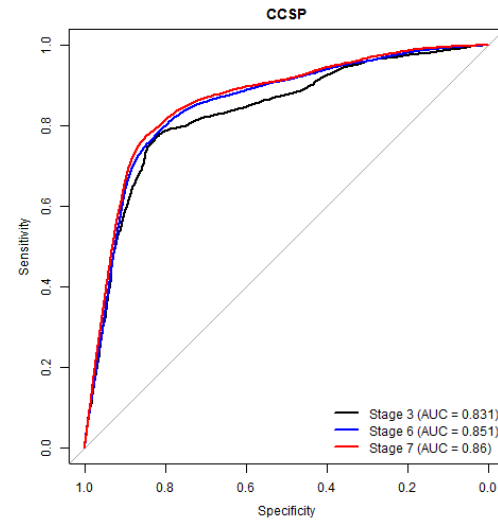
5.21.5 Habitat suitability ranking for patch delineation



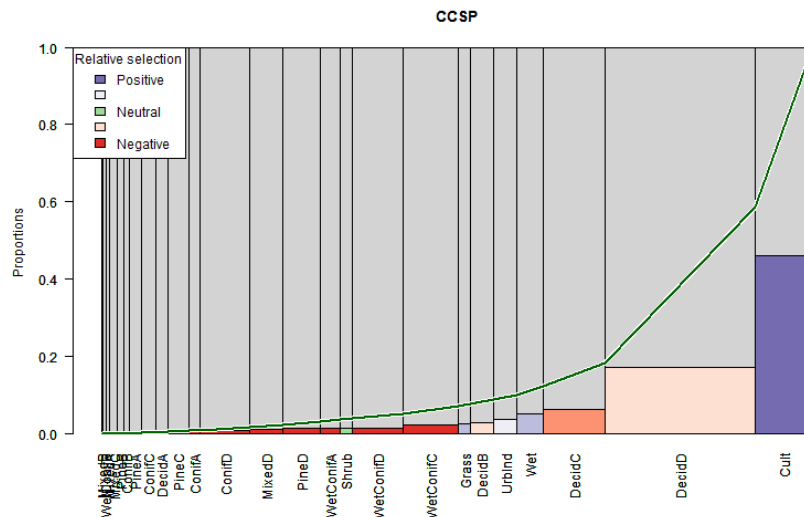
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.21.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

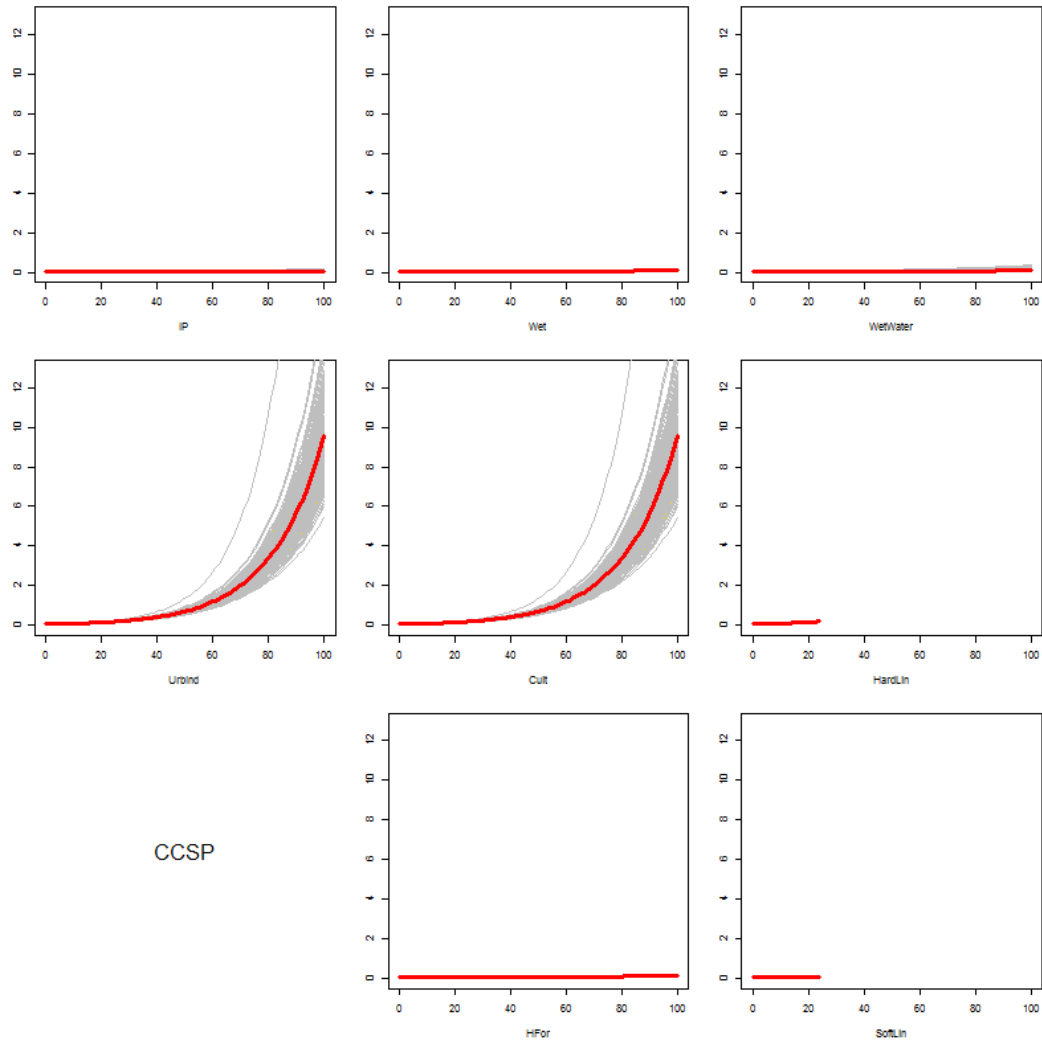


5.21.7 Relative habitat selection



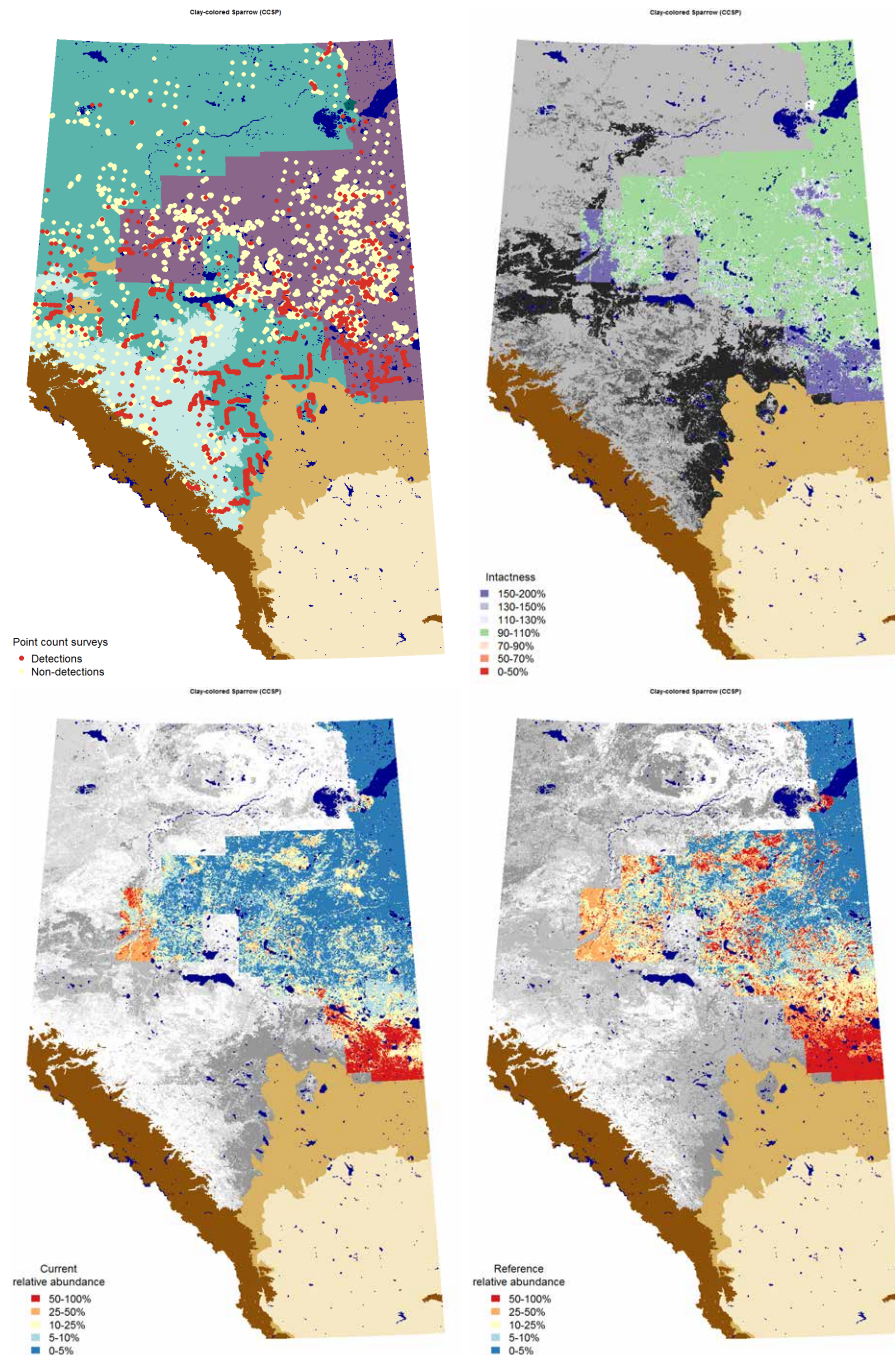
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.21.8 Quarter-section level responses



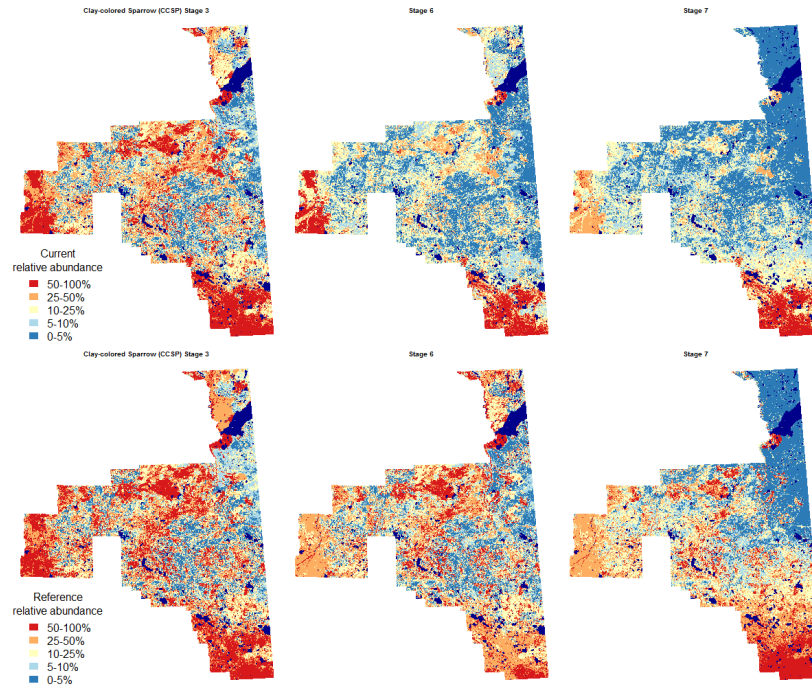
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.21.9 Maps



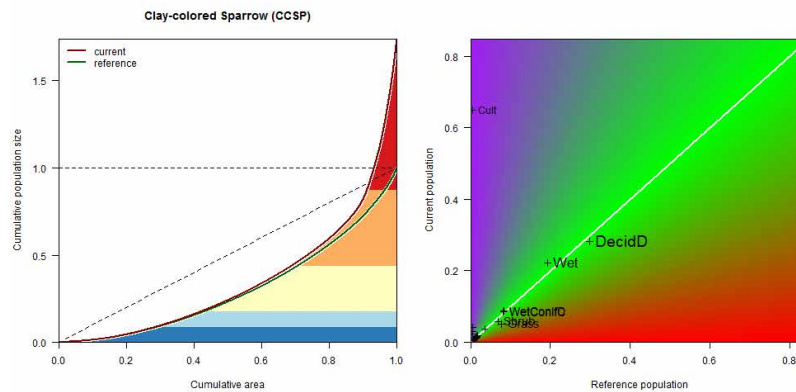
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.21.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.21.11 Population concentration



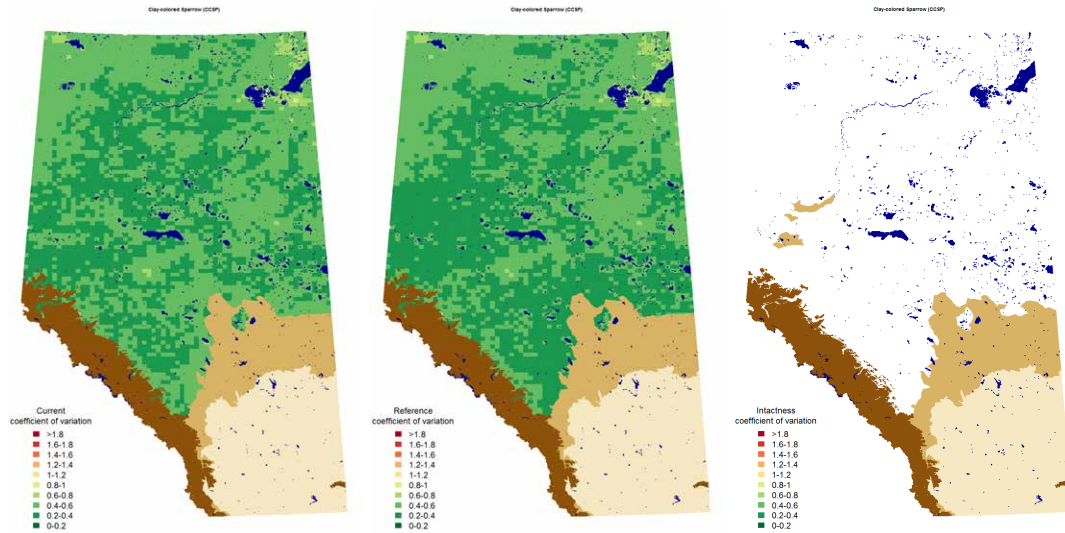
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.21.12 Potential population size

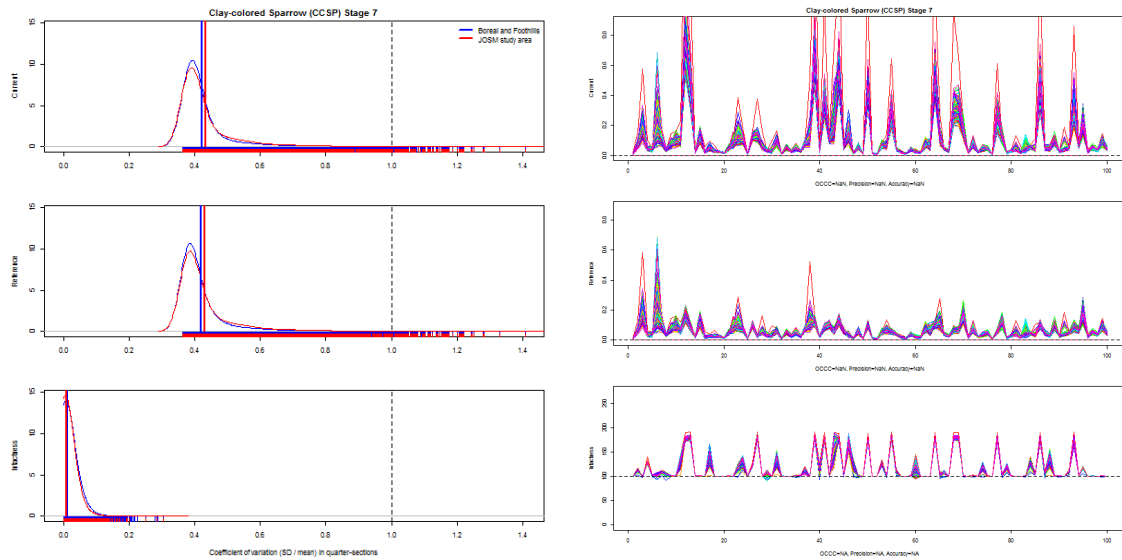
Estimated potential population size of Clay-colored Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.2013	0.1591	0.2566	0.2151	0.1750	0.2673
Wet	0.1588	0.1255	0.2025	0.1389	0.1130	0.1726
WetConifD	0.0625	0.0494	0.0797	0.0607	0.0494	0.0755
WetConifC	0.0608	0.0481	0.0775	0.0596	0.0485	0.0740
Grass	0.0369	0.0291	0.0470	0.0564	0.0459	0.0701
Shrub	0.0416	0.0329	0.0531	0.0502	0.0408	0.0624
DecidC	0.0273	0.0216	0.0348	0.0255	0.0208	0.0317
MixedD	0.0129	0.0102	0.0165	0.0133	0.0108	0.0165
ConifC	0.0112	0.0089	0.0143	0.0121	0.0098	0.0150
WetConifA	0.0112	0.0088	0.0143	0.0113	0.0092	0.0141
PineC	0.0106	0.0084	0.0135	0.0110	0.0089	0.0136
DecidB	0.0086	0.0068	0.0110	0.0106	0.0086	0.0131
WetConifB	0.0098	0.0078	0.0125	0.0102	0.0083	0.0126
ConifD	0.0093	0.0073	0.0118	0.0100	0.0081	0.0124
PineB	0.0089	0.0070	0.0113	0.0091	0.0074	0.0113
ConifA	0.0074	0.0058	0.0094	0.0088	0.0072	0.0110
PineD	0.0068	0.0054	0.0086	0.0071	0.0057	0.0088
ConifB	0.0037	0.0030	0.0048	0.0047	0.0038	0.0058
PineA	0.0028	0.0023	0.0036	0.0030	0.0024	0.0037
DecidA	0.0015	0.0012	0.0019	0.0024	0.0019	0.0030
MixedA	0.0006	0.0005	0.0007	0.0008	0.0007	0.0010
MixedB	0.0005	0.0004	0.0006	0.0006	0.0005	0.0008
MixedC	0.0006	0.0005	0.0007	0.0006	0.0005	0.0007
Cult	0.4636	0.3665	0.5911	0.0000	0.0000	0.0000
UrbInd	0.0209	0.0165	0.0266	0.0000	0.0000	0.0000
HardLin	0.0159	0.0126	0.0203	0.0000	0.0000	0.0000
SoftLin	0.0304	0.0240	0.0387	0.0000	0.0000	0.0000
HFor	0.0290	0.0230	0.0370	0.0000	0.0000	0.0000
Total	1.2553	0.9925	1.6005	0.7218	0.5871	0.8969
Loss	0.0007	0.0003	0.0019			
Gain	0.5298	0.3945	0.7192			

5.21.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.21.14 Variable selection frequencies

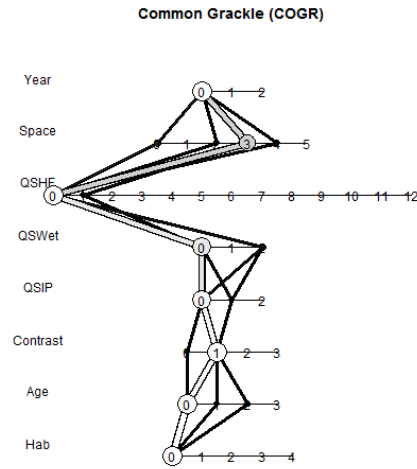
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	93.8	168	. + HabitatB
1.4	6.2	11	. + HabitatB + isHForC
2.2	41.9	75	. + Age + Age2 . + Age + Age2 + Age:isMix + Age:isPine
2.3	58.1	104	+ Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
3.1	100.0	179	. + ROAD
4.0	58.1	104	NULL
4.1	41.3	74	. + Remn_QS
4.2	0.6	1	. + Remn_QS + Remn2_QS
5.0	27.4	49	NULL
5.1	65.4	117	. + pWet_QS
5.2	7.3	13	. + pWetWater_QS
6.9	98.9	177	. + Succ_QS + Alien_QS + Alien2_QS
6.11	1.1	2	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.3	100.0	179	. + xlat + xlong + xlat:xlong
8.1	43.6	78	. + xYEAR
8.2	56.4	101	. + YR5F

5.22 Common Grackle (*Quiscalus quiscula*)

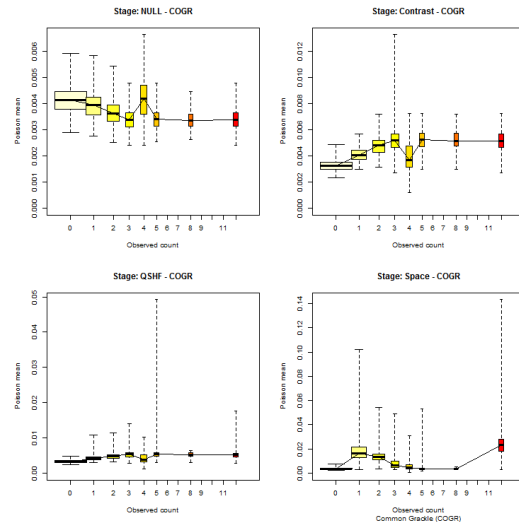
5.22.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

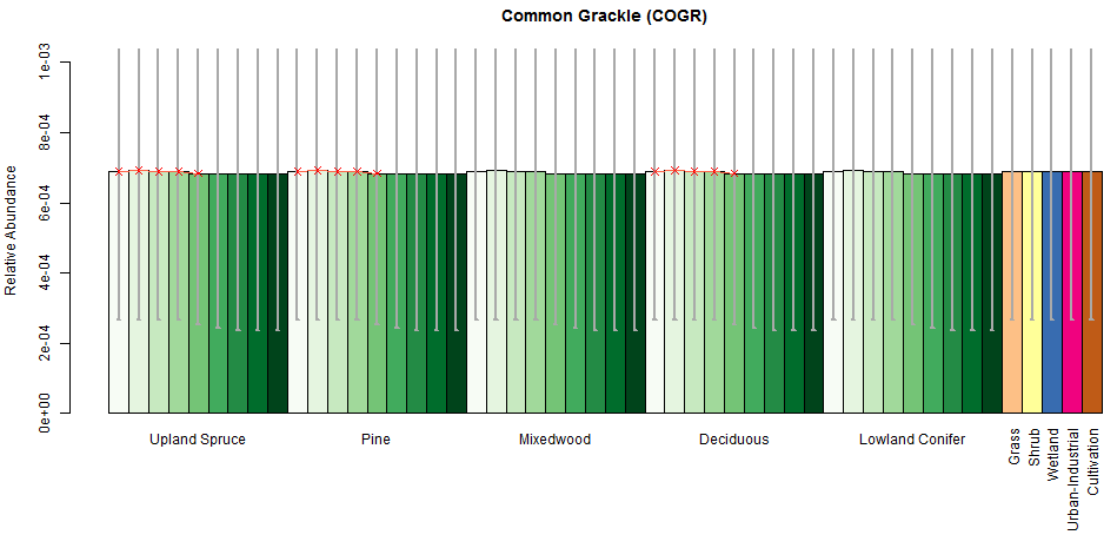


5.22.2 Cross validation

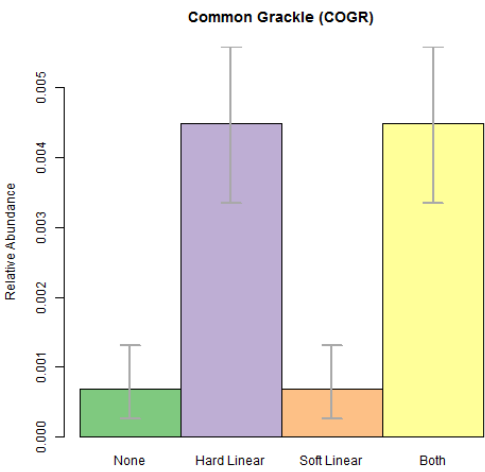
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.22.3 Point level habitat associations

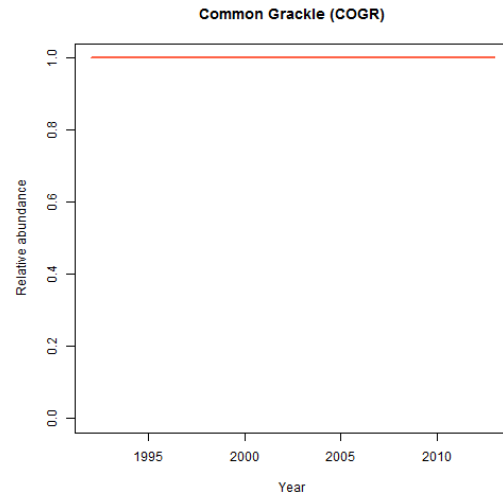


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

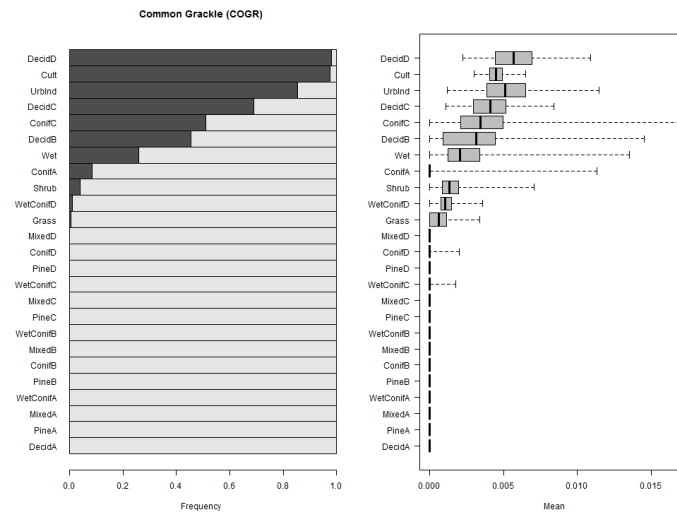


5.22.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



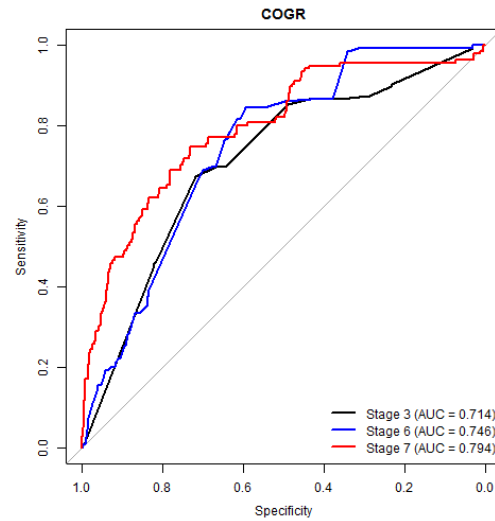
5.22.5 Habitat suitability ranking for patch delineation



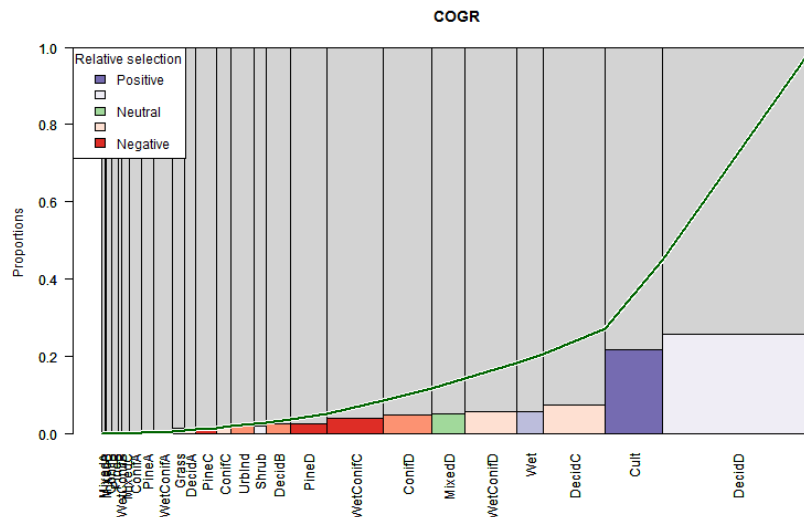
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.22.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

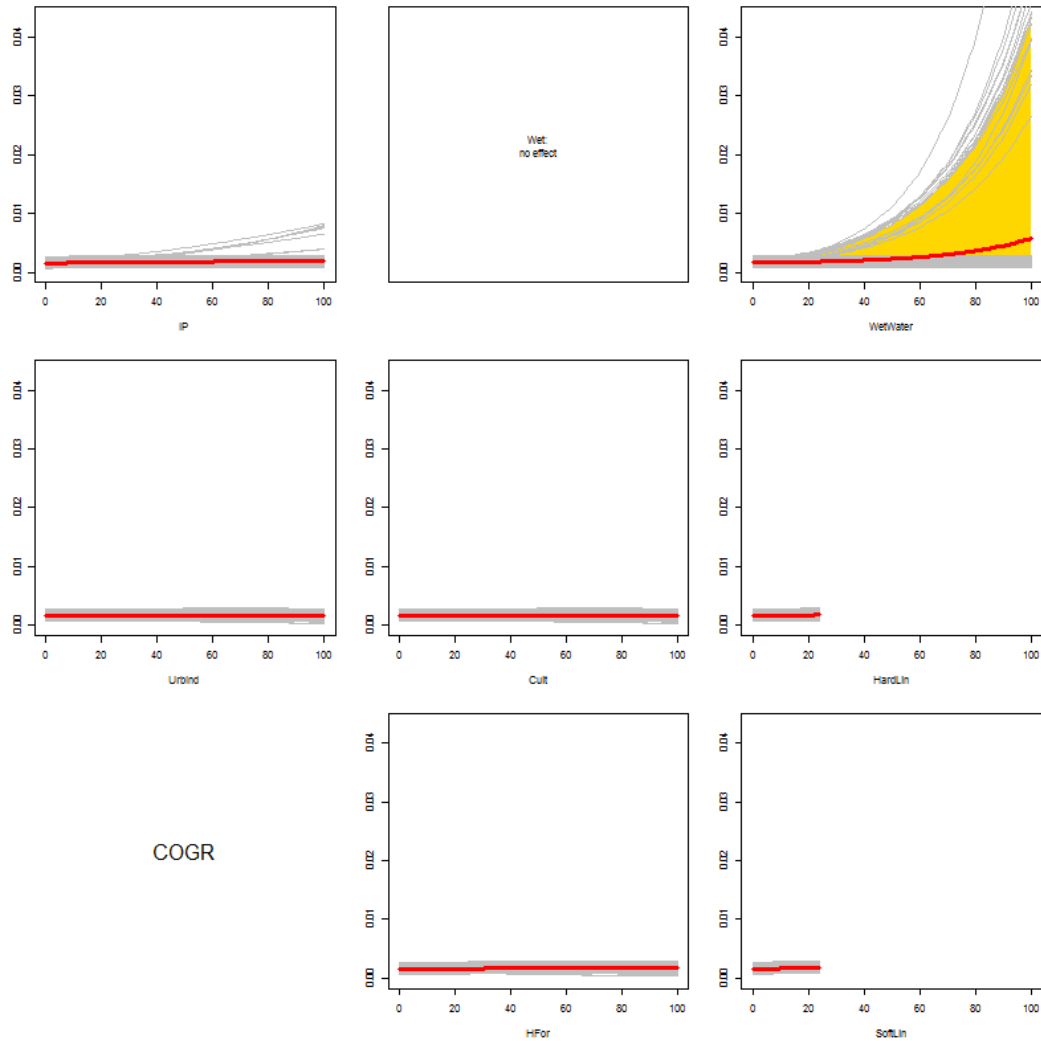


5.22.7 Relative habitat selection



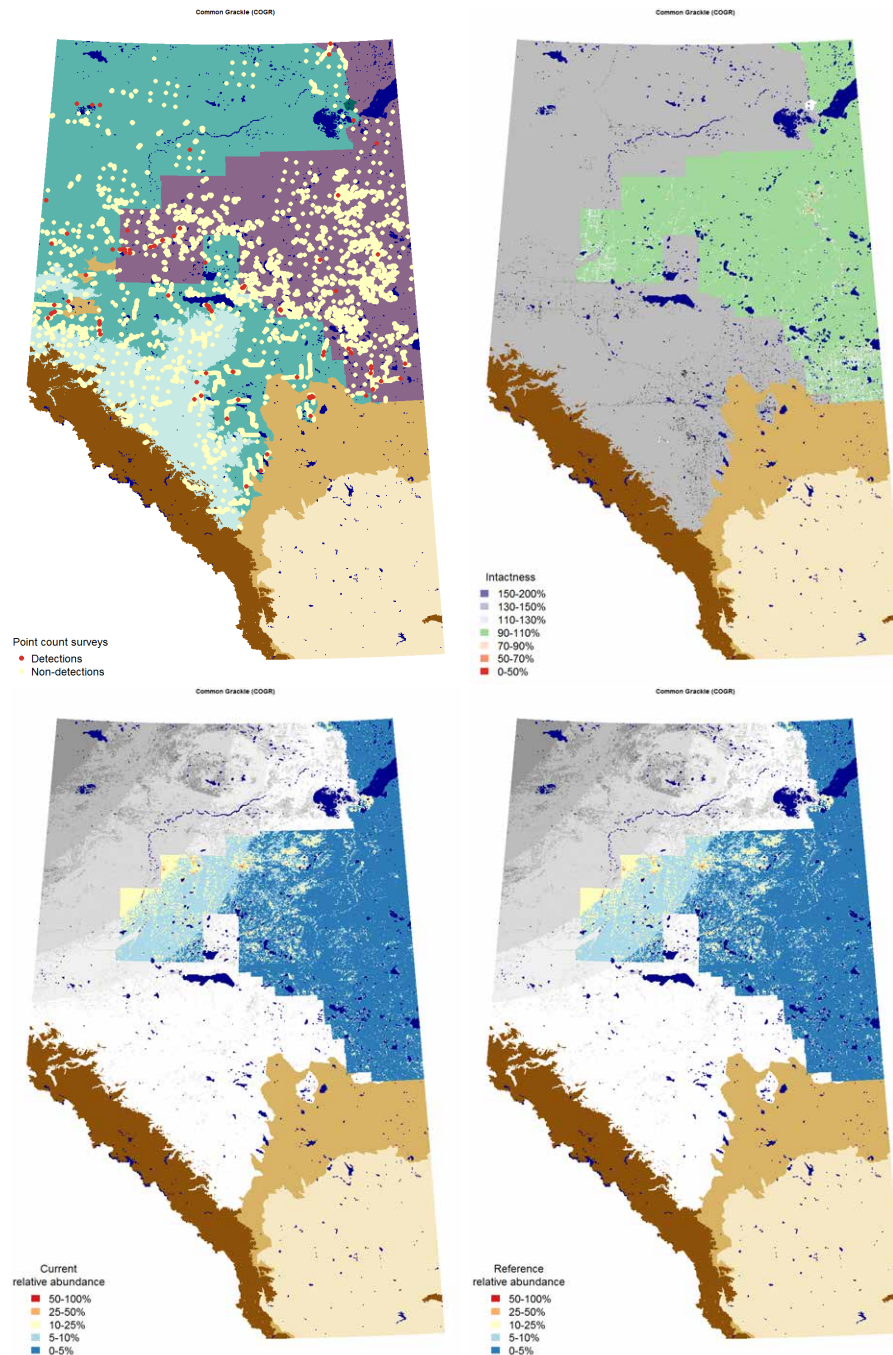
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.22.8 Quarter-section level responses



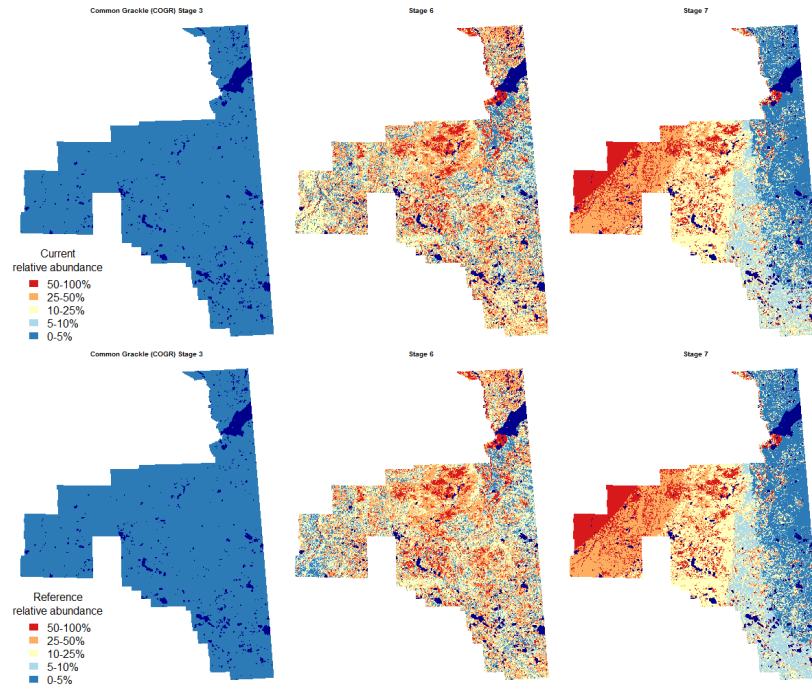
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.22.9 Maps



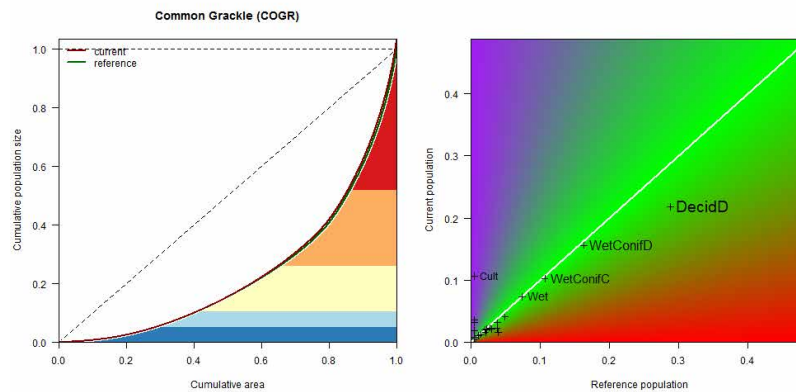
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.22.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.22.11 Population concentration



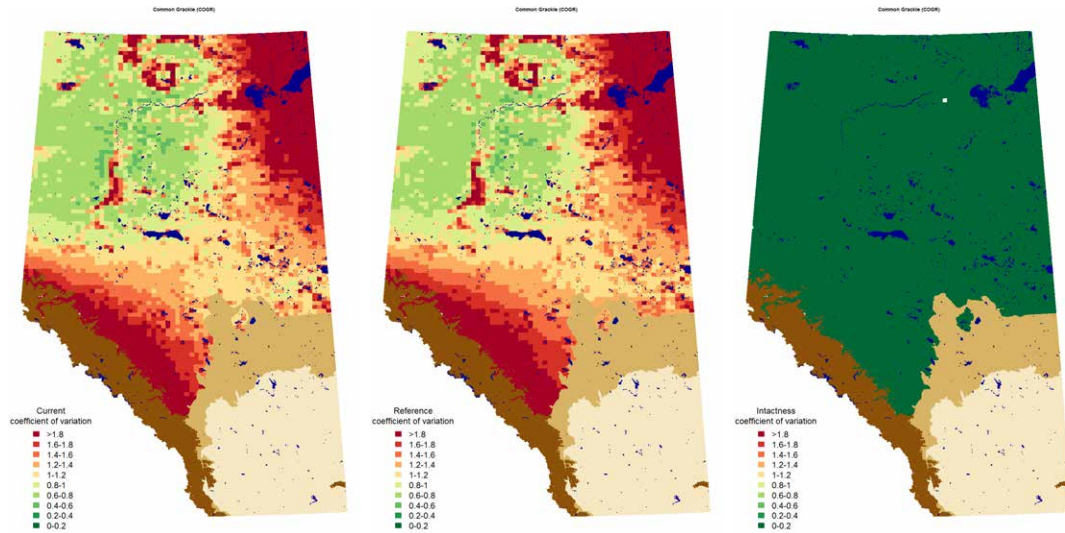
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.22.12 Potential population size

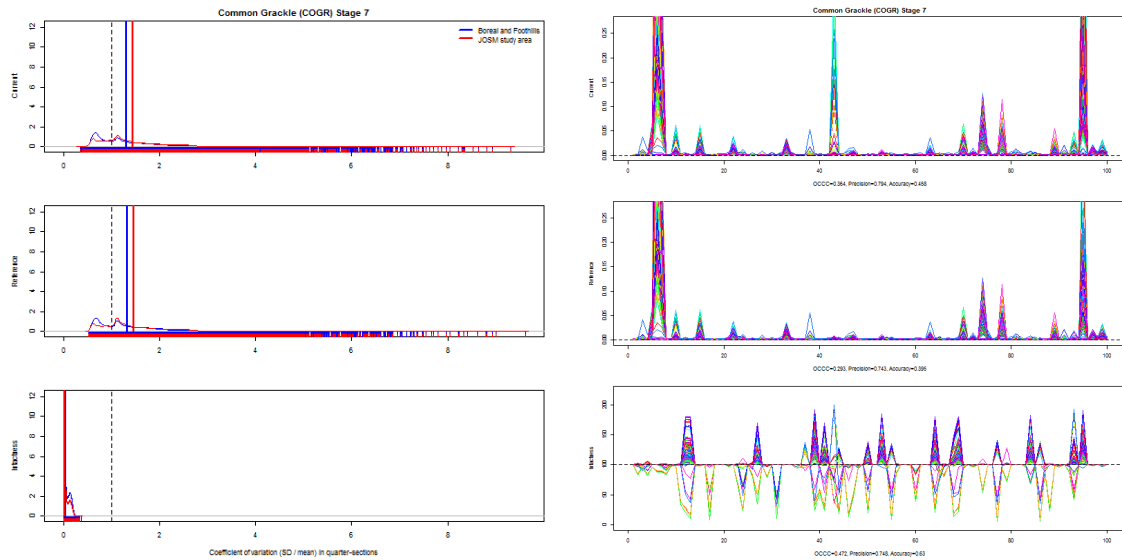
Estimated potential population size of Common Grackle in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0014	0.0005	0.0044	0.0019	0.0006	0.0058
WetConifD	0.0010	0.0003	0.0031	0.0011	0.0003	0.0033
WetConifC	0.0007	0.0002	0.0021	0.0007	0.0002	0.0022
Wet	0.0005	0.0002	0.0015	0.0005	0.0001	0.0015
ConifD	0.0003	0.0001	0.0008	0.0003	0.0001	0.0010
Grass	0.0001	0.0000	0.0003	0.0003	0.0001	0.0008
MixedD	0.0002	0.0001	0.0006	0.0003	0.0001	0.0008
Shrub	0.0002	0.0000	0.0005	0.0002	0.0001	0.0008
DecidC	0.0001	0.0000	0.0004	0.0002	0.0001	0.0006
ConifC	0.0002	0.0000	0.0005	0.0002	0.0001	0.0006
WetConifB	0.0001	0.0000	0.0004	0.0002	0.0000	0.0005
PineC	0.0001	0.0000	0.0004	0.0001	0.0000	0.0005
DecidB	0.0001	0.0000	0.0003	0.0001	0.0000	0.0004
WetConifA	0.0001	0.0000	0.0004	0.0001	0.0000	0.0004
PineD	0.0001	0.0000	0.0003	0.0001	0.0000	0.0003
PineB	0.0001	0.0000	0.0002	0.0001	0.0000	0.0002
ConifA	0.0000	0.0000	0.0001	0.0001	0.0000	0.0002
ConifB	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
DecidA	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
PineA	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0007	0.0002	0.0021	0.0000	0.0000	0.0000
UrbInd	0.0001	0.0000	0.0002	0.0000	0.0000	0.0000
HardLin	0.0002	0.0001	0.0007	0.0000	0.0000	0.0000
SoftLin	0.0001	0.0000	0.0004	0.0000	0.0000	0.0000
HFor	0.0002	0.0001	0.0006	0.0000	0.0000	0.0000
Total	0.0067	0.0021	0.0206	0.0065	0.0019	0.0202
Loss	0.0000	0.0000	0.0004			
Gain	0.0002	0.0001	0.0005			

5.22.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.22.14 Variable selection frequencies

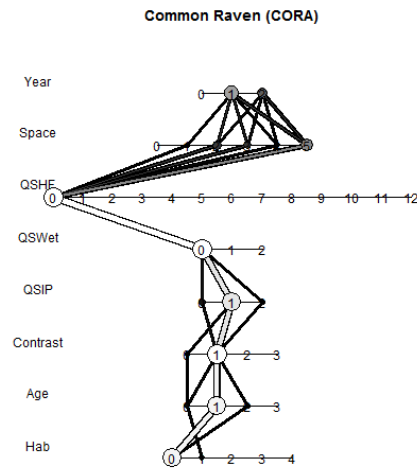
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	200	NULL
2.0	97.5	195	NULL
2.1	2.0	4	. + Age
2.2	0.5	1	. + Age + Age2
3.0	2.0	4	NULL
3.1	98.0	196	. + ROAD
4.0	95.5	191	NULL
4.1	4.5	9	. + Remn_QS
5.0	91.0	182	NULL
5.2	9.0	18	. + pWetWater_QS
6.0	98.5	197	NULL
6.1	1.5	3	. + THF_QS
7.0	13.0	26	NULL
7.2	1.0	2	. + xlat + xlong
7.3	81.0	162	. + xlat + xlong + xlat:xlong
7.4	5.0	10	. + xMAP + xPET + xMAT + xCMD
8.0	100.0	200	NULL

5.23 Common Raven (*Corvus corax*)

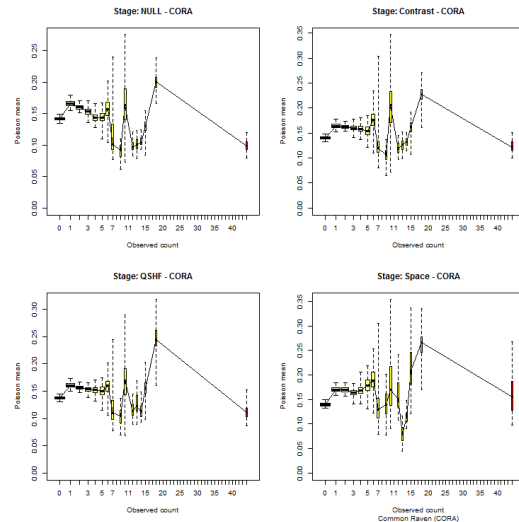
5.23.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

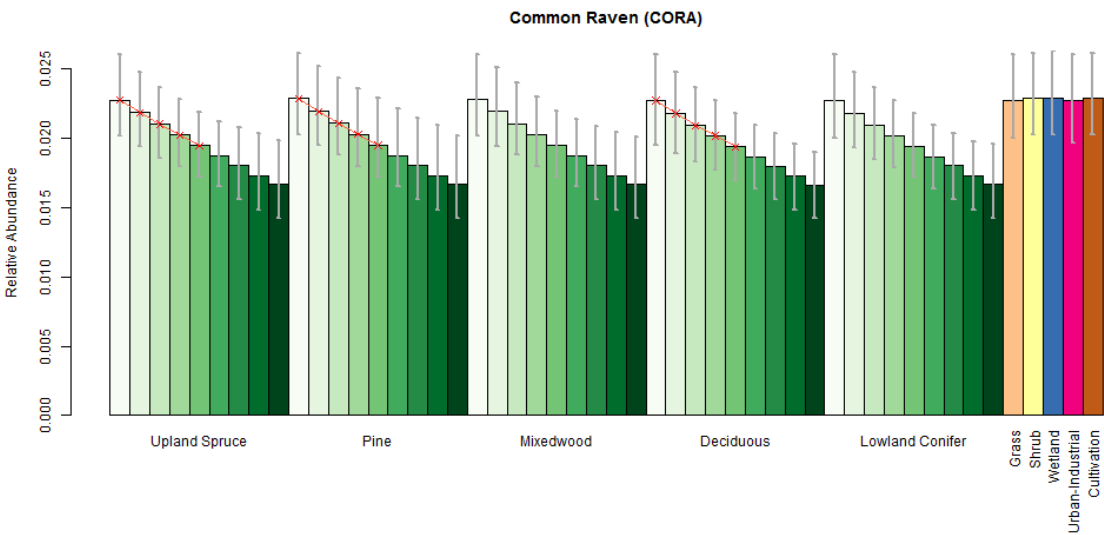


5.23.2 Cross validation

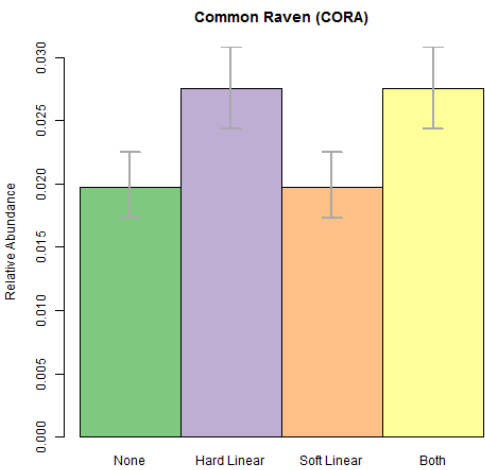
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.23.3 Point level habitat associations

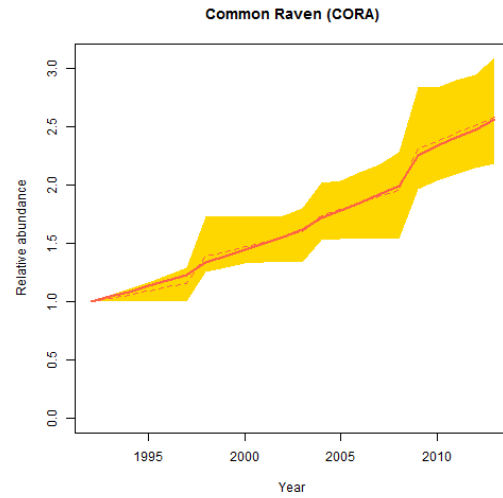


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

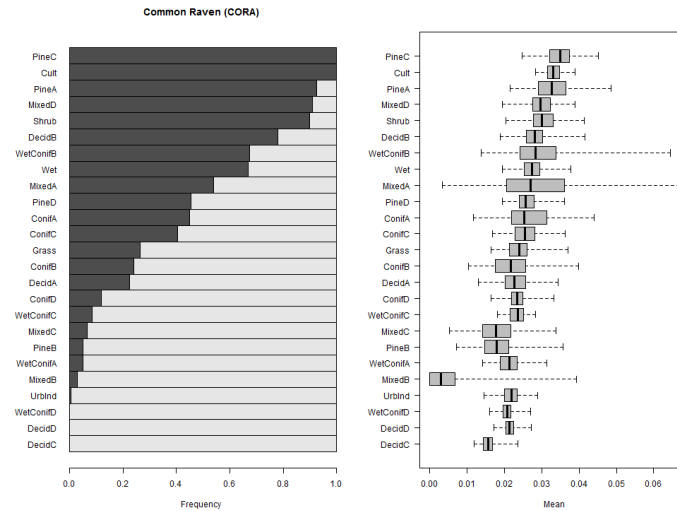


5.23.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



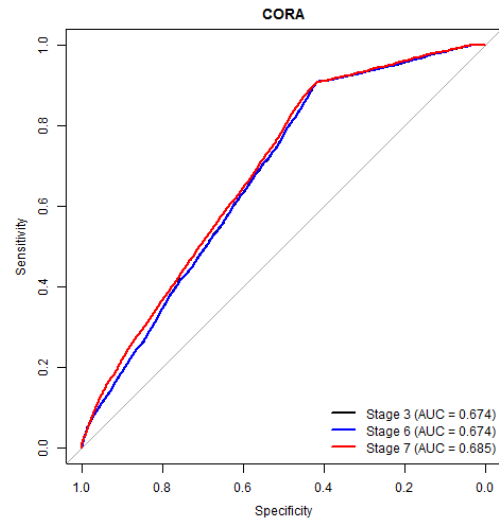
5.23.5 Habitat suitability ranking for patch delineation



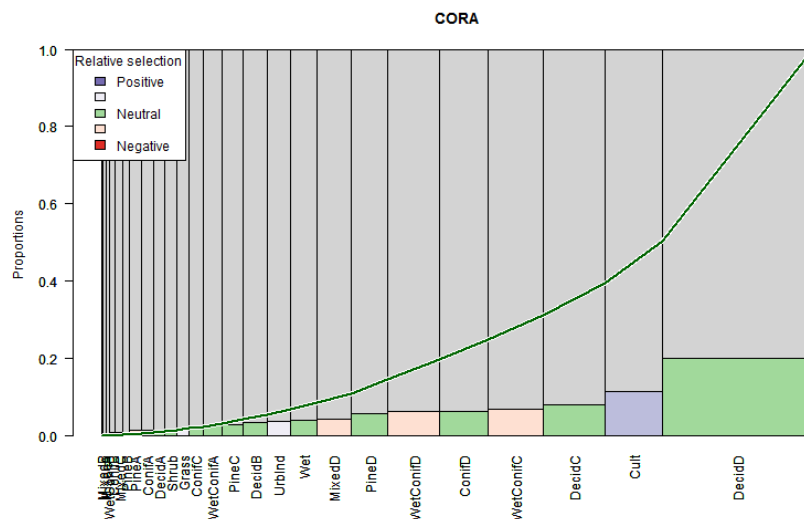
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.23.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

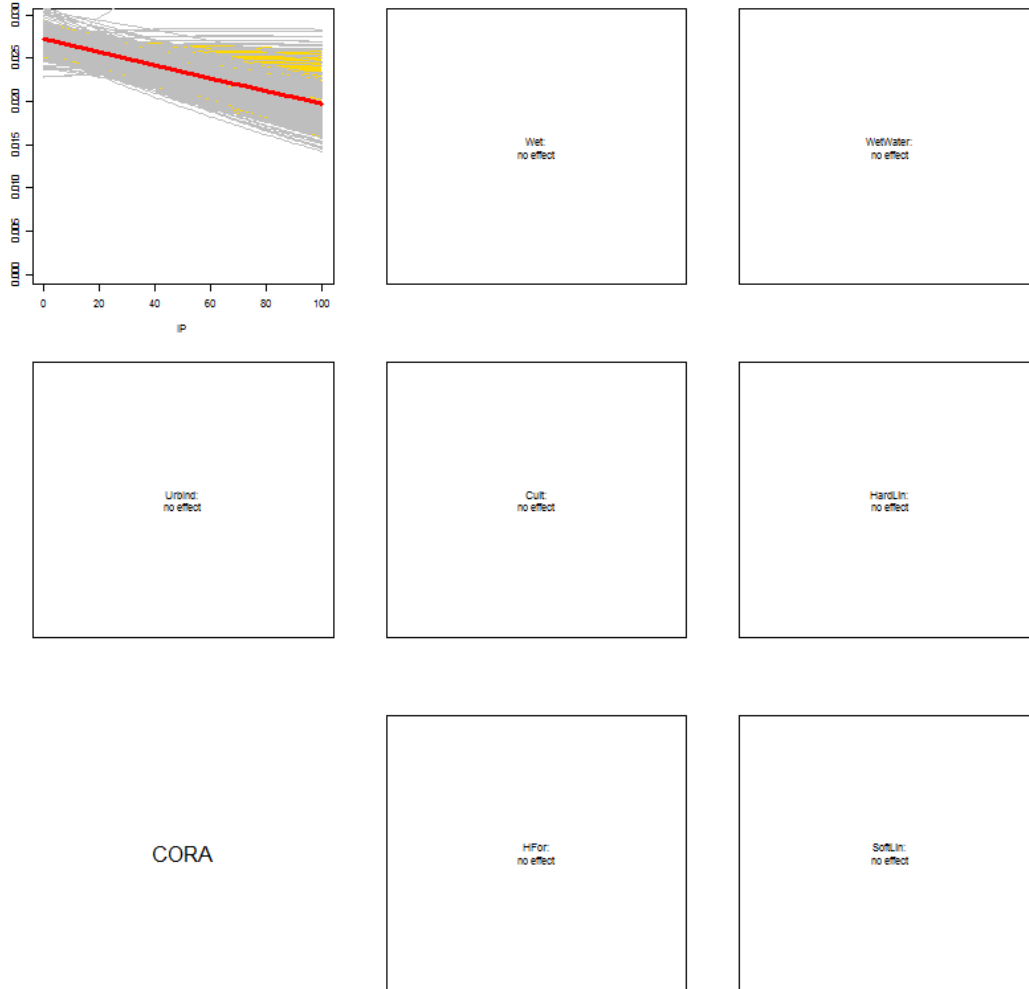


5.23.7 Relative habitat selection



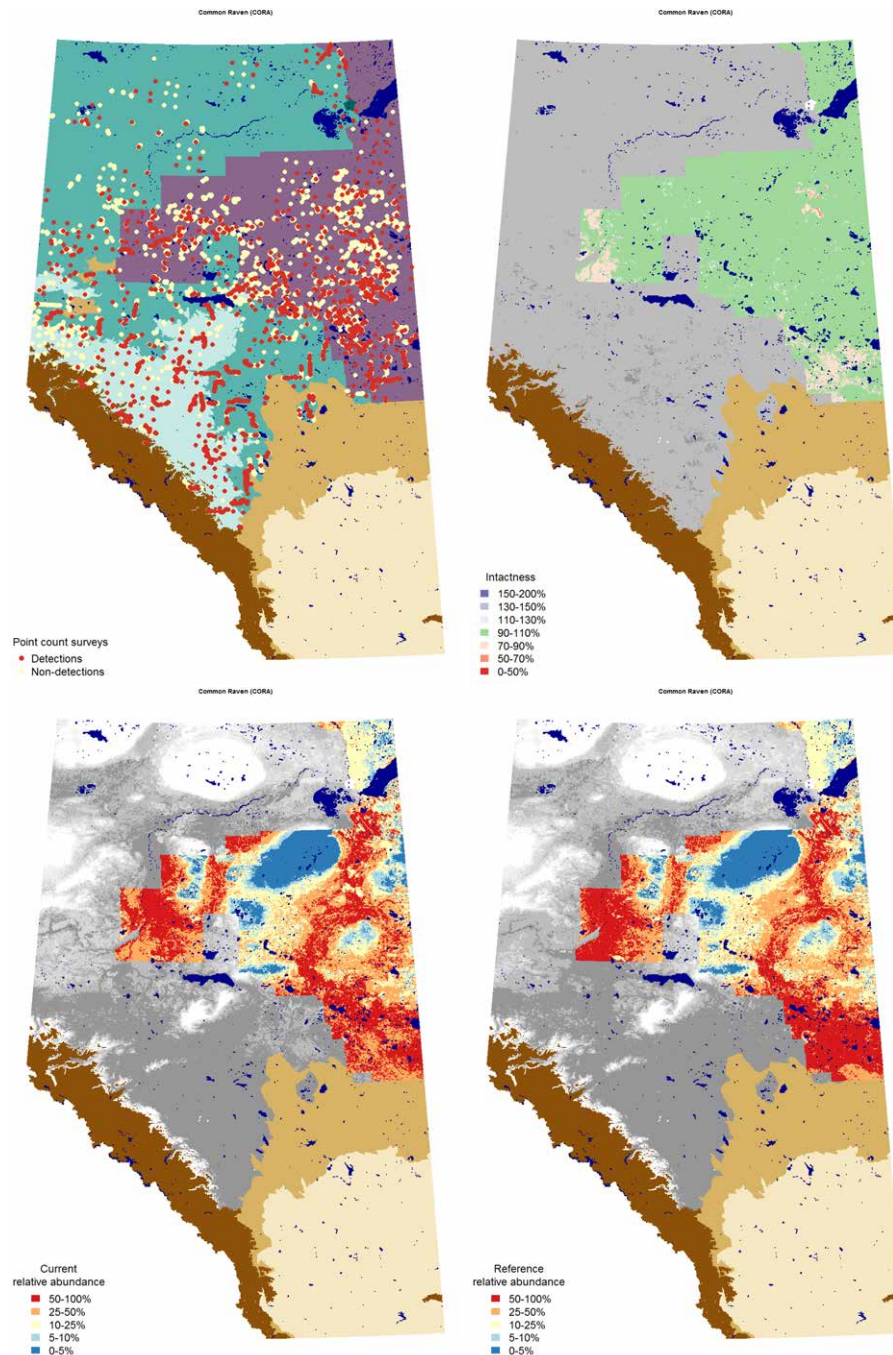
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.23.8 Quarter-section level responses



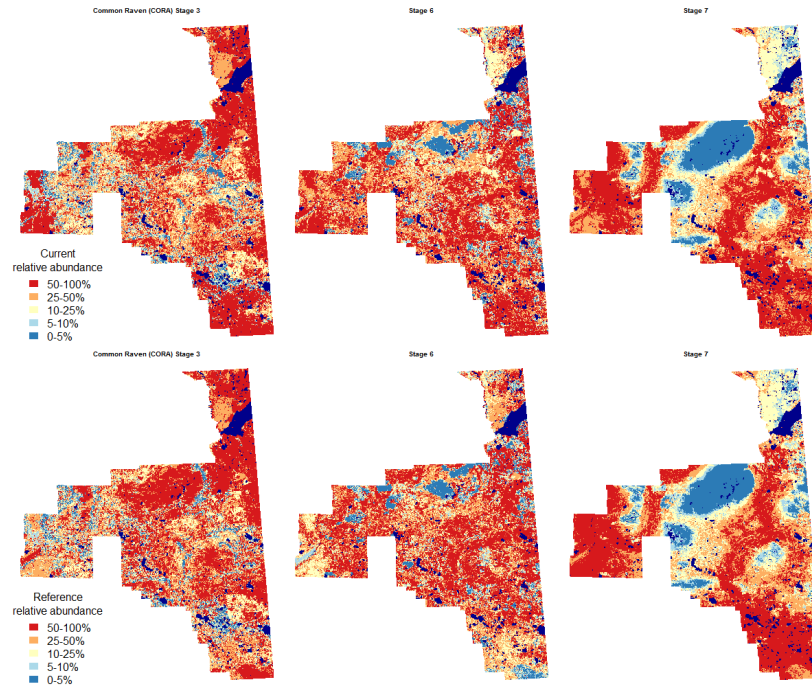
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.23.9 Maps



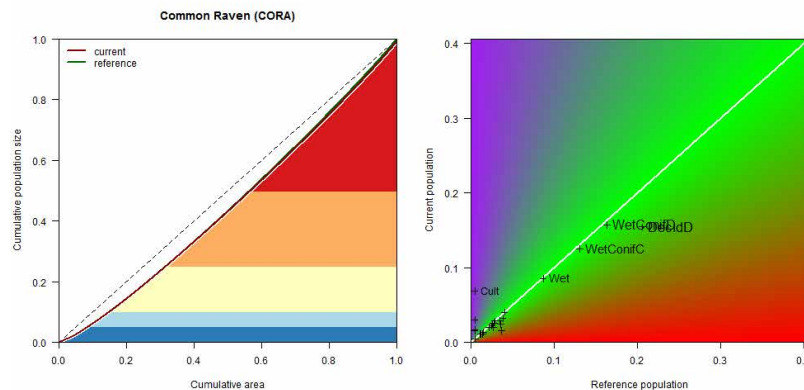
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.23.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.23.11 Population concentration



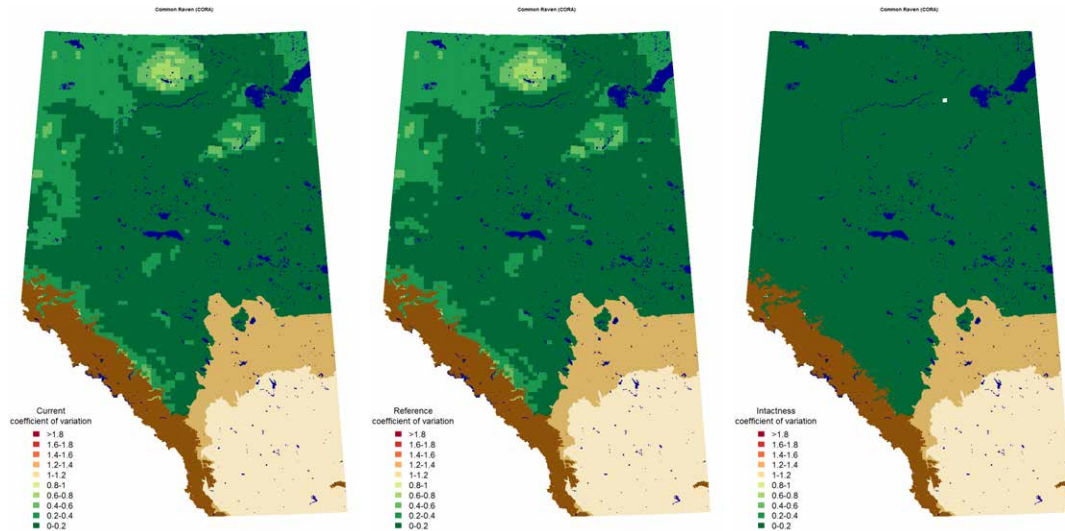
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.23.12 Potential population size

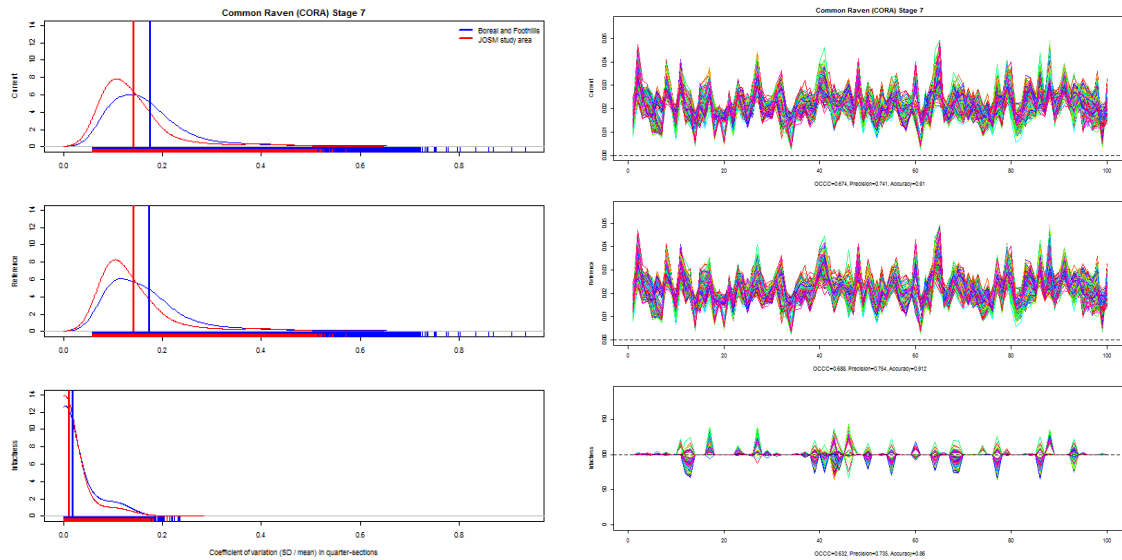
Estimated potential population size of Common Raven in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0499	0.0452	0.0553	0.0666	0.0601	0.0736
WetConifD	0.0508	0.0460	0.0563	0.0530	0.0478	0.0585
WetConifC	0.0405	0.0367	0.0449	0.0423	0.0382	0.0467
Wet	0.0276	0.0250	0.0306	0.0282	0.0254	0.0311
PineB	0.0130	0.0118	0.0144	0.0131	0.0119	0.0145
ConifD	0.0103	0.0093	0.0114	0.0125	0.0113	0.0138
Grass	0.0049	0.0045	0.0055	0.0121	0.0109	0.0133
Shrub	0.0079	0.0072	0.0088	0.0116	0.0104	0.0128
MixedD	0.0094	0.0085	0.0104	0.0113	0.0102	0.0125
WetConifA	0.0092	0.0083	0.0102	0.0095	0.0086	0.0105
PineC	0.0084	0.0076	0.0093	0.0092	0.0083	0.0101
DecidC	0.0065	0.0059	0.0072	0.0089	0.0080	0.0098
WetConifB	0.0080	0.0073	0.0089	0.0083	0.0075	0.0092
ConifC	0.0070	0.0064	0.0078	0.0083	0.0075	0.0091
PineD	0.0065	0.0059	0.0072	0.0071	0.0064	0.0079
ConifA	0.0043	0.0039	0.0048	0.0050	0.0046	0.0056
DecidB	0.0036	0.0032	0.0039	0.0047	0.0042	0.0052
ConifB	0.0035	0.0032	0.0039	0.0040	0.0037	0.0045
PineA	0.0037	0.0033	0.0041	0.0038	0.0034	0.0042
DecidA	0.0011	0.0010	0.0012	0.0019	0.0017	0.0021
MixedA	0.0005	0.0005	0.0006	0.0007	0.0007	0.0008
MixedB	0.0006	0.0005	0.0007	0.0007	0.0006	0.0008
MixedC	0.0004	0.0004	0.0005	0.0005	0.0005	0.0006
Cult	0.0223	0.0202	0.0247	0.0000	0.0000	0.0000
UrbInd	0.0048	0.0044	0.0054	0.0000	0.0000	0.0000
HardLin	0.0006	0.0006	0.0007	0.0000	0.0000	0.0000
SoftLin	0.0054	0.0049	0.0060	0.0000	0.0000	0.0000
HFor	0.0096	0.0087	0.0107	0.0000	0.0000	0.0000
Total	0.3205	0.2903	0.3554	0.3234	0.2917	0.3571
Loss	0.0042	0.0002	0.0079			
Gain	0.0019	0.0012	0.0032			

5.23.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.23.14 Variable selection frequencies

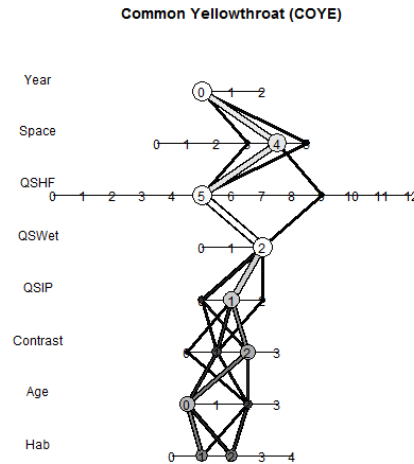
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	96.0	192	NULL
1.1	4.0	8	. + Habitat
2.0	4.0	8	NULL
2.1	95.5	191	. + Age
2.2	0.5	1	. + Age + Age2
3.0	0.5	1	NULL
3.1	99.5	199	. + ROAD
4.0	9.5	19	NULL
4.1	90.0	180	. + Remn_QS
4.2	0.5	1	. + Remn_QS + Remn2_QS
5.0	100.0	200	NULL
6.0	100.0	200	NULL
7.1	0.5	1	. + xlat
7.2	23.0	46	. + xlat + xlong
7.3	21.0	42	. + xlat + xlong + xlat:xlong
7.4	3.0	6	. + xMAP + xPET + xMAT + xCMD
7.5	52.5	105	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	63.0	126	. + xYEAR
8.2	37.0	74	. + YR5F

5.24 Common Yellowthroat (*Geothlypis trichas*)

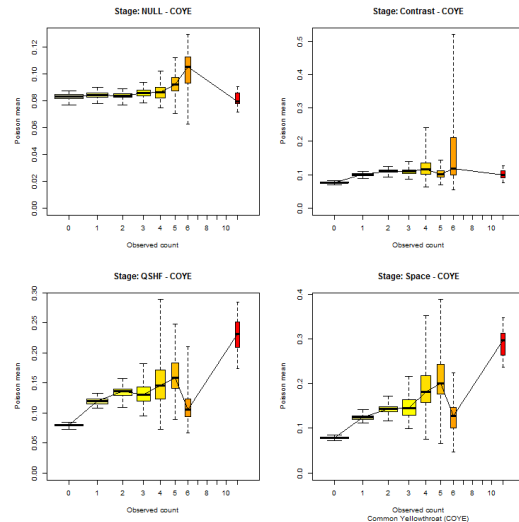
5.24.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

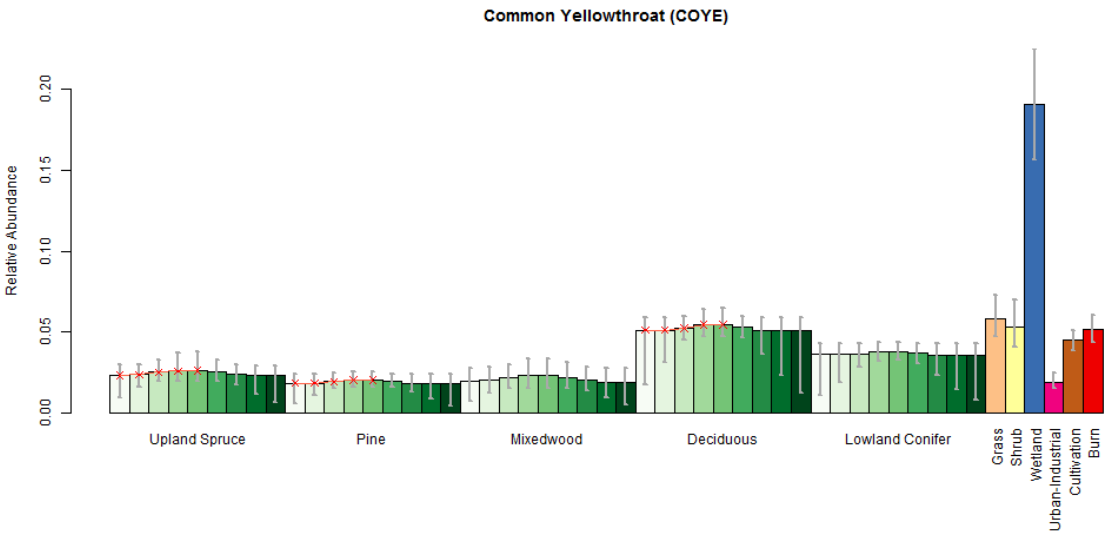


5.24.2 Cross validation

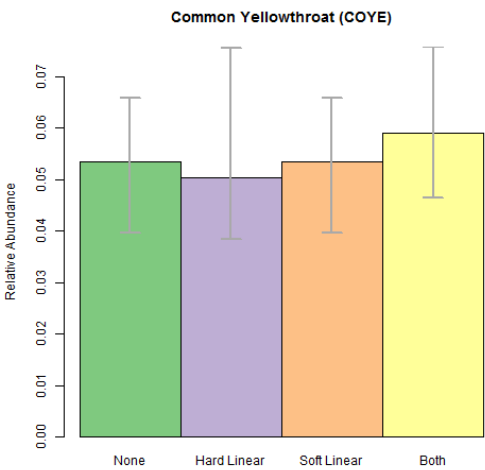
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.24.3 Point level habitat associations

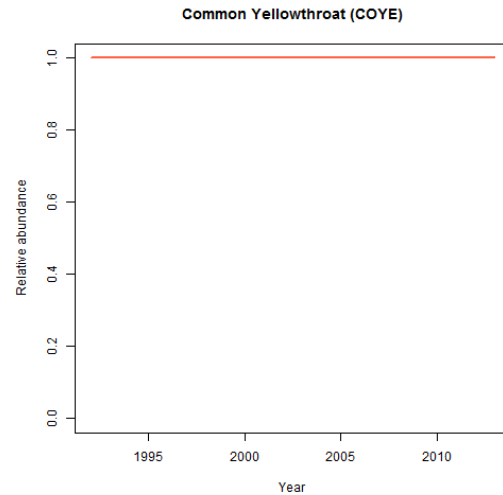


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

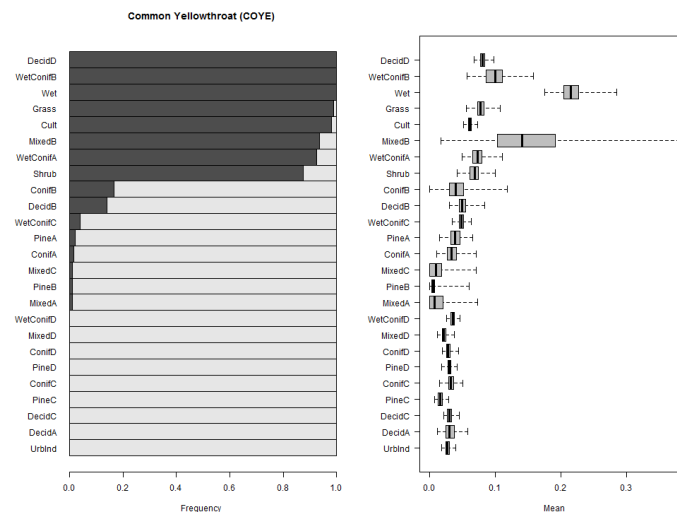


5.24.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



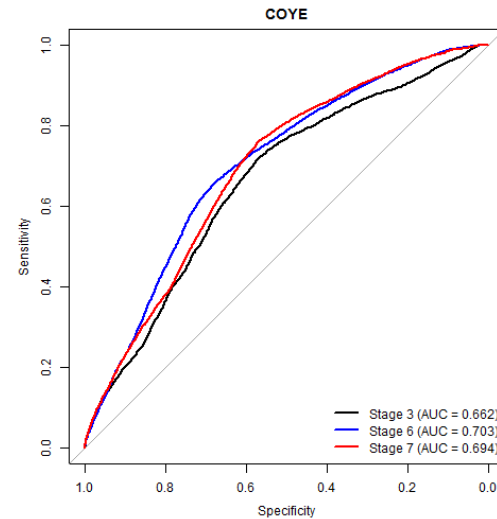
5.24.5 Habitat suitability ranking for patch delineation



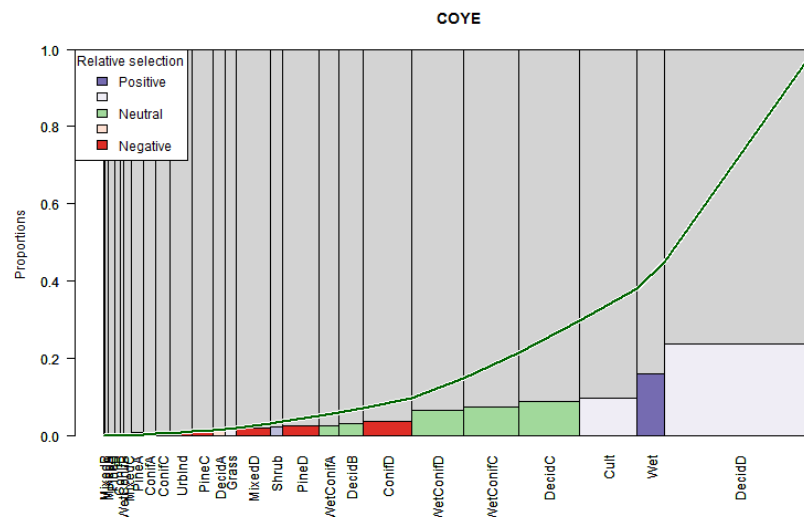
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.24.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

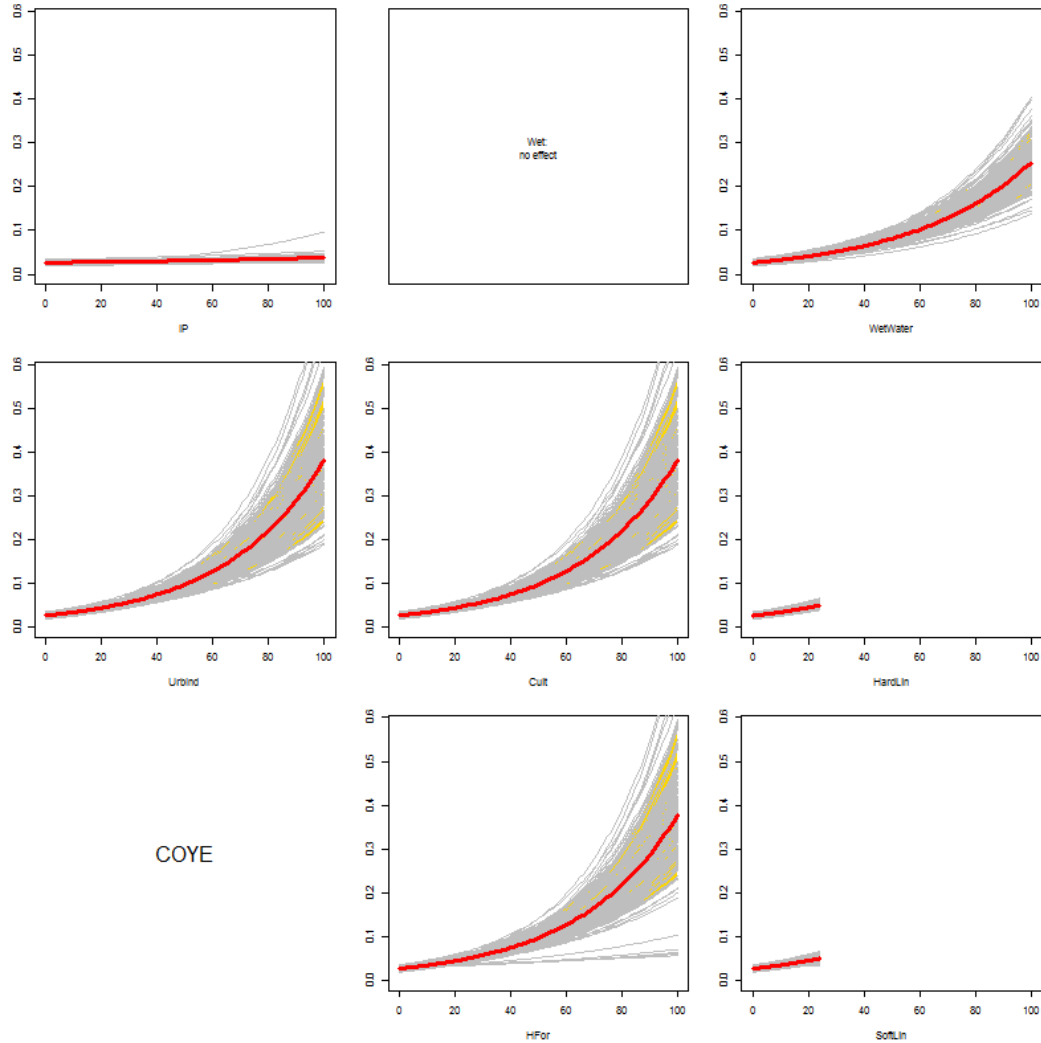


5.24.7 Relative habitat selection



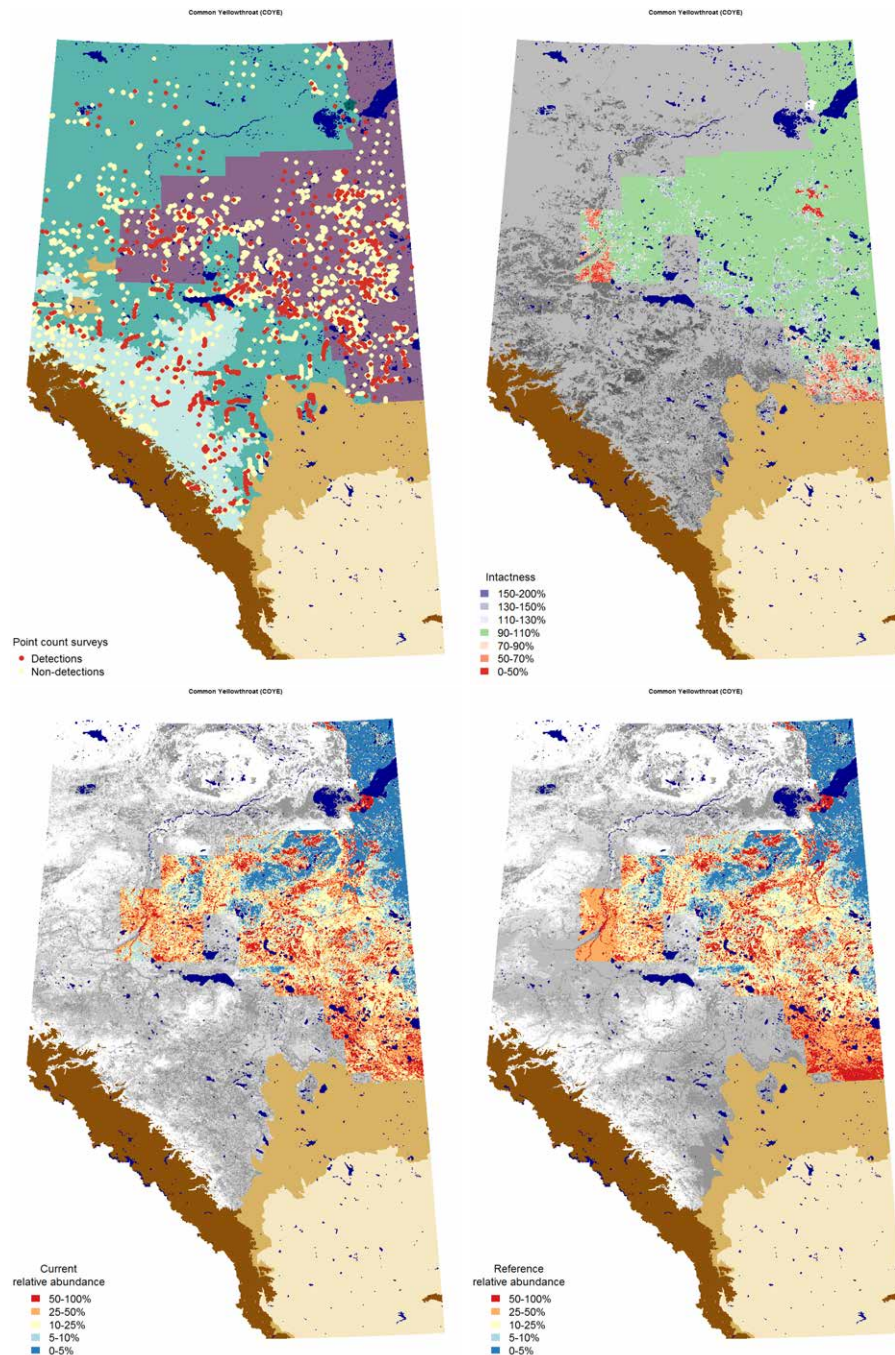
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.24.8 Quarter-section level responses



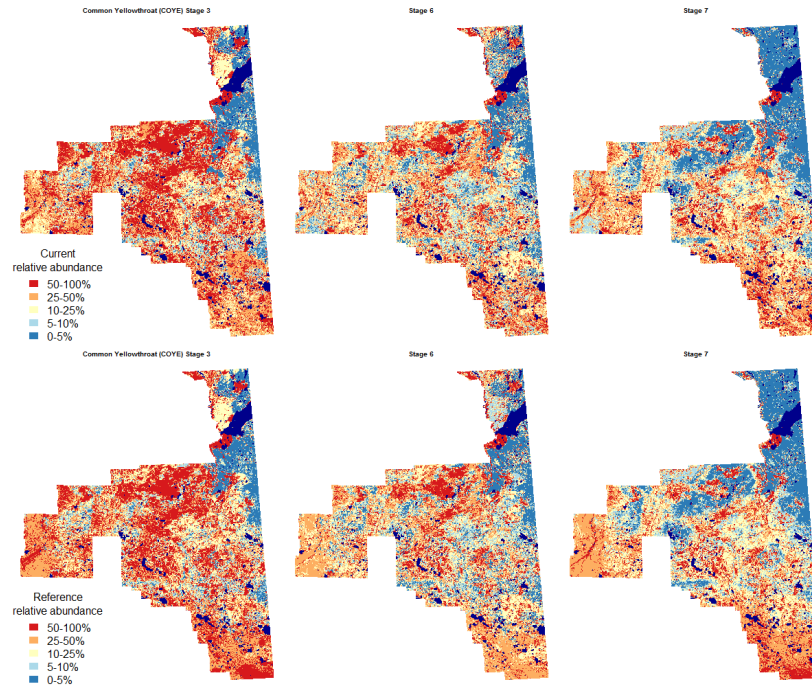
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.24.9 Maps



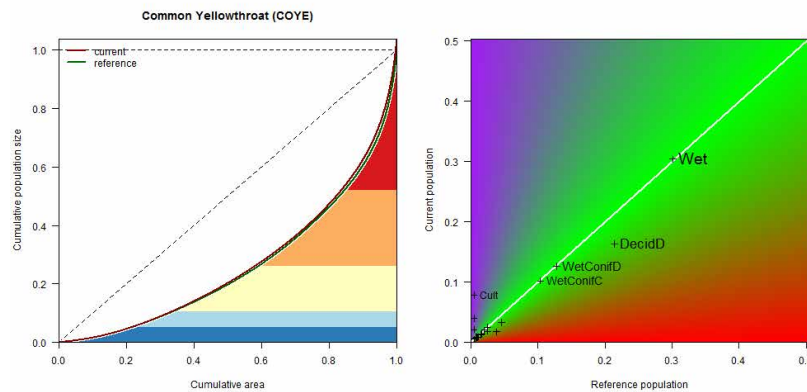
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.24.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.24.11 Population concentration



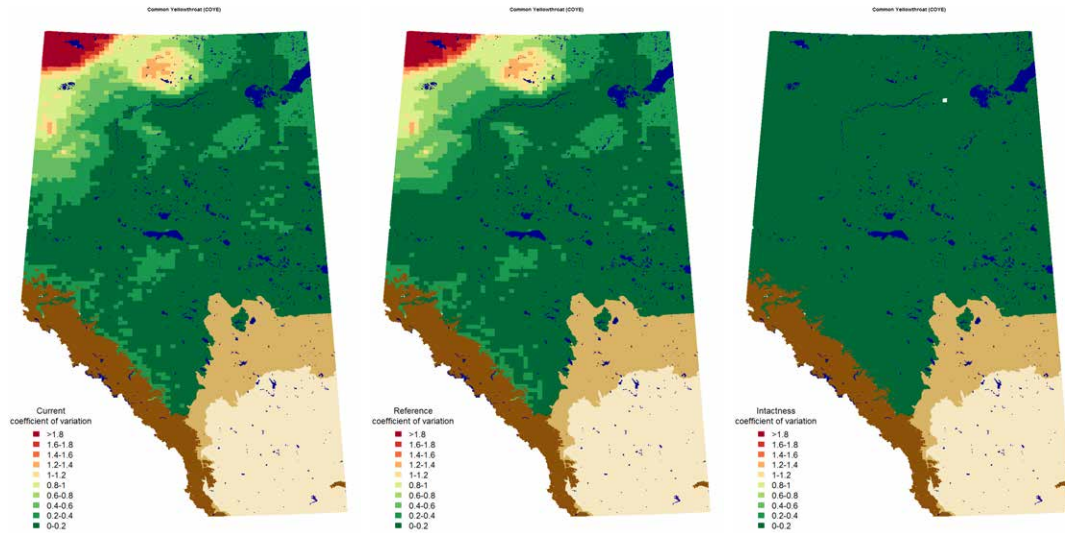
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.24.12 Potential population size

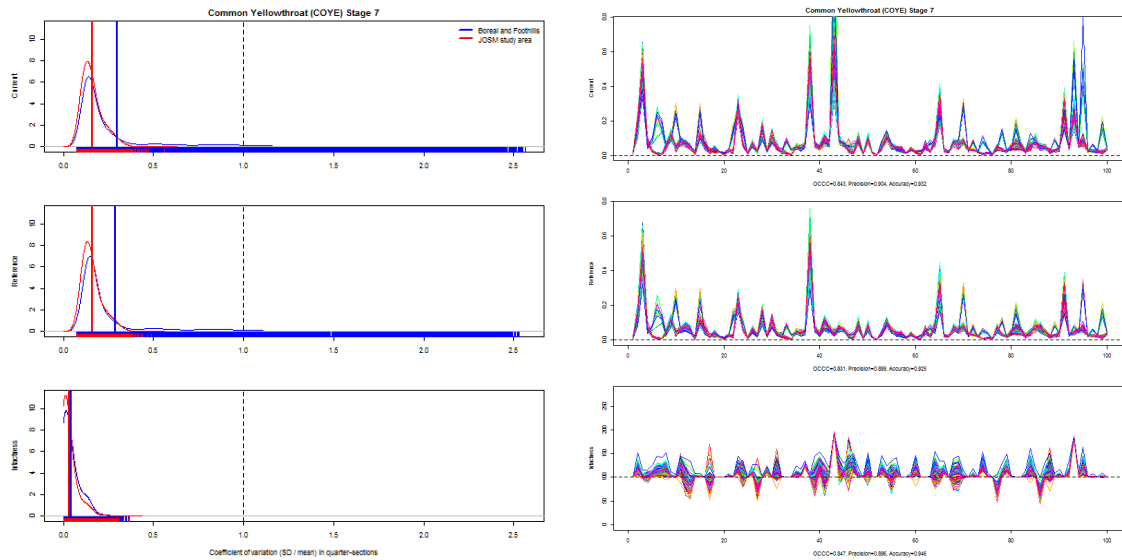
Estimated potential population size of Common Yellowthroat in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.2576	0.2293	0.2882	0.2526	0.2235	0.2850
DecidD	0.1386	0.1234	0.1551	0.1800	0.1592	0.2031
WetConifD	0.1071	0.0954	0.1198	0.1074	0.0951	0.1212
WetConifC	0.0866	0.0771	0.0969	0.0873	0.0773	0.0986
Shrub	0.0276	0.0246	0.0309	0.0389	0.0344	0.0439
Grass	0.0146	0.0130	0.0163	0.0325	0.0288	0.0367
WetConifA	0.0211	0.0188	0.0236	0.0211	0.0187	0.0238
DecidC	0.0156	0.0138	0.0174	0.0208	0.0184	0.0234
WetConifB	0.0170	0.0151	0.0190	0.0173	0.0153	0.0195
ConifD	0.0118	0.0105	0.0132	0.0139	0.0123	0.0157
MixedD	0.0108	0.0097	0.0121	0.0128	0.0113	0.0145
DecidB	0.0075	0.0066	0.0084	0.0099	0.0088	0.0112
ConifC	0.0074	0.0066	0.0083	0.0087	0.0077	0.0099
PineC	0.0072	0.0064	0.0081	0.0078	0.0069	0.0088
PineB	0.0071	0.0064	0.0080	0.0072	0.0063	0.0081
PineD	0.0056	0.0050	0.0063	0.0062	0.0055	0.0070
DecidA	0.0028	0.0025	0.0031	0.0042	0.0037	0.0047
ConifA	0.0032	0.0029	0.0036	0.0038	0.0033	0.0043
ConifB	0.0025	0.0022	0.0027	0.0029	0.0025	0.0032
PineA	0.0024	0.0021	0.0027	0.0025	0.0022	0.0028
MixedA	0.0004	0.0004	0.0005	0.0006	0.0005	0.0007
MixedB	0.0004	0.0004	0.0005	0.0005	0.0005	0.0006
MixedC	0.0004	0.0003	0.0004	0.0005	0.0004	0.0005
Cult	0.0662	0.0590	0.0741	0.0000	0.0000	0.0000
UrbInd	0.0038	0.0034	0.0043	0.0000	0.0000	0.0000
HardLin	0.0019	0.0017	0.0021	0.0000	0.0000	0.0000
SoftLin	0.0335	0.0298	0.0375	0.0000	0.0000	0.0000
HFor	0.0179	0.0159	0.0200	0.0000	0.0000	0.0000
Total	0.8789	0.7824	0.9833	0.8394	0.7426	0.9472
Loss	0.0187	0.0085	0.0326			
Gain	0.0513	0.0265	0.0852			

5.24.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.24.14 Variable selection frequencies

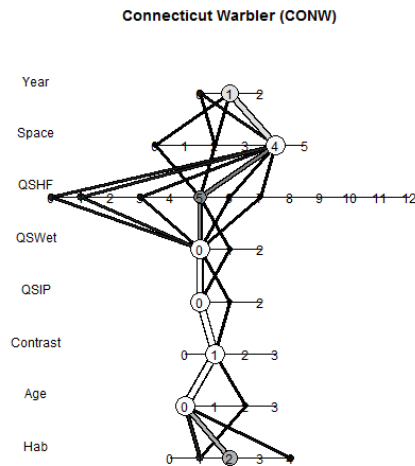
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	52.0	104	. + Habitat
1.2	48.0	96	. + HabitatB
2.0	73.0	146	NULL
2.2	27.0	54	. + Age + Age2
3.0	0.5	1	NULL
3.1	31.5	63	. + ROAD
3.2	68.0	136	. + SoftLin_PC
4.0	20.0	40	NULL
4.1	79.5	159	. + Remn_QS
4.2	0.5	1	. + Remn_QS + Remn2_QS
5.2	100.0	200	. + pWetWater_QS
6.5	97.5	195	. + THF_QS + THF2_QS
6.9	2.5	5	. + Succ_QS + Alien_QS + Alien2_QS
7.3	5.0	10	. + xlat + xlong + xlat:xlong
7.4	90.0	180	. + xMAP + xPET + xMAT + xCMD
7.5	5.0	10	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	100.0	200	NULL

5.25 Connecticut Warbler (*Oporornis agilis*)

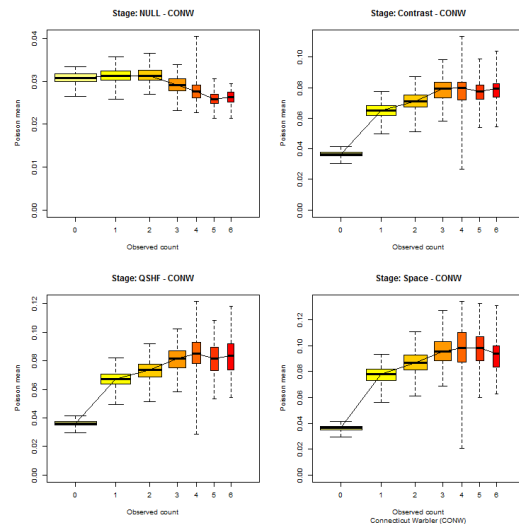
5.25.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

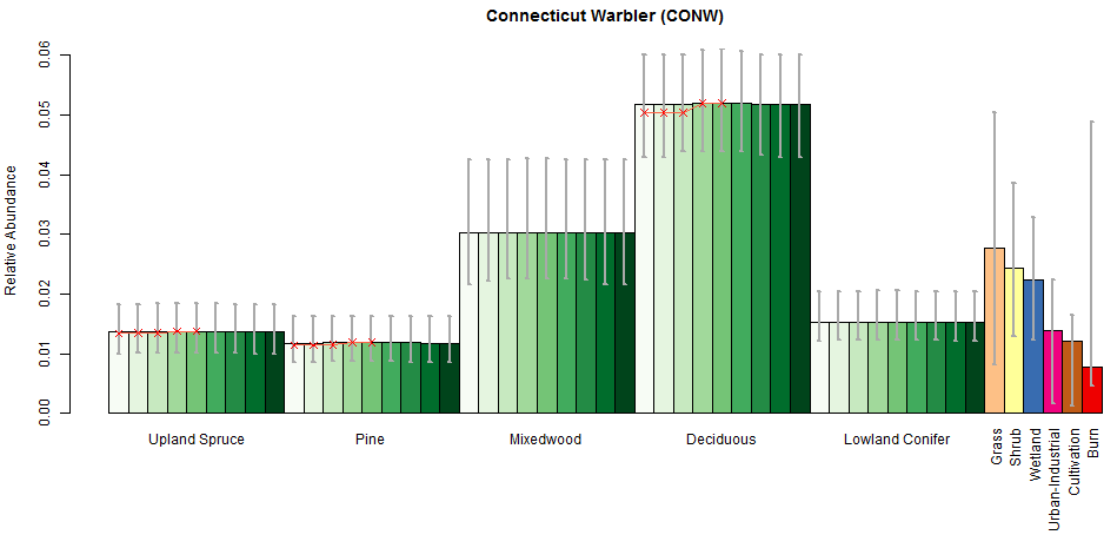


5.25.2 Cross validation

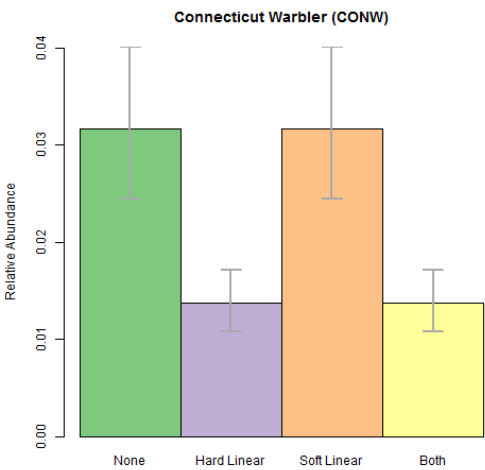
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.25.3 Point level habitat associations

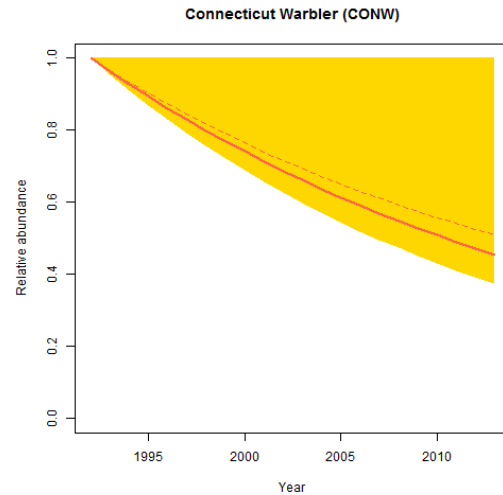


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

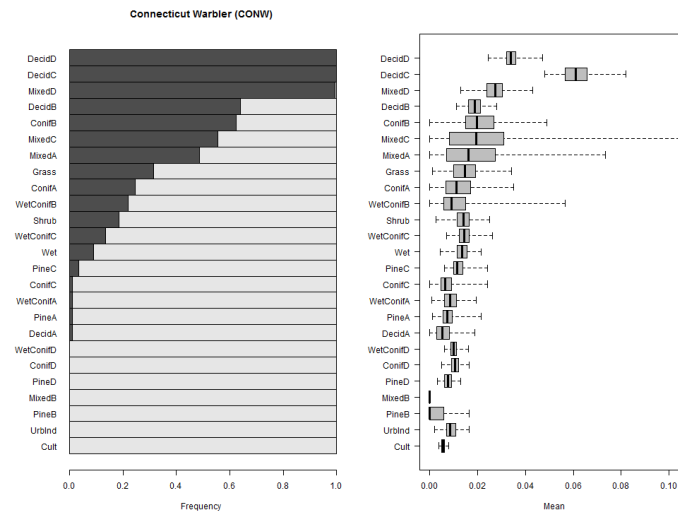


5.25.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



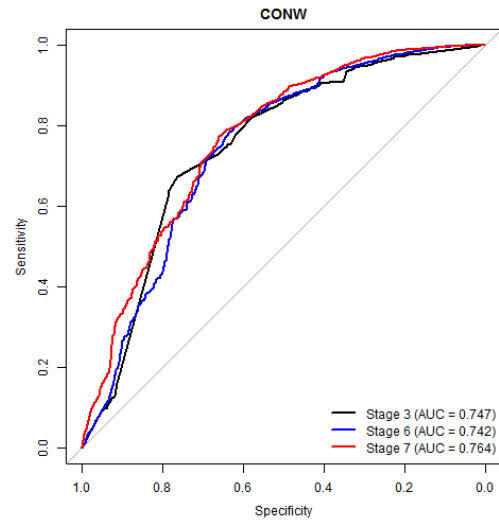
5.25.5 Habitat suitability ranking for patch delineation



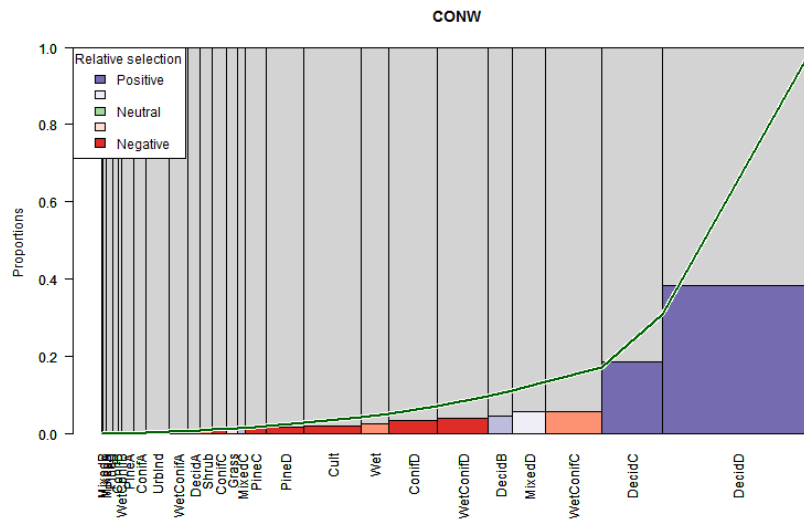
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.25.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

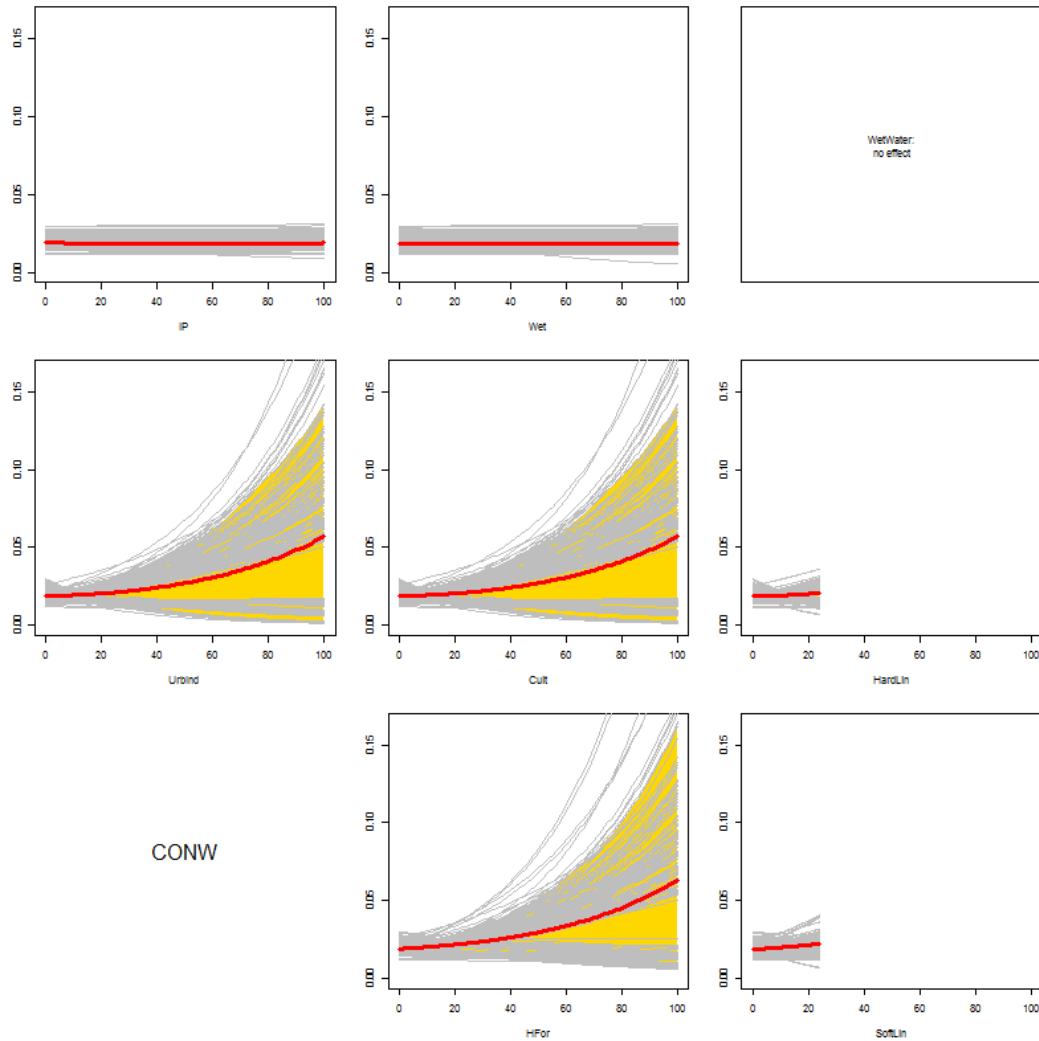


5.25.7 Relative habitat selection



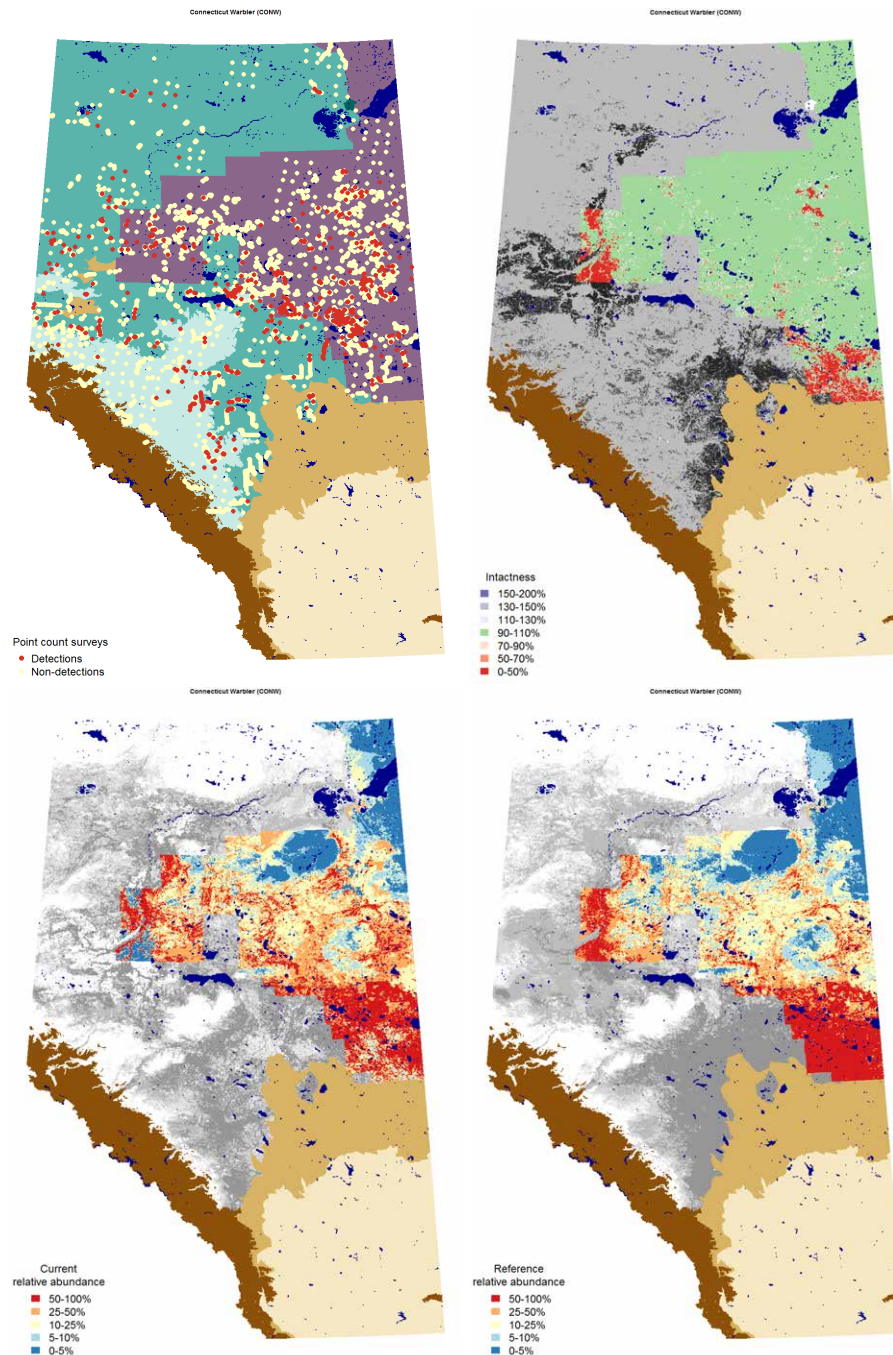
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.25.8 Quarter-section level responses



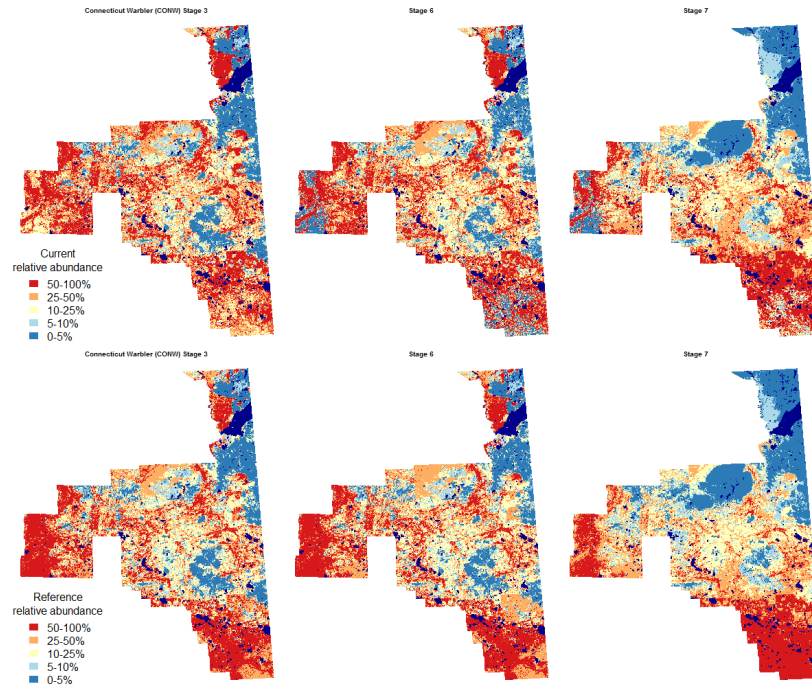
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.25.9 Maps



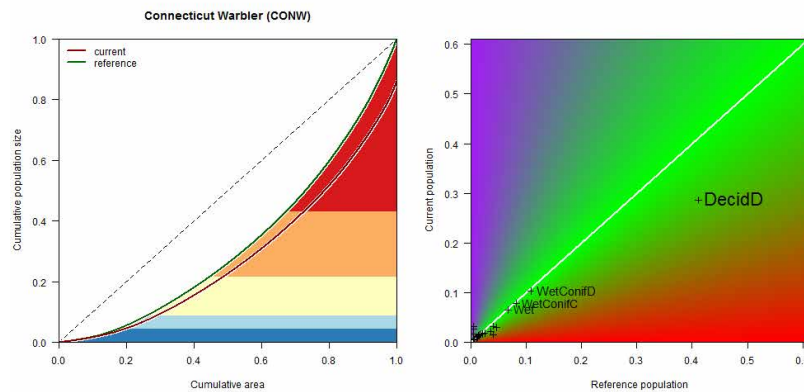
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.25.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.25.11 Population concentration



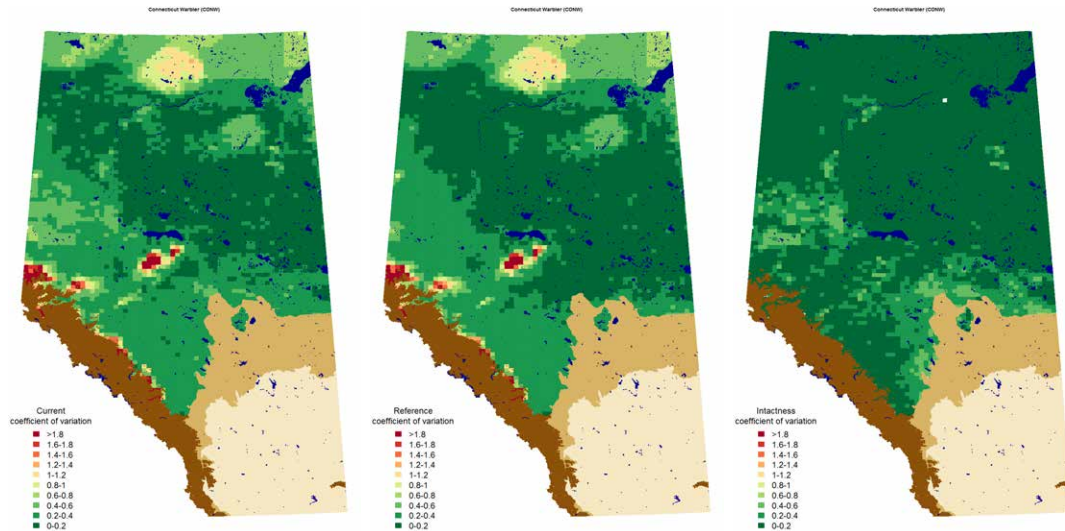
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.25.12 Potential population size

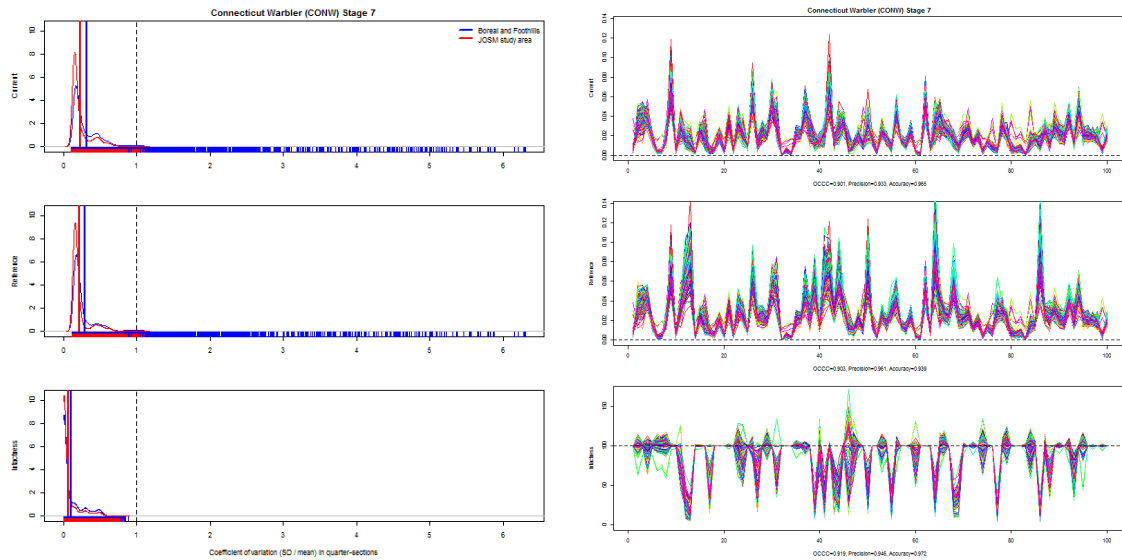
Estimated potential population size of Connecticut Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1249	0.1058	0.1487	0.1790	0.1443	0.2170
WetConifD	0.0449	0.0380	0.0534	0.0473	0.0382	0.0574
WetConifC	0.0339	0.0287	0.0403	0.0357	0.0288	0.0433
Wet	0.0283	0.0240	0.0337	0.0294	0.0237	0.0356
DecidC	0.0130	0.0110	0.0154	0.0202	0.0163	0.0245
Grass	0.0064	0.0054	0.0076	0.0178	0.0144	0.0216
MixedD	0.0141	0.0119	0.0168	0.0175	0.0141	0.0212
Shrub	0.0096	0.0082	0.0115	0.0158	0.0127	0.0191
DecidB	0.0079	0.0067	0.0094	0.0110	0.0089	0.0134
ConifD	0.0074	0.0063	0.0089	0.0093	0.0075	0.0113
WetConifA	0.0075	0.0064	0.0090	0.0078	0.0063	0.0095
PineB	0.0068	0.0057	0.0081	0.0068	0.0055	0.0083
PineC	0.0059	0.0050	0.0070	0.0066	0.0053	0.0080
WetConifB	0.0060	0.0051	0.0071	0.0062	0.0050	0.0076
PineD	0.0048	0.0041	0.0058	0.0054	0.0044	0.0066
ConifC	0.0043	0.0037	0.0052	0.0053	0.0043	0.0065
DecidA	0.0026	0.0022	0.0031	0.0046	0.0037	0.0056
ConifA	0.0023	0.0020	0.0027	0.0029	0.0023	0.0035
PineA	0.0020	0.0017	0.0024	0.0021	0.0017	0.0026
ConifB	0.0016	0.0013	0.0019	0.0019	0.0015	0.0023
MixedA	0.0007	0.0006	0.0008	0.0011	0.0009	0.0013
MixedB	0.0006	0.0005	0.0007	0.0007	0.0006	0.0009
MixedC	0.0004	0.0004	0.0005	0.0006	0.0005	0.0007
Cult	0.0116	0.0098	0.0138	0.0000	0.0000	0.0000
UrbInd	0.0030	0.0026	0.0036	0.0000	0.0000	0.0000
HardLin	0.0003	0.0002	0.0003	0.0000	0.0000	0.0000
SoftLin	0.0075	0.0064	0.0090	0.0000	0.0000	0.0000
HFor	0.0140	0.0119	0.0167	0.0000	0.0000	0.0000
Total	0.3724	0.3154	0.4435	0.4353	0.3509	0.5277
Loss	0.0589	0.0342	0.1109			
Gain	0.0027	0.0000	0.0153			

5.25.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.25.14 Variable selection frequencies

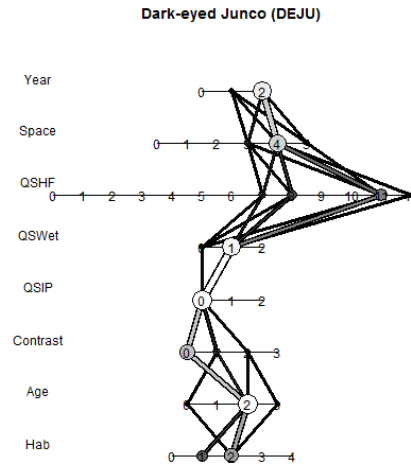
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	22.0	44	. + Habitat
1.2	69.5	139	. + HabitatB
1.4	8.5	17	. + HabitatB + isHForC
2.0	98.5	197	NULL
2.2	1.5	3	. + Age + Age2
3.1	100.0	200	. + ROAD
4.0	98.5	197	NULL
4.1	1.5	3	. + Remn_QS
5.0	99.5	199	NULL
5.1	0.5	1	. + pWet_QS
6.0	14.5	29	NULL
6.1	19.0	38	. + THF_QS
6.3	10.0	20	. + Succ_QS + Alien_QS
6.5	54.0	108	. + THF_QS + THF2_QS
6.6	1.0	2	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.7	1.5	3	. + Succ_QS + Alien_QS + Succ2_QS
7.0	1.5	3	NULL
7.2	1.0	2	. + xlat + xlong
7.4	97.5	195	. + xMAP + xPET + xMAT + xCMD
8.0	11.5	23	NULL
8.1	88.5	177	. + xYEAR

5.26 Dark-eyed Junco (*Junco hyemalis*)

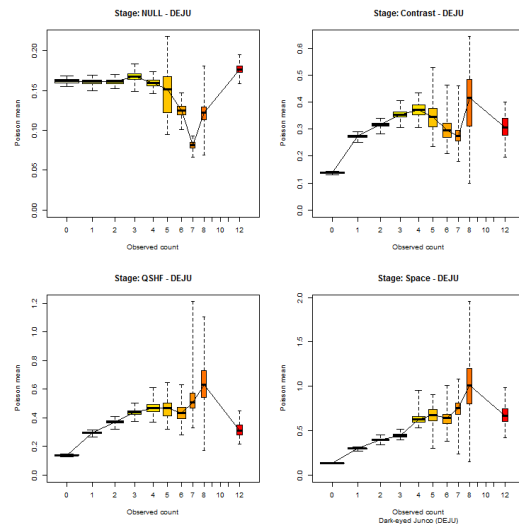
5.26.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

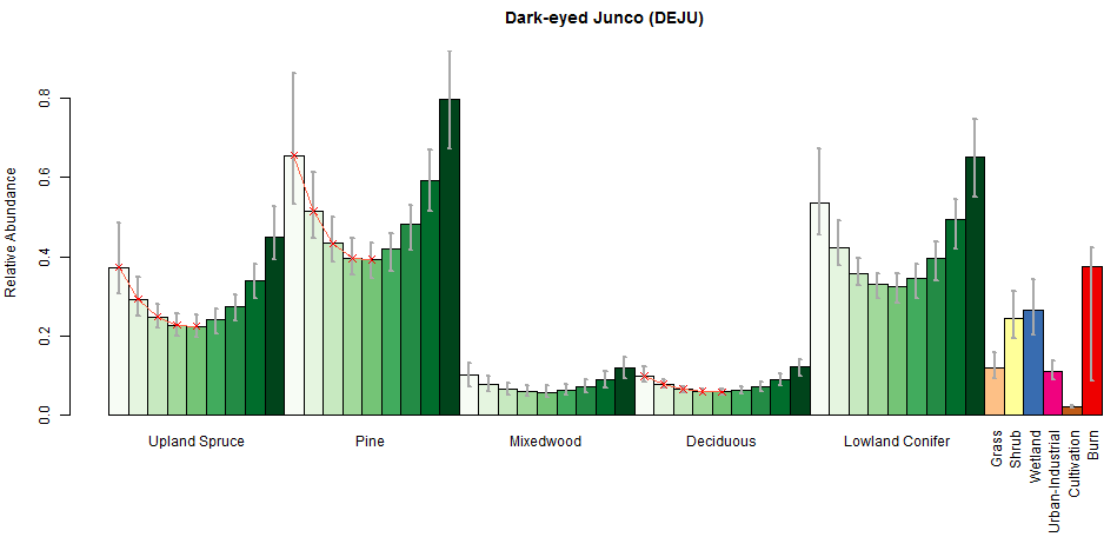


5.26.2 Cross validation

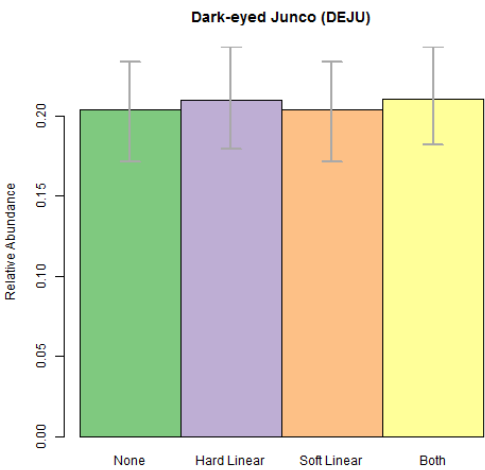
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.26.3 Point level habitat associations

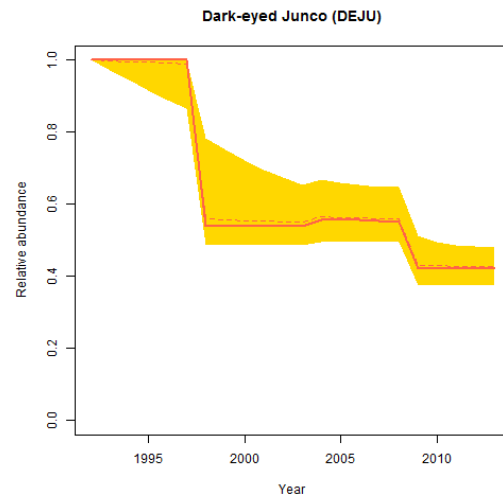


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

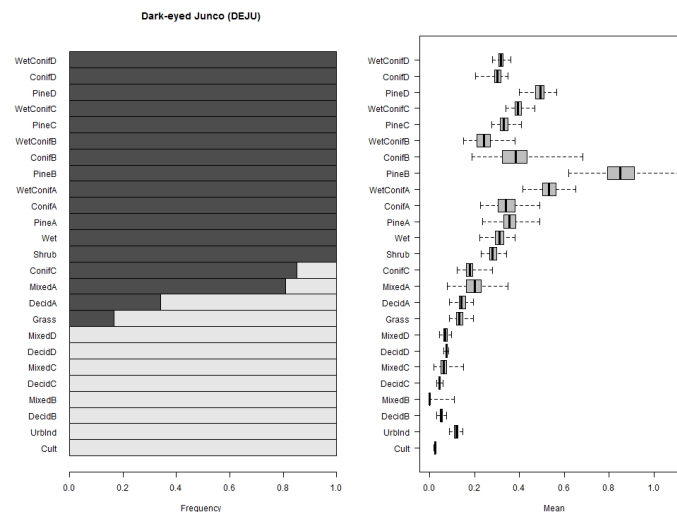


5.26.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



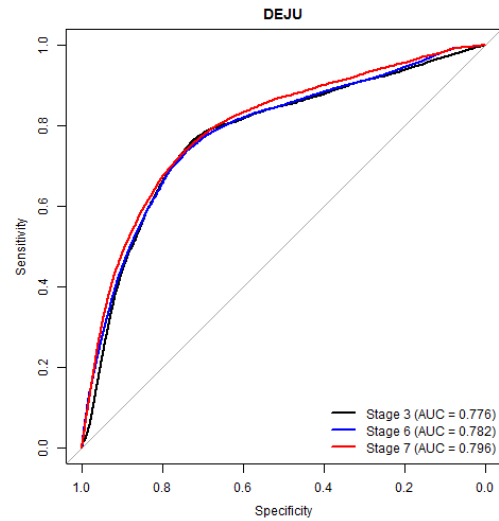
5.26.5 Habitat suitability ranking for patch delineation



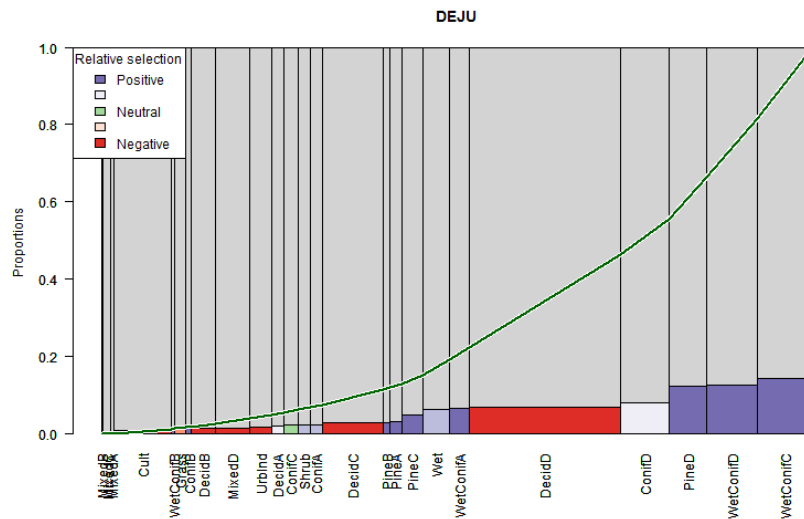
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.26.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

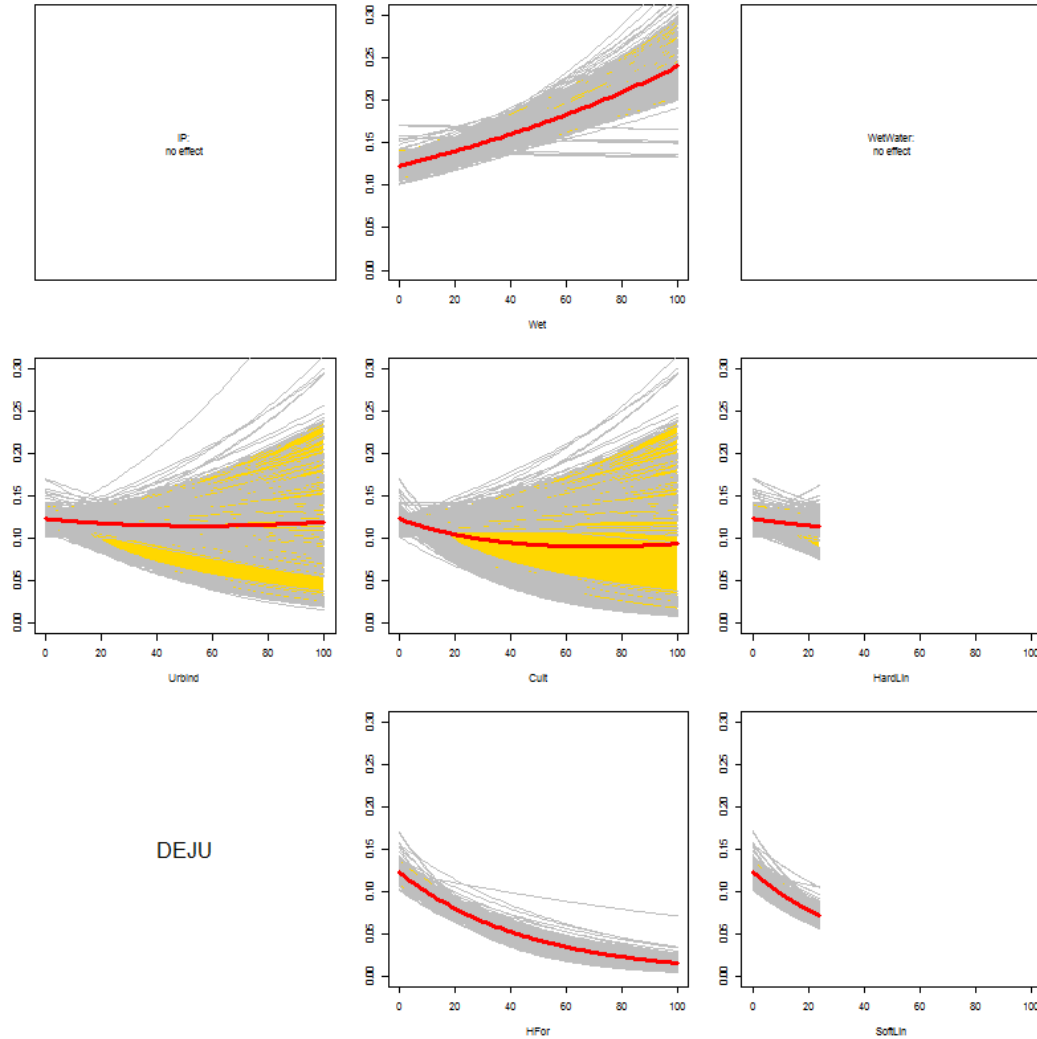


5.26.7 Relative habitat selection



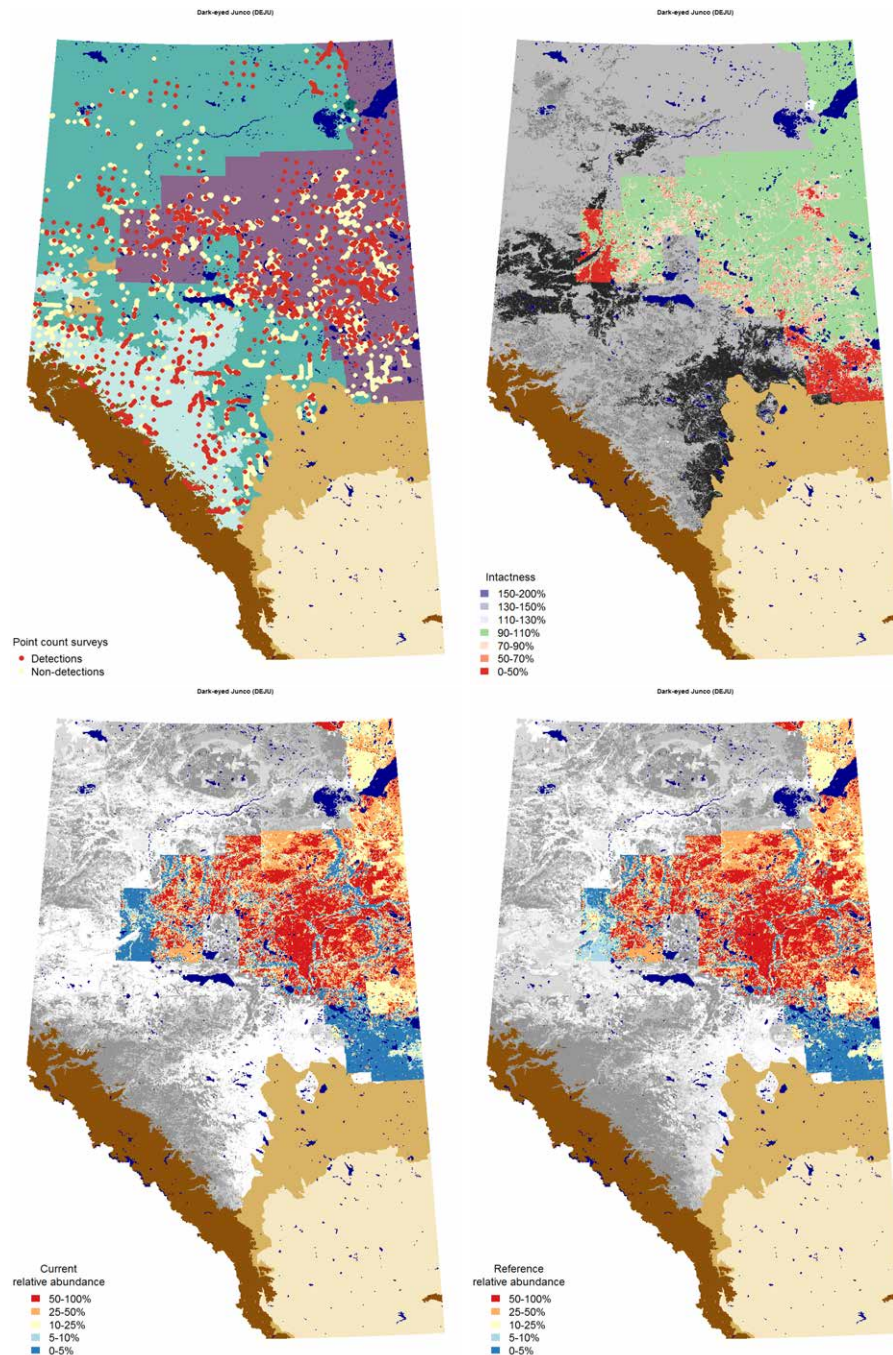
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.26.8 Quarter-section level responses



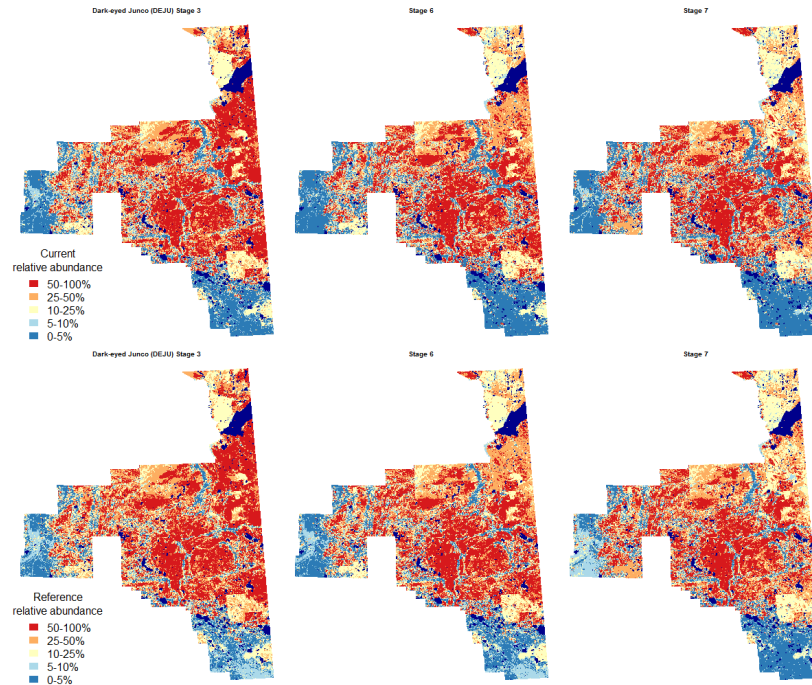
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.26.9 Maps



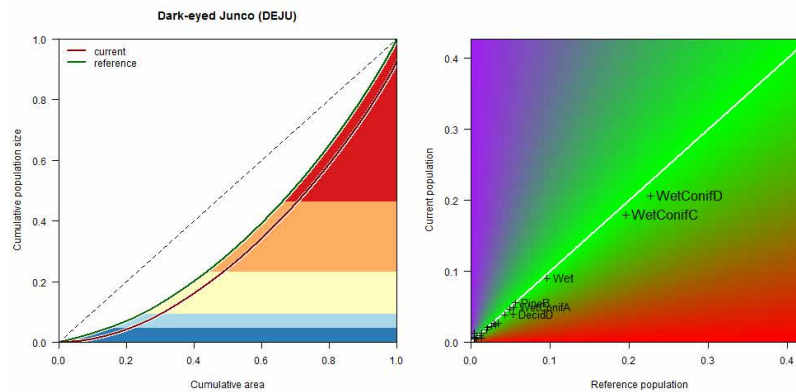
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.26.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.26.11 Population concentration



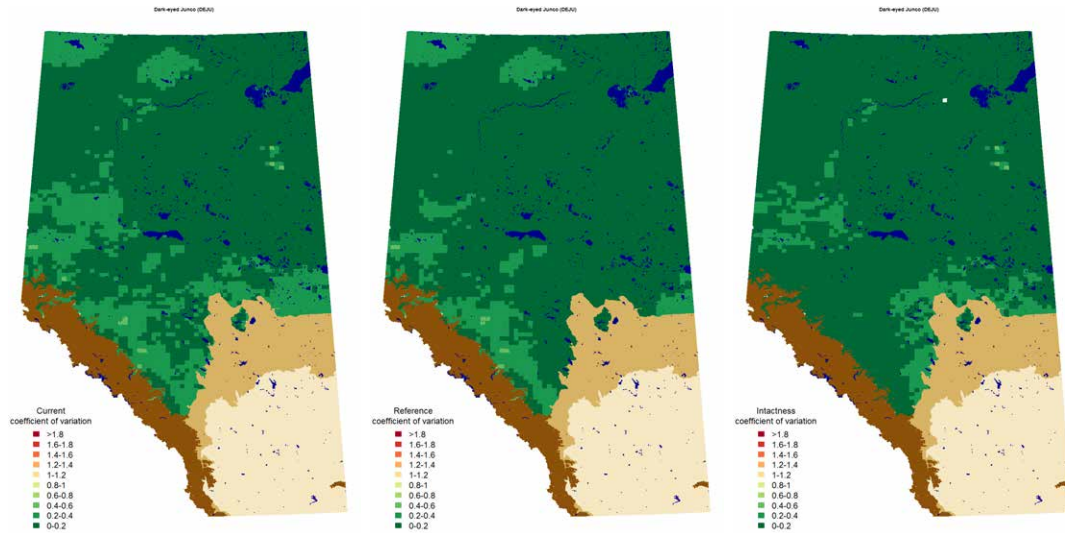
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.26.12 Potential population size

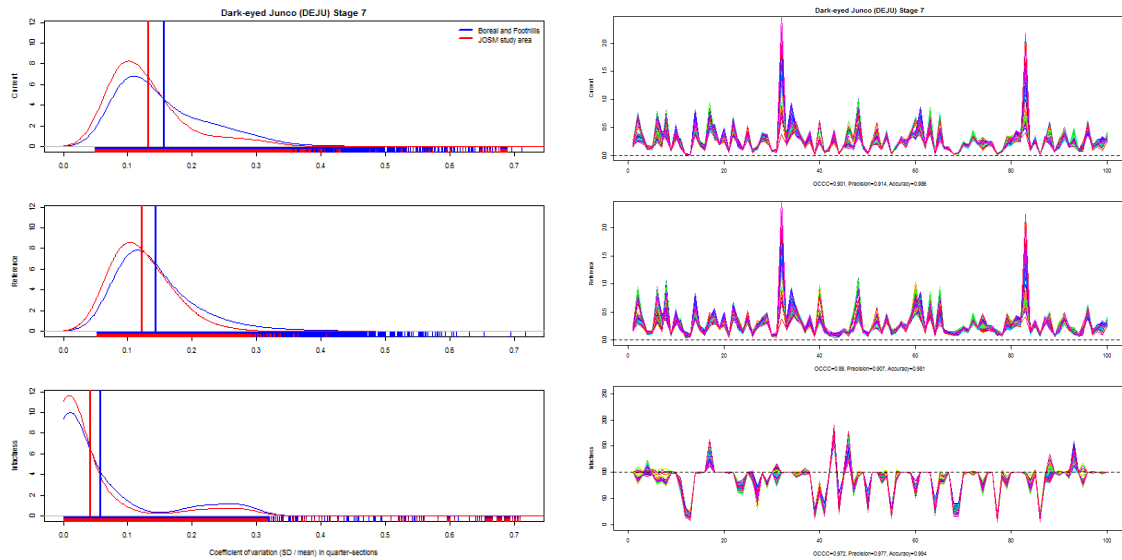
Estimated potential population size of Dark-eyed Junco in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.8838	0.8064	0.9643	0.9721	0.8778	1.0672
WetConifC	0.7698	0.7024	0.8400	0.8396	0.7582	0.9218
Wet	0.3868	0.3529	0.4220	0.4134	0.3733	0.4539
PineB	0.2382	0.2173	0.2599	0.2425	0.2190	0.2663
WetConifA	0.2116	0.1931	0.2309	0.2322	0.2097	0.2549
DecidD	0.1681	0.1534	0.1835	0.2295	0.2073	0.2520
WetConifB	0.2001	0.1826	0.2184	0.2109	0.1905	0.2315
PineC	0.1674	0.1528	0.1827	0.1841	0.1662	0.2021
ConifD	0.1167	0.1065	0.1274	0.1482	0.1338	0.1627
Shrub	0.1048	0.0957	0.1144	0.1351	0.1220	0.1483
PineD	0.1142	0.1042	0.1246	0.1273	0.1149	0.1397
ConifC	0.0971	0.0886	0.1060	0.1146	0.1034	0.1258
PineA	0.0885	0.0808	0.0966	0.0931	0.0841	0.1022
ConifA	0.0749	0.0684	0.0818	0.0884	0.0798	0.0971
ConifB	0.0550	0.0502	0.0600	0.0619	0.0559	0.0679
Grass	0.0263	0.0240	0.0287	0.0597	0.0539	0.0656
MixedD	0.0414	0.0378	0.0452	0.0514	0.0465	0.0565
DecidC	0.0259	0.0236	0.0282	0.0344	0.0311	0.0378
DecidB	0.0195	0.0178	0.0212	0.0250	0.0225	0.0274
DecidA	0.0060	0.0055	0.0066	0.0093	0.0084	0.0102
MixedB	0.0037	0.0034	0.0040	0.0042	0.0038	0.0046
MixedA	0.0029	0.0026	0.0031	0.0042	0.0038	0.0046
MixedC	0.0023	0.0021	0.0025	0.0028	0.0025	0.0030
Cult	0.0202	0.0184	0.0220	0.0000	0.0000	0.0000
UrbInd	0.0285	0.0260	0.0311	0.0000	0.0000	0.0000
HardLin	0.0024	0.0022	0.0026	0.0000	0.0000	0.0000
SoftLin	0.0534	0.0487	0.0582	0.0000	0.0000	0.0000
HFor	0.0539	0.0492	0.0588	0.0000	0.0000	0.0000
Total	3.9635	3.6164	4.3248	4.2840	3.8685	4.7030
Loss	0.3271	0.2294	0.4238			
Gain	0.0047	0.0024	0.0092			

5.26.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.26.14 Variable selection frequencies

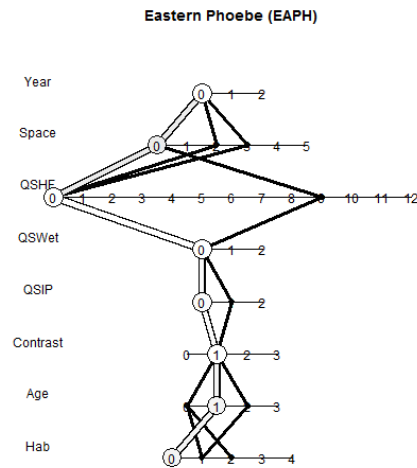
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	38.0	76	. + Habitat
1.2	62.0	124	. + HabitatB
2.0	0.5	1	NULL
2.2	99.0	198	. + Age + Age2 . + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
2.3	0.5	1	
3.0	74.5	149	NULL
3.1	19.5	39	. + ROAD
3.2	6.0	12	. + SoftLin_PC
4.0	100.0	200	NULL
5.0	4.0	8	NULL
5.1	96.0	192	. + pWet_QS
6.7	16.5	33	. + Succ_QS + Alien_QS + Succ2_QS
6.8	33.5	67	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.11	49.5	99	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
6.12	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.3	14.5	29	. + xlat + xlong + xlat:xlong
7.4	82.5	165	. + xMAP + xPET + xMAT + xCMD
7.5	3.0	6	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	6.5	13	. + xYEAR
8.2	93.5	187	. + YR5F

5.27 Eastern Phoebe (*Sayornis phoebe*)

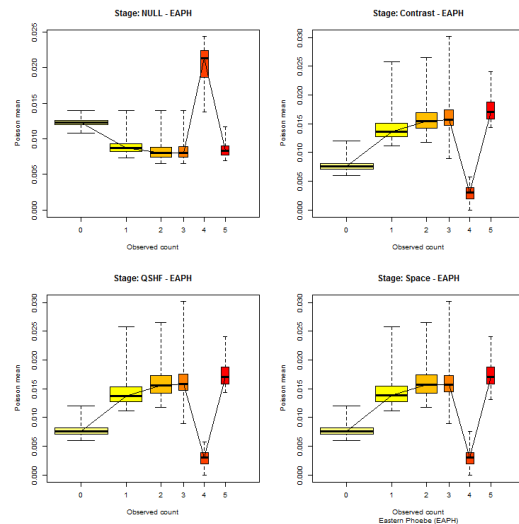
5.27.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

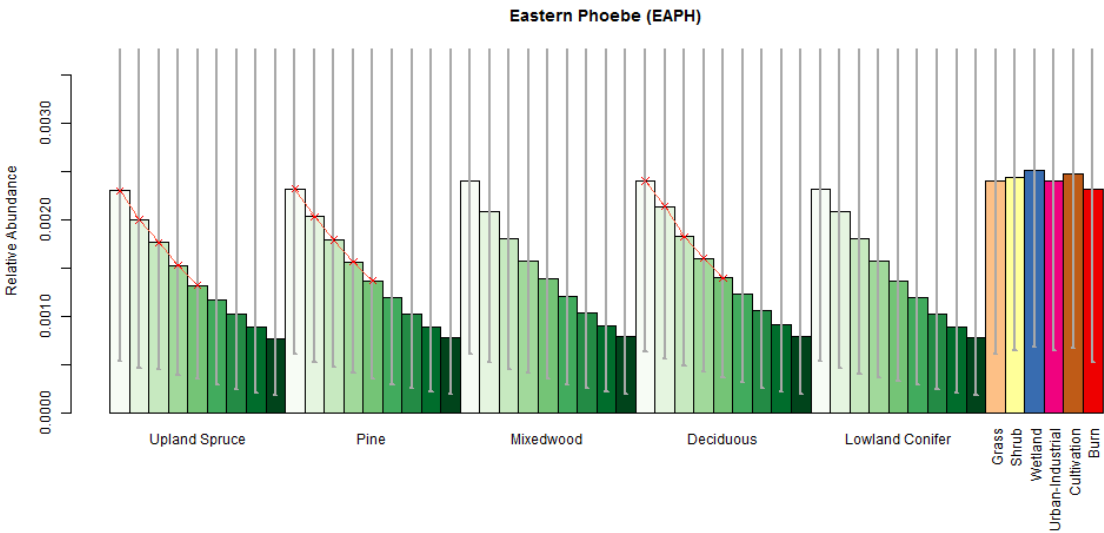


5.27.2 Cross validation

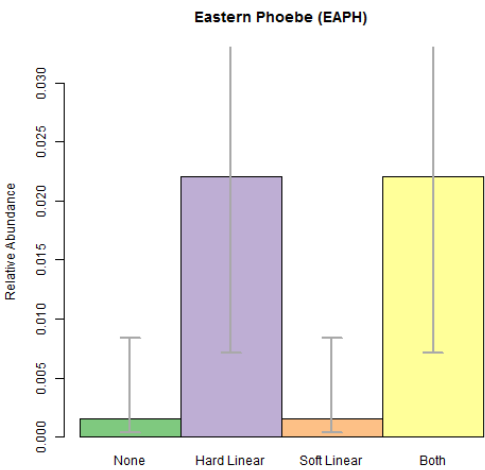
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.27.3 Point level habitat associations

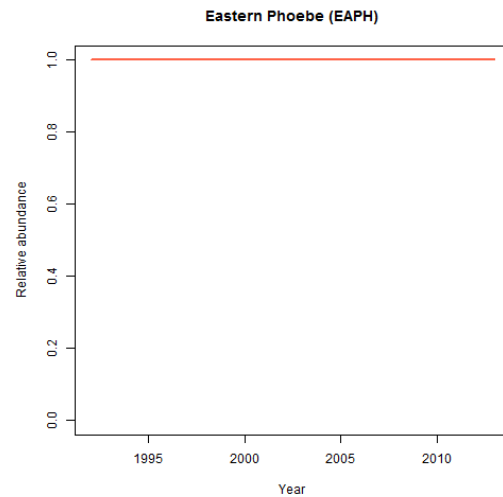


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

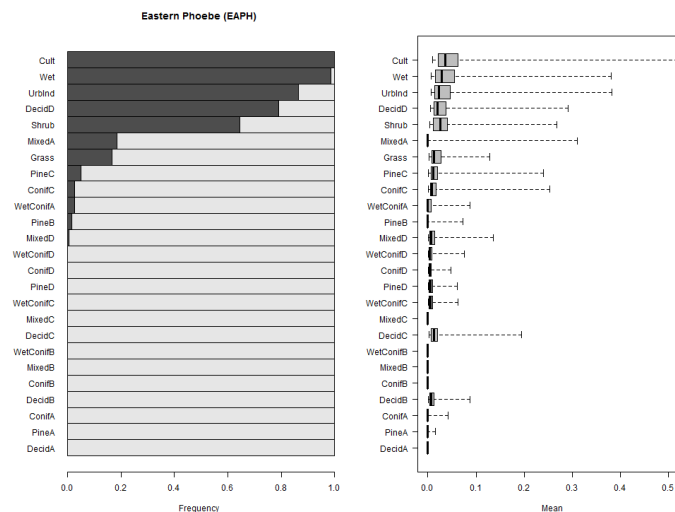


5.27.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



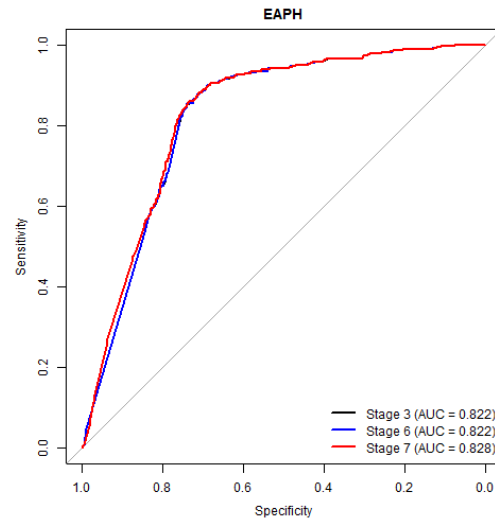
5.27.5 Habitat suitability ranking for patch delineation



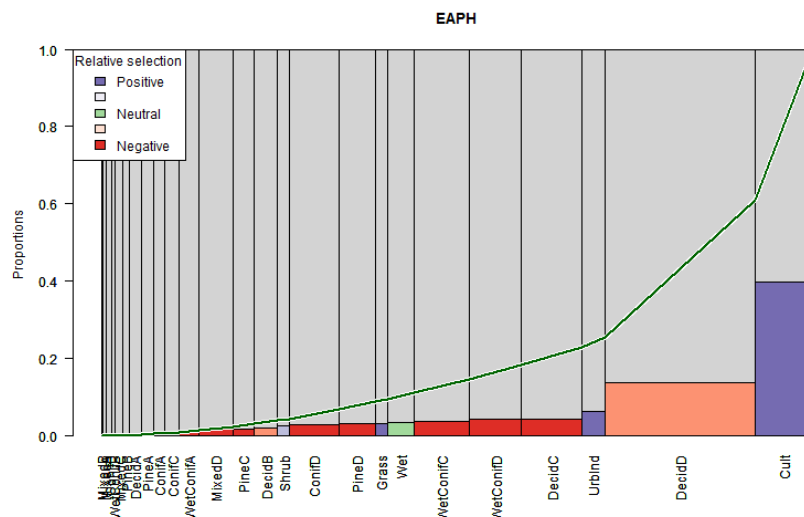
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.27.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

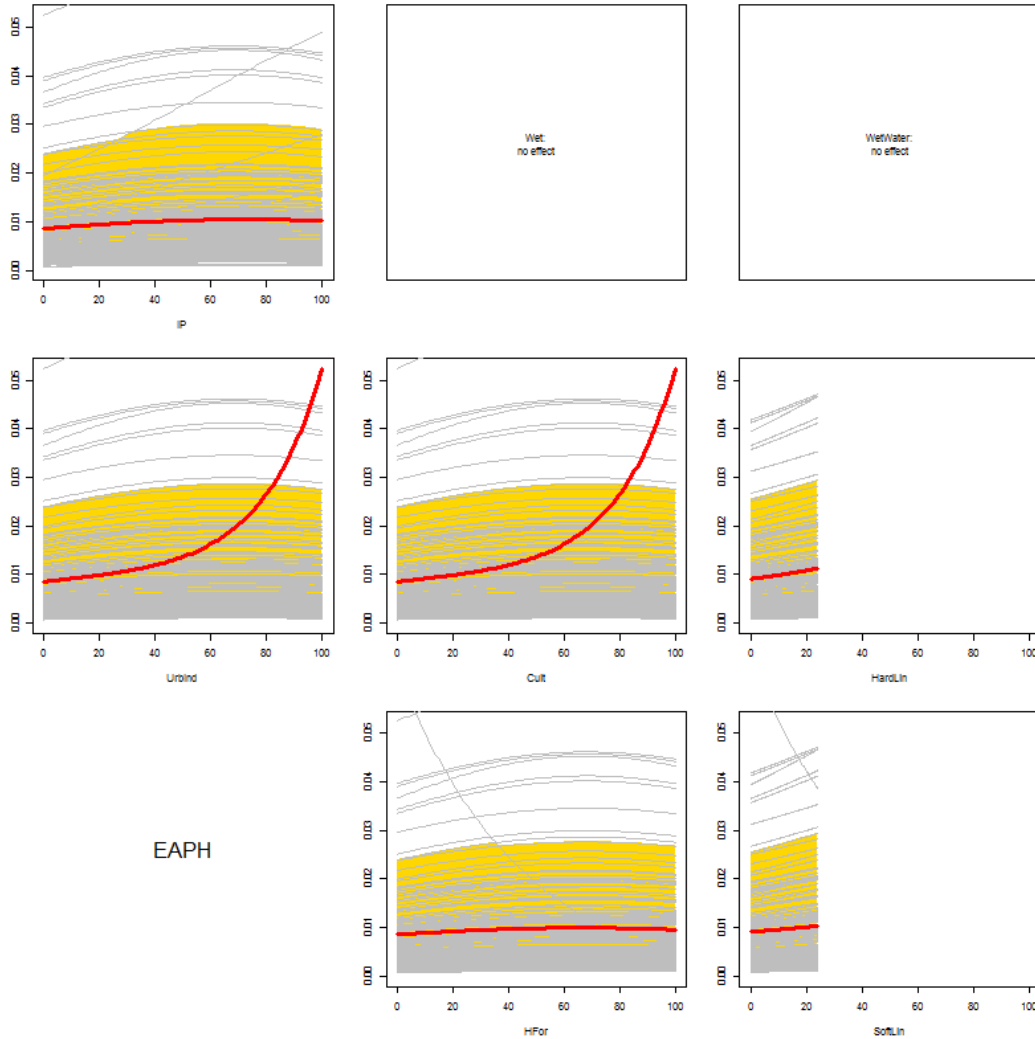


5.27.7 Relative habitat selection



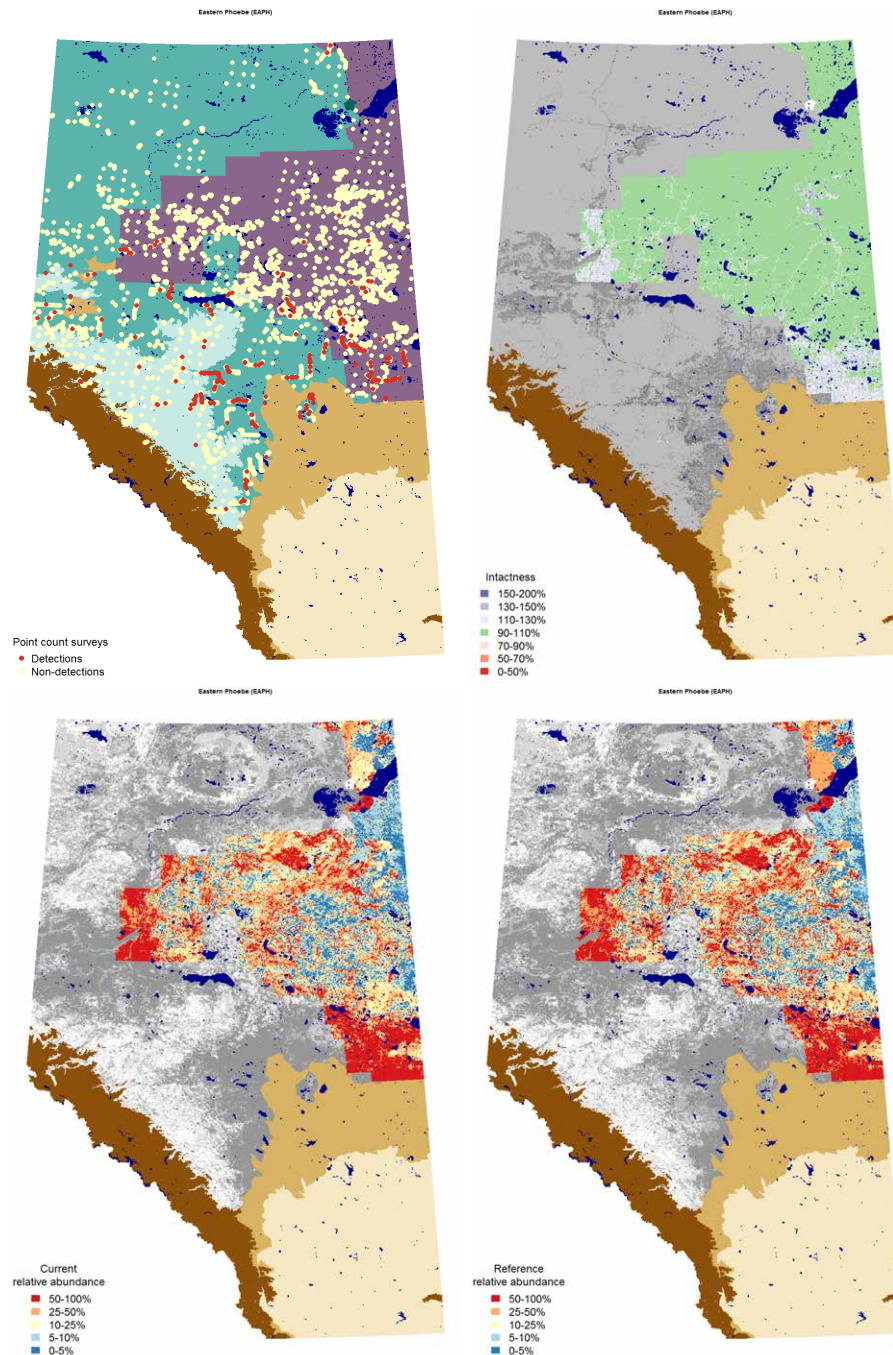
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.27.8 Quarter-section level responses



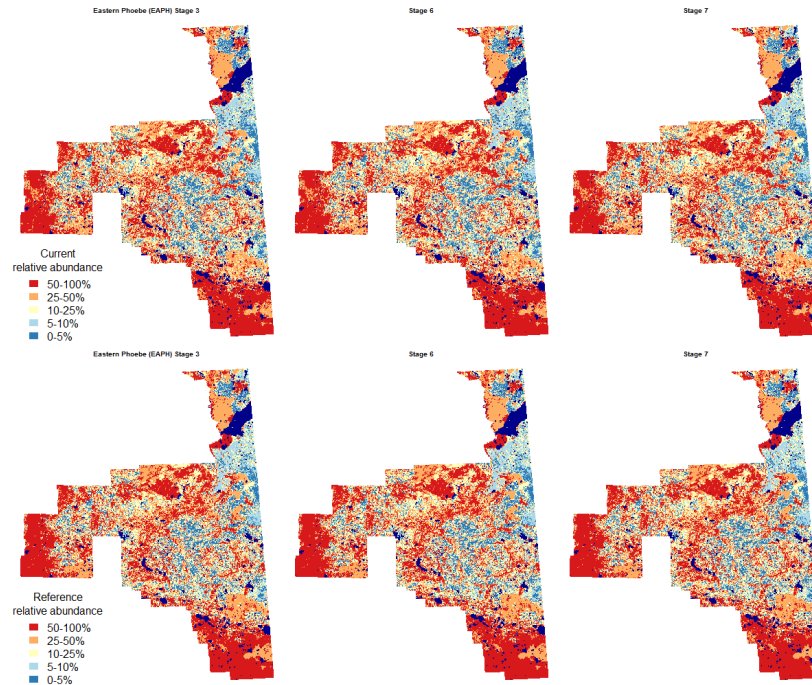
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.27.9 Maps



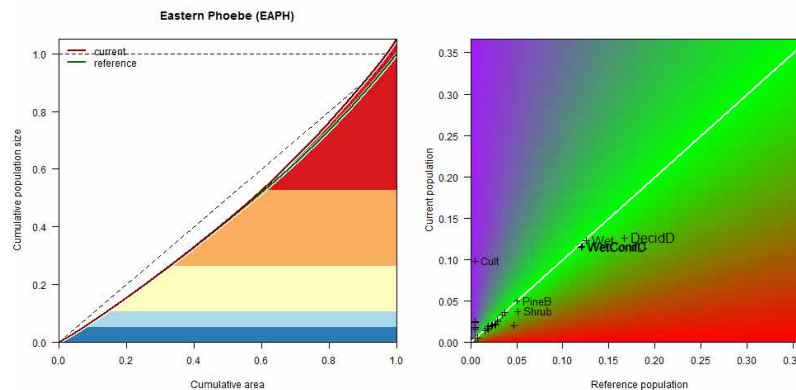
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.27.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSH study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSH area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.27.11 Population concentration



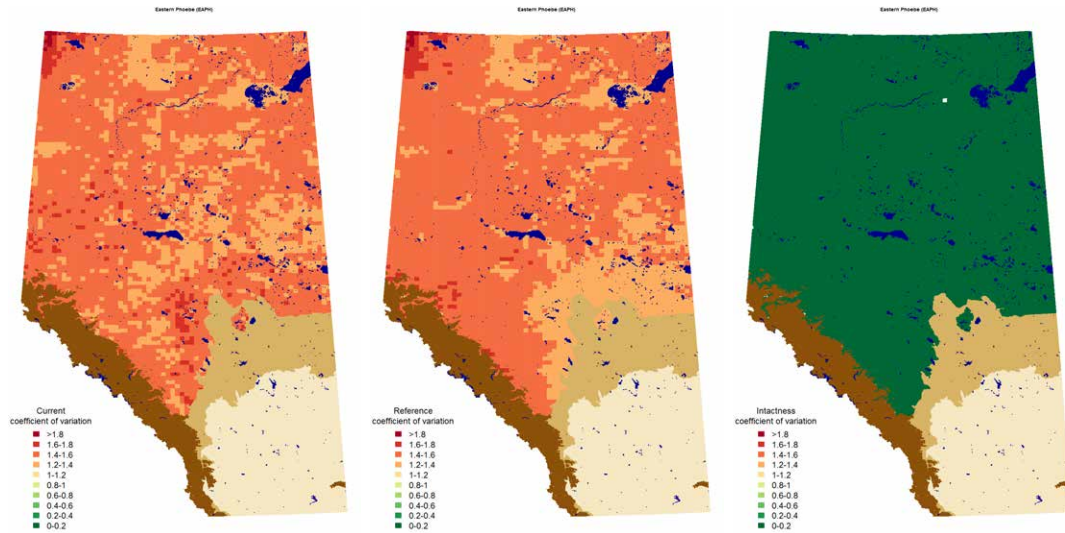
Lorenz curves (left) based on 10% of the quarter-sections in the JOSH study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.27.12 Potential population size

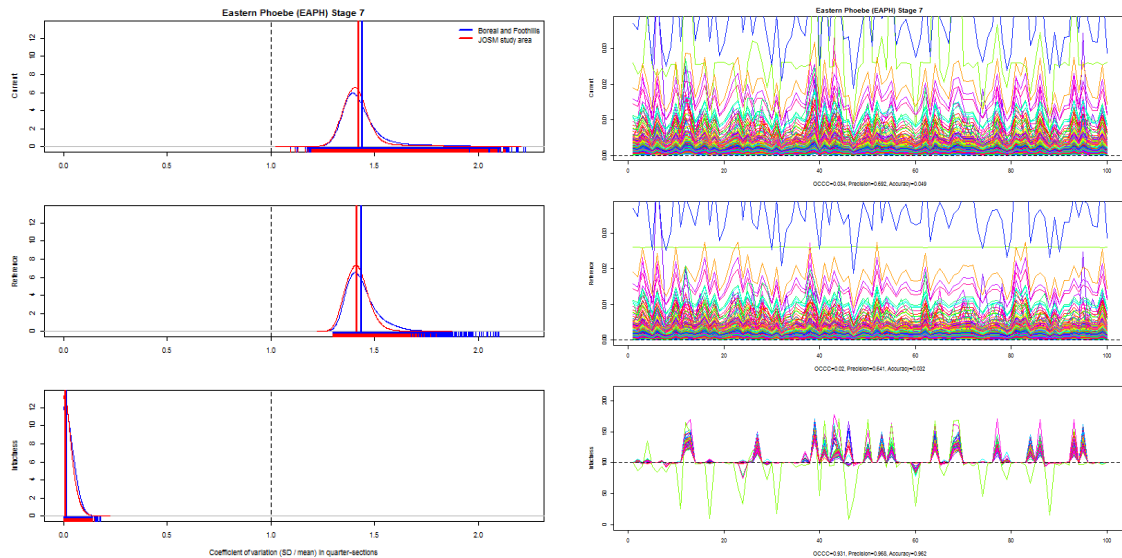
Estimated potential population size of Eastern Phoebe in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0034	0.0009	0.0178	0.0046	0.0012	0.0229
Wet	0.0034	0.0009	0.0174	0.0035	0.0009	0.0172
WetConifC	0.0032	0.0009	0.0164	0.0033	0.0009	0.0166
WetConifD	0.0032	0.0009	0.0163	0.0033	0.0009	0.0165
Shrub	0.0010	0.0003	0.0052	0.0014	0.0004	0.0070
PineB	0.0014	0.0004	0.0070	0.0014	0.0004	0.0069
Grass	0.0005	0.0001	0.0028	0.0013	0.0003	0.0064
WetConifA	0.0010	0.0003	0.0051	0.0010	0.0003	0.0051
WetConifB	0.0009	0.0002	0.0047	0.0009	0.0003	0.0047
MixedD	0.0007	0.0002	0.0035	0.0008	0.0002	0.0040
PineC	0.0007	0.0002	0.0039	0.0008	0.0002	0.0040
DecidC	0.0006	0.0002	0.0030	0.0008	0.0002	0.0038
ConifD	0.0006	0.0002	0.0031	0.0007	0.0002	0.0037
ConifC	0.0006	0.0002	0.0029	0.0007	0.0002	0.0033
ConifA	0.0005	0.0001	0.0028	0.0006	0.0002	0.0031
PineA	0.0005	0.0001	0.0027	0.0005	0.0001	0.0027
DecidB	0.0004	0.0001	0.0022	0.0005	0.0001	0.0027
PineD	0.0005	0.0001	0.0024	0.0005	0.0001	0.0025
ConifB	0.0004	0.0001	0.0020	0.0004	0.0001	0.0022
DecidA	0.0001	0.0000	0.0007	0.0002	0.0001	0.0010
MixedA	0.0001	0.0000	0.0003	0.0001	0.0000	0.0004
MixedB	0.0001	0.0000	0.0004	0.0001	0.0000	0.0004
MixedC	0.0000	0.0000	0.0002	0.0000	0.0000	0.0002
Cult	0.0027	0.0007	0.0139	0.0000	0.0000	0.0000
UrbInd	0.0005	0.0001	0.0025	0.0000	0.0000	0.0000
HardLin	0.0007	0.0002	0.0034	0.0000	0.0000	0.0000
SoftLin	0.0004	0.0001	0.0022	0.0000	0.0000	0.0000
HFor	0.0007	0.0002	0.0035	0.0000	0.0000	0.0000
Total	0.0287	0.0078	0.1483	0.0275	0.0073	0.1373
Loss	0.0001	0.0000	0.0004			
Gain	0.0015	0.0005	0.0075			

5.27.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.27.14 Variable selection frequencies

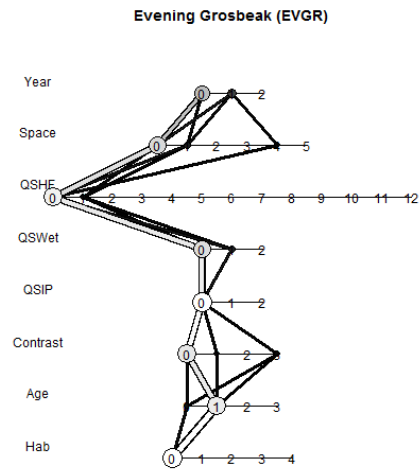
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	95.5	191	NULL
1.1	2.0	4	. + Habitat
1.2	2.5	5	. + HabitatB
2.0	4.0	8	NULL
2.1	95.5	191	. + Age
2.2	0.5	1	. + Age + Age2
3.1	100.0	200	. + ROAD
4.0	98.0	196	NULL
4.1	2.0	4	. + Remn_QS
5.0	100.0	200	NULL
6.0	99.5	199	NULL
6.9	0.5	1	. + Succ_QS + Alien_QS + Alien2_QS
7.0	92.5	185	NULL
7.2	4.0	8	. + xlat + xlong
7.3	3.5	7	. + xlat + xlong + xlat:xlong
8.0	100.0	200	NULL

5.28 Evening Grosbeak (*Coccothraustes vespertinus*)

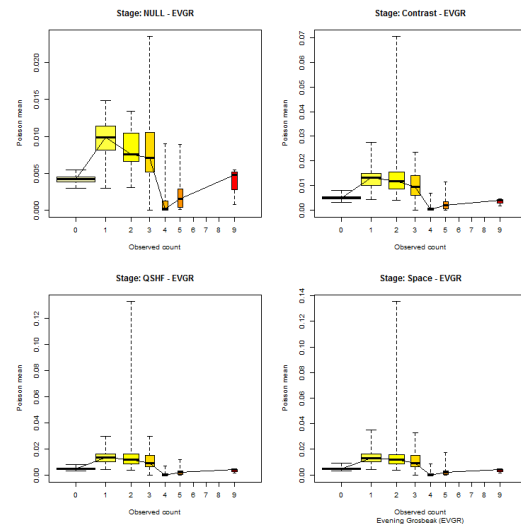
5.28.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

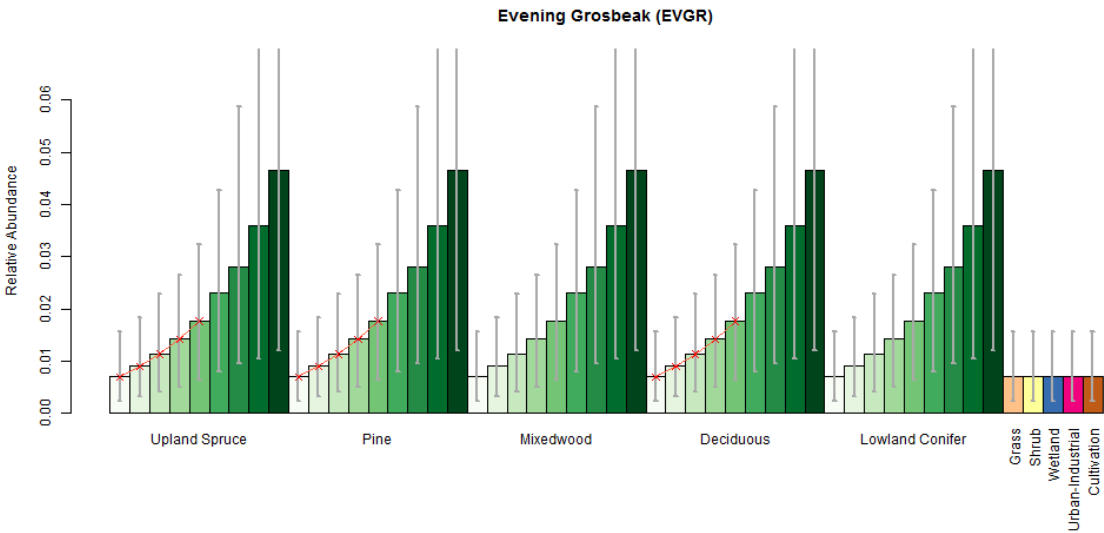


5.28.2 Cross validation

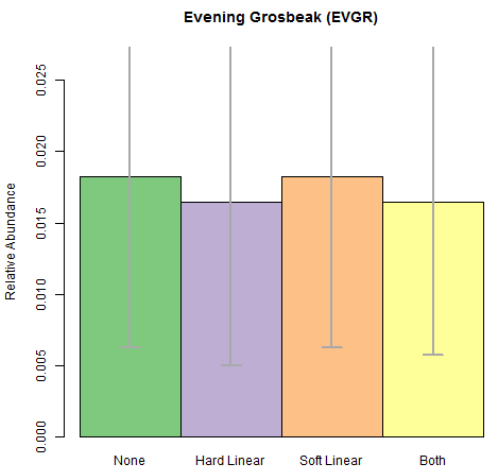
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.28.3 Point level habitat associations

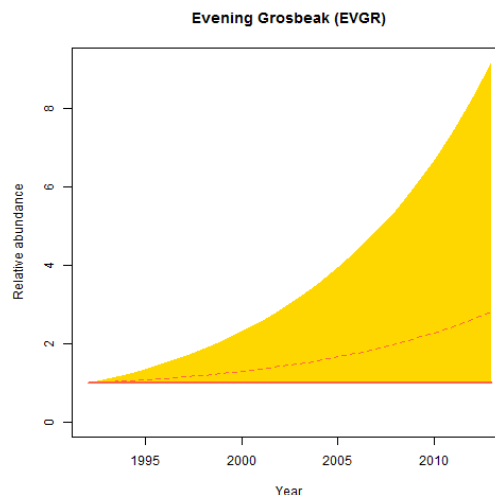


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

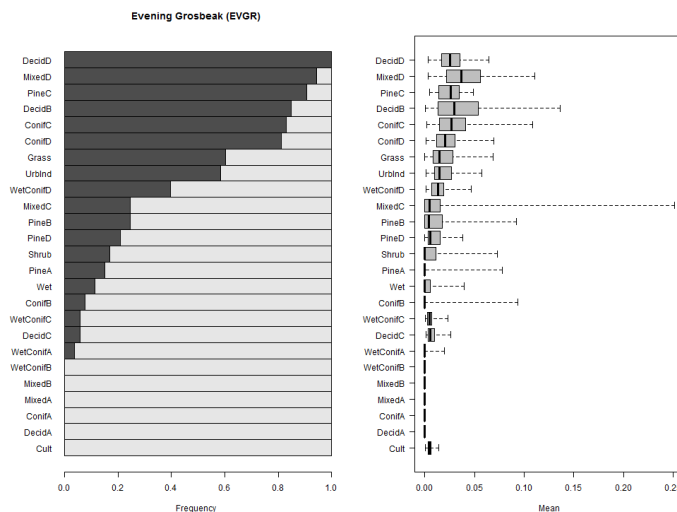


5.28.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



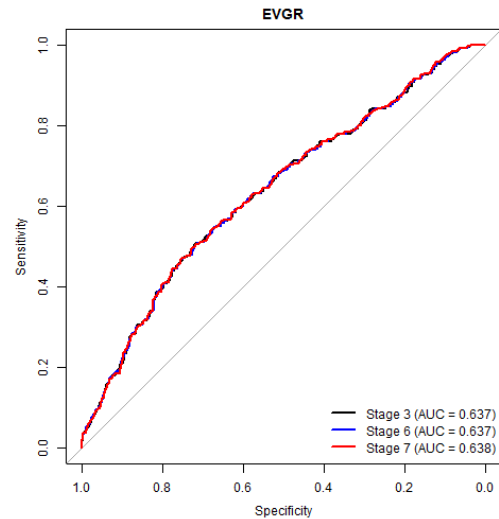
5.28.5 Habitat suitability ranking for patch delineation



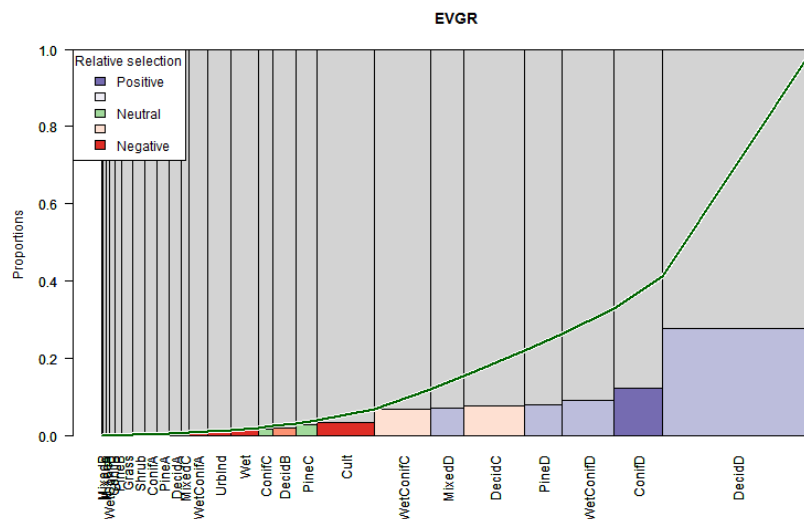
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.28.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

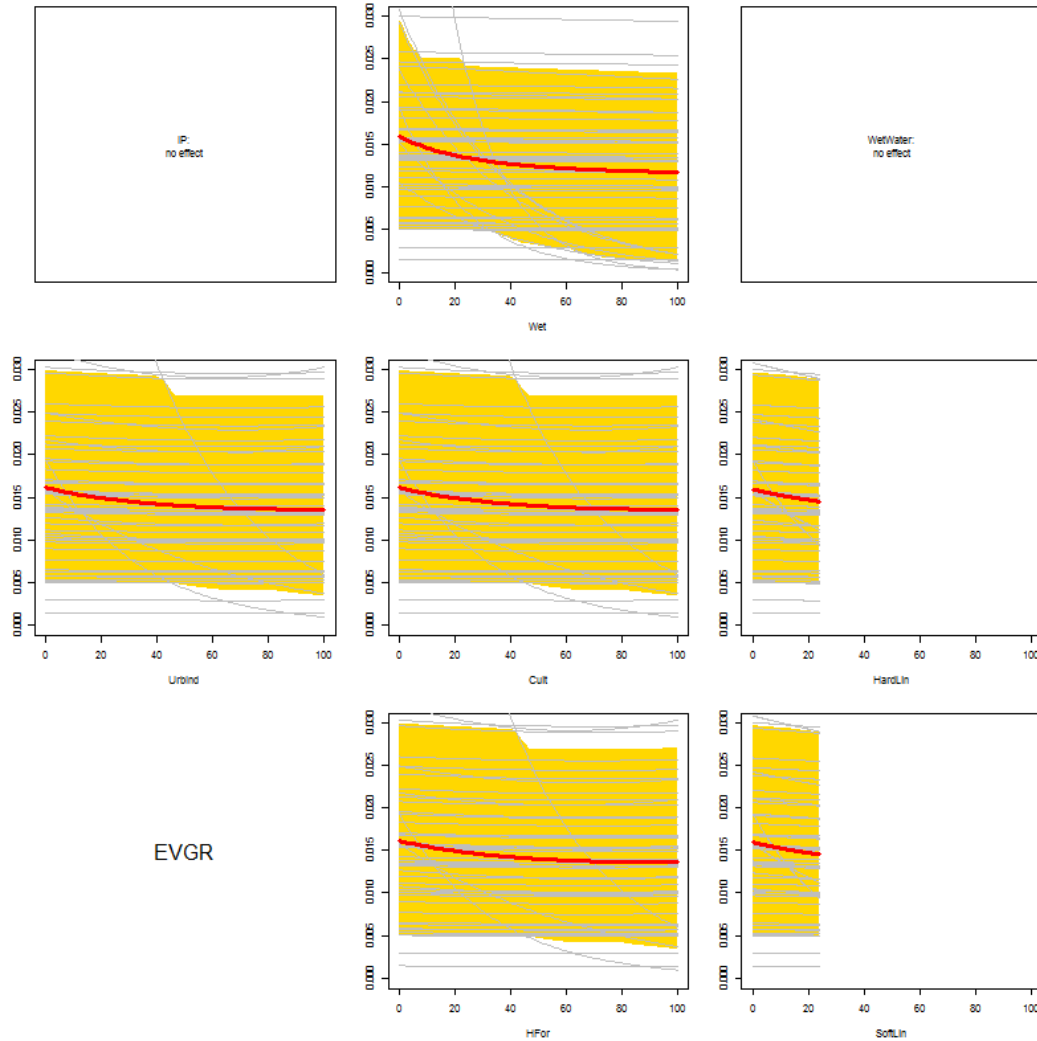


5.28.7 Relative habitat selection



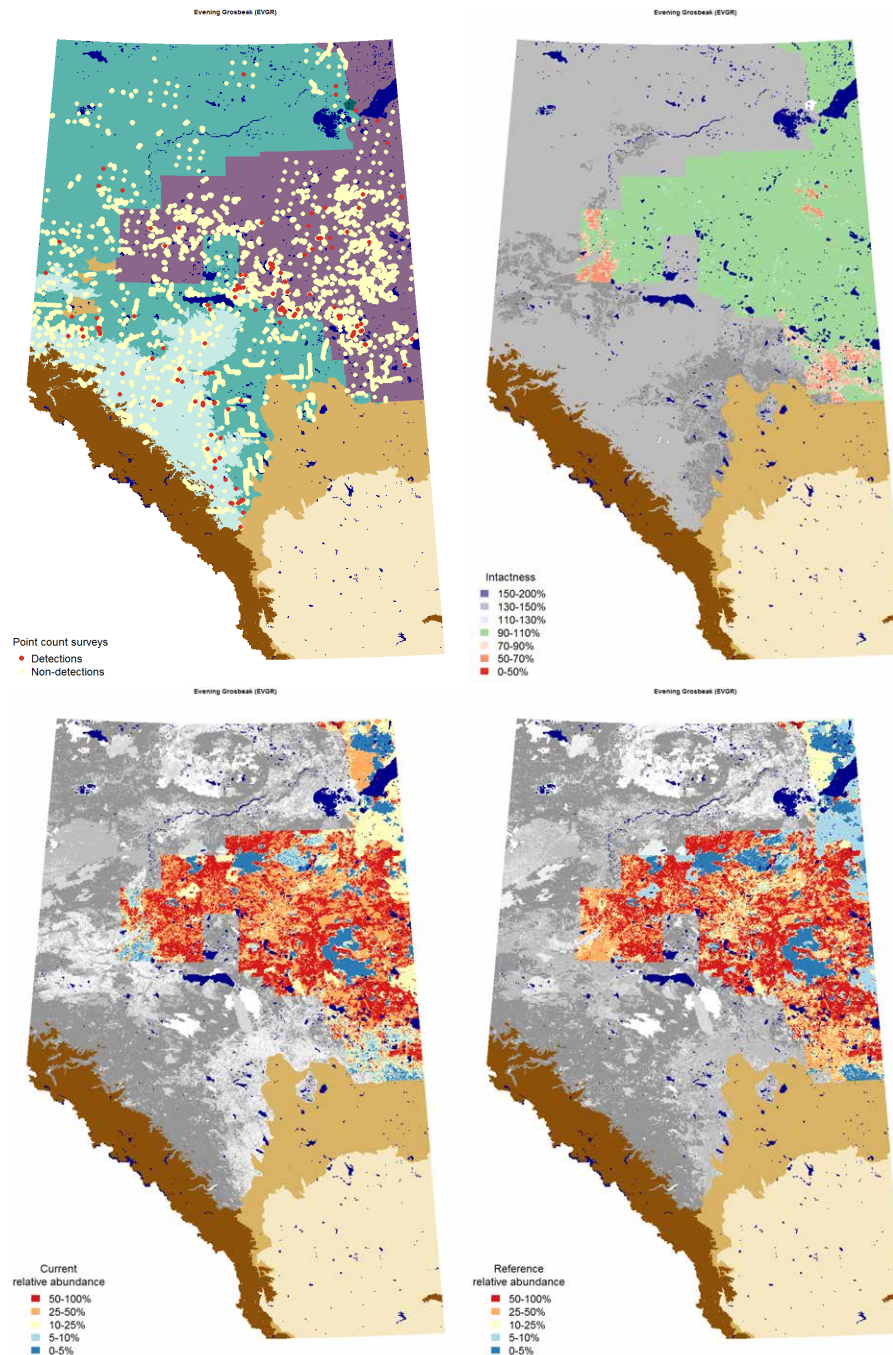
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.28.8 Quarter-section level responses



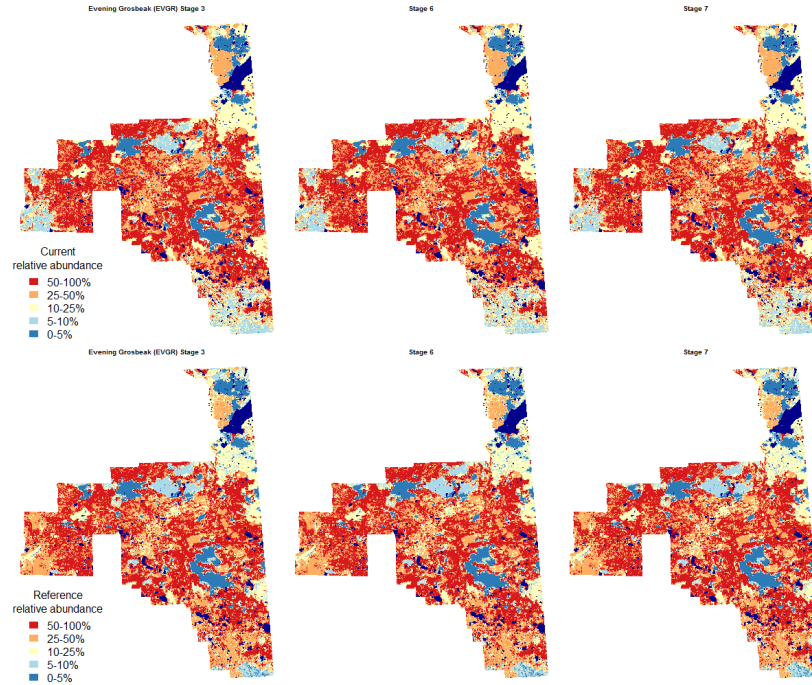
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.28.9 Maps



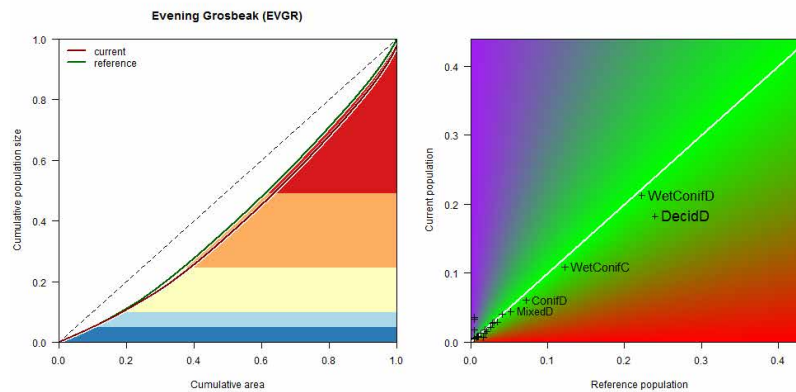
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.28.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.28.11 Population concentration



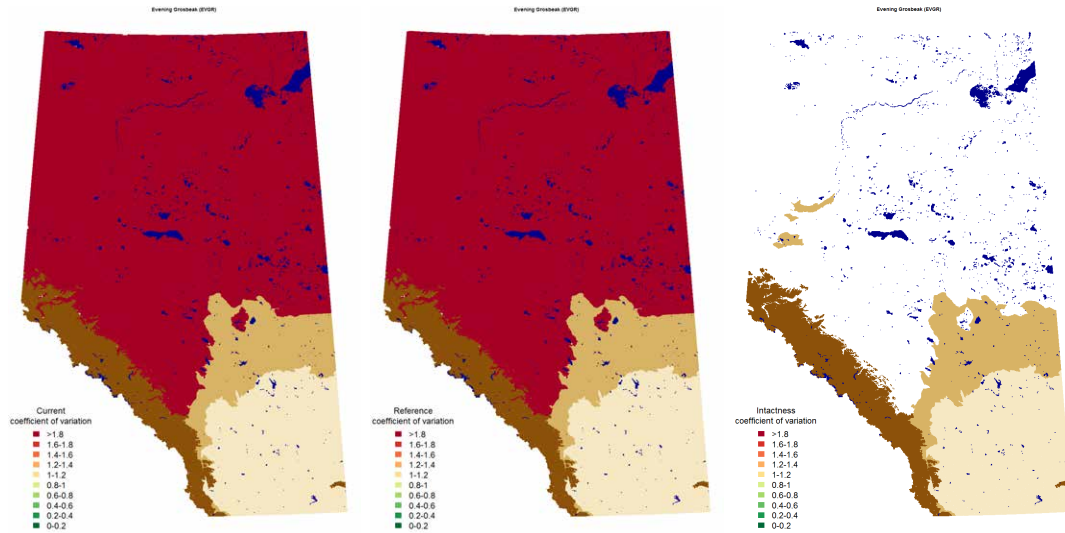
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.28.12 Potential population size

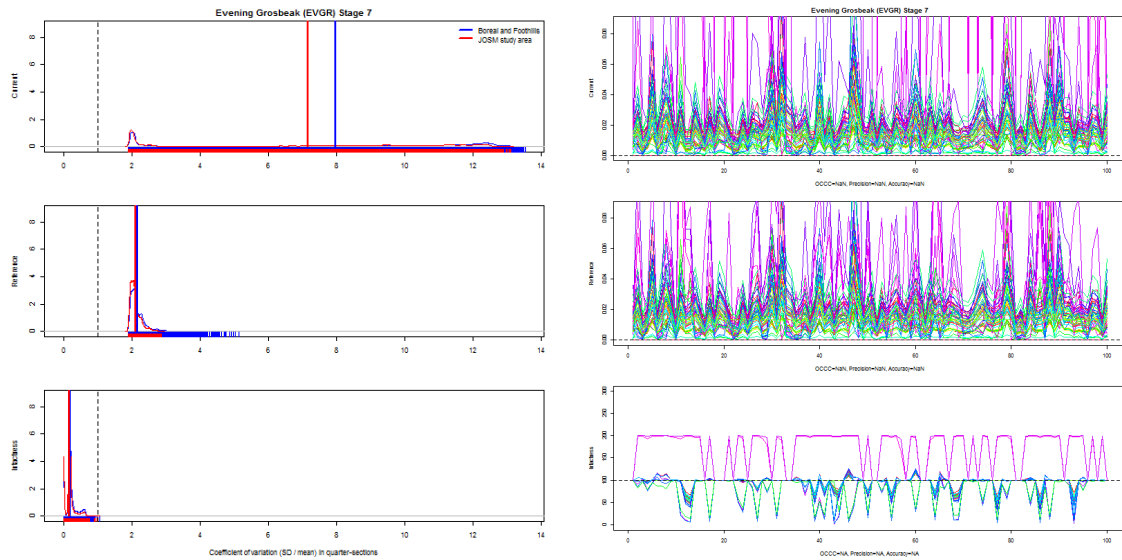
Estimated potential population size of Evening Grosbeak in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0434	0.0136	0.1036	0.0562	0.0191	0.1046
WetConifD	0.0505	0.0158	0.1207	0.0521	0.0177	0.0971
WetConifC	0.0258	0.0081	0.0615	0.0287	0.0097	0.0534
ConifD	0.0144	0.0045	0.0344	0.0170	0.0058	0.0317
MixedD	0.0106	0.0033	0.0252	0.0122	0.0042	0.0228
Wet	0.0096	0.0030	0.0229	0.0096	0.0033	0.0179
PineD	0.0070	0.0022	0.0166	0.0082	0.0028	0.0152
PineC	0.0068	0.0021	0.0161	0.0072	0.0024	0.0134
PineB	0.0066	0.0021	0.0158	0.0066	0.0022	0.0123
ConifC	0.0053	0.0017	0.0126	0.0061	0.0021	0.0113
DecidC	0.0038	0.0012	0.0091	0.0050	0.0017	0.0093
WetConifB	0.0042	0.0013	0.0101	0.0043	0.0015	0.0080
Shrub	0.0032	0.0010	0.0077	0.0043	0.0015	0.0080
Grass	0.0017	0.0005	0.0041	0.0039	0.0013	0.0072
WetConifA	0.0030	0.0009	0.0072	0.0031	0.0010	0.0058
DecidB	0.0019	0.0006	0.0046	0.0024	0.0008	0.0045
ConifB	0.0019	0.0006	0.0045	0.0021	0.0007	0.0039
ConifA	0.0018	0.0006	0.0042	0.0020	0.0007	0.0037
PineA	0.0017	0.0005	0.0041	0.0018	0.0006	0.0033
DecidA	0.0004	0.0001	0.0009	0.0007	0.0002	0.0012
MixedB	0.0003	0.0001	0.0008	0.0004	0.0001	0.0007
MixedC	0.0003	0.0001	0.0006	0.0003	0.0001	0.0006
MixedA	0.0002	0.0001	0.0005	0.0003	0.0001	0.0005
Cult	0.0079	0.0025	0.0188	0.0000	0.0000	0.0000
UrbInd	0.0015	0.0005	0.0036	0.0000	0.0000	0.0000
HardLin	0.0004	0.0001	0.0009	0.0000	0.0000	0.0000
SoftLin	0.0042	0.0013	0.0100	0.0000	0.0000	0.0000
HFor	0.0085	0.0027	0.0203	0.0000	0.0000	0.0000
Total	0.2269	0.0710	0.5417	0.2343	0.0795	0.4365
Loss	0.0086	0.0006	0.0312			
Gain	0.0012	0.0000	0.0076			

5.28.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.28.14 Variable selection frequencies

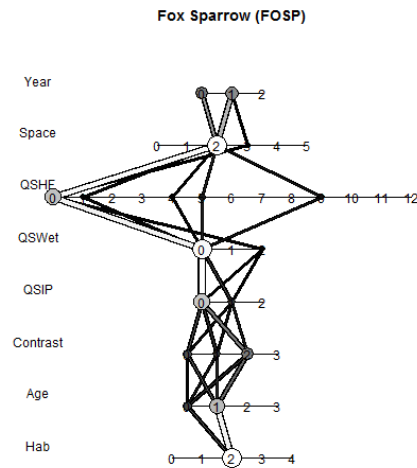
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	53	NULL
2.0	7.5	4	NULL
2.1	92.5	49	. + Age
3.0	90.6	48	NULL
3.1	5.7	3	. + ROAD
3.3	3.8	2	. + ROAD + SoftLin_PC
4.0	100.0	53	NULL
5.0	86.8	46	NULL
5.1	13.2	7	. + pWet_QS
6.0	94.3	50	NULL
6.1	5.7	3	. + THF_QS
7.0	84.9	45	NULL
7.1	11.3	6	. + xlat
7.4	3.8	2	. + xMAP + xPET + xMAT + xCMD
8.0	73.6	39	NULL
8.1	26.4	14	. + xYEAR

5.29 Fox Sparrow (*Passerella iliaca*)

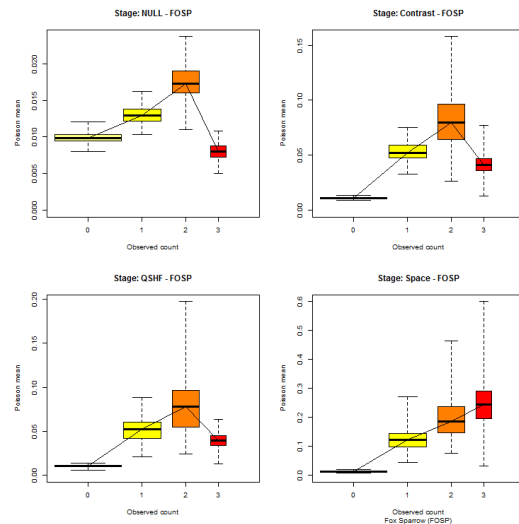
5.29.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

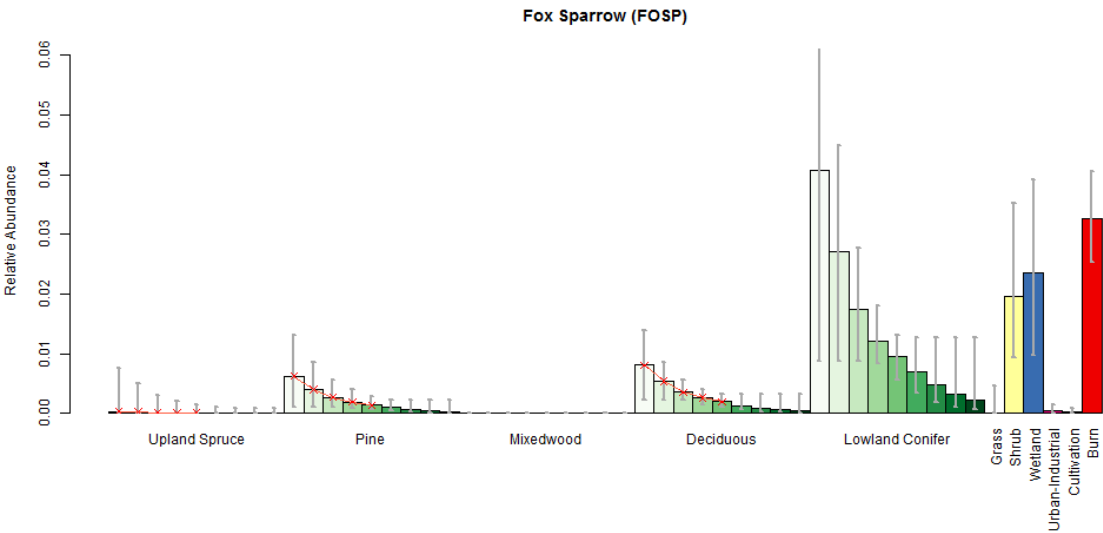


5.29.2 Cross validation

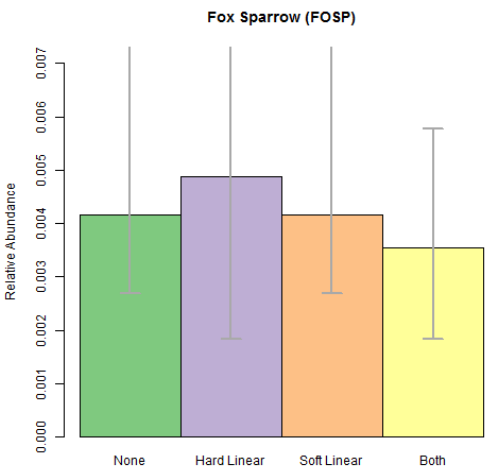
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.29.3 Point level habitat associations

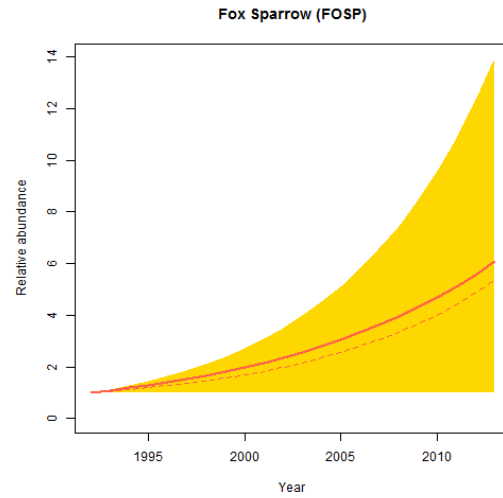


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

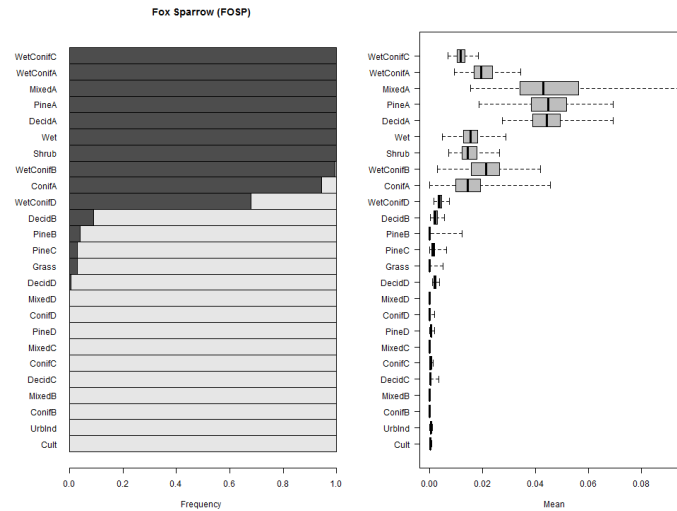


5.29.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



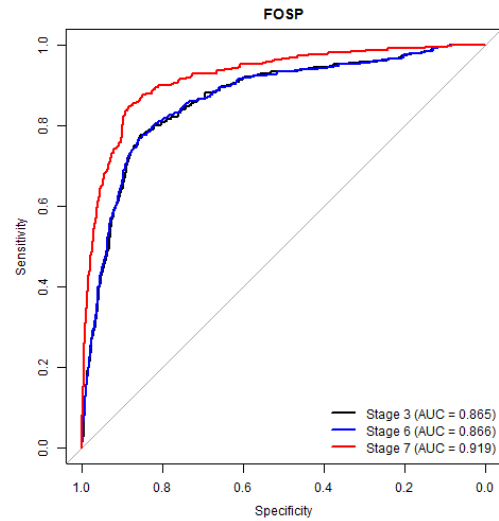
5.29.5 Habitat suitability ranking for patch delineation



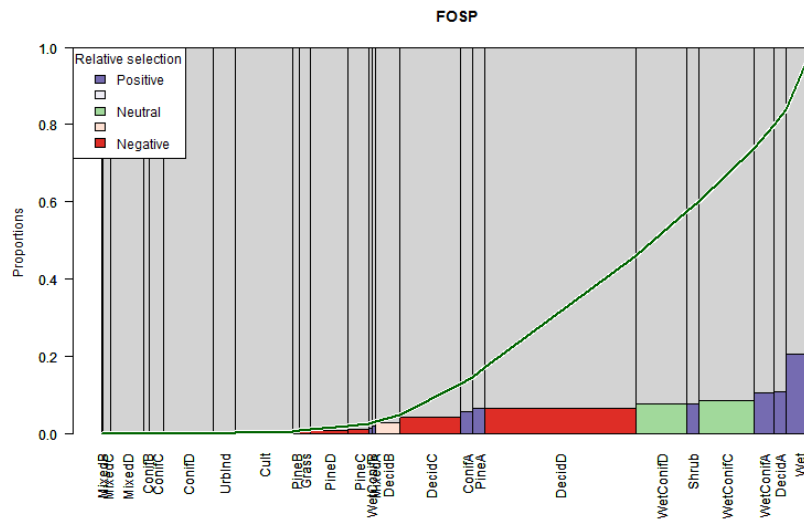
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.29.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

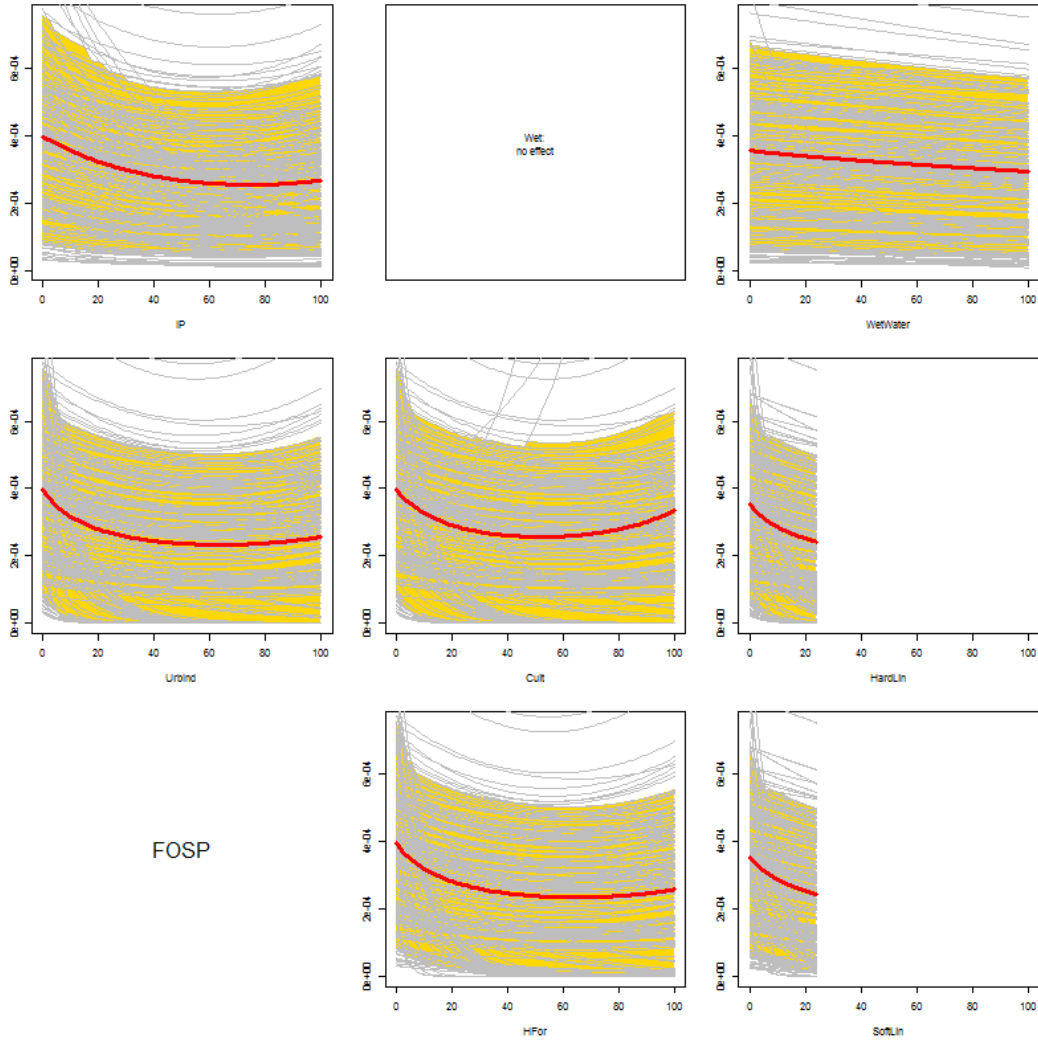


5.29.7 Relative habitat selection



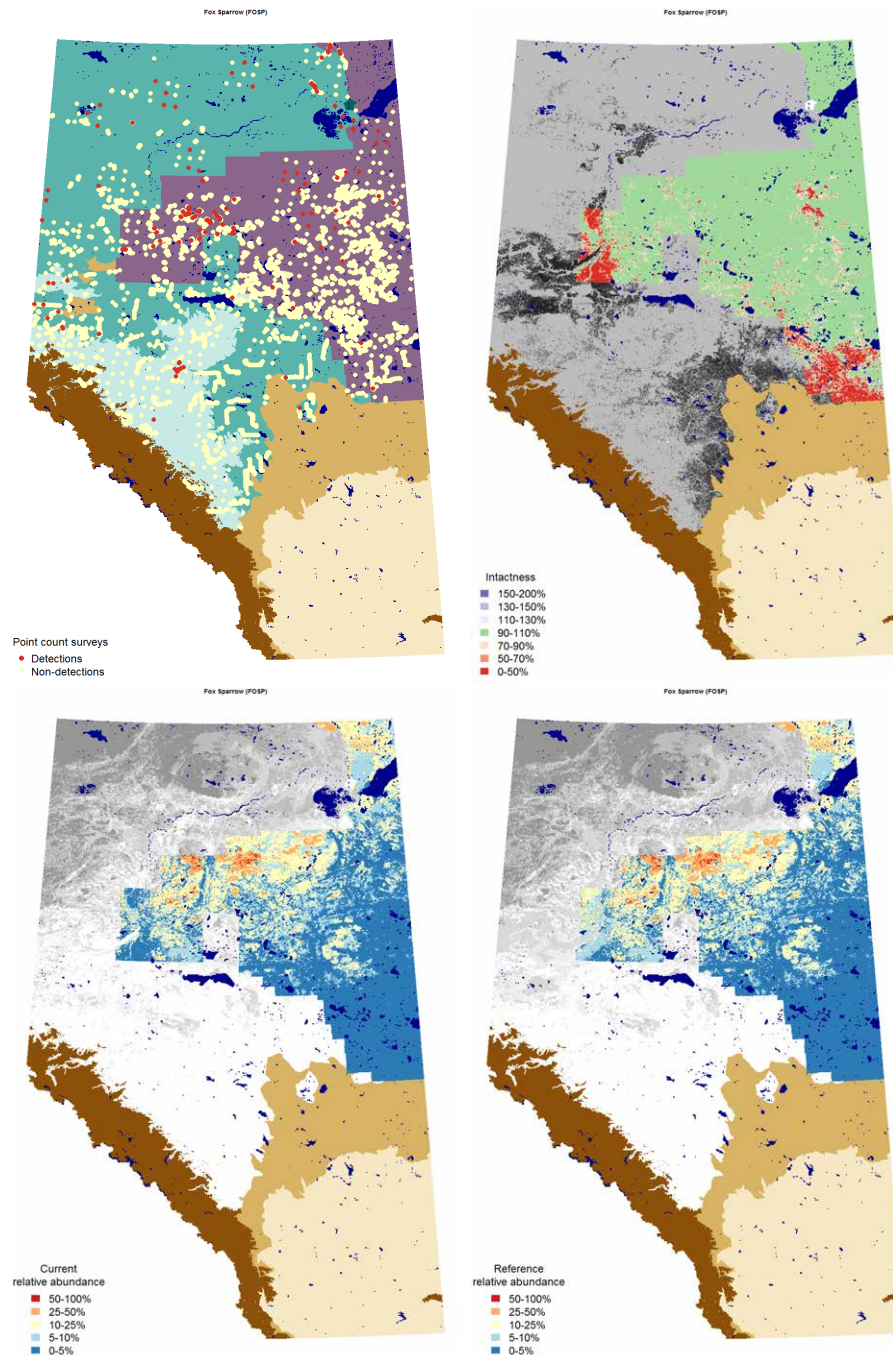
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.29.8 Quarter-section level responses



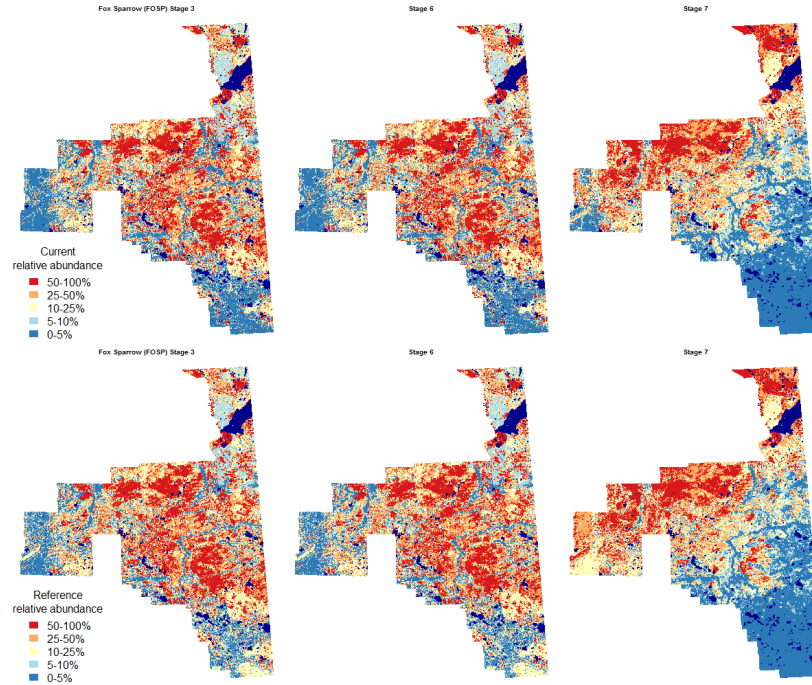
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.29.9 Maps



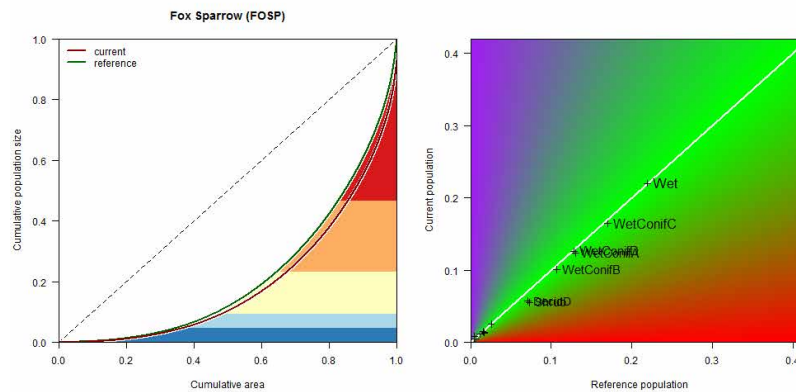
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.29.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.29.11 Population concentration



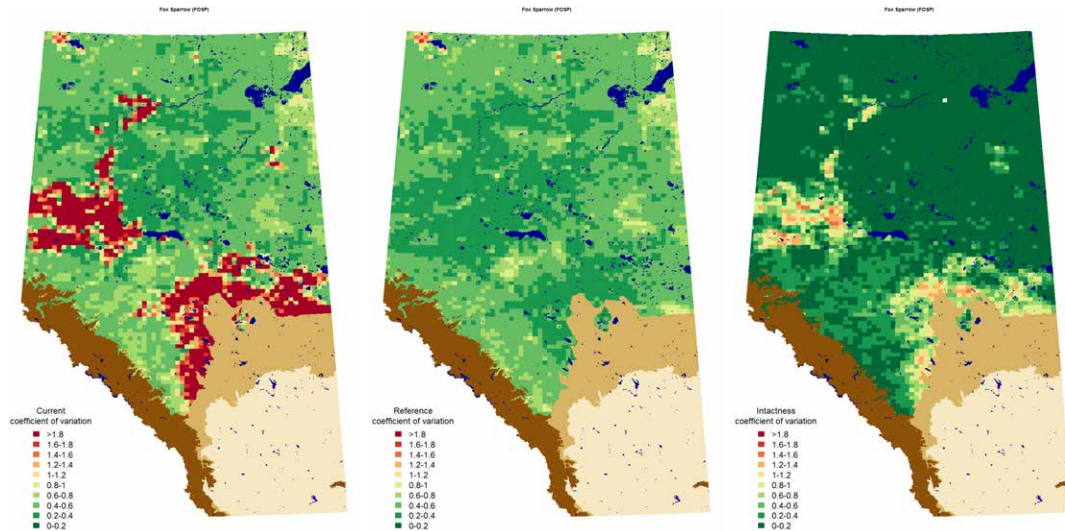
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.29.12 Potential population size

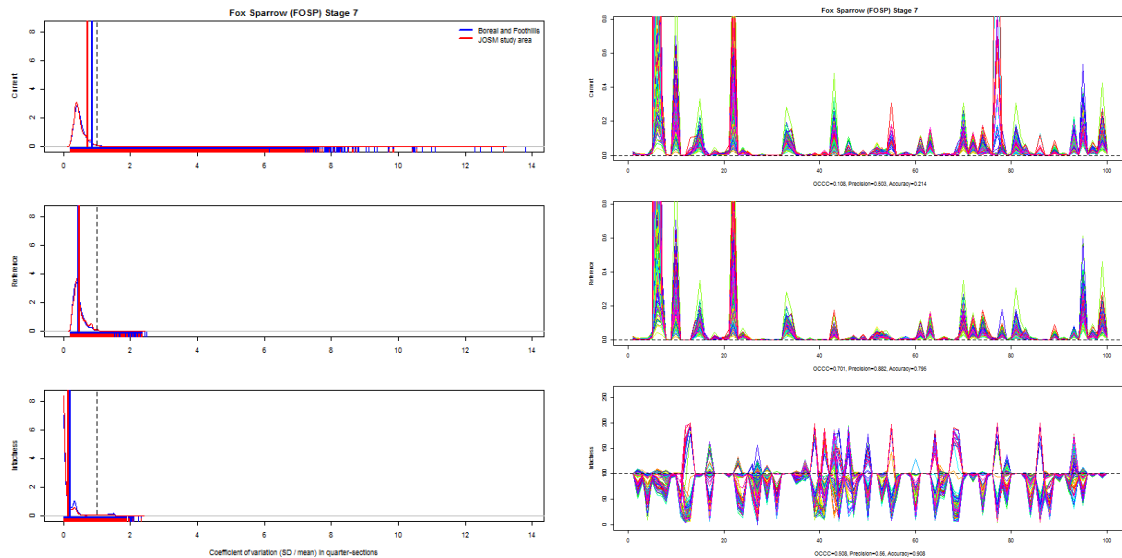
Estimated potential population size of Fox Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.0248	0.0134	0.0757	0.0254	0.0137	0.0439
WetConifC	0.0185	0.0100	0.0565	0.0197	0.0106	0.0342
WetConifA	0.0140	0.0076	0.0426	0.0151	0.0081	0.0261
WetConifD	0.0142	0.0077	0.0435	0.0149	0.0080	0.0258
WetConifB	0.0114	0.0062	0.0347	0.0124	0.0067	0.0215
Shrub	0.0062	0.0034	0.0189	0.0085	0.0046	0.0147
DecidD	0.0064	0.0035	0.0196	0.0082	0.0045	0.0143
PineB	0.0029	0.0015	0.0087	0.0030	0.0016	0.0051
DecidB	0.0015	0.0008	0.0045	0.0020	0.0011	0.0035
DecidC	0.0015	0.0008	0.0046	0.0020	0.0011	0.0035
PineA	0.0017	0.0009	0.0052	0.0018	0.0010	0.0031
PineC	0.0012	0.0007	0.0038	0.0014	0.0007	0.0024
DecidA	0.0005	0.0003	0.0016	0.0007	0.0004	0.0013
PineD	0.0005	0.0002	0.0014	0.0005	0.0003	0.0009
ConifA	0.0001	0.0000	0.0002	0.0001	0.0000	0.0002
ConifC	0.0001	0.0000	0.0002	0.0001	0.0000	0.0001
ConifB	0.0001	0.0000	0.0002	0.0001	0.0000	0.0001
ConifD	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
Grass	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0005	0.0003	0.0017	0.0000	0.0000	0.0000
UrbInd	0.0001	0.0001	0.0004	0.0000	0.0000	0.0000
HardLin	0.0001	0.0001	0.0003	0.0000	0.0000	0.0000
SoftLin	0.0010	0.0005	0.0030	0.0000	0.0000	0.0000
HFor	0.0009	0.0005	0.0026	0.0000	0.0000	0.0000
Total	0.1082	0.0585	0.3301	0.1158	0.0625	0.2006
Loss	0.0067	0.0031	0.0242			
Gain	0.0002	0.0001	0.2119			

5.29.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.29.14 Variable selection frequencies

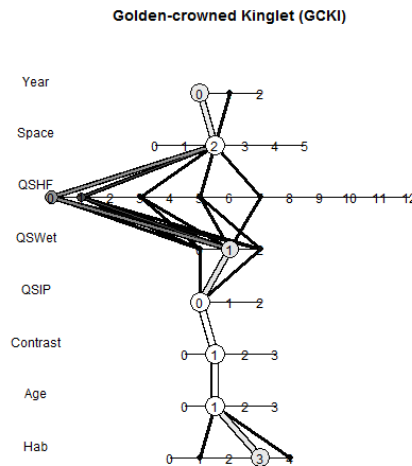
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	100.0	200	. + HabitatB
2.0	27.5	55	NULL
2.1	72.5	145	. + Age
3.0	30.0	60	NULL
3.1	22.0	44	. + ROAD
3.2	48.0	96	. + SoftLin_PC
4.0	78.0	156	NULL
4.1	22.0	44	. + Remn_QS
5.0	97.5	195	NULL
5.2	2.5	5	. + pWetWater_QS
6.0	75.5	151	NULL
6.1	3.0	6	. + THF_QS
6.4	2.0	4	. + Succ_QS + Noncult_QS + Cult_QS
6.5	12.0	24	. + THF_QS + THF2_QS
6.9	7.5	15	. + Succ_QS + Alien_QS + Alien2_QS
7.2	99.5	199	. + xlat + xlong
7.3	0.5	1	. + xlat + xlong + xlat:xlong
8.0	45.5	91	NULL
8.1	54.5	109	. + xYEAR

5.30 Golden-crowned Kinglet (*Regulus satrapa*)

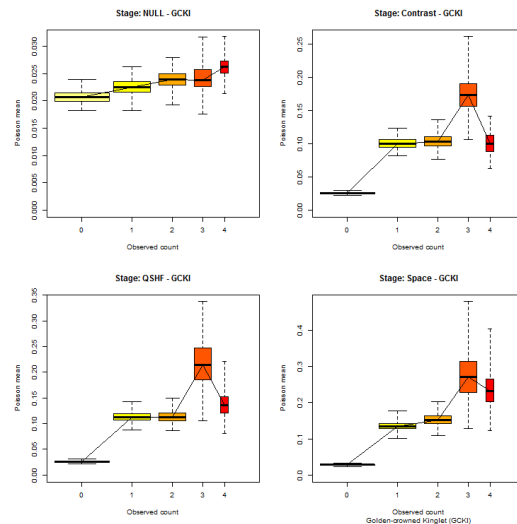
5.30.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

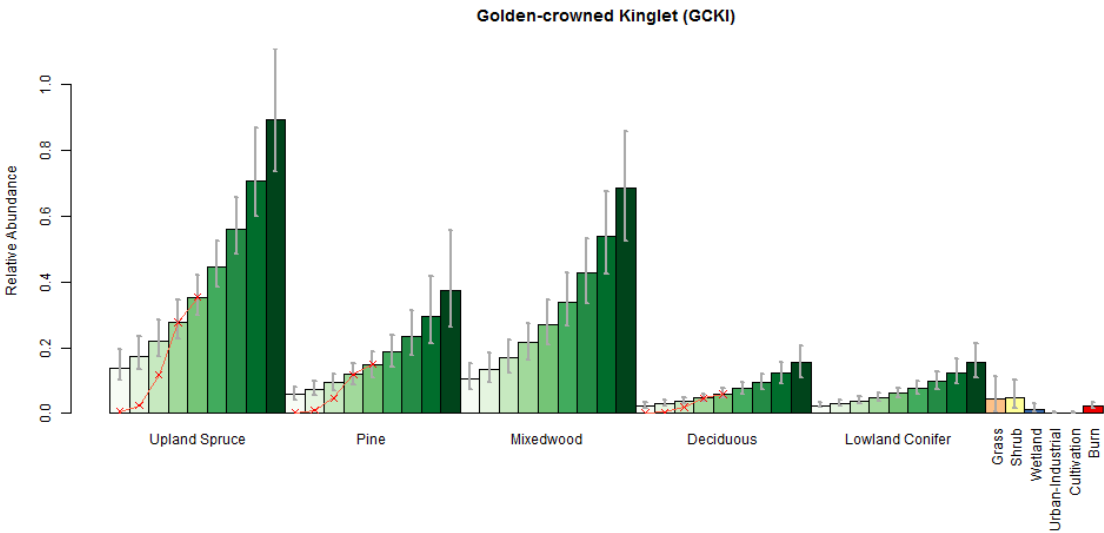


5.30.2 Cross validation

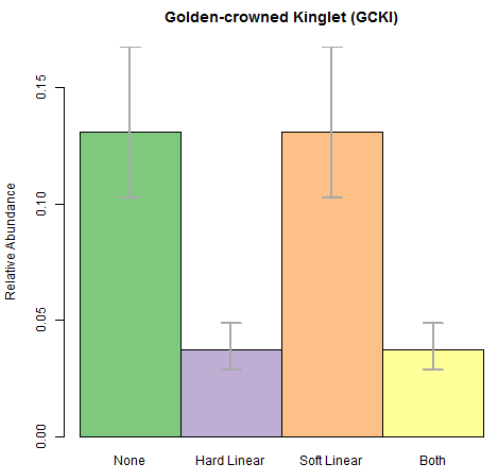
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.30.3 Point level habitat associations

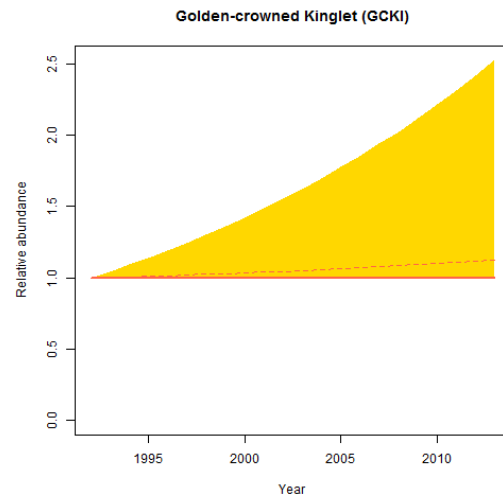


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

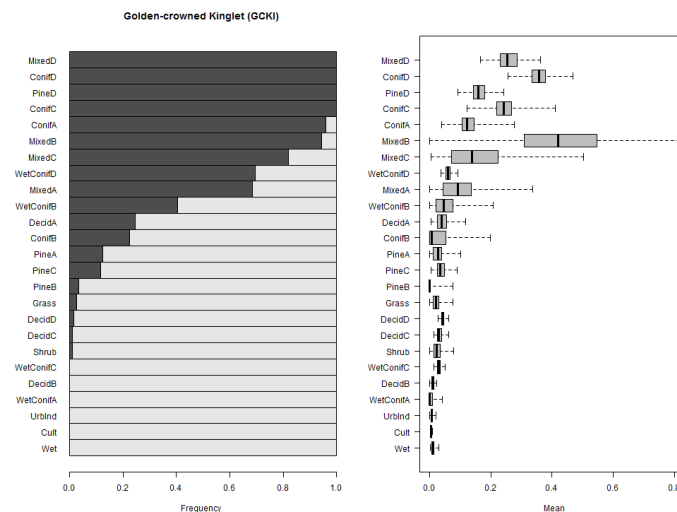


5.30.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



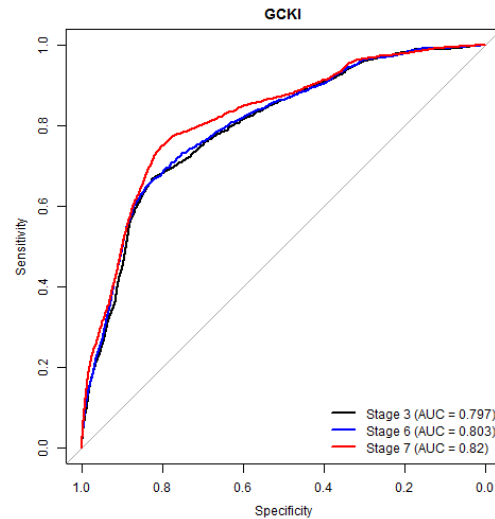
5.30.5 Habitat suitability ranking for patch delineation



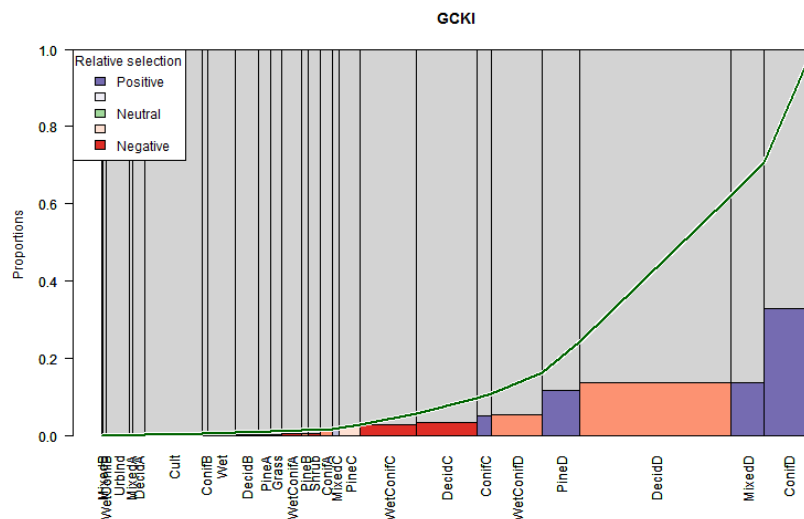
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.30.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

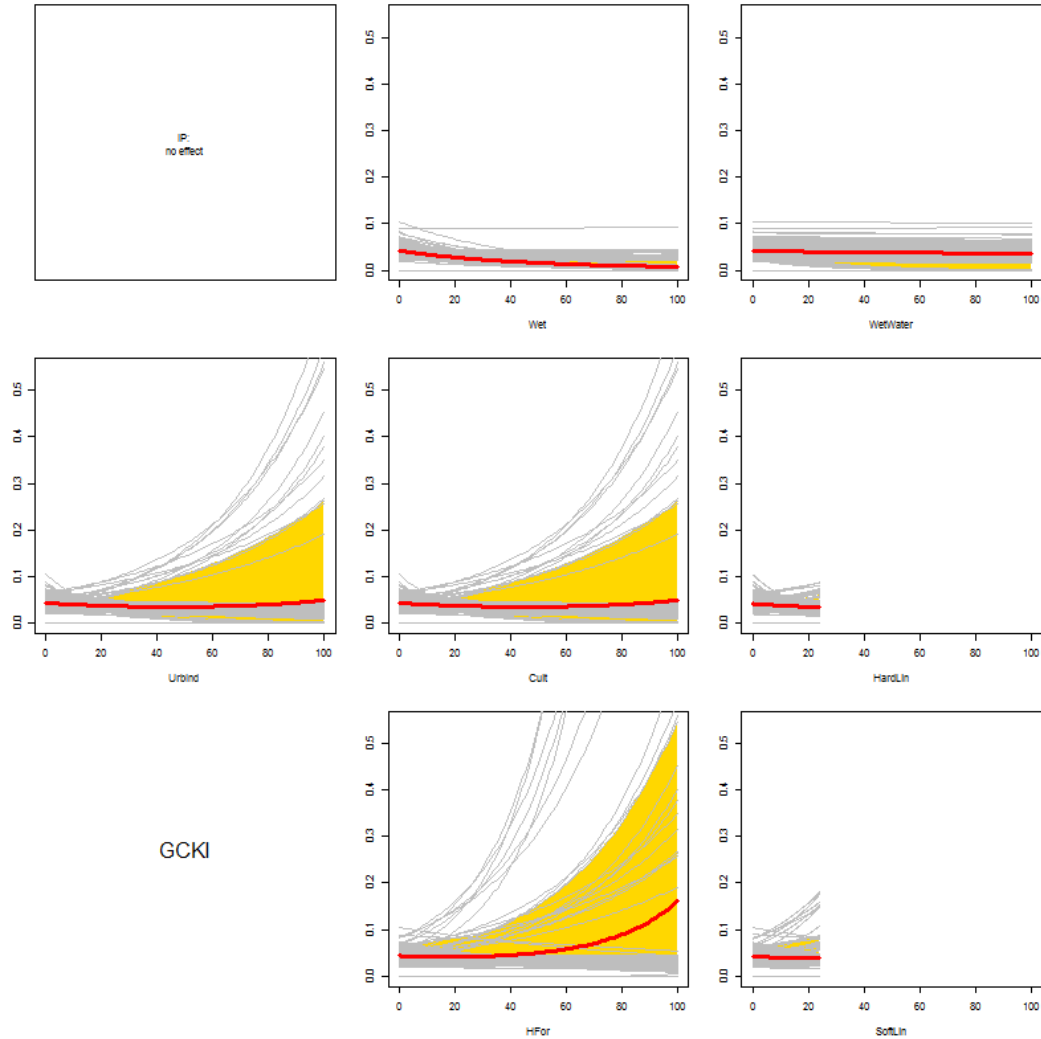


5.30.7 Relative habitat selection



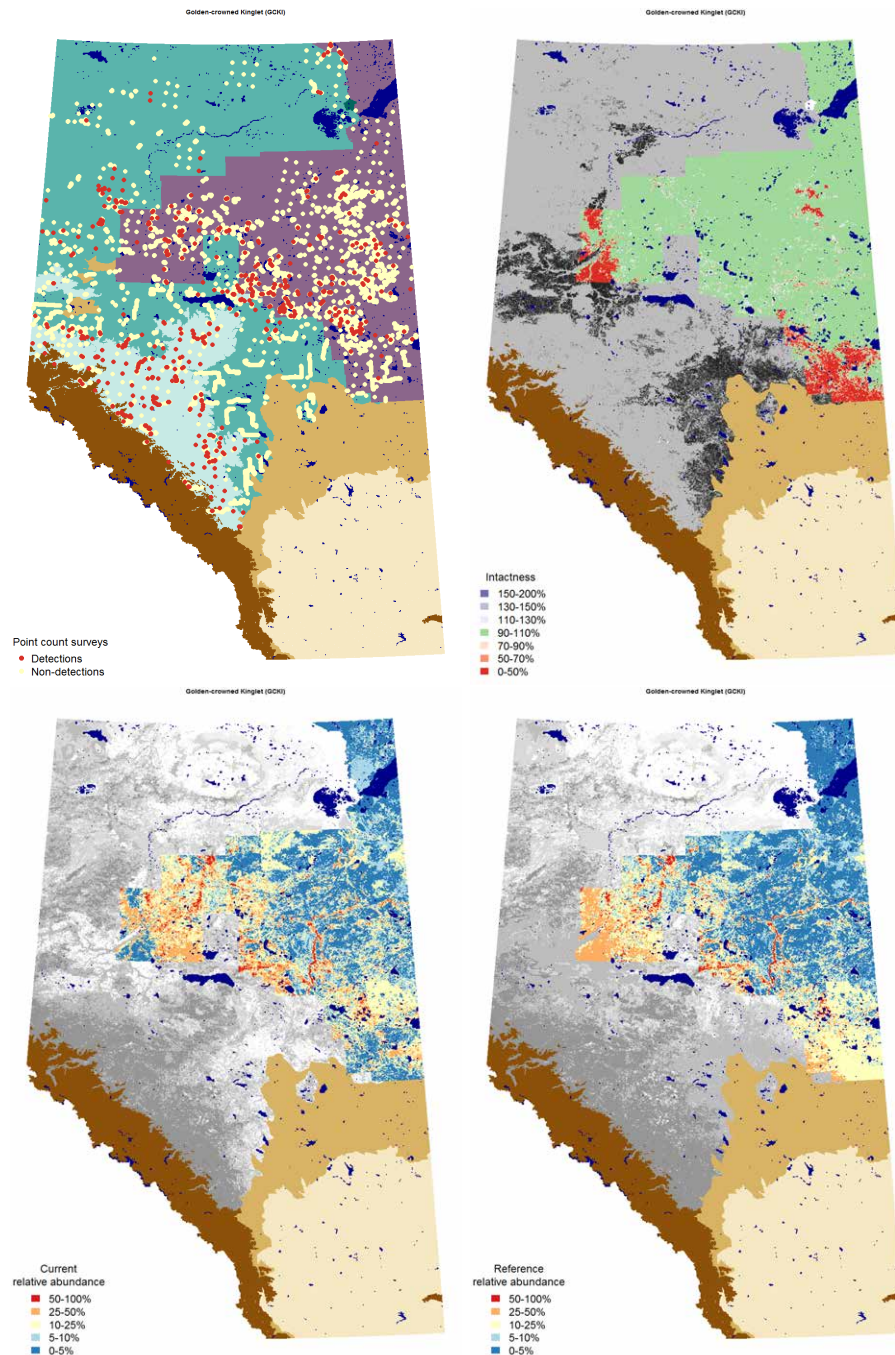
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.30.8 Quarter-section level responses



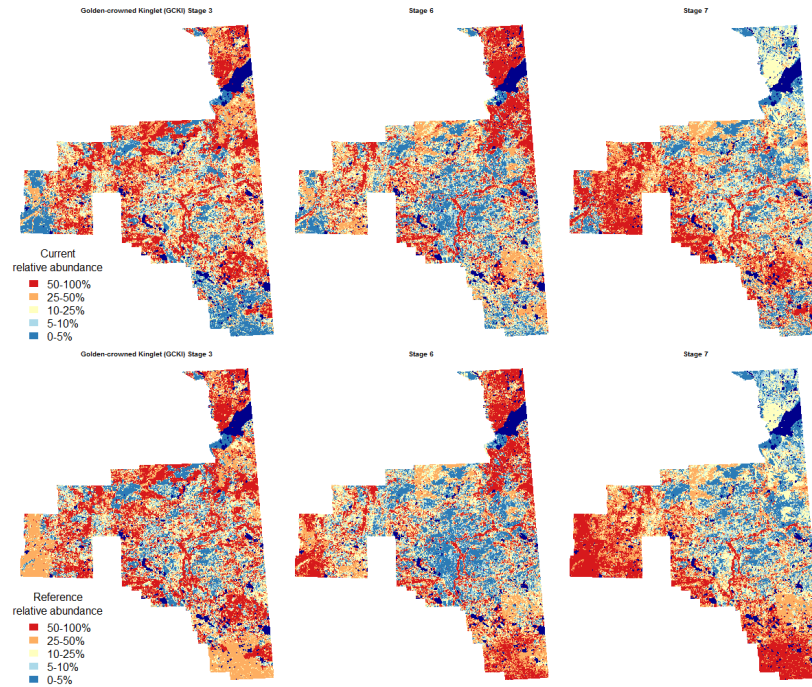
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.30.9 Maps



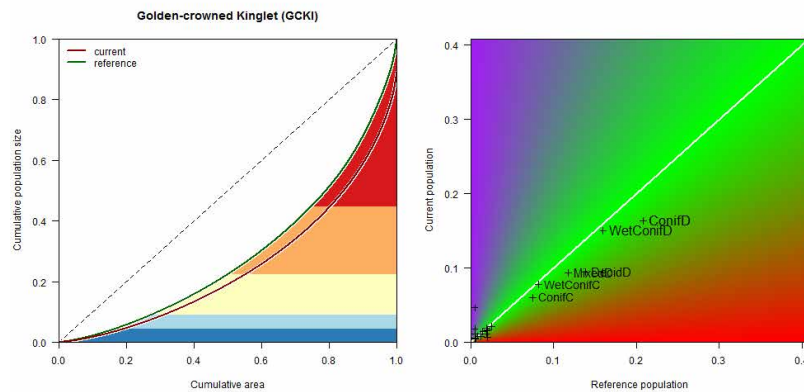
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.30.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.30.11 Population concentration



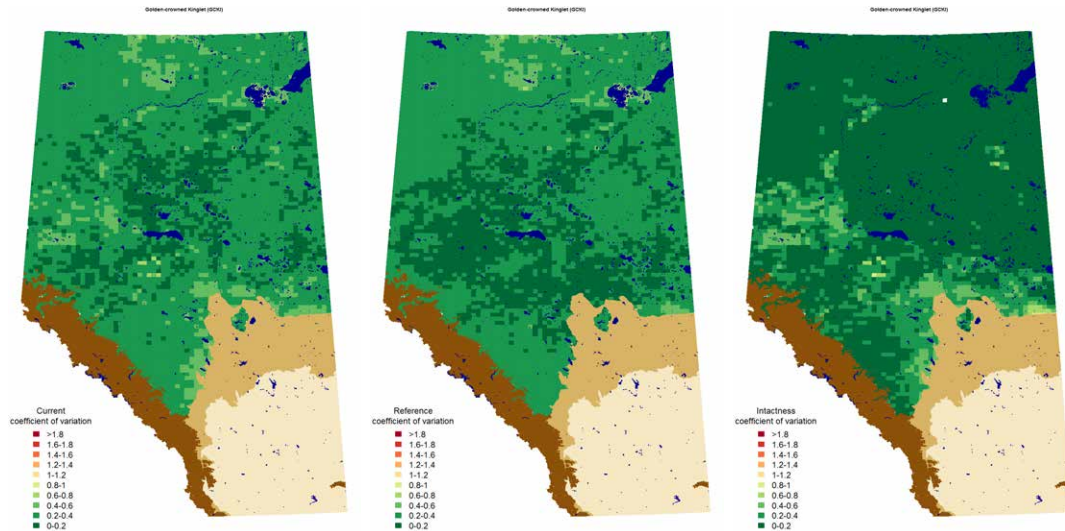
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.30.12 Potential population size

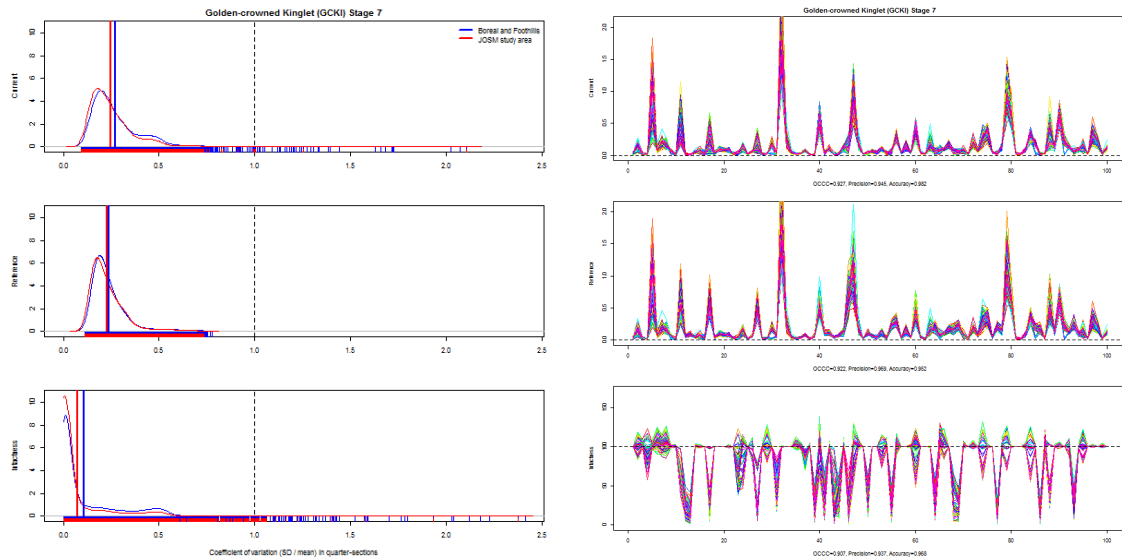
Estimated potential population size of Golden-crowned Kinglet in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
ConifD	0.1851	0.1566	0.2135	0.2357	0.1955	0.2837
WetConifD	0.1696	0.1436	0.1956	0.1810	0.1501	0.2178
DecidD	0.1072	0.0907	0.1237	0.1564	0.1297	0.1883
MixedD	0.1054	0.0892	0.1215	0.1331	0.1104	0.1602
WetConifC	0.0878	0.0743	0.1013	0.0924	0.0766	0.1112
ConifC	0.0679	0.0575	0.0783	0.0851	0.0706	0.1025
PineD	0.0239	0.0202	0.0275	0.0287	0.0238	0.0345
PineC	0.0245	0.0208	0.0283	0.0284	0.0236	0.0342
Grass	0.0078	0.0066	0.0090	0.0231	0.0192	0.0278
ConifA	0.0188	0.0159	0.0217	0.0229	0.0190	0.0275
PineB	0.0218	0.0184	0.0251	0.0221	0.0183	0.0266
Shrub	0.0129	0.0110	0.0149	0.0221	0.0183	0.0266
ConifB	0.0181	0.0153	0.0208	0.0220	0.0182	0.0264
Wet	0.0166	0.0141	0.0192	0.0168	0.0139	0.0202
DecidC	0.0090	0.0076	0.0104	0.0140	0.0116	0.0168
WetConifB	0.0129	0.0109	0.0148	0.0135	0.0112	0.0163
WetConifA	0.0095	0.0080	0.0109	0.0100	0.0083	0.0120
DecidB	0.0048	0.0040	0.0055	0.0068	0.0056	0.0082
PineA	0.0058	0.0049	0.0067	0.0061	0.0050	0.0073
MixedC	0.0028	0.0024	0.0033	0.0037	0.0031	0.0045
MixedB	0.0031	0.0026	0.0035	0.0037	0.0031	0.0045
MixedA	0.0017	0.0015	0.0020	0.0026	0.0022	0.0032
DecidA	0.0008	0.0007	0.0010	0.0015	0.0013	0.0019
Cult	0.0125	0.0106	0.0144	0.0000	0.0000	0.0000
UrbInd	0.0023	0.0019	0.0026	0.0000	0.0000	0.0000
HardLin	0.0004	0.0003	0.0005	0.0000	0.0000	0.0000
SoftLin	0.0198	0.0168	0.0228	0.0000	0.0000	0.0000
HFor	0.0524	0.0443	0.0604	0.0000	0.0000	0.0000
Total	1.0053	0.8508	1.1594	1.1318	0.9385	1.3622
Loss	0.1213	0.0911	0.2600			
Gain	0.0185	0.0006	0.0573			

5.30.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.30.14 Variable selection frequencies

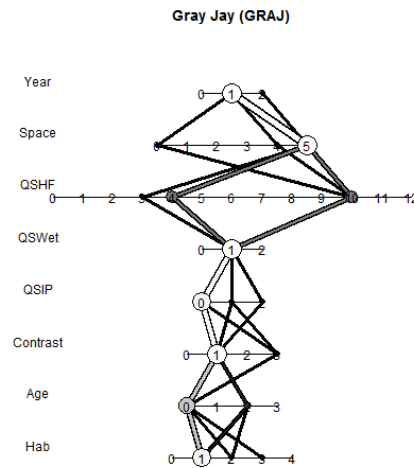
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	5.5	11	. + Habitat
1.3	91.5	183	. + Habitat + isHForC
1.4	3.0	6	. + HabitatB + isHForC
2.1	100.0	200	. + Age
3.1	100.0	200	. + ROAD
4.0	100.0	200	NULL
5.0	3.0	6	NULL
5.1	89.5	179	. + pWet_QS
5.2	7.5	15	. + pWetWater_QS
6.0	58.5	117	NULL
6.1	30.0	60	. + THF_QS
6.3	1.0	2	. + Succ_QS + Alien_QS
6.5	6.5	13	. + THF_QS + THF2_QS
6.7	4.0	8	. + Succ_QS + Alien_QS + Succ2_QS
7.2	100.0	200	. + xlat + xlong
8.0	92.0	184	NULL
8.1	8.0	16	. + xYEAR

5.31 Gray Jay (*Perisoreus canadensis*)

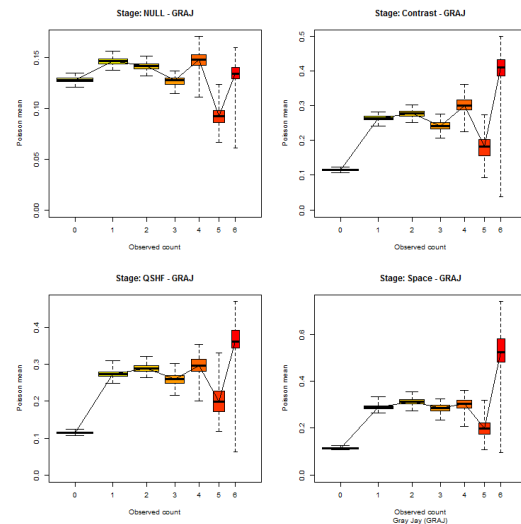
5.31.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

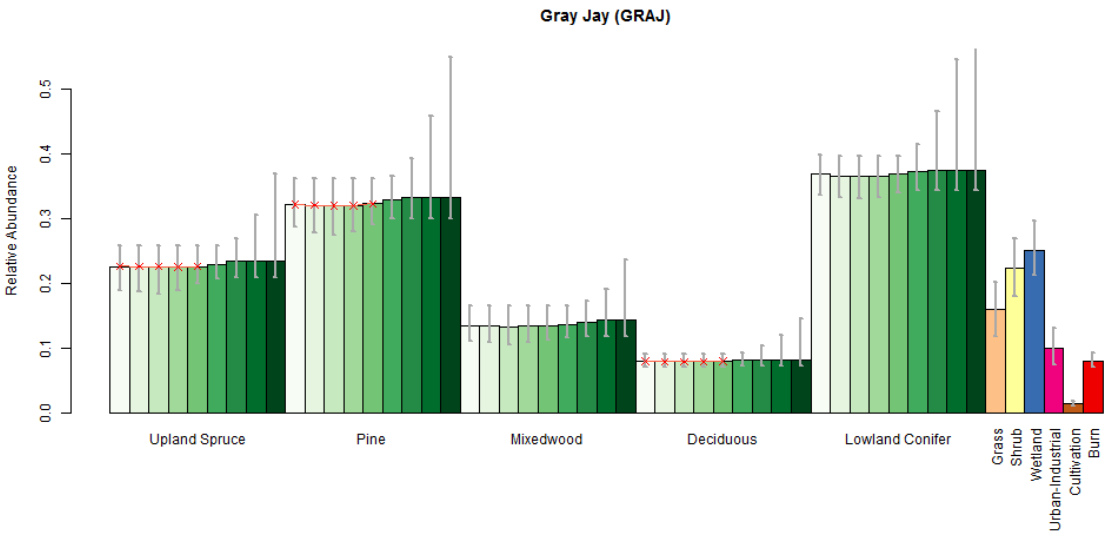


5.31.2 Cross validation

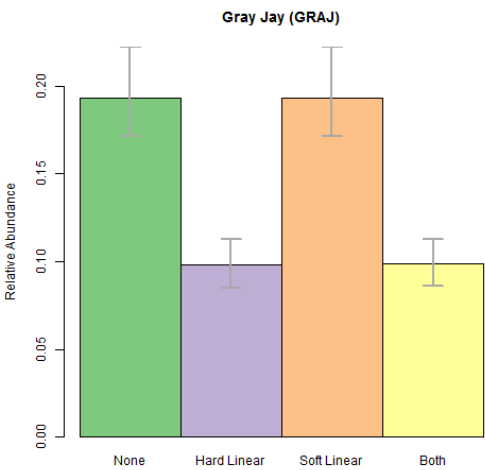
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.31.3 Point level habitat associations



Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

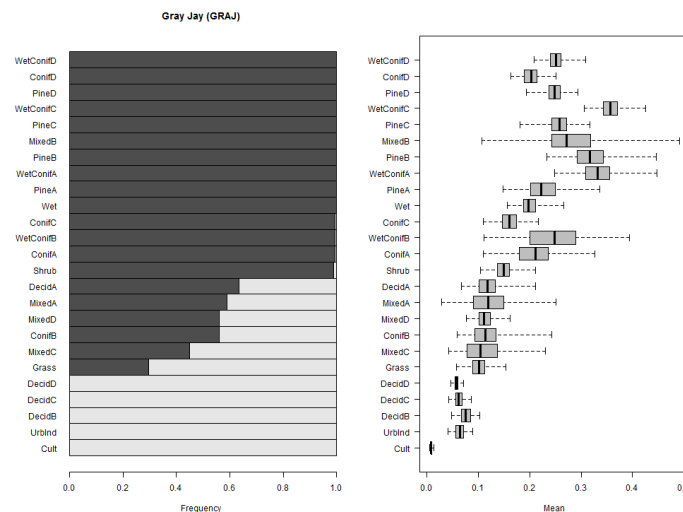


5.31.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



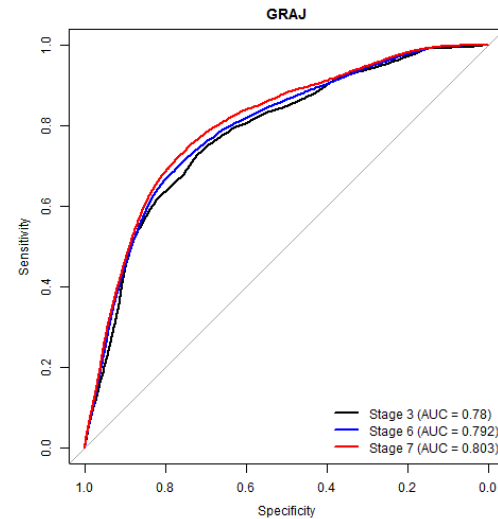
5.31.5 Habitat suitability ranking for patch delineation



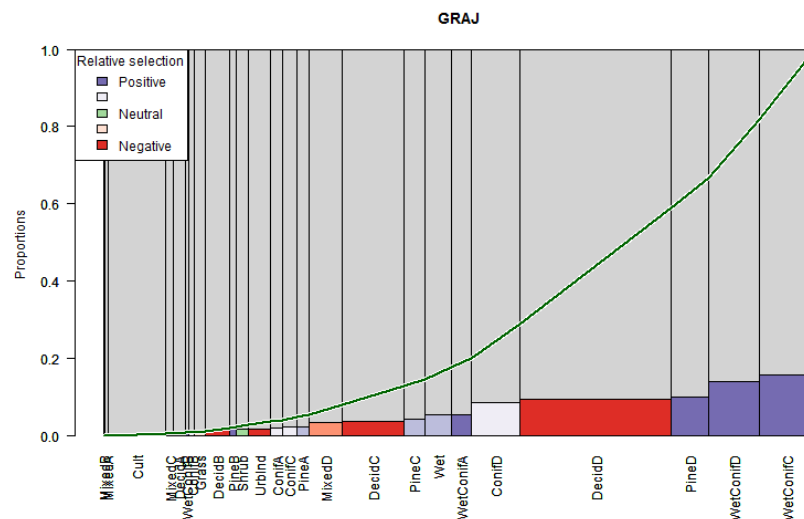
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.31.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

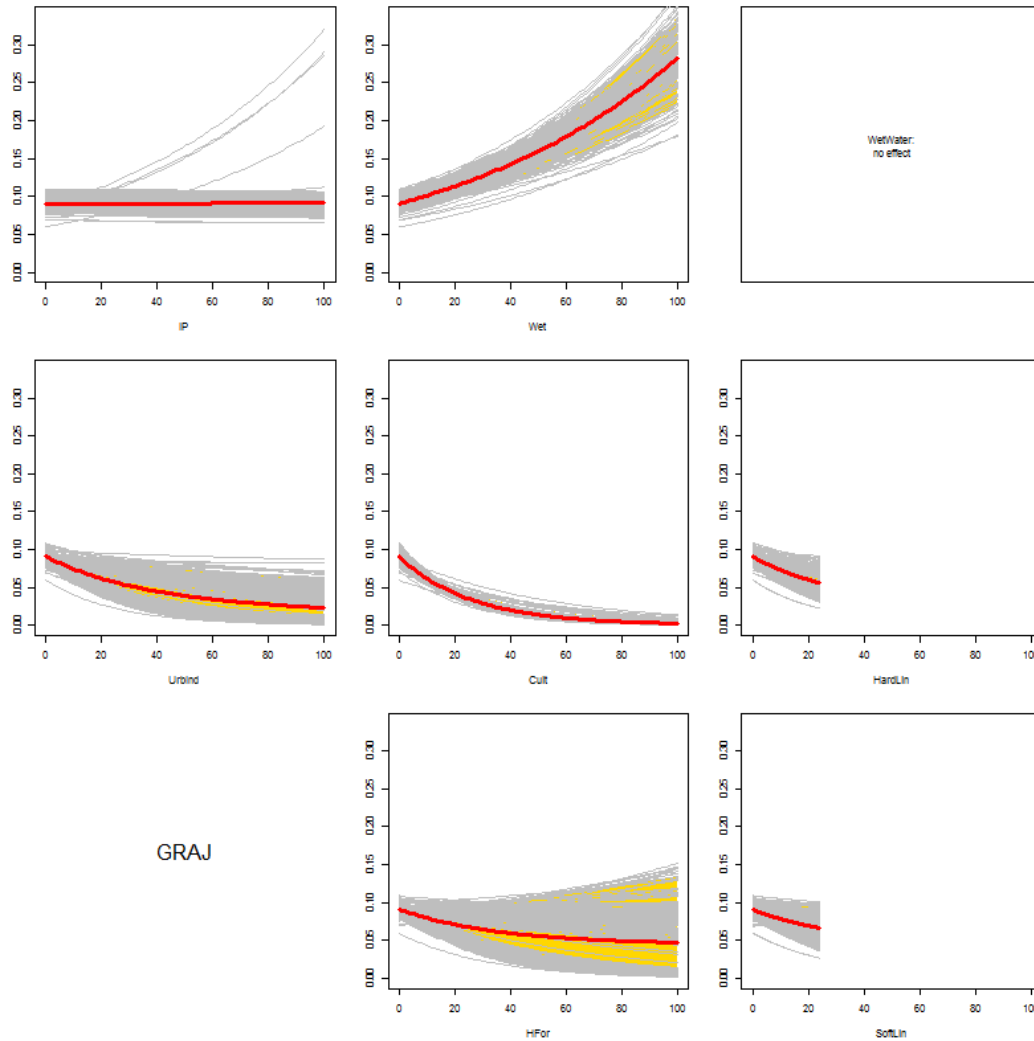


5.31.7 Relative habitat selection



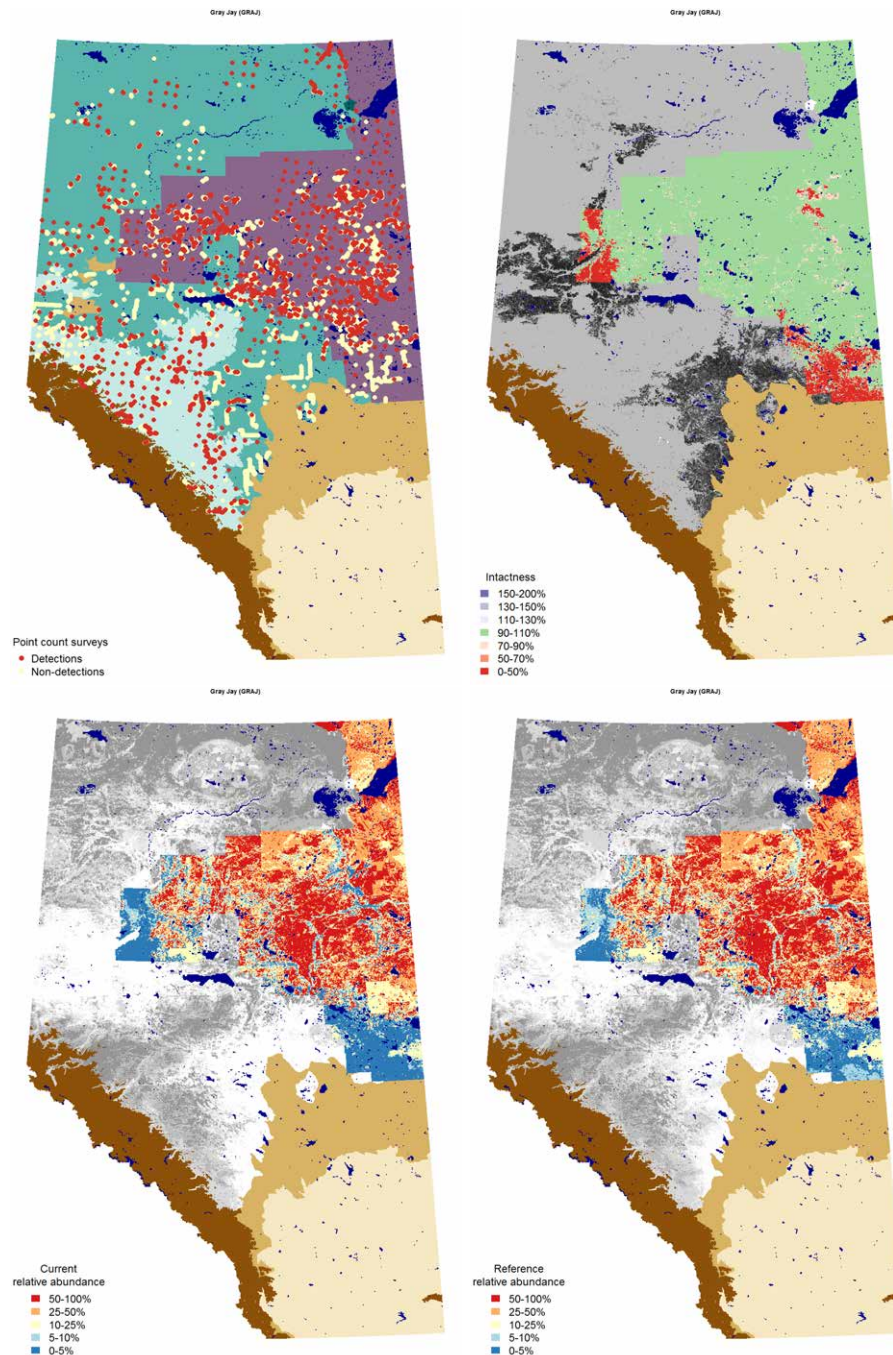
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.31.8 Quarter-section level responses



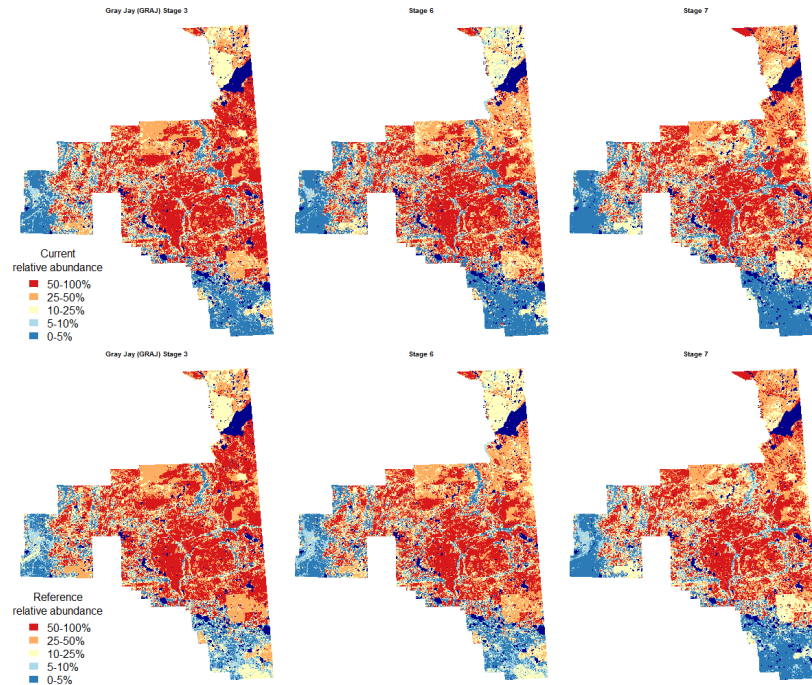
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.31.9 Maps



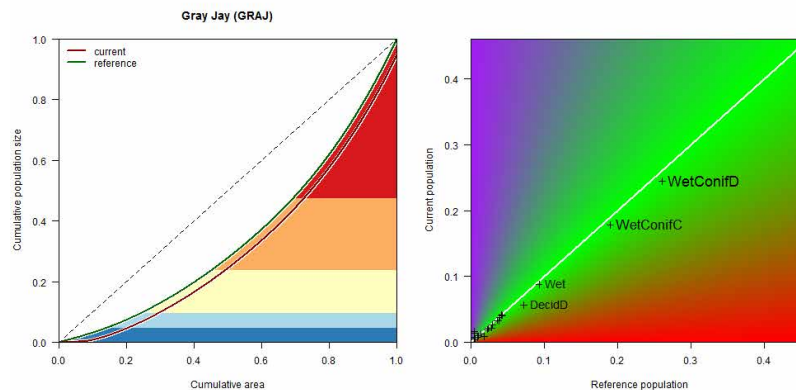
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.31.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.31.11 Population concentration



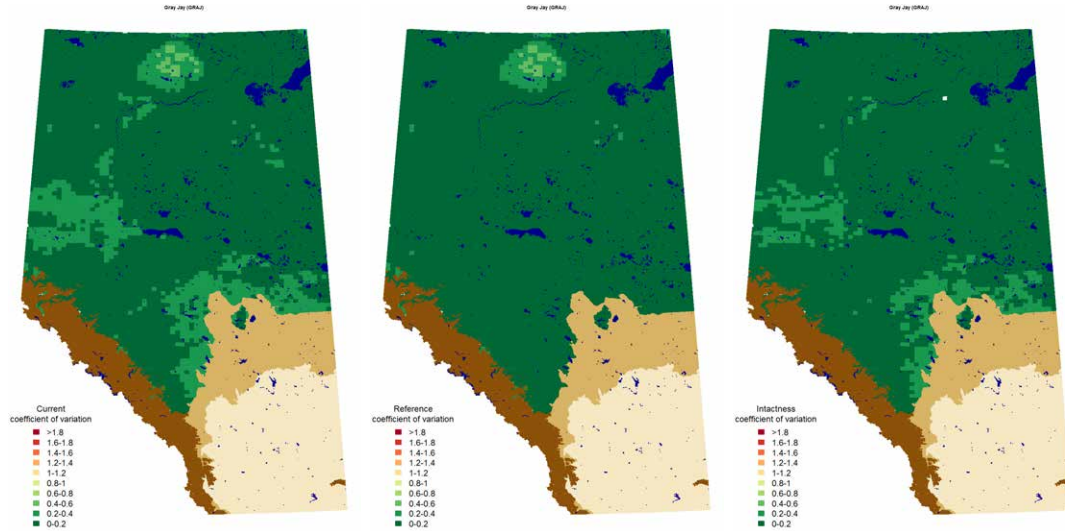
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.31.12 Potential population size

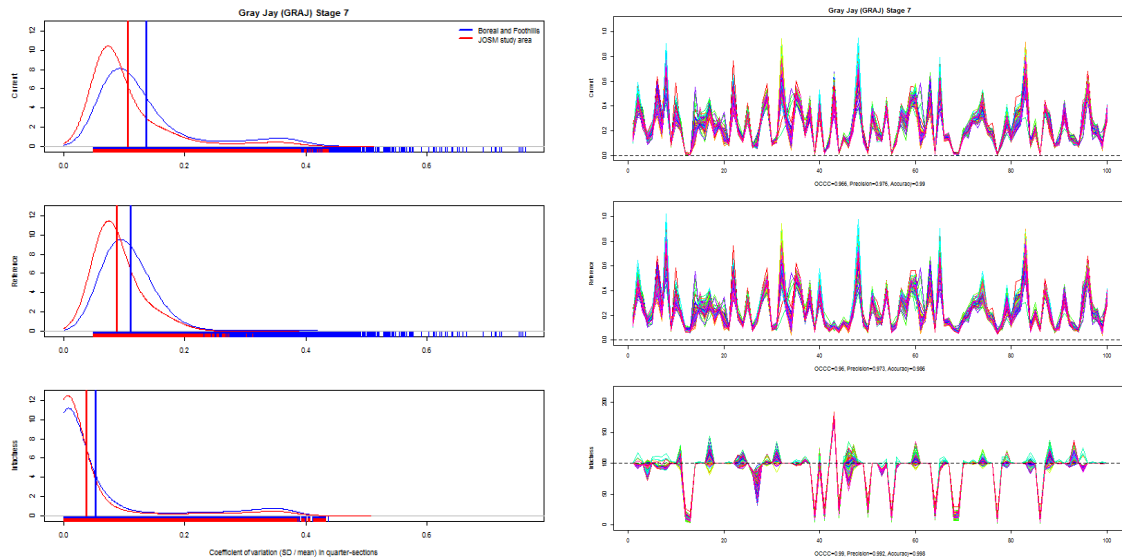
Estimated potential population size of Gray Jay in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.9950	0.9246	1.0721	1.0558	0.9844	1.1402
WetConifC	0.7235	0.6722	0.7795	0.7695	0.7175	0.8310
Wet	0.3579	0.3326	0.3856	0.3772	0.3517	0.4073
DecidD	0.2314	0.2150	0.2493	0.2939	0.2741	0.3174
WetConifA	0.1657	0.1540	0.1786	0.1742	0.1624	0.1881
PineB	0.1694	0.1574	0.1825	0.1706	0.1591	0.1842
WetConifB	0.1540	0.1431	0.1659	0.1594	0.1486	0.1721
ConifD	0.1312	0.1219	0.1414	0.1548	0.1443	0.1672
PineC	0.1351	0.1256	0.1456	0.1451	0.1353	0.1567
PineD	0.1097	0.1019	0.1182	0.1193	0.1112	0.1288
Shrub	0.0895	0.0831	0.0964	0.1143	0.1066	0.1234
ConifC	0.0850	0.0790	0.0916	0.0973	0.0907	0.1051
MixedD	0.0788	0.0732	0.0849	0.0922	0.0860	0.0996
Grass	0.0376	0.0349	0.0405	0.0752	0.0701	0.0812
ConifA	0.0488	0.0454	0.0526	0.0571	0.0532	0.0616
PineA	0.0531	0.0494	0.0572	0.0553	0.0516	0.0598
ConifB	0.0390	0.0362	0.0420	0.0439	0.0409	0.0474
DecidC	0.0289	0.0268	0.0311	0.0372	0.0347	0.0402
DecidB	0.0196	0.0182	0.0211	0.0244	0.0228	0.0264
DecidA	0.0066	0.0061	0.0071	0.0094	0.0088	0.0102
MixedA	0.0041	0.0038	0.0044	0.0057	0.0053	0.0061
MixedB	0.0048	0.0045	0.0052	0.0055	0.0051	0.0059
MixedC	0.0033	0.0030	0.0035	0.0038	0.0036	0.0041
Cult	0.0139	0.0129	0.0150	0.0000	0.0000	0.0000
UrbInd	0.0314	0.0292	0.0339	0.0000	0.0000	0.0000
HardLin	0.0011	0.0011	0.0012	0.0000	0.0000	0.0000
SoftLin	0.0544	0.0505	0.0586	0.0000	0.0000	0.0000
HFor	0.0687	0.0639	0.0740	0.0000	0.0000	0.0000
Total	3.8415	3.5694	4.1390	4.0412	3.7679	4.3639
Loss	0.2181	0.1739	0.2739			
Gain	0.0069	0.0021	0.0185			

5.31.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.31.14 Variable selection frequencies

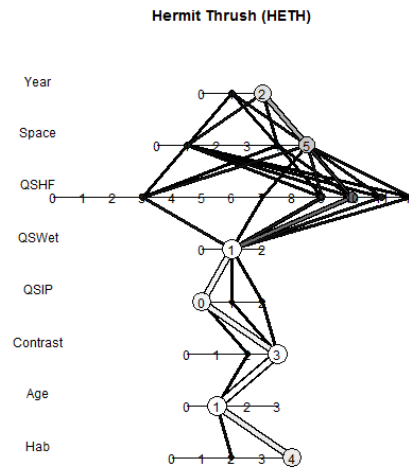
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	96.0	192	. + Habitat
1.2	2.5	5	. + HabitatB
1.3	1.5	3	. + Habitat + isHForC
2.0	79.0	158	NULL
2.2	21.0	42	. + Age + Age2
3.1	98.0	196	. + ROAD
3.3	2.0	4	. + ROAD + SoftLin_PC
4.0	95.5	191	NULL
4.1	2.5	5	. + Remn_QS
4.2	2.0	4	. + Remn_QS + Remn2_QS
5.1	100.0	200	. + pWet_QS
6.3	4.5	9	. + Succ_QS + Alien_QS
6.4	47.5	95	. + Succ_QS + Noncult_QS + Cult_QS
6.10	48.0	96	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
7.0	0.5	1	NULL
7.4	1.0	2	. + xMAP + xPET + xMAT + xCMD
7.5	98.5	197	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	99.5	199	. + xYEAR
8.2	0.5	1	. + YR5F

5.32 Hermit Thrush (*Catharus guttatus*)

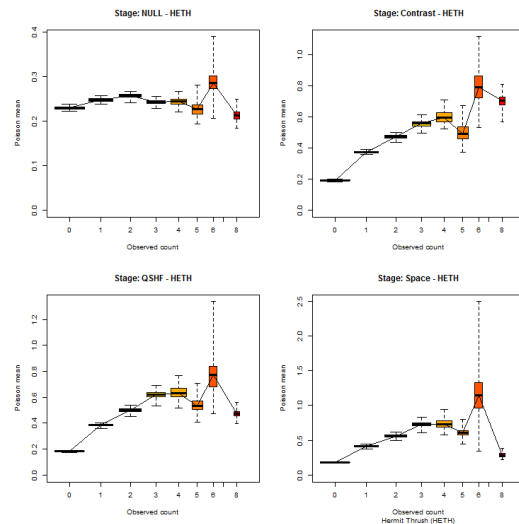
5.32.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

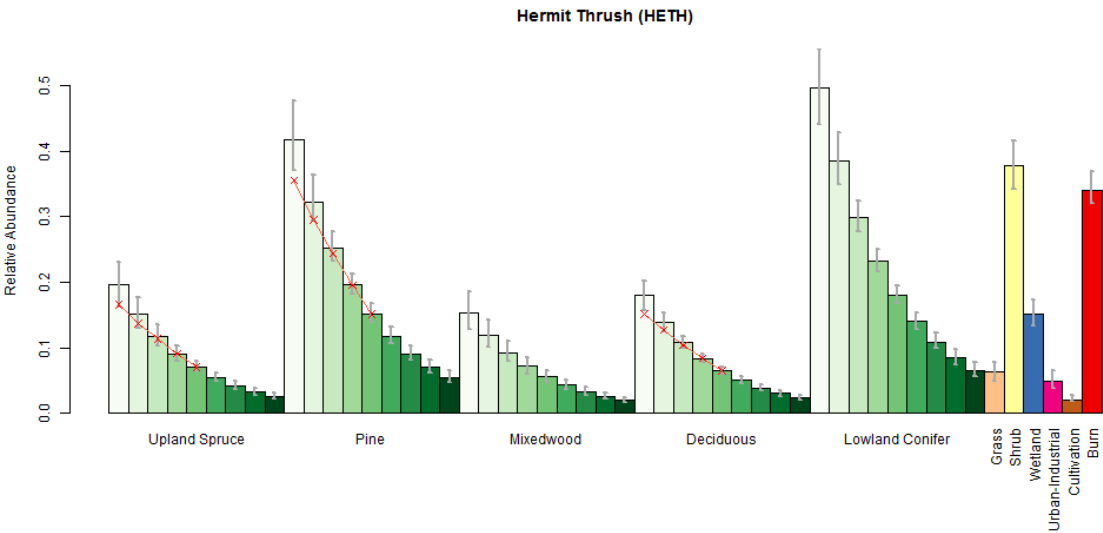


5.32.2 Cross validation

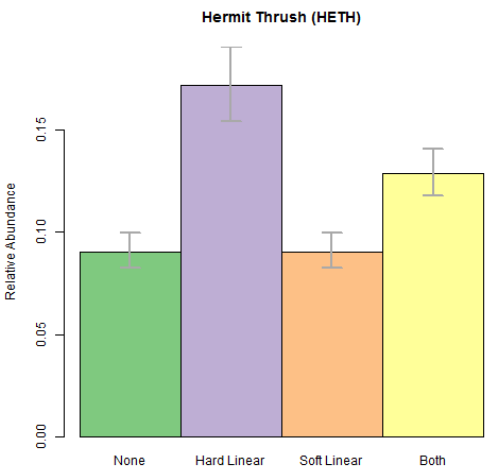
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.32.3 Point level habitat associations

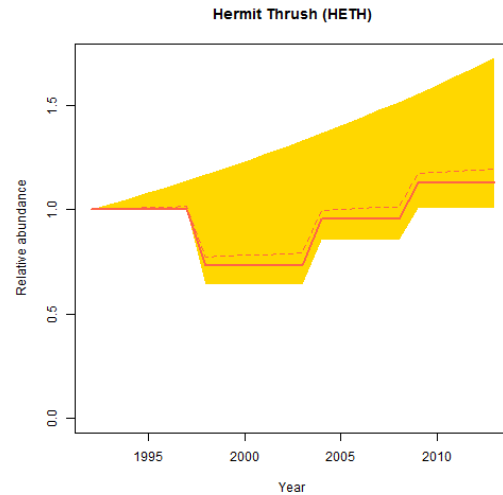


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

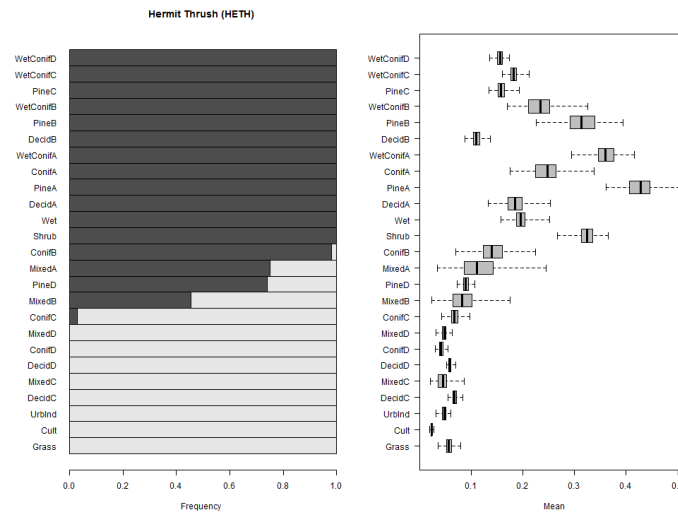


5.32.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



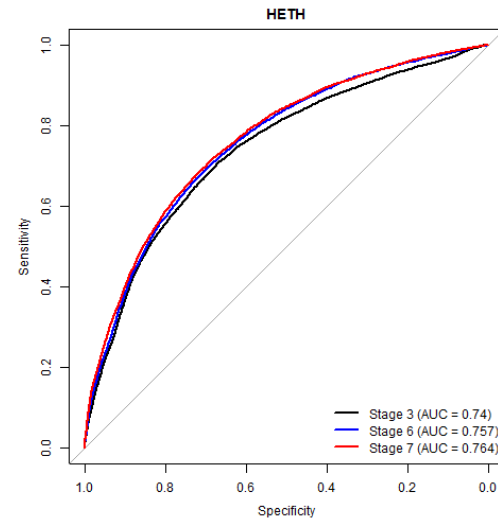
5.32.5 Habitat suitability ranking for patch delineation



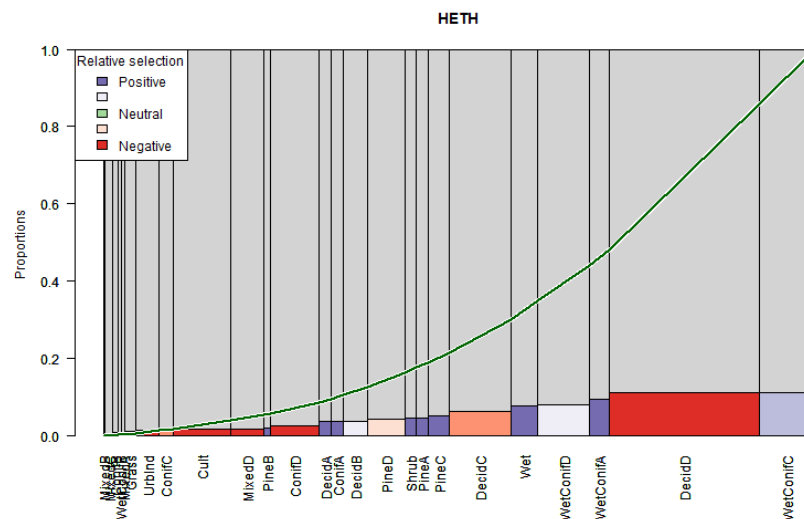
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.32.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

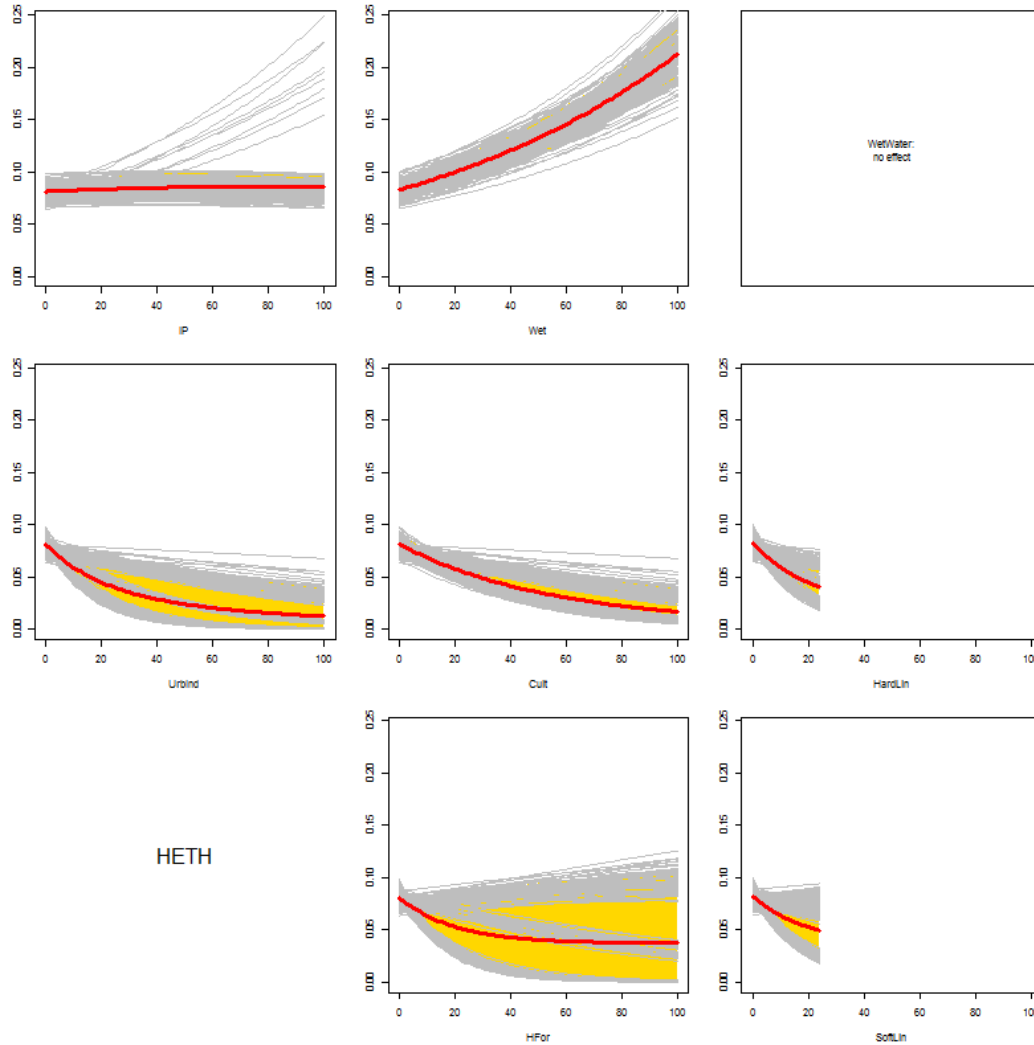


5.32.7 Relative habitat selection



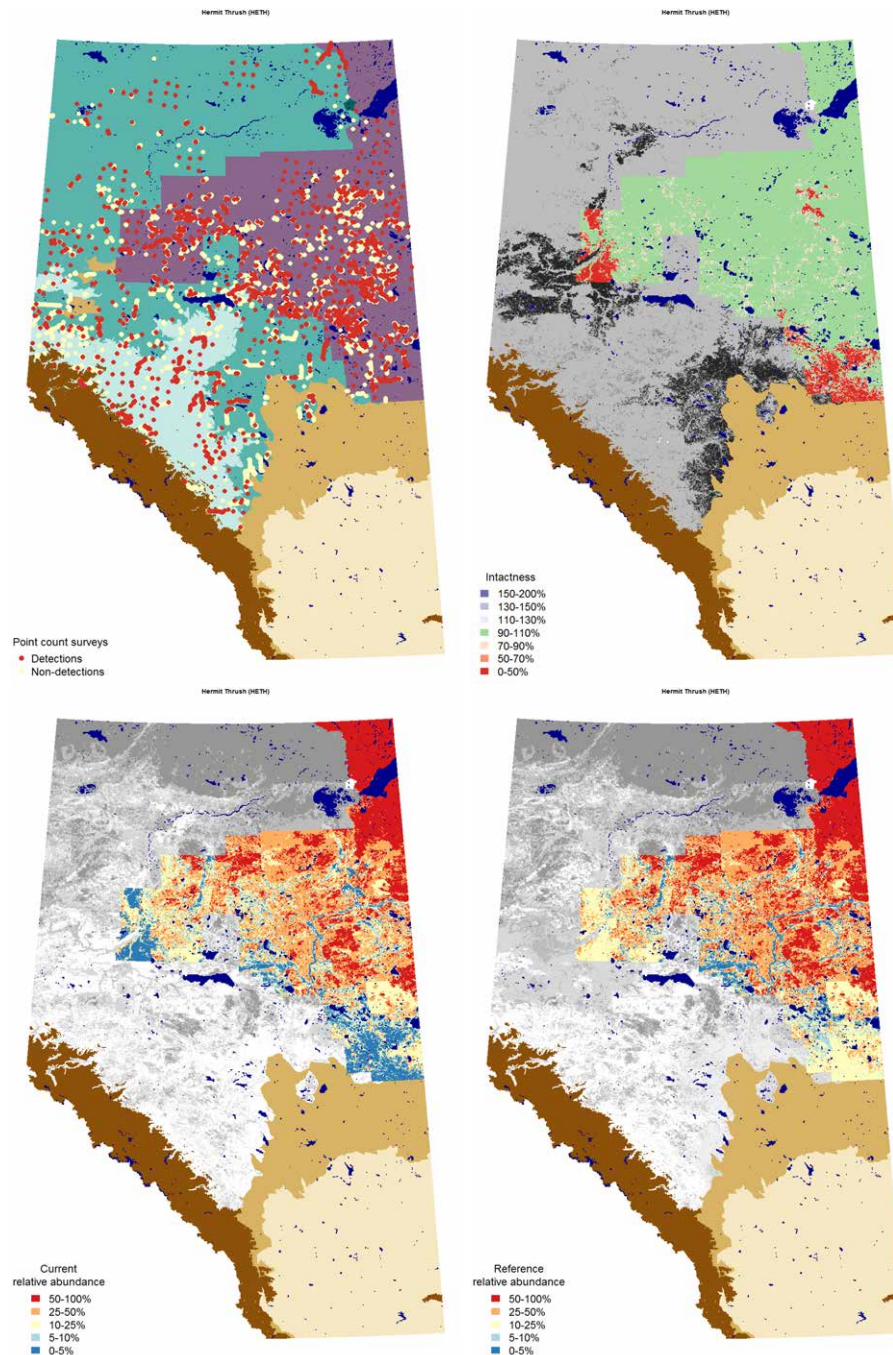
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.32.8 Quarter-section level responses



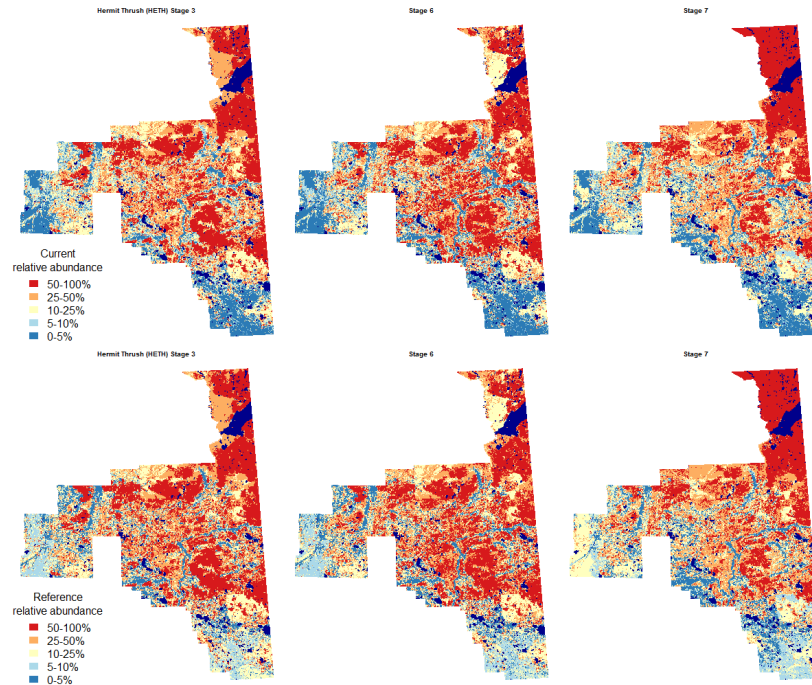
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.32.9 Maps



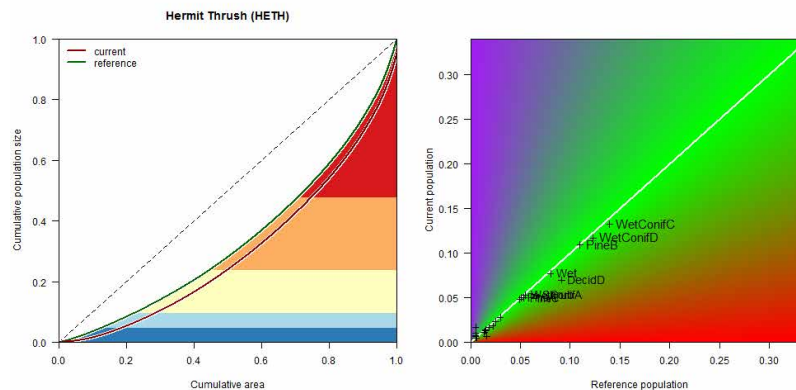
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.32.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.32.11 Population concentration



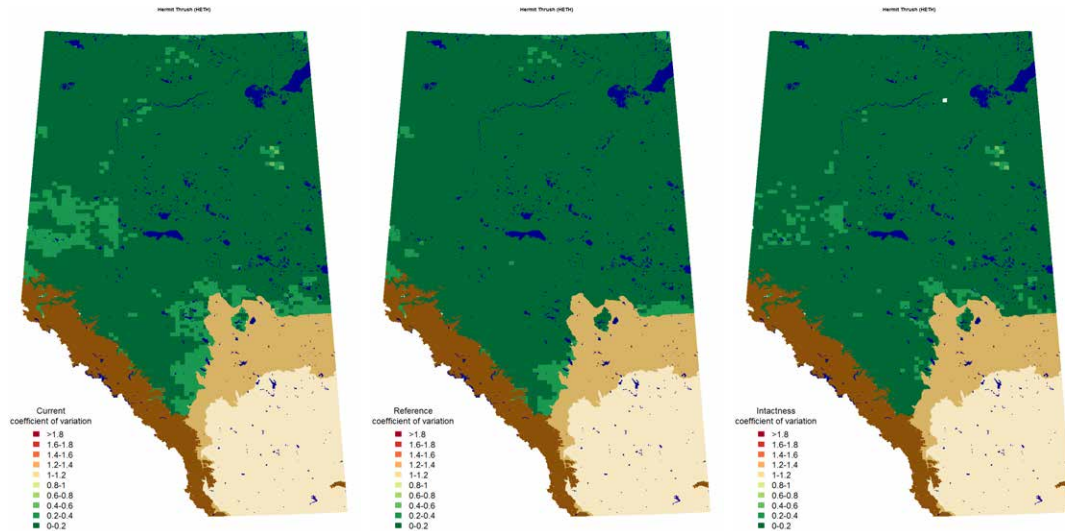
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.32.12 Potential population size

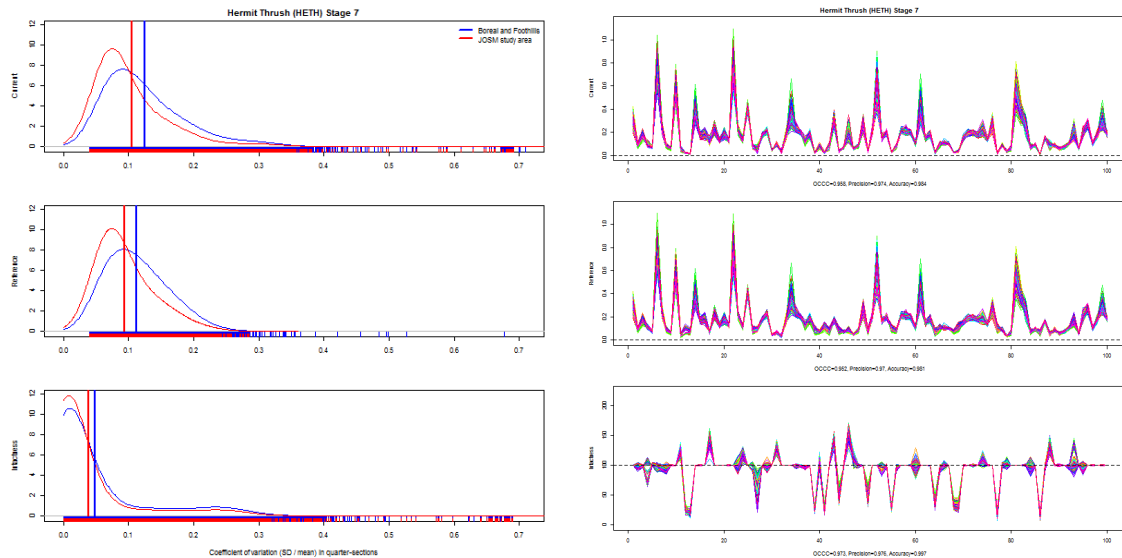
Estimated potential population size of Hermit Thrush in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifC	0.3923	0.3664	0.4254	0.4125	0.3854	0.4476
WetConifD	0.3468	0.3239	0.3761	0.3636	0.3397	0.3946
PineB	0.3240	0.3026	0.3513	0.3245	0.3031	0.3521
DecidD	0.2069	0.1932	0.2243	0.2703	0.2526	0.2933
Wet	0.2287	0.2136	0.2480	0.2368	0.2212	0.2570
Shrub	0.1564	0.1461	0.1696	0.1958	0.1829	0.2125
WetConifA	0.1570	0.1467	0.1703	0.1622	0.1515	0.1760
PineC	0.1479	0.1382	0.1604	0.1584	0.1480	0.1719
PineA	0.1484	0.1386	0.1610	0.1511	0.1411	0.1639
WetConifB	0.1427	0.1333	0.1548	0.1462	0.1366	0.1586
PineD	0.0819	0.0765	0.0888	0.0879	0.0821	0.0954
ConifA	0.0681	0.0636	0.0739	0.0740	0.0691	0.0803
DecidC	0.0537	0.0502	0.0582	0.0661	0.0617	0.0717
ConifC	0.0494	0.0461	0.0535	0.0554	0.0518	0.0601
Grass	0.0207	0.0193	0.0224	0.0470	0.0440	0.0510
ConifB	0.0411	0.0384	0.0446	0.0444	0.0414	0.0481
ConifD	0.0374	0.0349	0.0405	0.0435	0.0407	0.0472
DecidB	0.0338	0.0315	0.0366	0.0411	0.0384	0.0446
MixedD	0.0335	0.0312	0.0363	0.0392	0.0366	0.0425
DecidA	0.0122	0.0114	0.0133	0.0171	0.0160	0.0186
MixedB	0.0052	0.0049	0.0057	0.0057	0.0053	0.0062
MixedA	0.0042	0.0040	0.0046	0.0054	0.0051	0.0059
MixedC	0.0030	0.0028	0.0033	0.0034	0.0032	0.0037
Cult	0.0316	0.0295	0.0343	0.0000	0.0000	0.0000
UrbInd	0.0202	0.0189	0.0219	0.0000	0.0000	0.0000
HardLin	0.0016	0.0015	0.0017	0.0000	0.0000	0.0000
SoftLin	0.0220	0.0205	0.0239	0.0000	0.0000	0.0000
HFor	0.0505	0.0471	0.0547	0.0000	0.0000	0.0000
Total	2.8212	2.6350	3.0595	2.9518	2.7577	3.2030
Loss	0.1579	0.1000	0.1950			
Gain	0.0162	0.0073	0.0293			

5.32.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.32.14 Variable selection frequencies

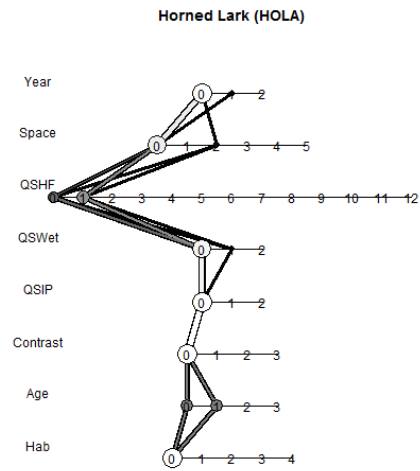
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	8.0	16	. + HabitatB
1.4	92.0	184	. + HabitatB + isHForC
2.1	100.0	200	. + Age
3.2	0.5	1	. + SoftLin_PC
3.3	99.5	199	. + ROAD + SoftLin_PC
4.0	95.0	190	NULL
4.1	0.5	1	. + Remn_QS
4.2	4.5	9	. + Remn_QS + Remn2_QS
5.1	100.0	200	. + pWet_QS
6.3	13.5	27	. + Succ_QS + Alien_QS
6.7	3.5	7	. + Succ_QS + Alien_QS + Succ2_QS
6.9	20.0	40	. + Succ_QS + Alien_QS + Alien2_QS
6.10	43.0	86	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.11	11.5	23	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
6.12	8.5	17	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.1	15.0	30	. + xlat
7.4	6.0	12	. + xMAP + xPET + xMAT + xCMD
7.5	79.0	158	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	11.5	23	. + xYEAR
8.2	88.5	177	. + YR5F

5.33 Horned Lark (*Eremophila alpestris*)

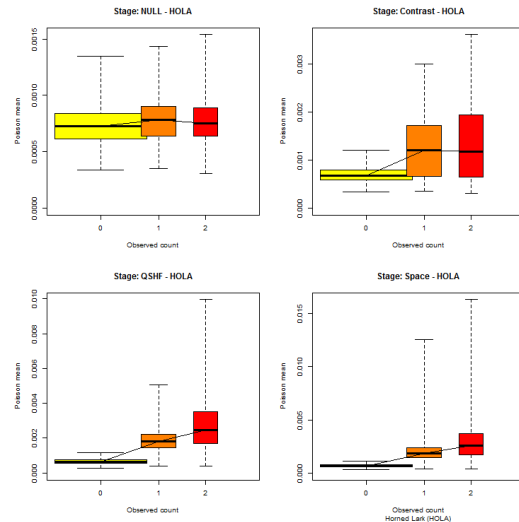
5.33.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

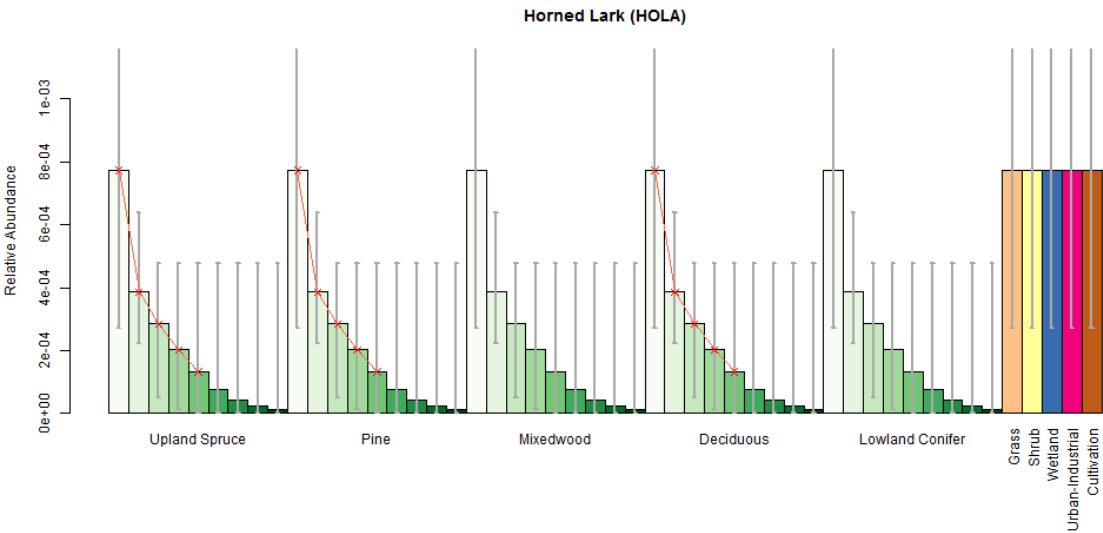


5.33.2 Cross validation

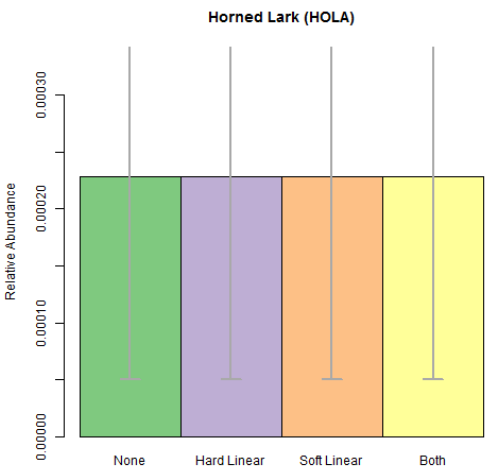
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.33.3 Point level habitat associations

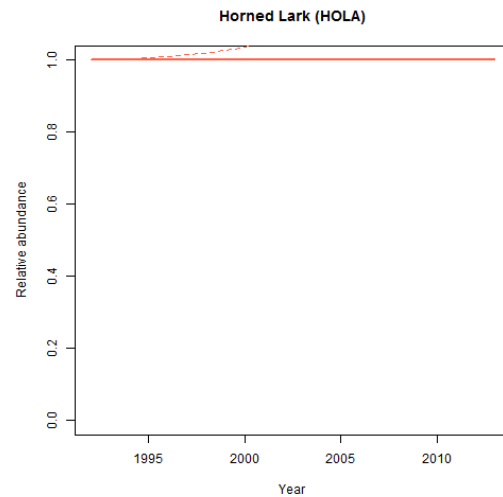


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

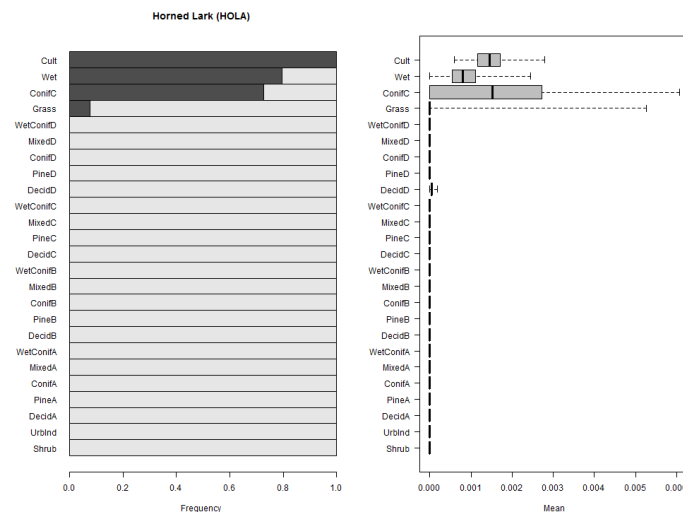


5.33.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



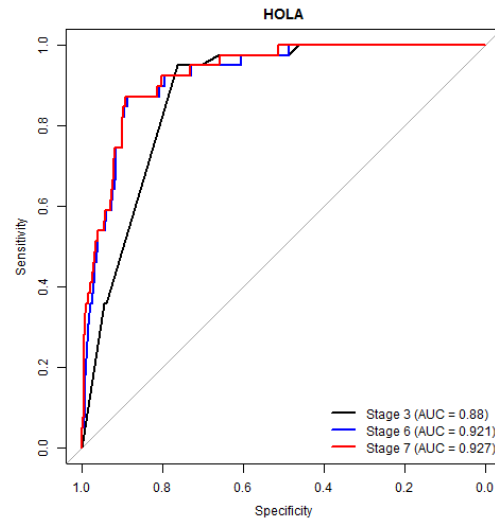
5.33.5 Habitat suitability ranking for patch delineation



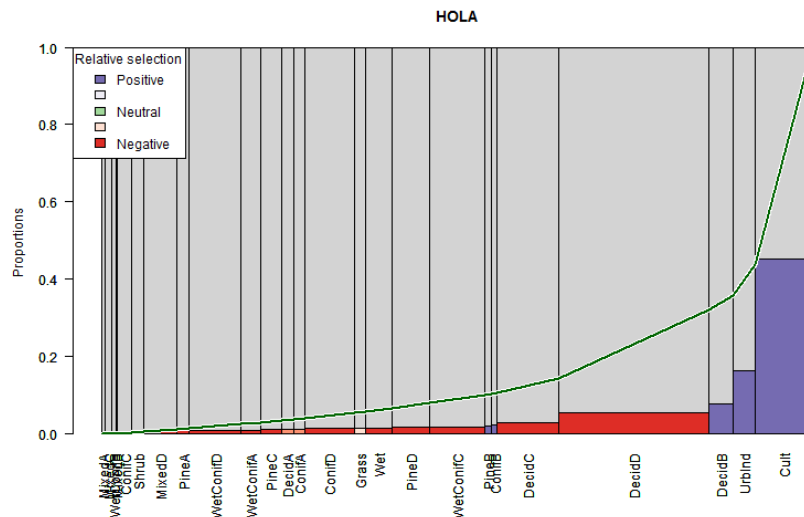
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.33.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

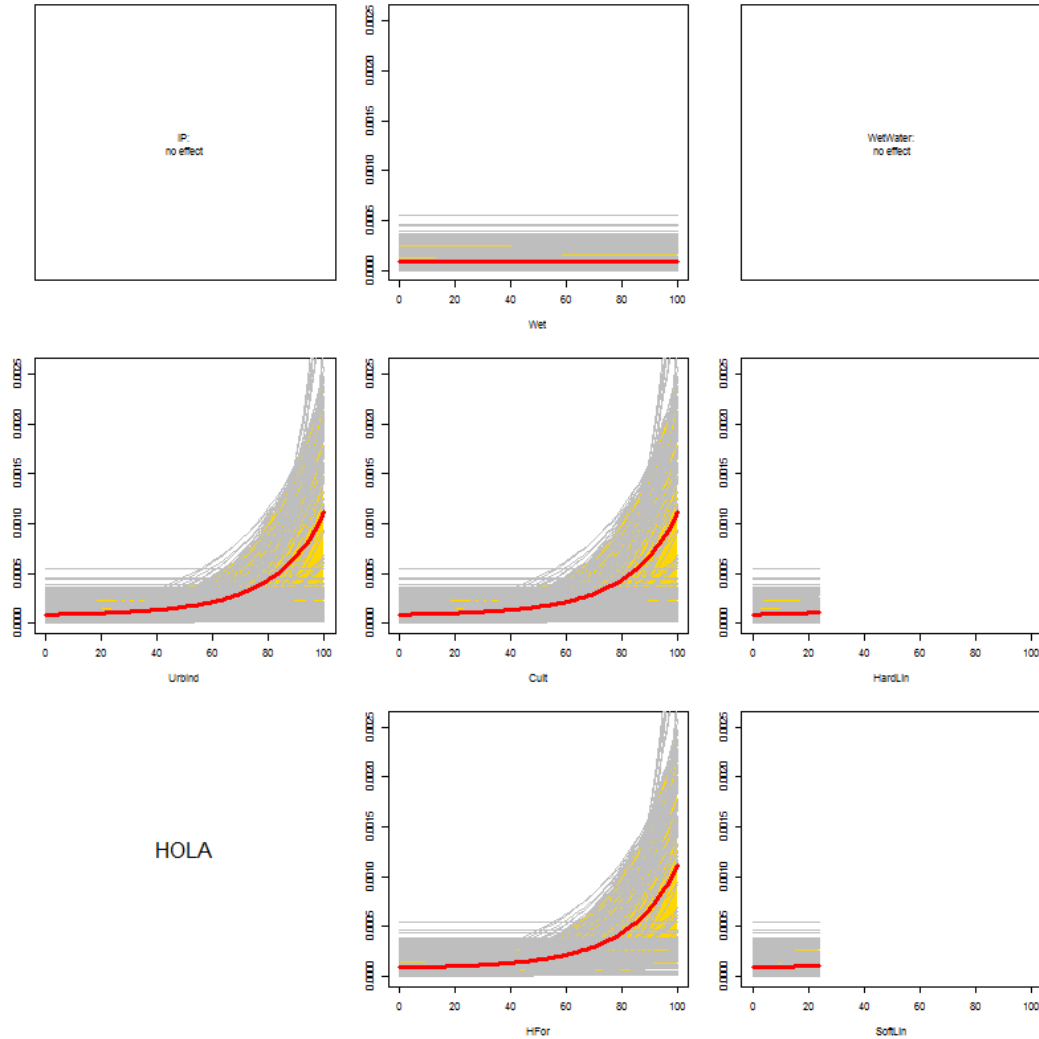


5.33.7 Relative habitat selection



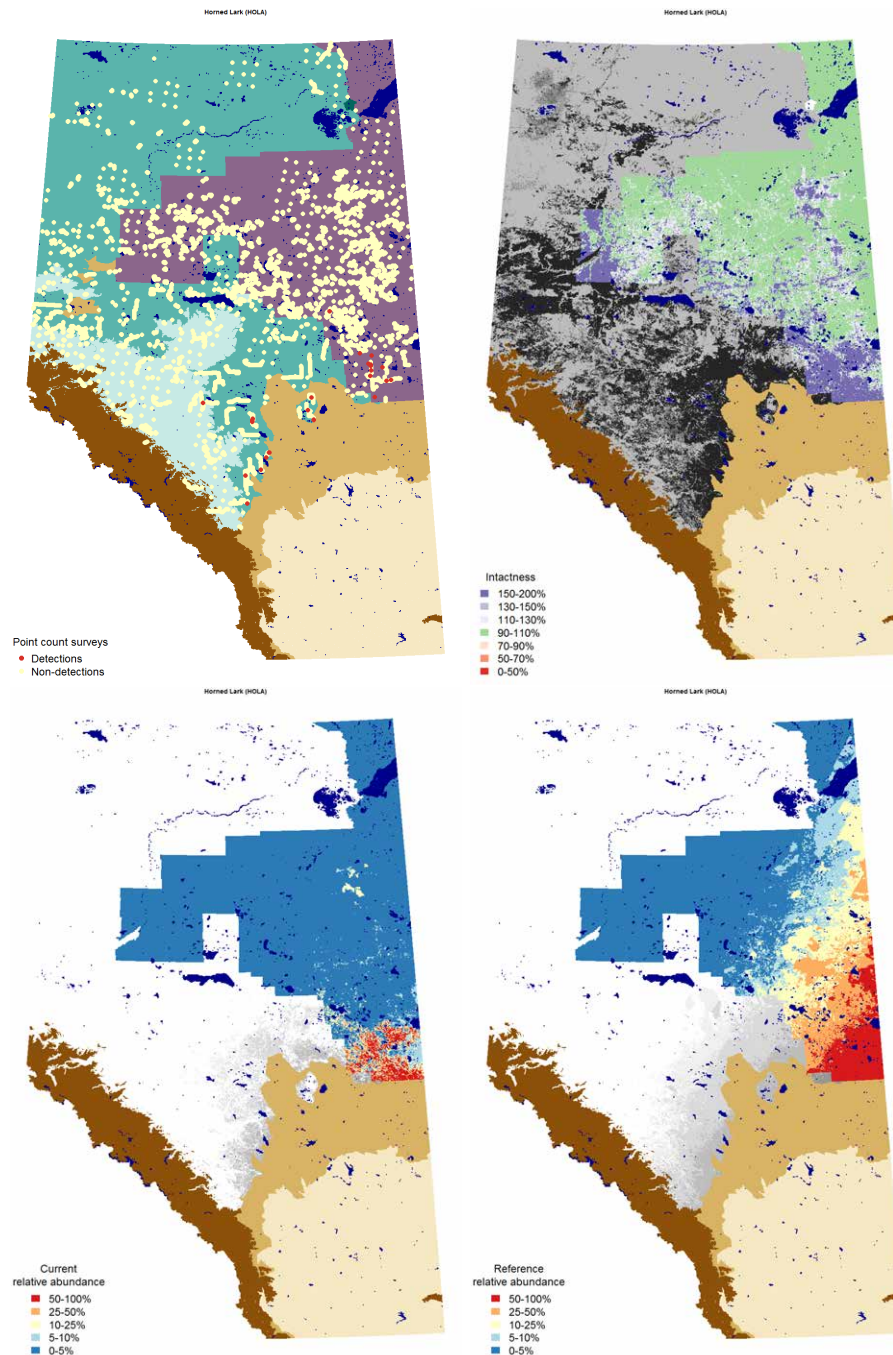
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.33.8 Quarter-section level responses



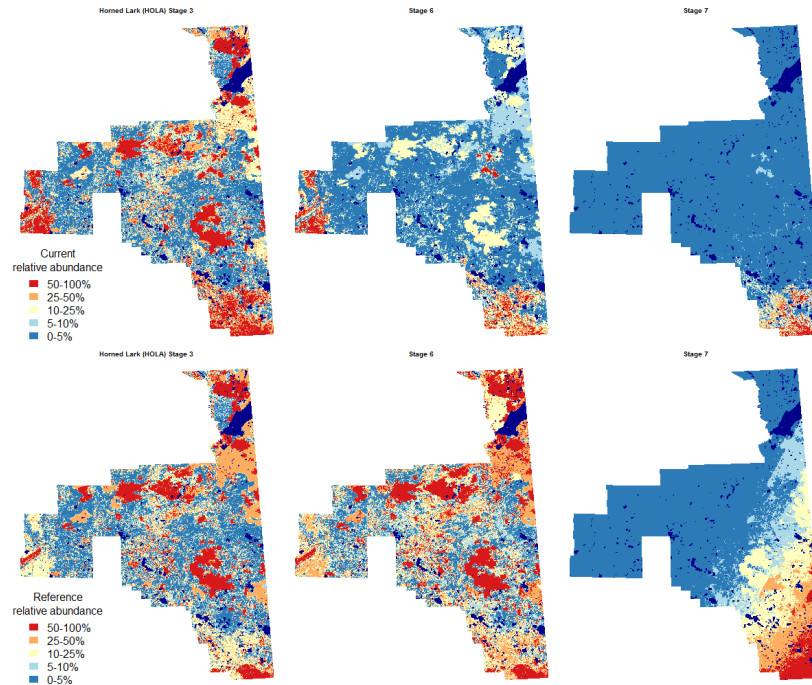
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.33.9 Maps



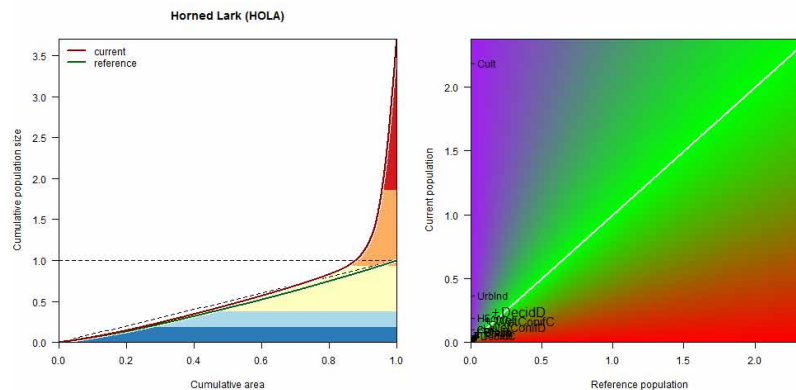
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.33.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.33.11 Population concentration



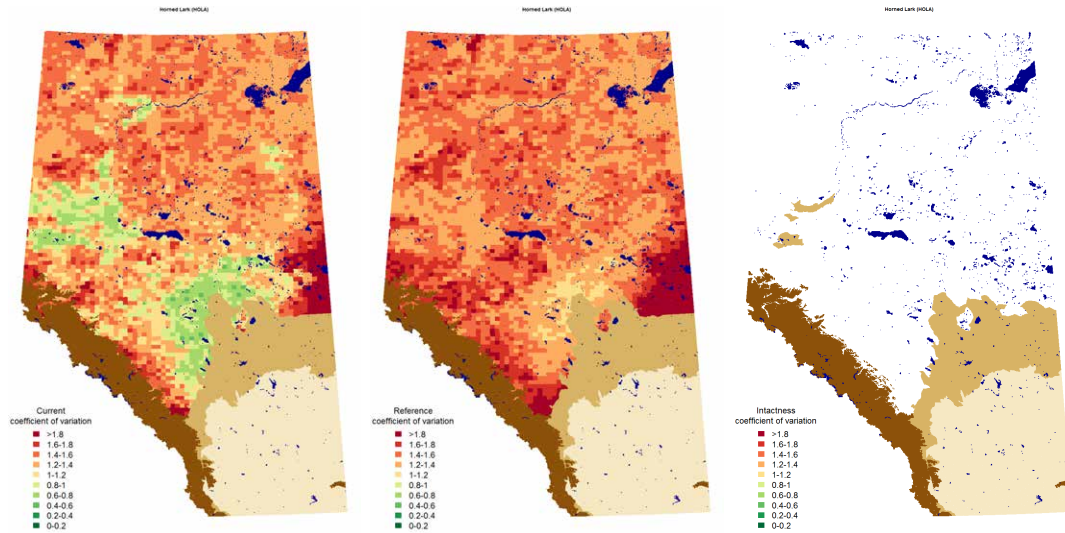
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.33.12 Potential population size

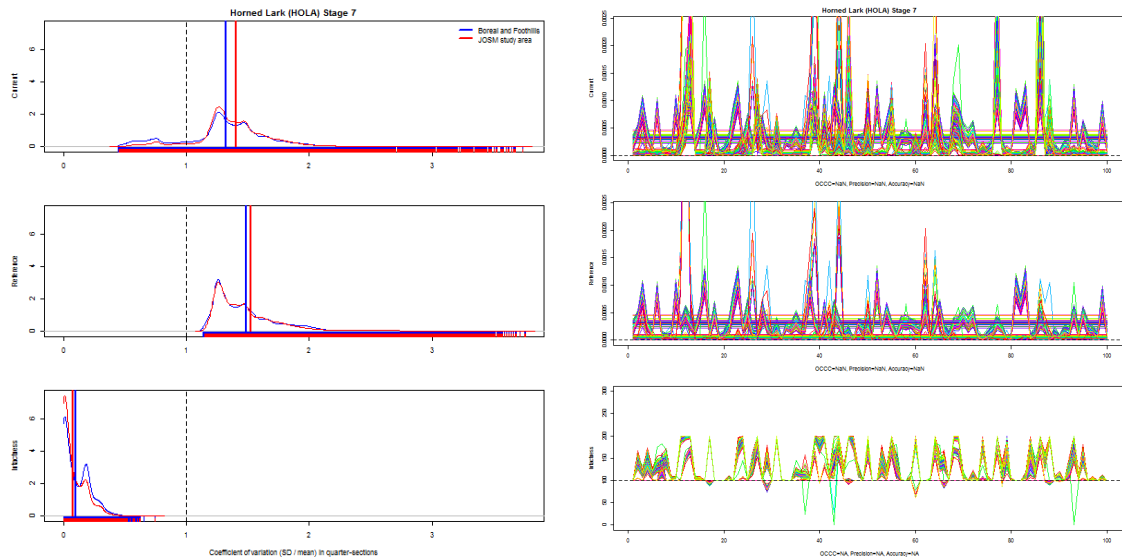
Estimated potential population size of Horned Lark in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0002	0.0001	0.0005	0.0001	0.0000	0.0012
WetConifC	0.0001	0.0001	0.0003	0.0001	0.0000	0.0009
Wet	0.0001	0.0001	0.0003	0.0001	0.0000	0.0008
WetConifD	0.0001	0.0000	0.0002	0.0001	0.0000	0.0007
PineB	0.0000	0.0000	0.0001	0.0000	0.0000	0.0004
Shrub	0.0001	0.0000	0.0001	0.0000	0.0000	0.0004
Grass	0.0001	0.0000	0.0002	0.0000	0.0000	0.0003
WetConifA	0.0000	0.0000	0.0001	0.0000	0.0000	0.0003
WetConifB	0.0000	0.0000	0.0001	0.0000	0.0000	0.0003
DecidC	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002
PineC	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002
MixedD	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002
ConifC	0.0000	0.0000	0.0001	0.0000	0.0000	0.0002
ConifA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
DecidB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
PineA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
ConifD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
ConifB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
PineD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
DecidA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0017	0.0008	0.0043	0.0000	0.0000	0.0000
UrbInd	0.0003	0.0001	0.0007	0.0000	0.0000	0.0000
HardLin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SoftLin	0.0001	0.0000	0.0002	0.0000	0.0000	0.0000
HFor	0.0001	0.0001	0.0004	0.0000	0.0000	0.0000
Total	0.0031	0.0016	0.0081	0.0007	0.0000	0.0070
Loss	0.0000	0.0000	0.0000			
Gain	0.0016	0.0000	0.0028			

5.33.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.33.14 Variable selection frequencies

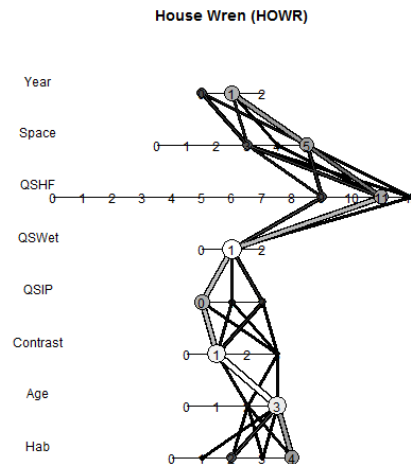
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	186	NULL
2.0	49.5	92	NULL
2.1	50.5	94	. + Age
3.0	100.0	186	NULL
4.0	100.0	186	NULL
5.0	96.2	179	NULL
5.1	3.8	7	. + pWet_QS
6.0	41.9	78	NULL
6.1	58.1	108	. + THF_QS
7.0	93.0	173	NULL
7.2	7.0	13	. + xlat + xlong
8.0	99.5	185	NULL
8.1	0.5	1	. + xYEAR

5.34 House Wren (*Troglodytes aedon*)

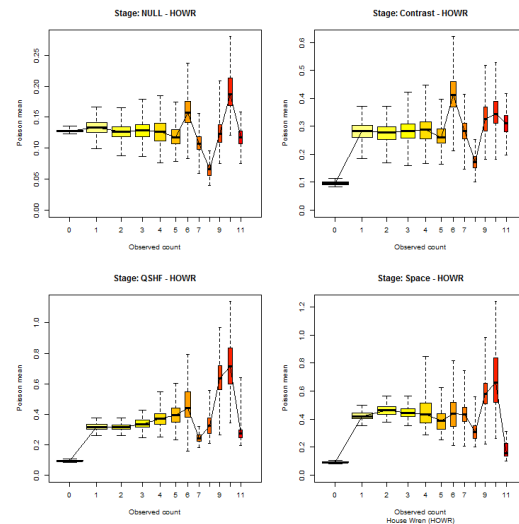
5.34.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

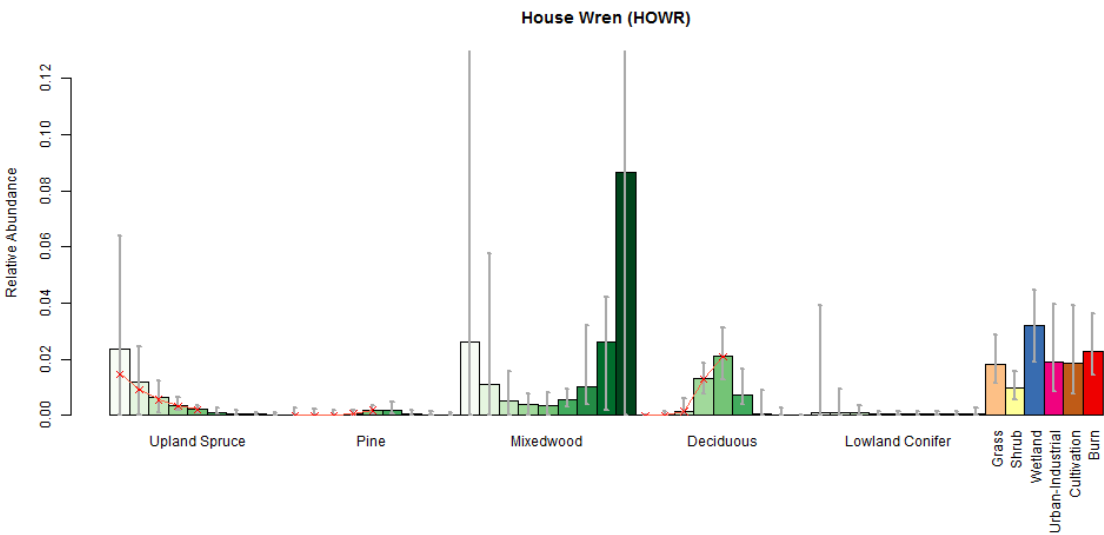


5.34.2 Cross validation

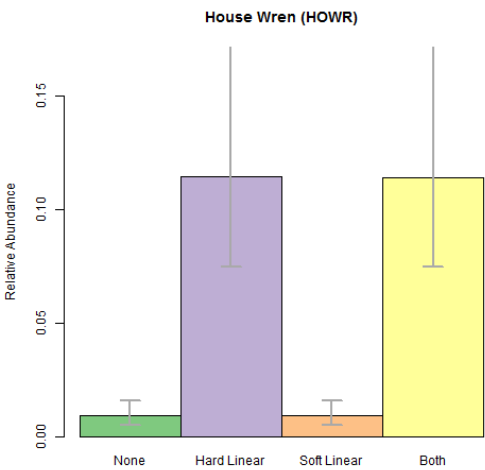
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.34.3 Point level habitat associations

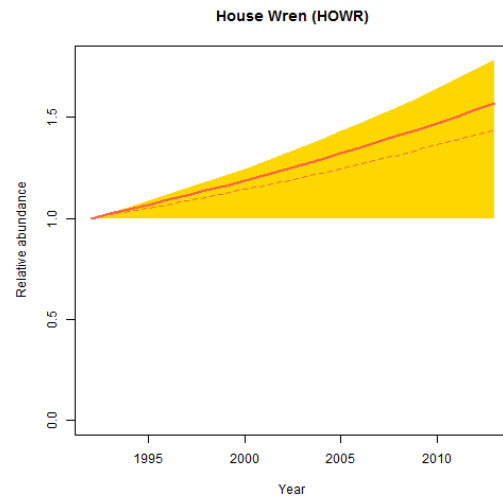


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

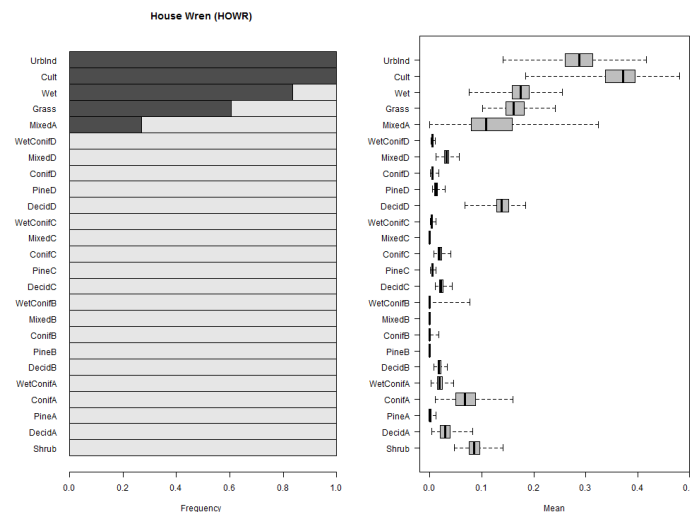


5.34.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



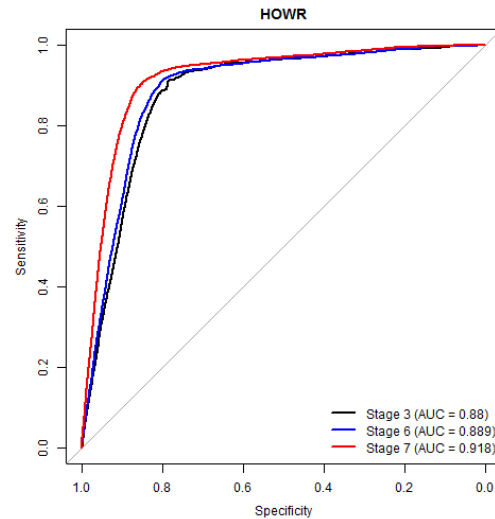
5.34.5 Habitat suitability ranking for patch delineation



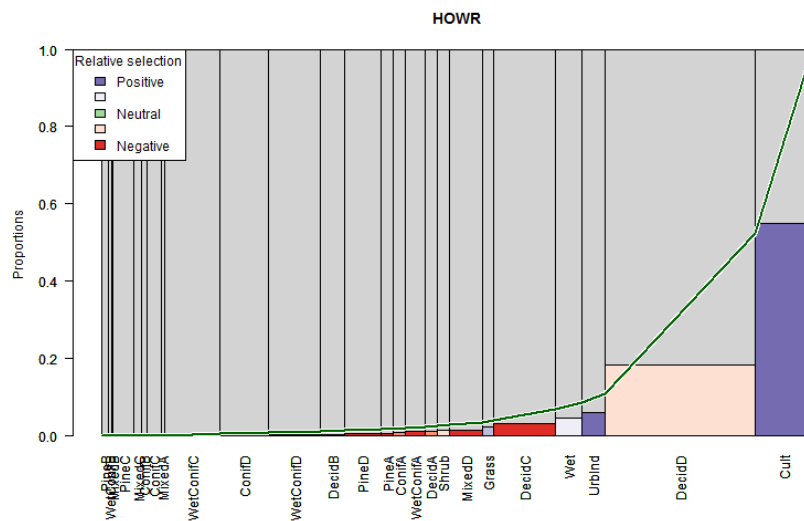
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.34.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

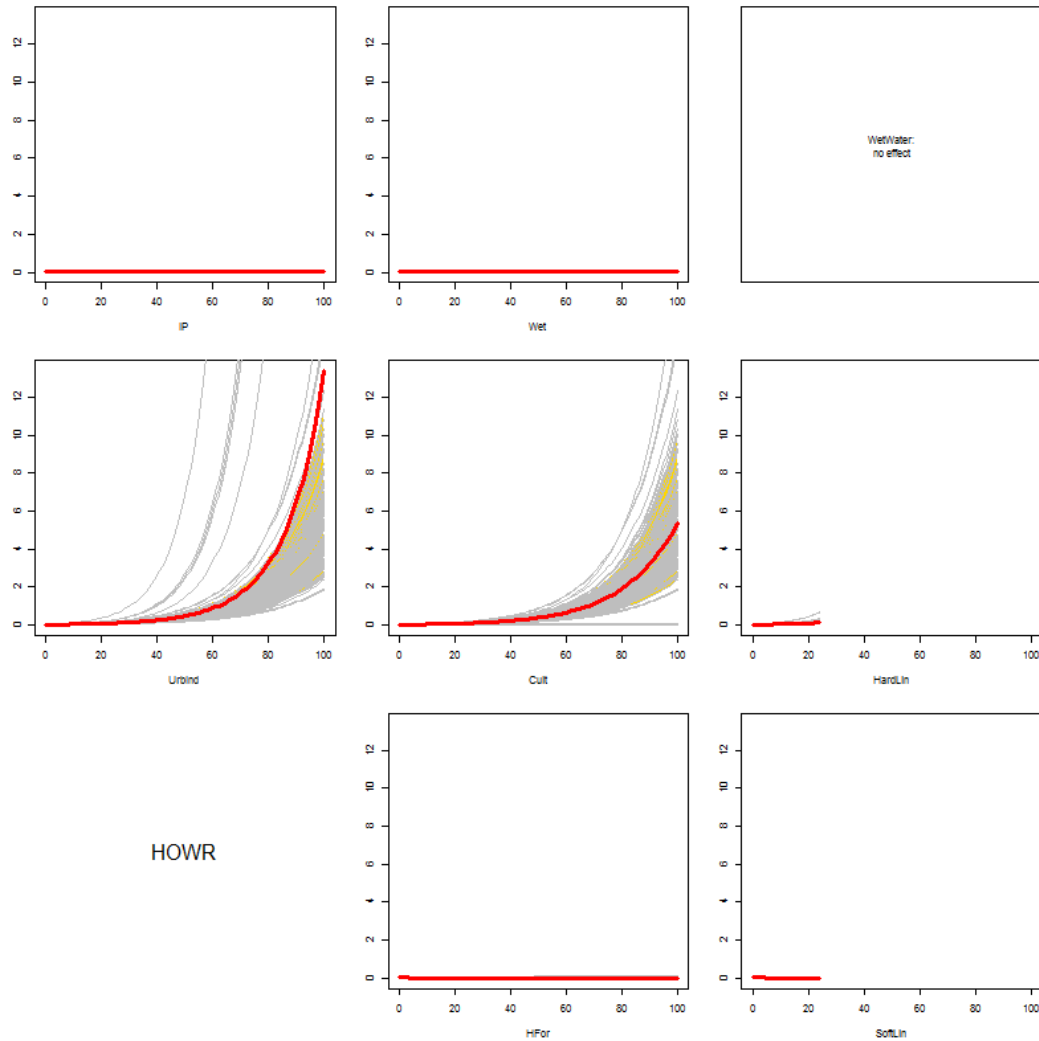


5.34.7 Relative habitat selection



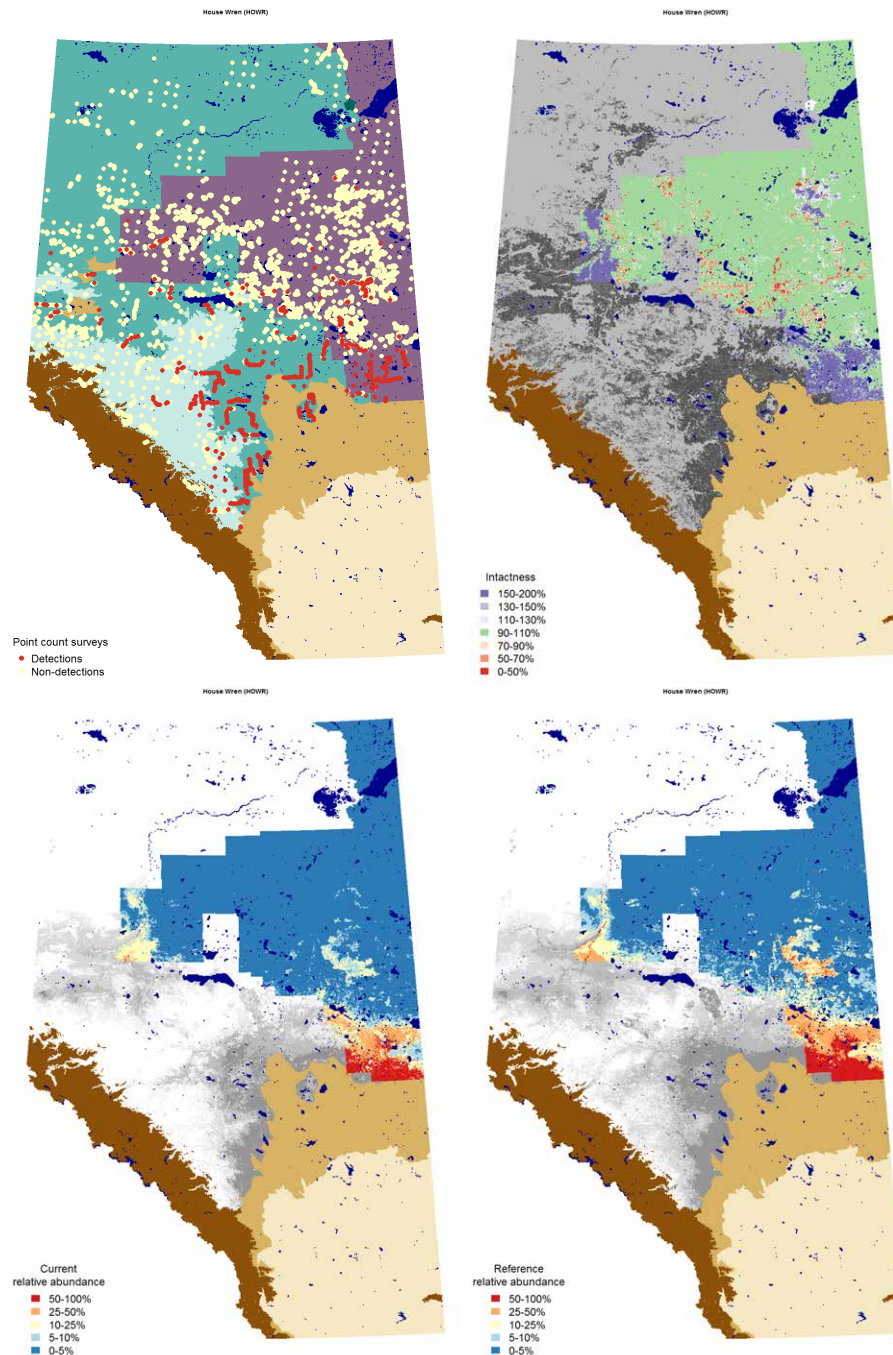
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.34.8 Quarter-section level responses



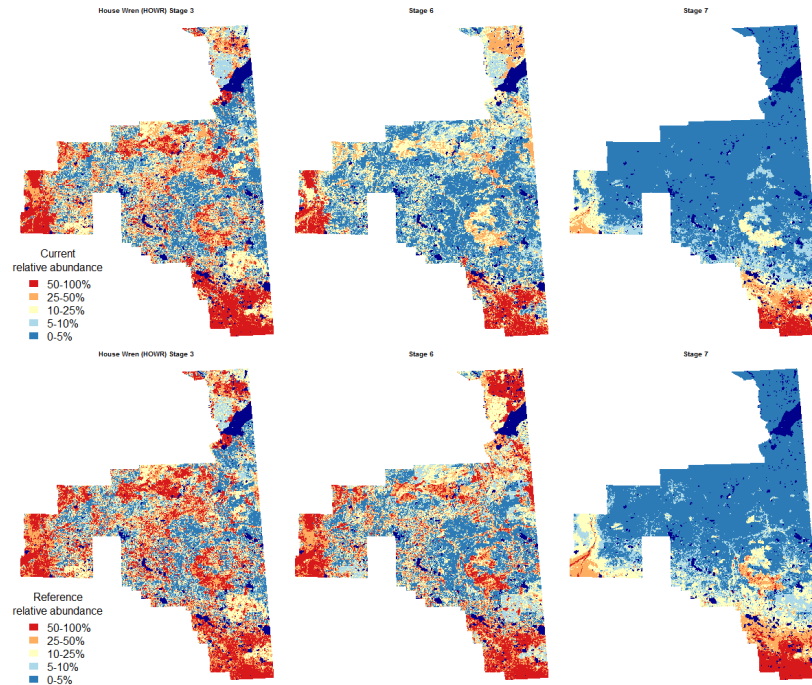
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.34.9 Maps



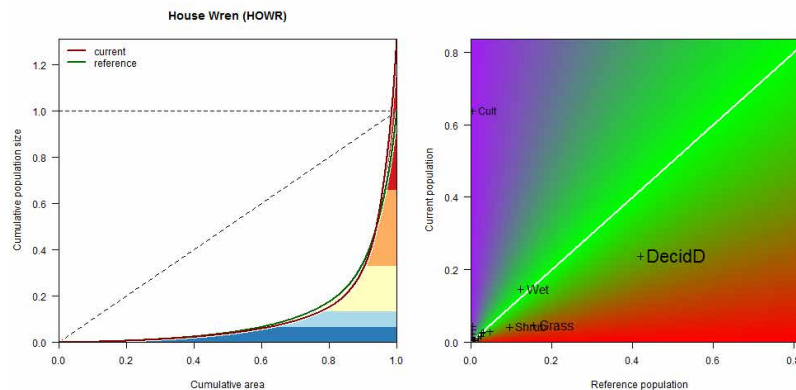
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.34.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.34.11 Population concentration



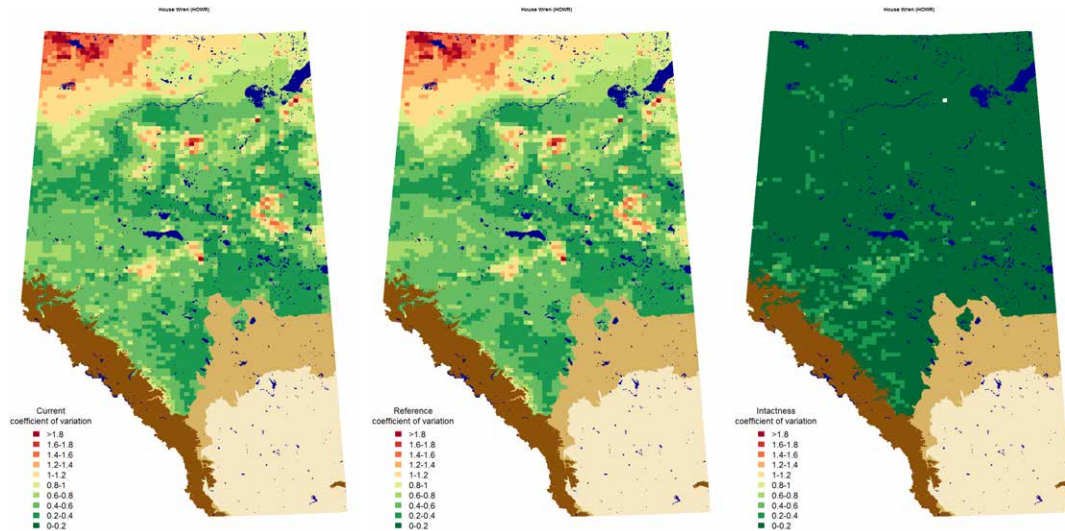
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.34.12 Potential population size

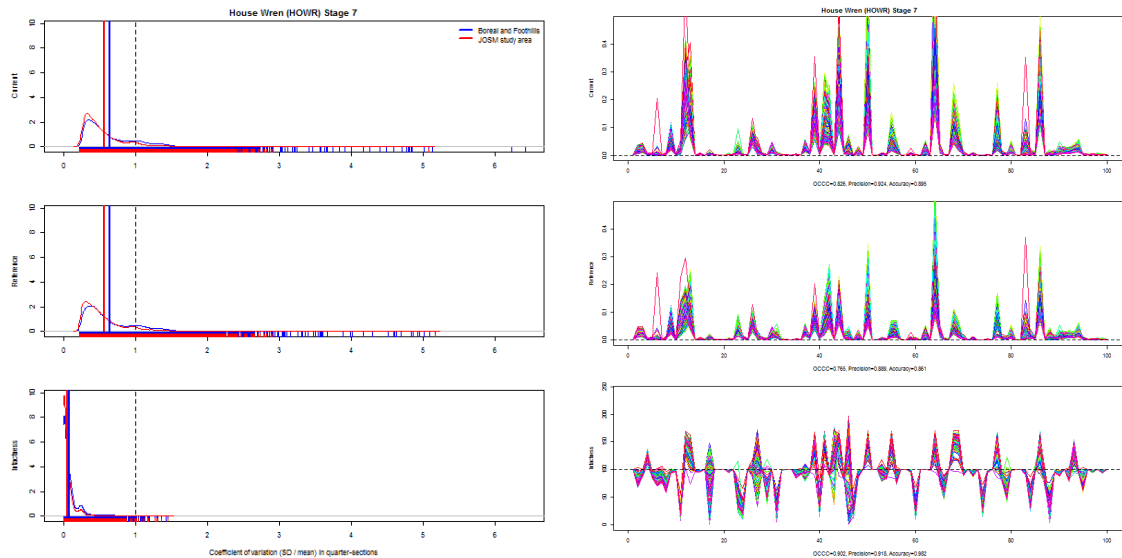
Estimated potential population size of House Wren in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0461	0.0285	0.0645	0.0839	0.0529	0.1251
Grass	0.0088	0.0055	0.0123	0.0310	0.0196	0.0463
Wet	0.0285	0.0176	0.0399	0.0248	0.0156	0.0369
Shrub	0.0080	0.0049	0.0112	0.0194	0.0122	0.0290
MixedD	0.0056	0.0035	0.0078	0.0096	0.0061	0.0143
WetConifD	0.0053	0.0033	0.0074	0.0062	0.0039	0.0092
WetConifC	0.0048	0.0030	0.0067	0.0055	0.0035	0.0082
DecidC	0.0032	0.0020	0.0044	0.0051	0.0032	0.0076
ConifA	0.0022	0.0014	0.0031	0.0039	0.0025	0.0059
ConifC	0.0012	0.0007	0.0016	0.0021	0.0013	0.0031
MixedA	0.0008	0.0005	0.0011	0.0019	0.0012	0.0028
ConifD	0.0008	0.0005	0.0012	0.0016	0.0010	0.0023
PineD	0.0008	0.0005	0.0011	0.0012	0.0008	0.0018
ConifB	0.0007	0.0004	0.0009	0.0011	0.0007	0.0016
PineC	0.0003	0.0002	0.0005	0.0005	0.0003	0.0008
WetConifB	0.0004	0.0002	0.0005	0.0004	0.0003	0.0006
MixedB	0.0002	0.0001	0.0003	0.0004	0.0003	0.0006
MixedC	0.0002	0.0001	0.0003	0.0004	0.0002	0.0006
DecidB	0.0002	0.0001	0.0003	0.0003	0.0002	0.0005
WetConifA	0.0003	0.0002	0.0004	0.0003	0.0002	0.0005
DecidA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PineB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PineA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.1243	0.0769	0.1739	0.0000	0.0000	0.0000
UrbInd	0.0083	0.0052	0.0117	0.0000	0.0000	0.0000
HardLin	0.0045	0.0028	0.0063	0.0000	0.0000	0.0000
SoftLin	0.0065	0.0040	0.0092	0.0000	0.0000	0.0000
HFor	0.0024	0.0015	0.0033	0.0000	0.0000	0.0000
Total	0.2645	0.1637	0.3700	0.1996	0.1259	0.2978
Loss	0.0146	0.0074	0.0258			
Gain	0.0726	0.0328	0.1318			

5.34.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.34.14 Variable selection frequencies

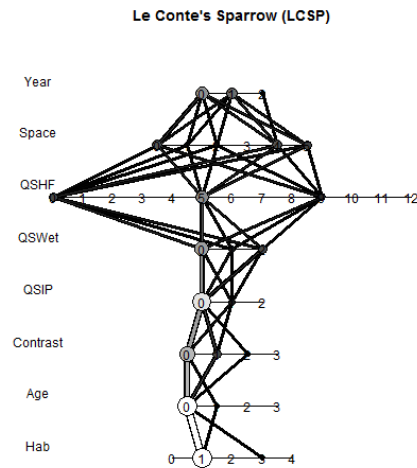
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	0.5	1	. + Habitat
1.2	36.5	73	. + HabitatB
1.3	2.0	4	. + Habitat + isHForC
1.4	61.0	122	. + HabitatB + isHForC
2.2	7.5	15	. + Age + Age2
			. + Age + Age2 + Age:isMix + Age:isPine
2.3	92.5	185	+ Age:isUplConif + Age:isWetConif +
			Age2:isMix + Age2:isPine + Age2:isUplConif
			+ Age2:isWetConif
3.1	95.5	191	. + ROAD
3.3	4.5	9	. + ROAD + SoftLin_PC
4.0	68.5	137	NULL
4.1	9.0	18	. + Remn_QS
4.2	22.5	45	. + Remn_QS + Remn2_QS
5.1	100.0	200	. + pWet_QS
6.9	31.5	63	. + Succ_QS + Alien_QS + Alien2_QS
6.11	65.5	131	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
6.12	3.0	6	. + Succ_QS + Noncult_QS + Cult_QS +
			Succ2_QS + Noncult2_QS
7.3	36.0	72	. + xlat + xlong + xlat:xlong
7.4	0.5	1	. + xMAP + xPET + xMAT + xCMD
7.5	63.5	127	. + xMAP + xPET + xMAT + xCMD +
			xMAP:xPET + xMAT:xCMD
8.0	30.5	61	NULL
8.1	69.5	139	. + xYEAR

5.35 Le Conte's Sparrow (*Ammodramus leconteii*)

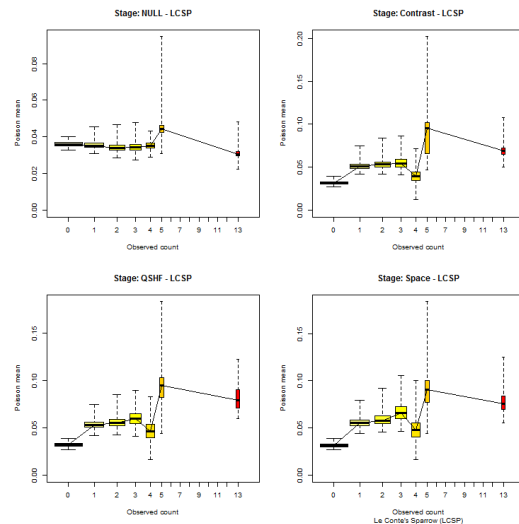
5.35.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

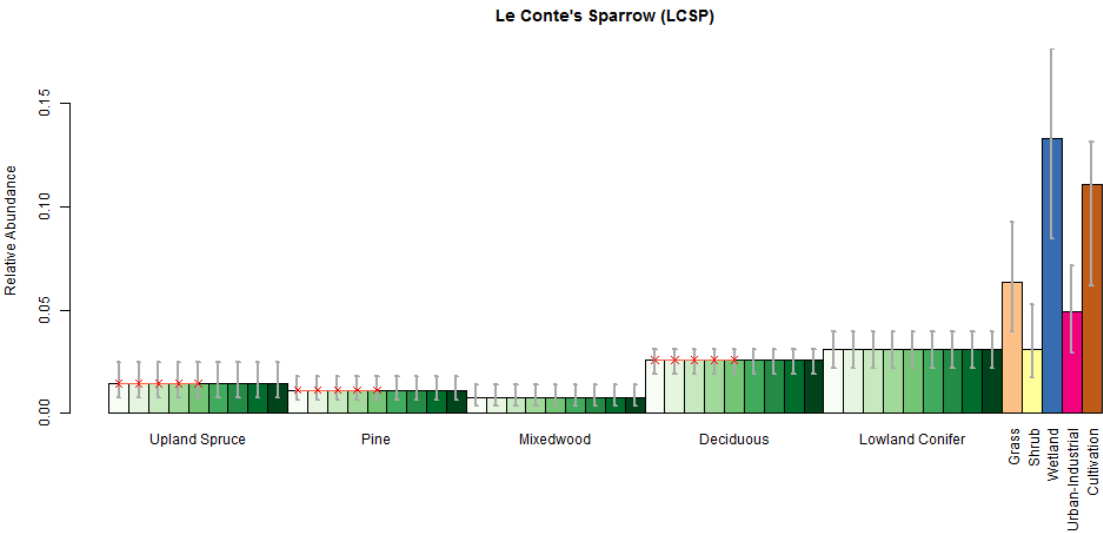


5.35.2 Cross validation

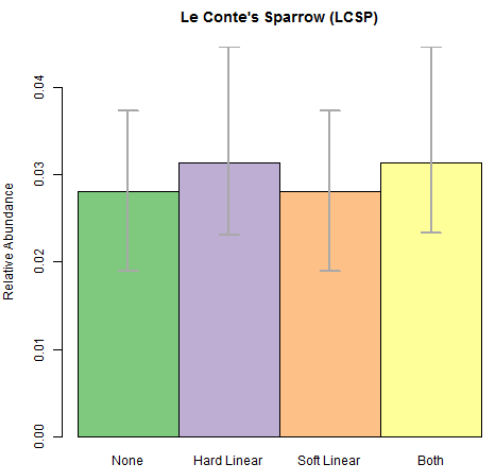
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.35.3 Point level habitat associations

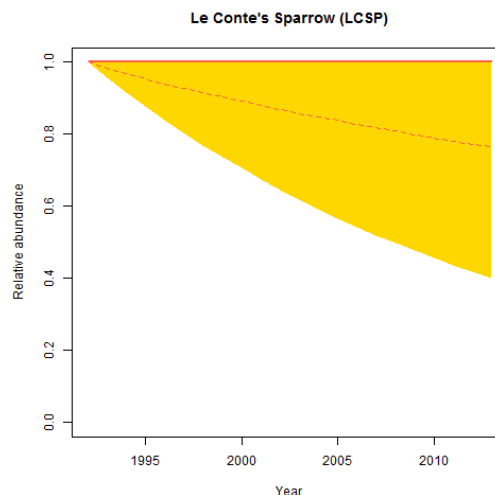


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

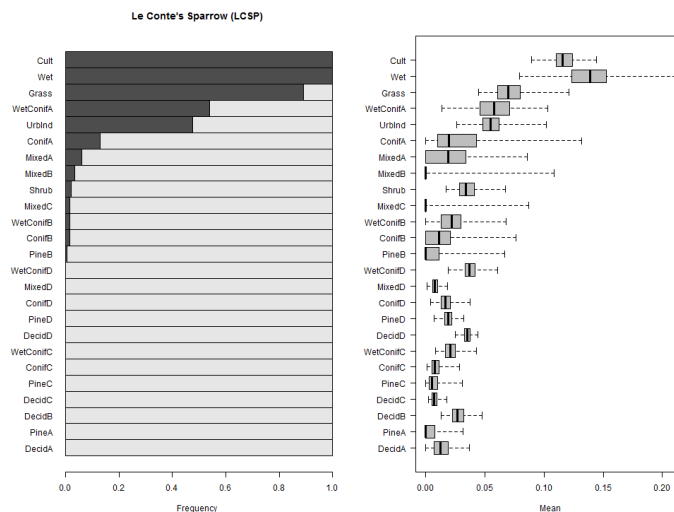


5.35.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



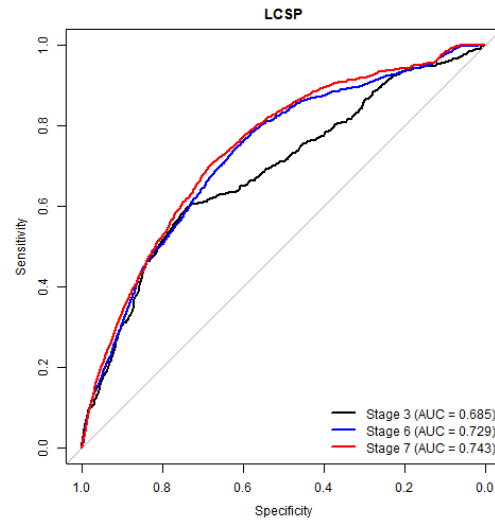
5.35.5 Habitat suitability ranking for patch delineation



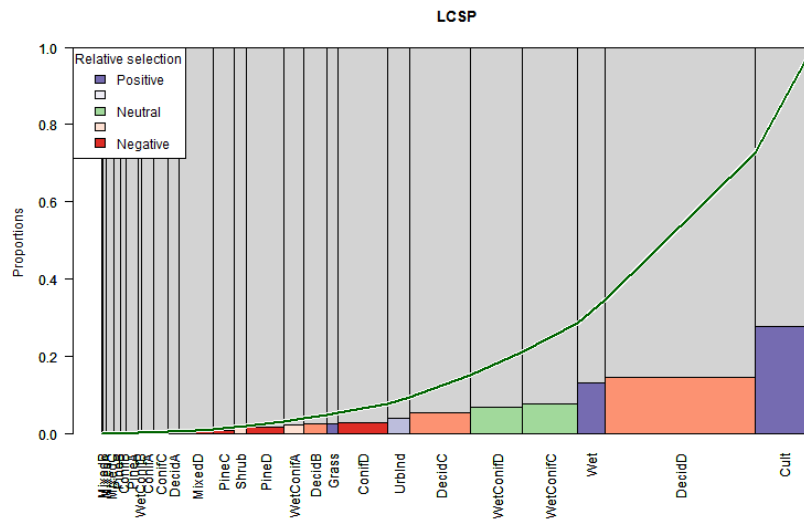
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.35.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

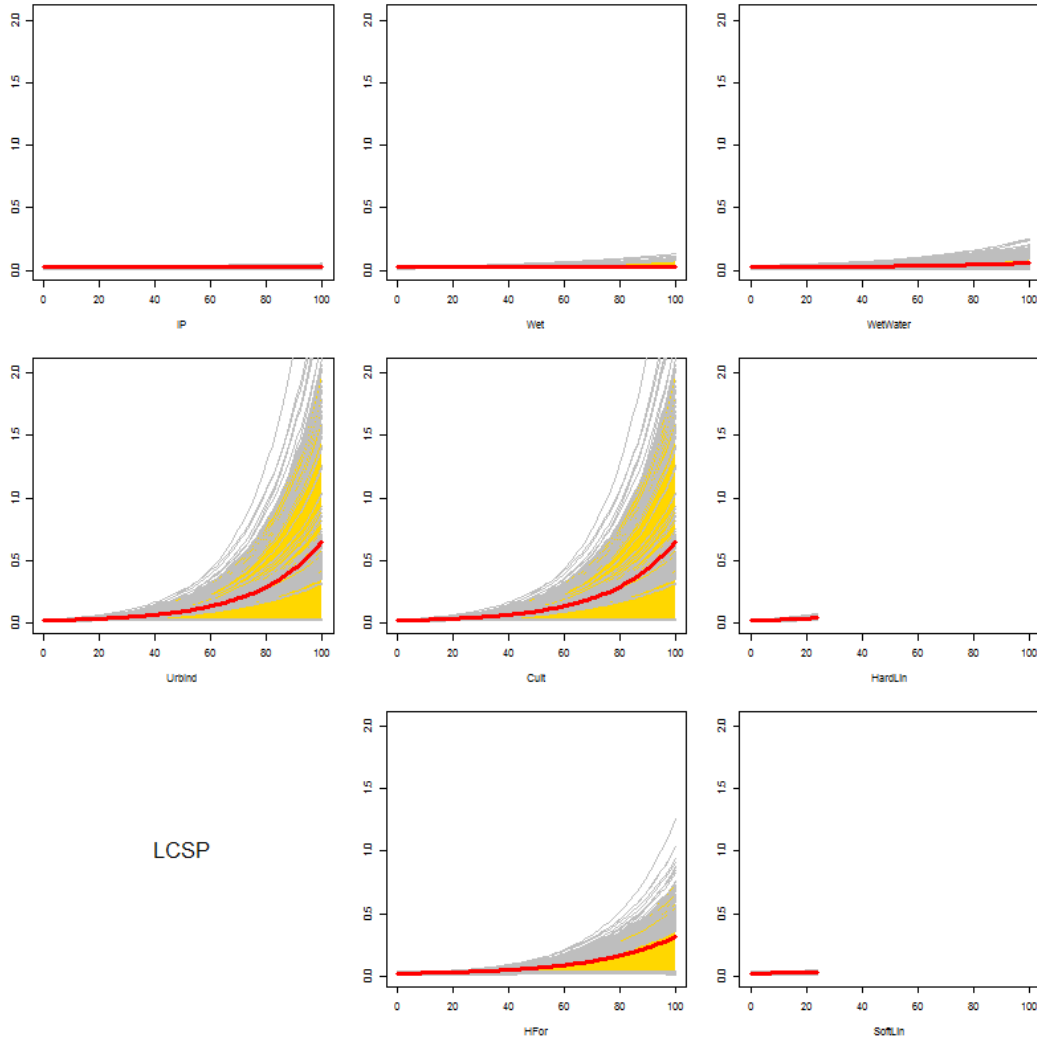


5.35.7 Relative habitat selection



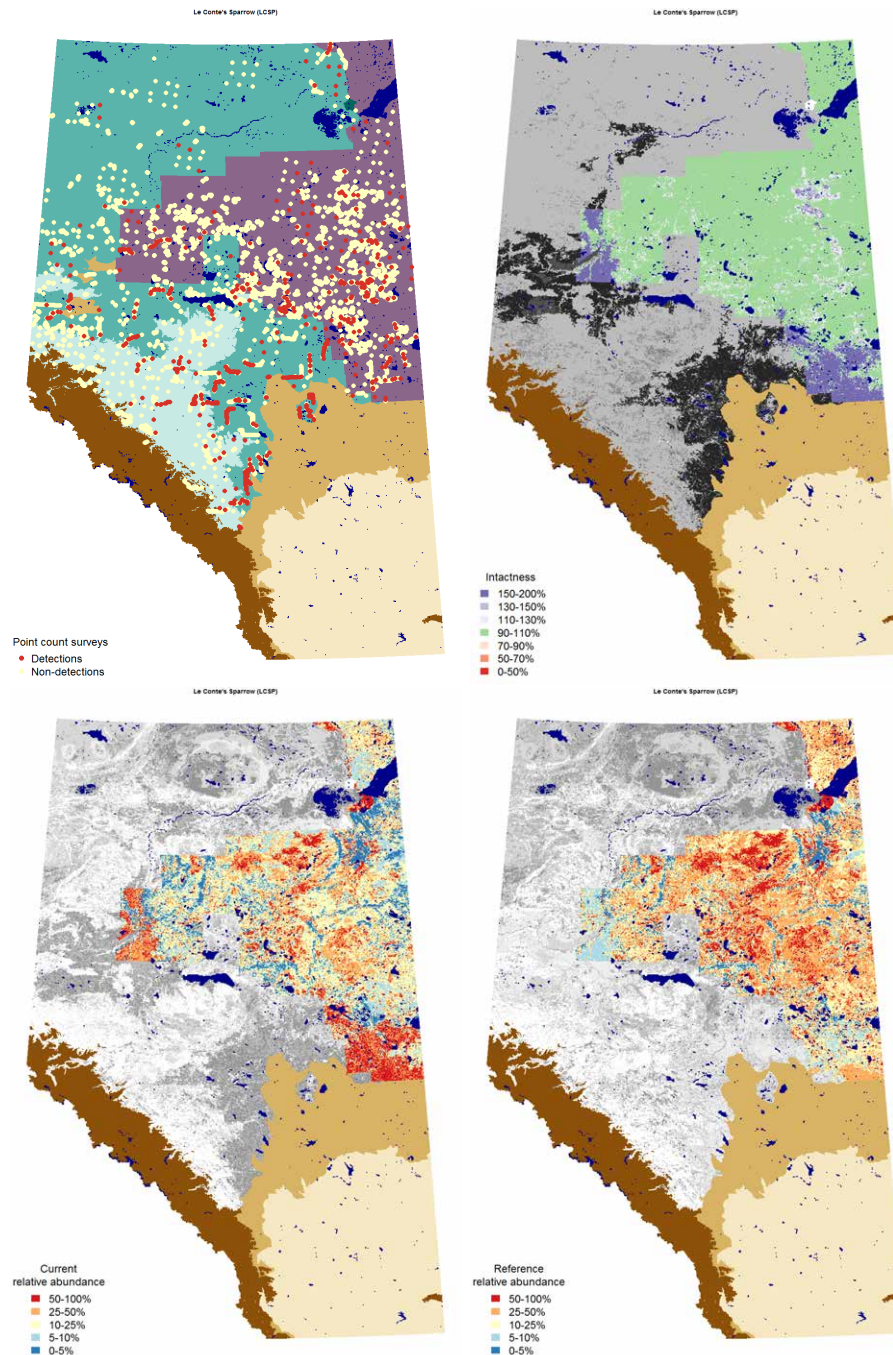
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.35.8 Quarter-section level responses



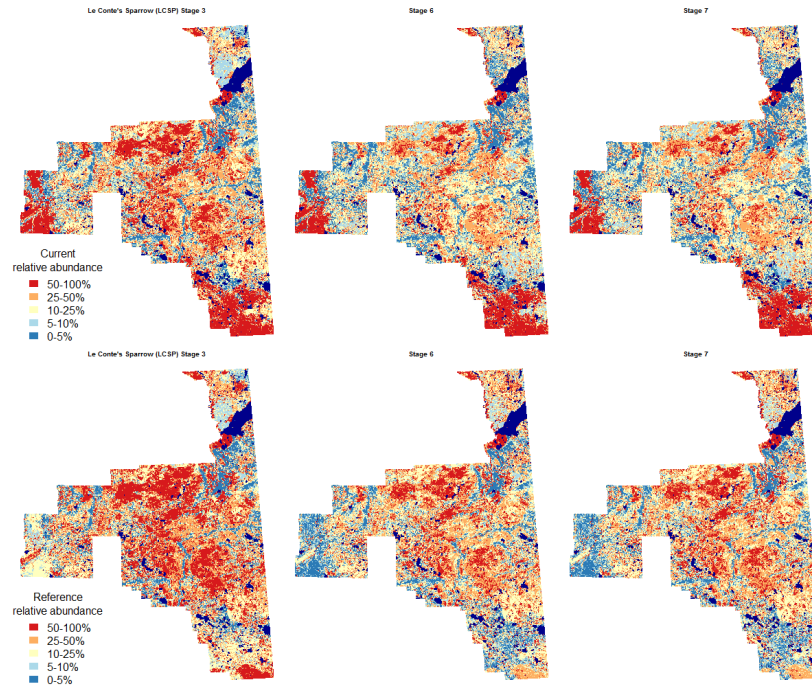
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.35.9 Maps



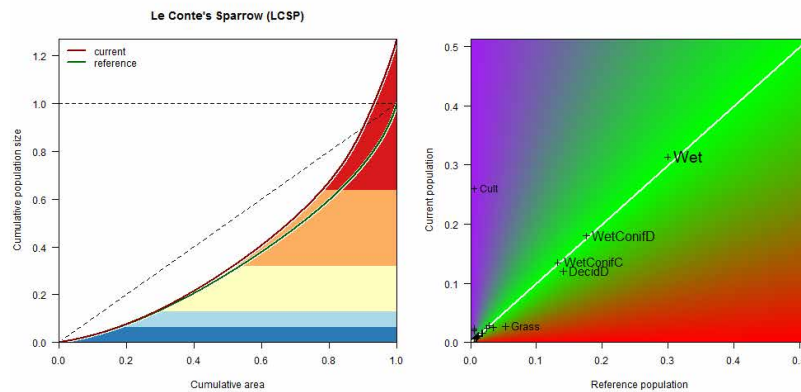
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.35.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.35.11 Population concentration



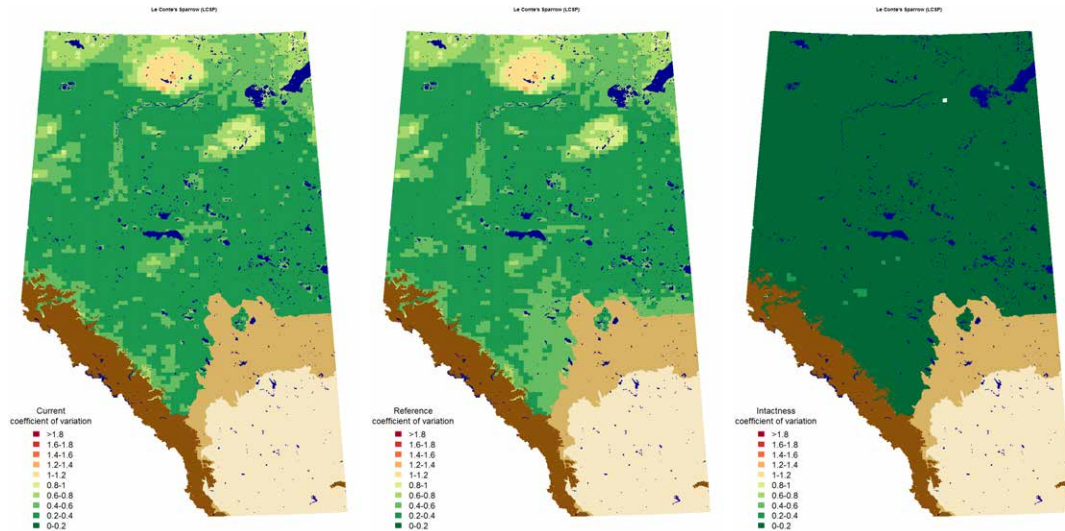
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.35.12 Potential population size

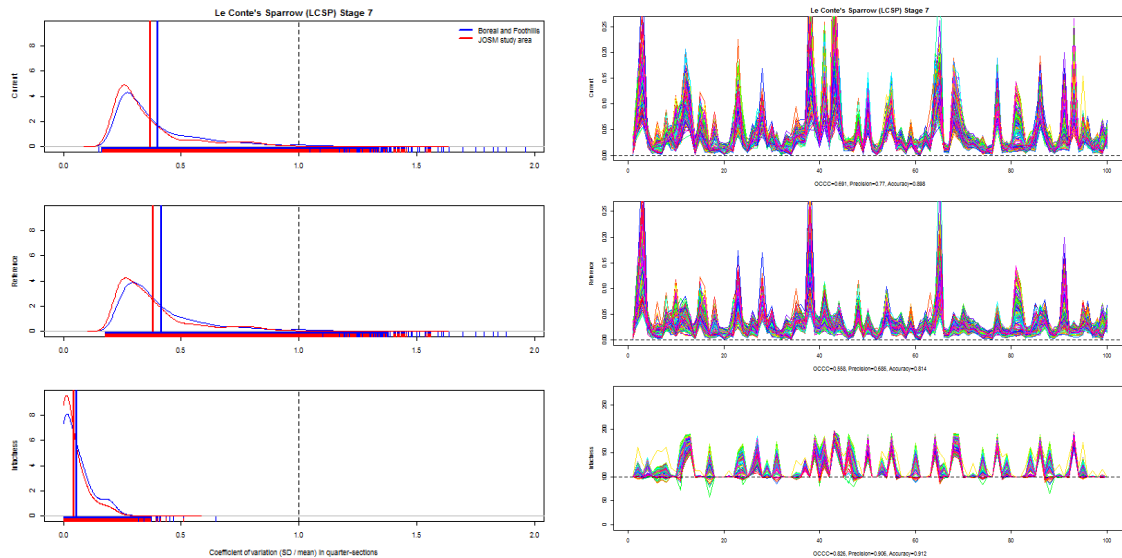
Estimated potential population size of Le Conte's Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.1365	0.1048	0.1761	0.1332	0.1020	0.1763
WetConifD	0.0782	0.0601	0.1009	0.0782	0.0599	0.1035
DecidD	0.0522	0.0400	0.0673	0.0627	0.0480	0.0831
WetConifC	0.0587	0.0451	0.0758	0.0590	0.0451	0.0781
Grass	0.0116	0.0089	0.0150	0.0237	0.0181	0.0314
Shrub	0.0111	0.0085	0.0143	0.0152	0.0116	0.0201
WetConifA	0.0124	0.0095	0.0160	0.0125	0.0096	0.0166
WetConifB	0.0105	0.0081	0.0136	0.0110	0.0084	0.0146
DecidC	0.0066	0.0050	0.0085	0.0081	0.0062	0.0107
ConifD	0.0067	0.0052	0.0087	0.0075	0.0057	0.0099
PineB	0.0050	0.0039	0.0065	0.0052	0.0039	0.0068
ConifC	0.0041	0.0032	0.0053	0.0048	0.0036	0.0063
PineC	0.0043	0.0033	0.0056	0.0047	0.0036	0.0062
DecidB	0.0032	0.0025	0.0042	0.0043	0.0033	0.0056
PineD	0.0036	0.0027	0.0046	0.0038	0.0029	0.0051
MixedD	0.0033	0.0025	0.0042	0.0036	0.0028	0.0048
ConifA	0.0021	0.0016	0.0027	0.0024	0.0018	0.0032
ConifB	0.0015	0.0012	0.0020	0.0018	0.0014	0.0024
PineA	0.0016	0.0012	0.0021	0.0017	0.0013	0.0022
DecidA	0.0010	0.0007	0.0013	0.0015	0.0012	0.0020
MixedA	0.0001	0.0001	0.0002	0.0002	0.0001	0.0003
MixedB	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002
MixedC	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002
Cult	0.1130	0.0867	0.1458	0.0000	0.0000	0.0000
UrbInd	0.0083	0.0064	0.0108	0.0000	0.0000	0.0000
HardLin	0.0013	0.0010	0.0017	0.0000	0.0000	0.0000
SoftLin	0.0096	0.0074	0.0124	0.0000	0.0000	0.0000
HFor	0.0100	0.0076	0.0128	0.0000	0.0000	0.0000
Total	0.5568	0.4275	0.7186	0.4454	0.3410	0.5896
Loss	0.0005	0.0000	0.0082			
Gain	0.1126	0.0427	0.1841			

5.35.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.35.14 Variable selection frequencies

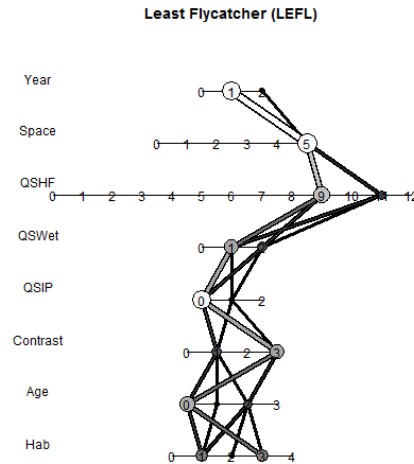
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	99.0	198	. + Habitat
1.3	1.0	2	. + Habitat + isHForC
2.0	99.5	199	NULL
2.1	0.5	1	. + Age
3.0	71.0	142	NULL
3.1	28.5	57	. + ROAD
3.2	0.5	1	. + SoftLin_PC
4.0	89.5	179	NULL
4.1	10.5	21	. + Remn_QS
5.0	61.5	123	NULL
5.1	9.0	18	. + pWet_QS
5.2	29.5	59	. + pWetWater_QS
6.0	28.0	56	NULL
6.5	54.5	109	. + THF_QS + THF2_QS
6.9	17.5	35	. + Succ_QS + Alien_QS + Alien2_QS
7.0	33.5	67	NULL
7.1	3.5	7	. + xlat
7.2	5.0	10	. + xlat + xlong
7.4	32.5	65	. + xMAP + xPET + xMAT + xCMD
7.5	25.5	51	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	56.5	113	NULL
8.1	43.0	86	. + xYEAR
8.2	0.5	1	. + YR5F

5.36 Least Flycatcher (*Empidonax minimus*)

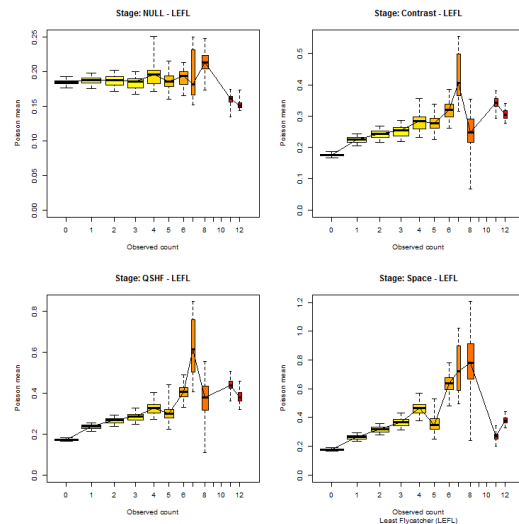
5.36.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

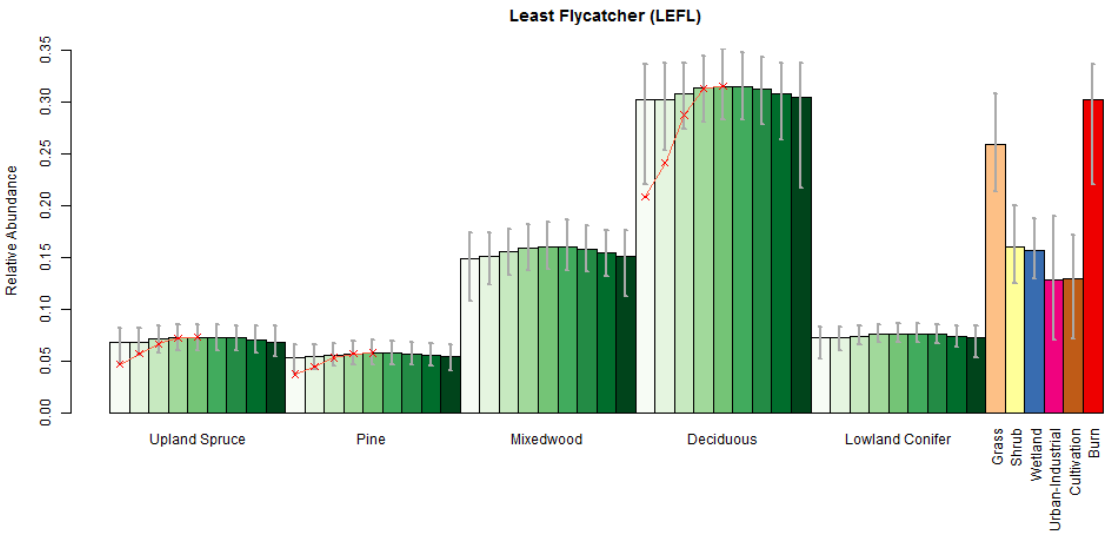


5.36.2 Cross validation

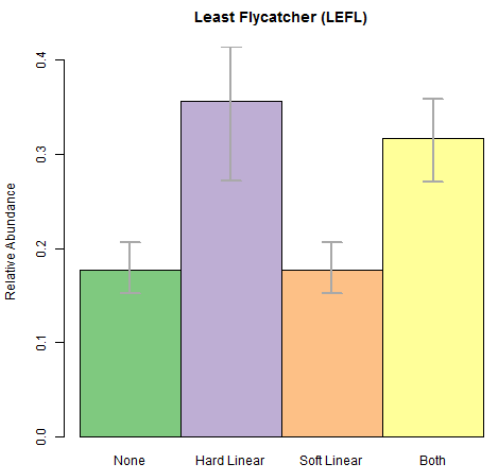
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.36.3 Point level habitat associations

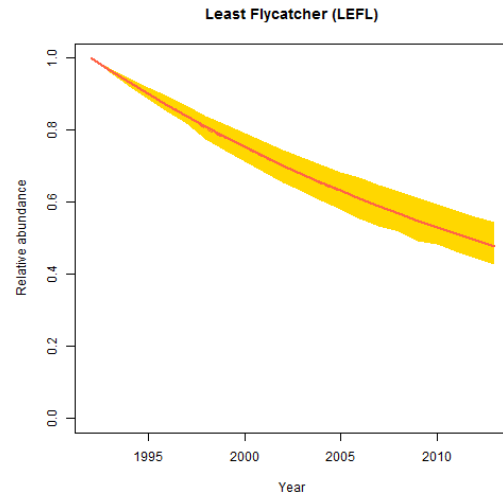


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

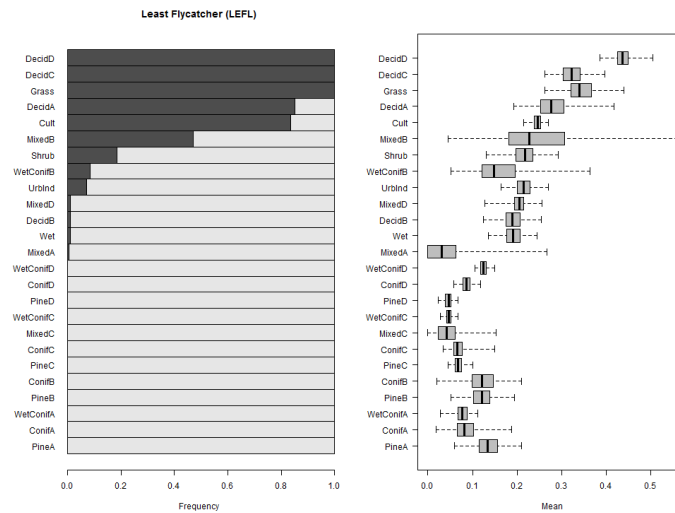


5.36.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



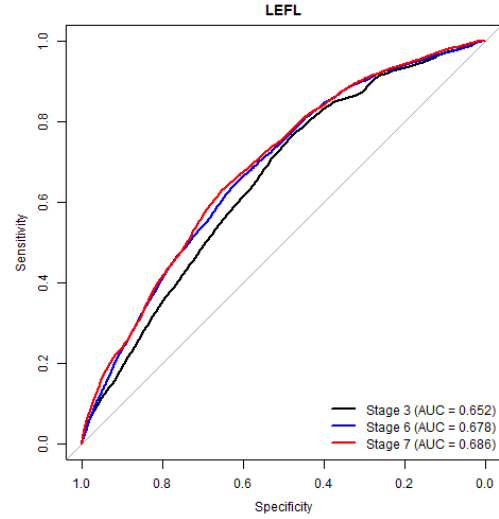
5.36.5 Habitat suitability ranking for patch delineation



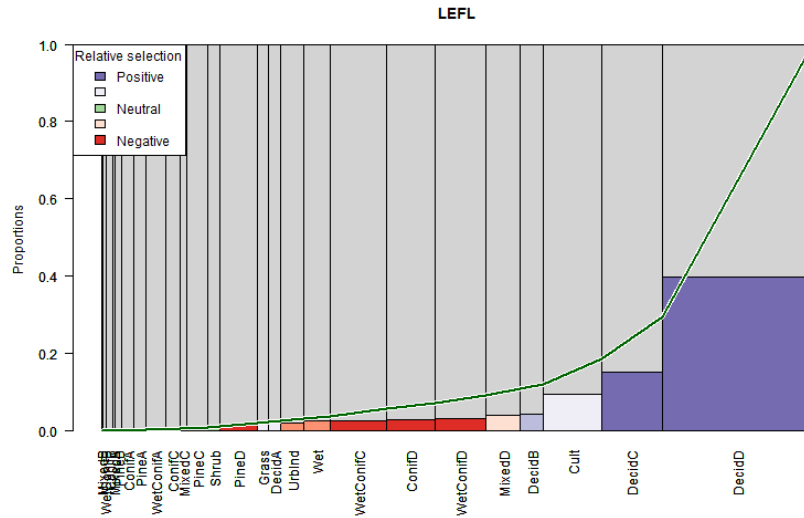
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.36.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

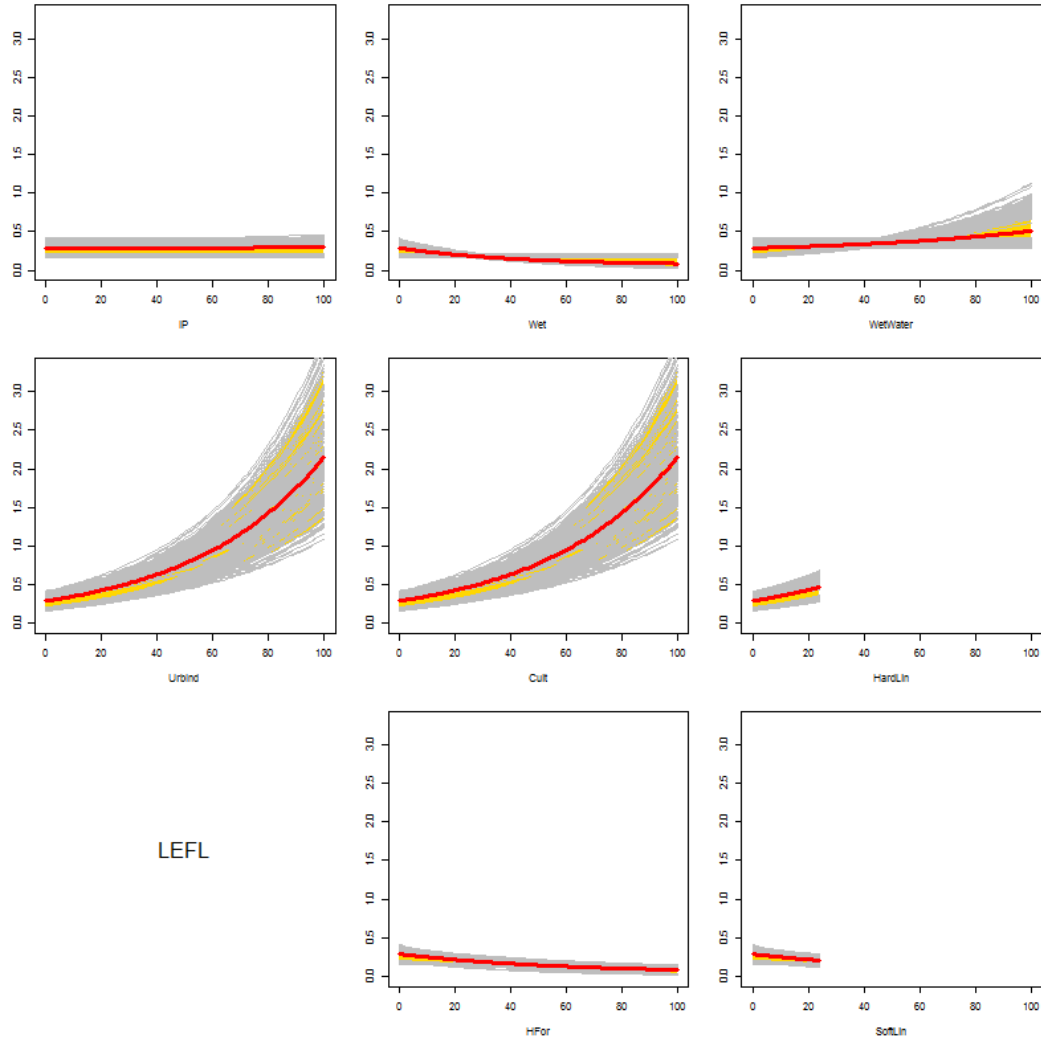


5.36.7 Relative habitat selection



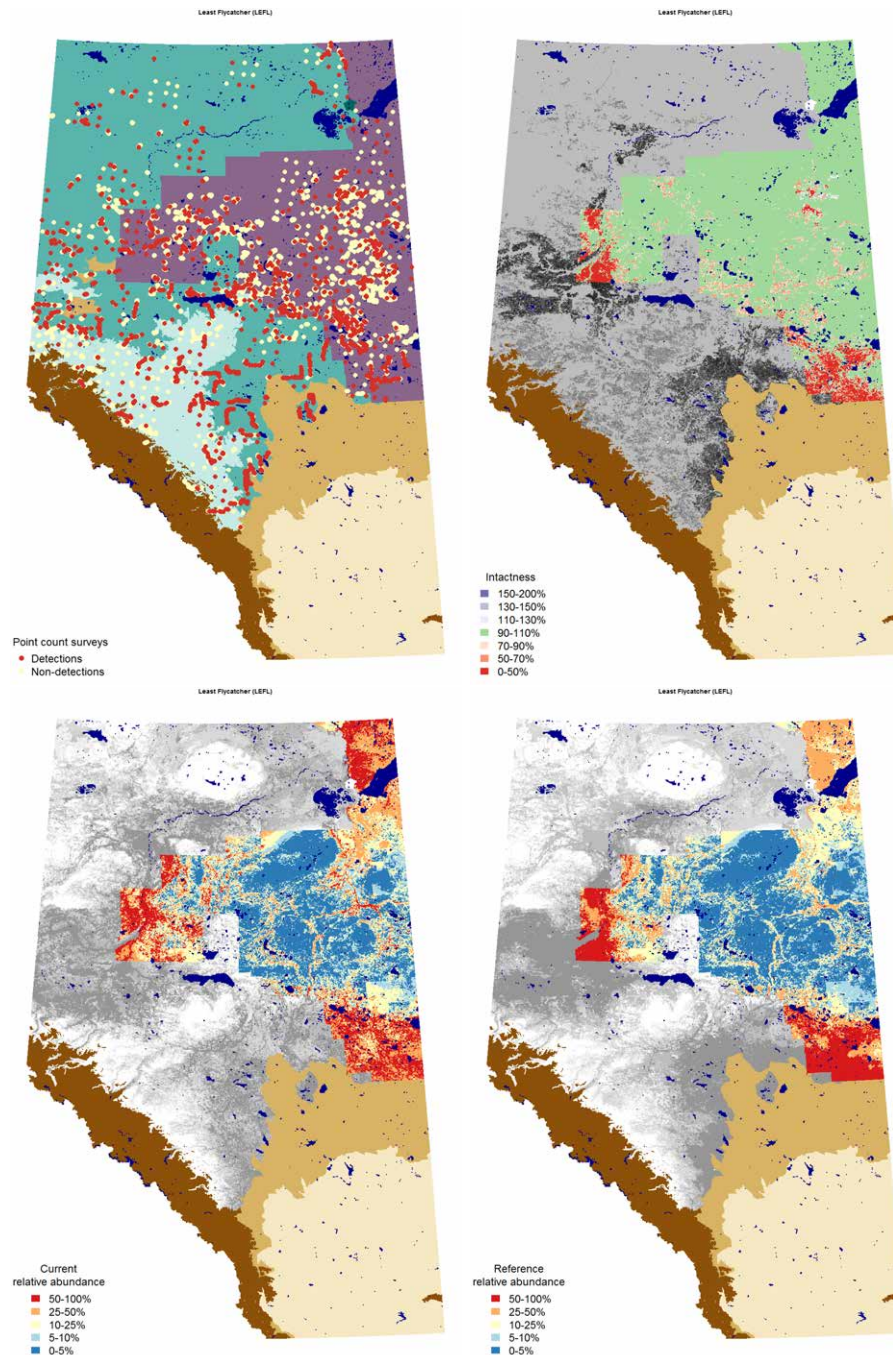
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.36.8 Quarter-section level responses



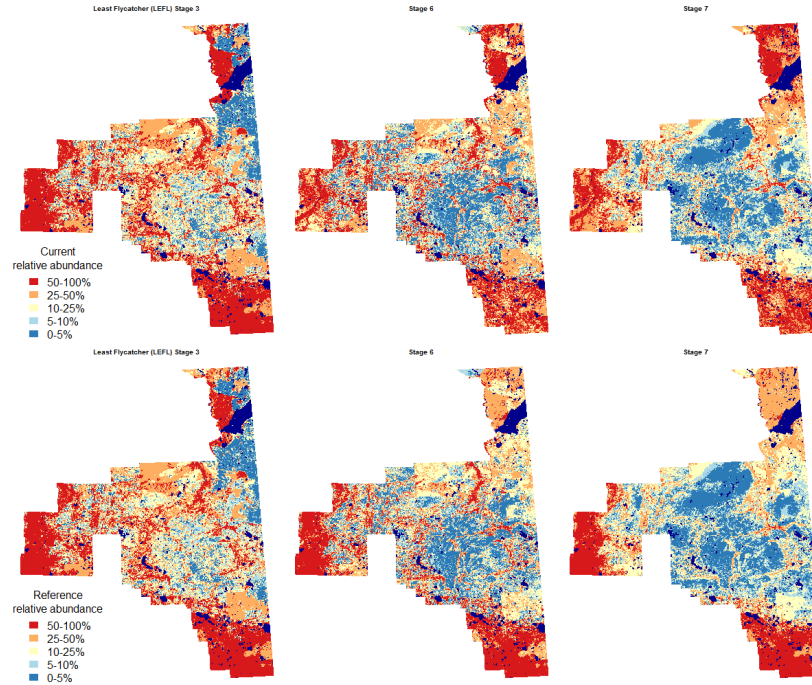
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.36.9 Maps



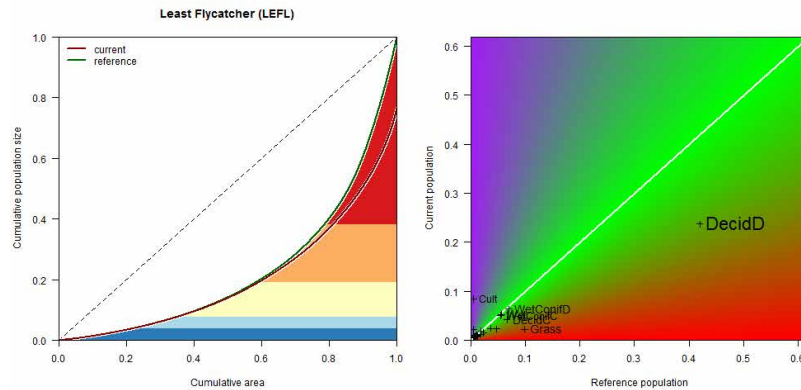
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.36.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.36.11 Population concentration



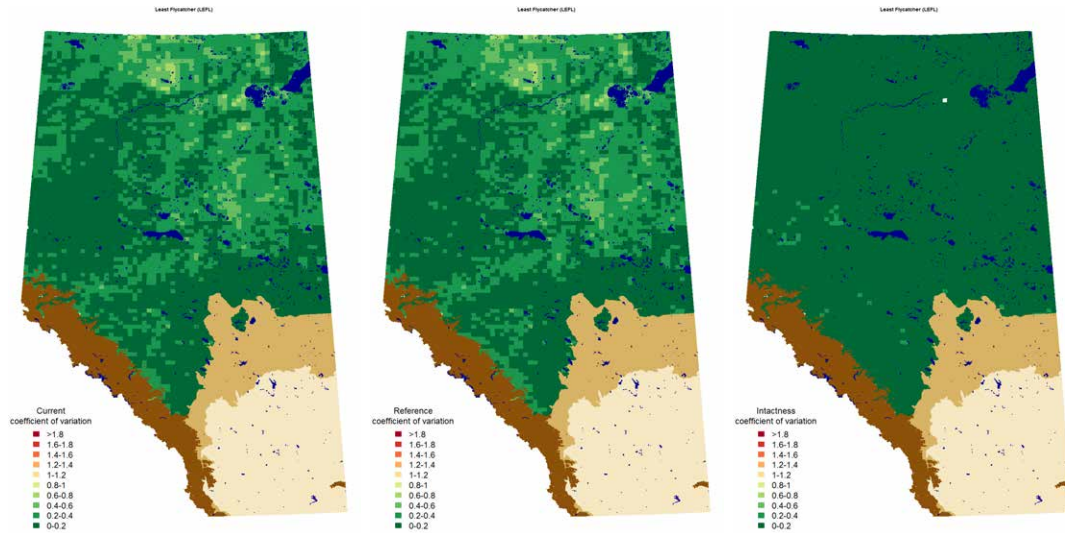
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.36.12 Potential population size

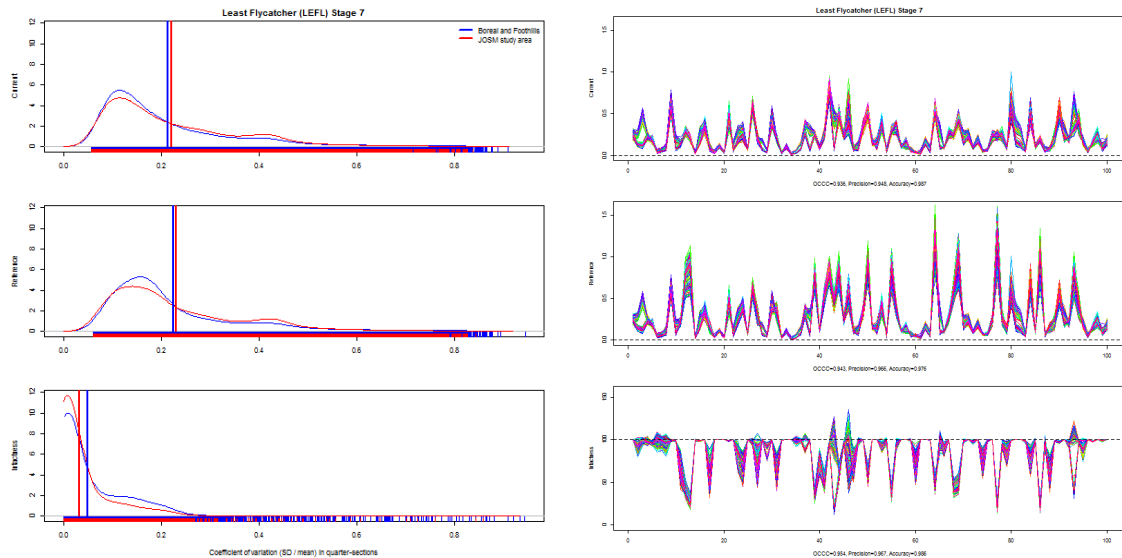
Estimated potential population size of Least Flycatcher in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.7893	0.7058	0.9012	1.3751	1.2420	1.5254
Grass	0.0759	0.0679	0.0867	0.3226	0.2913	0.3578
WetConifD	0.2117	0.1893	0.2417	0.2288	0.2067	0.2538
DecidC	0.1392	0.1245	0.1589	0.2180	0.1969	0.2419
Wet	0.1768	0.1581	0.2019	0.1841	0.1663	0.2042
WetConifC	0.1670	0.1493	0.1907	0.1794	0.1621	0.1991
Shrub	0.0770	0.0688	0.0879	0.1559	0.1408	0.1729
MixedD	0.0816	0.0730	0.0932	0.1219	0.1101	0.1352
DecidB	0.0509	0.0455	0.0581	0.0753	0.0680	0.0835
PineB	0.0639	0.0572	0.0730	0.0637	0.0575	0.0707
ConifD	0.0410	0.0367	0.0469	0.0617	0.0557	0.0684
ConifC	0.0298	0.0267	0.0340	0.0405	0.0365	0.0449
WetConifB	0.0375	0.0335	0.0428	0.0386	0.0349	0.0428
PineC	0.0314	0.0281	0.0359	0.0384	0.0346	0.0425
WetConifA	0.0308	0.0276	0.0352	0.0320	0.0289	0.0355
PineD	0.0255	0.0228	0.0291	0.0314	0.0283	0.0348
ConifA	0.0223	0.0199	0.0254	0.0249	0.0225	0.0277
DecidA	0.0117	0.0105	0.0134	0.0240	0.0216	0.0266
PineA	0.0223	0.0199	0.0255	0.0226	0.0204	0.0250
ConifB	0.0187	0.0168	0.0214	0.0206	0.0186	0.0228
MixedB	0.0056	0.0050	0.0064	0.0066	0.0059	0.0073
MixedC	0.0042	0.0038	0.0048	0.0059	0.0054	0.0066
MixedA	0.0039	0.0035	0.0045	0.0057	0.0051	0.0063
Cult	0.2797	0.2502	0.3194	0.0000	0.0000	0.0000
UrbInd	0.0322	0.0288	0.0368	0.0000	0.0000	0.0000
HardLin	0.0079	0.0071	0.0090	0.0000	0.0000	0.0000
SoftLin	0.0165	0.0148	0.0189	0.0000	0.0000	0.0000
HFor	0.0751	0.0671	0.0857	0.0000	0.0000	0.0000
Total	2.5296	2.2620	2.8883	3.2775	2.9602	3.6357
Loss	0.7577	0.4614	0.9547			
Gain	0.0041	0.0021	0.0105			

5.36.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.36.14 Variable selection frequencies

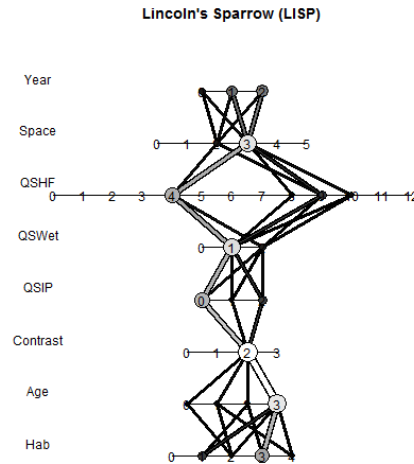
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	49.5	99	. + Habitat
1.2	0.5	1	. + HabitatB
1.3	50.0	100	. + Habitat + isHForC
2.0	69.5	139	NULL
2.1	0.5	1	. + Age
2.2	30.0	60	. + Age + Age2
3.1	34.0	68	. + ROAD
3.3	66.0	132	. + ROAD + SoftLin_PC
4.0	97.0	194	NULL
4.1	3.0	6	. + Remn_QS
5.1	65.5	131	. + pWet_QS
5.2	34.5	69	. + pWetWater_QS
6.9	76.0	152	. + Succ_QS + Alien_QS + Alien2_QS
6.11	24.0	48	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.5	100.0	200	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	97.0	194	. + xYEAR
8.2	3.0	6	. + YR5F

5.37 Lincoln's Sparrow (*Melospiza lincolni*)

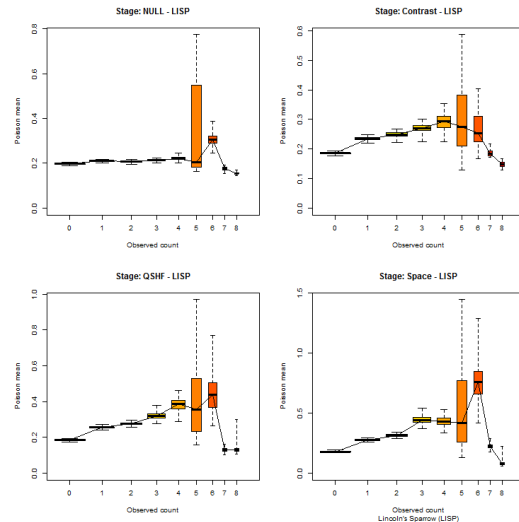
5.37.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

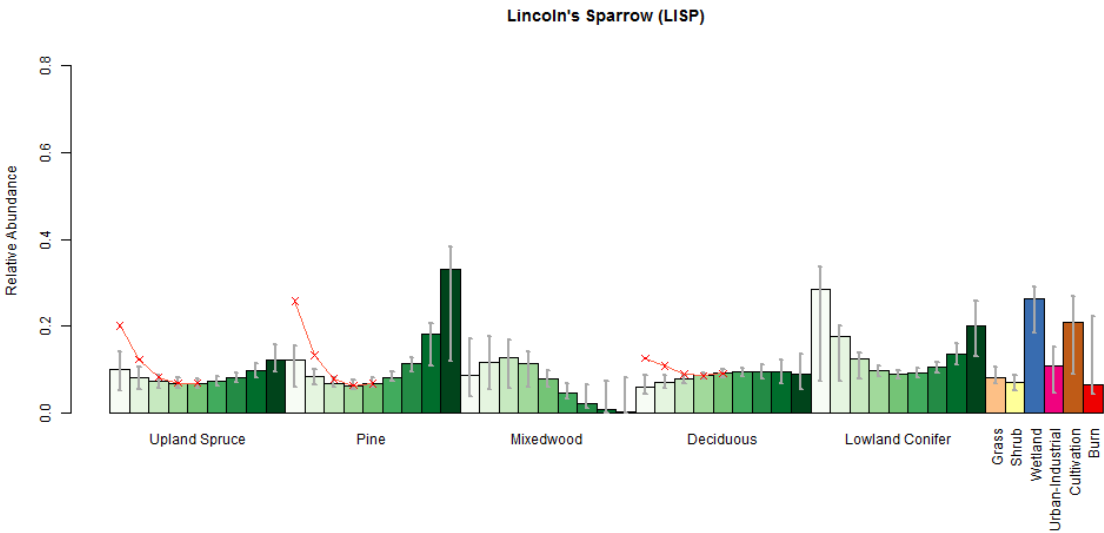


5.37.2 Cross validation

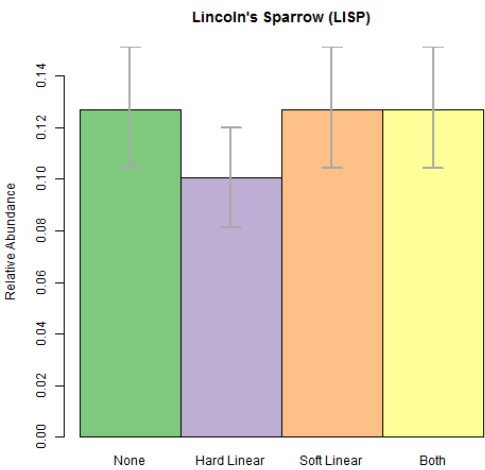
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.37.3 Point level habitat associations

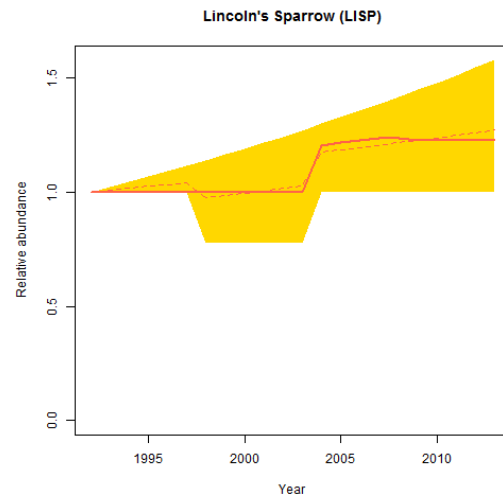


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

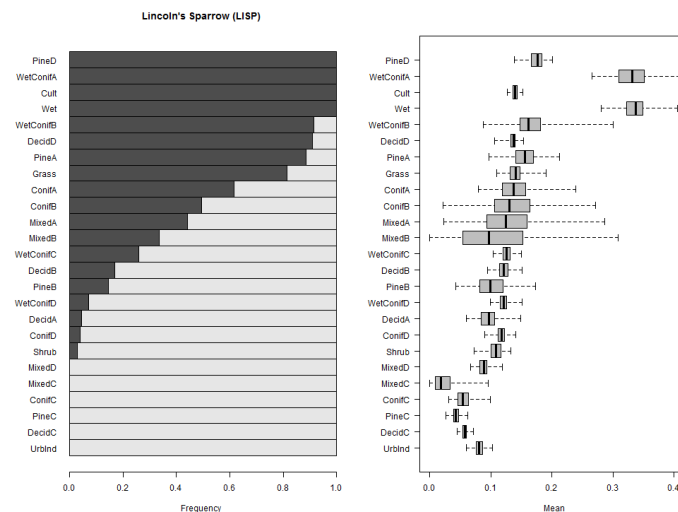


5.37.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



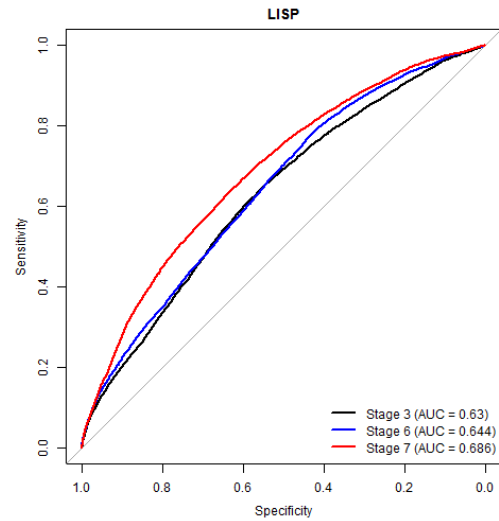
5.37.5 Habitat suitability ranking for patch delineation



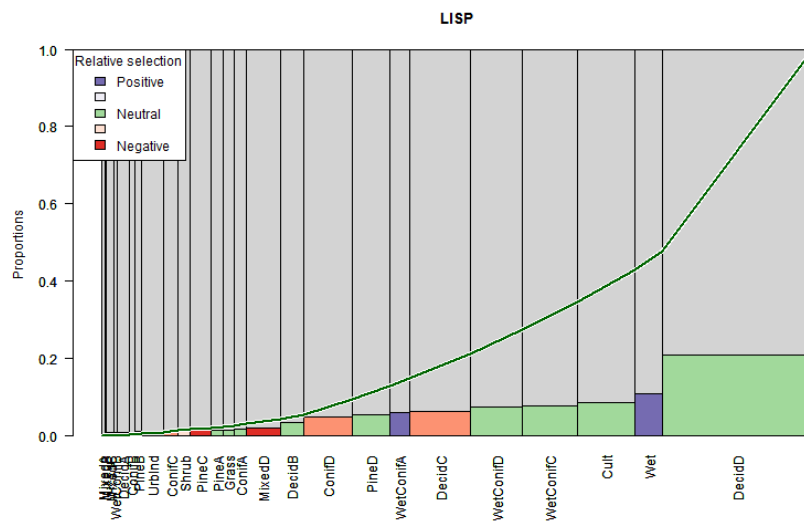
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.37.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

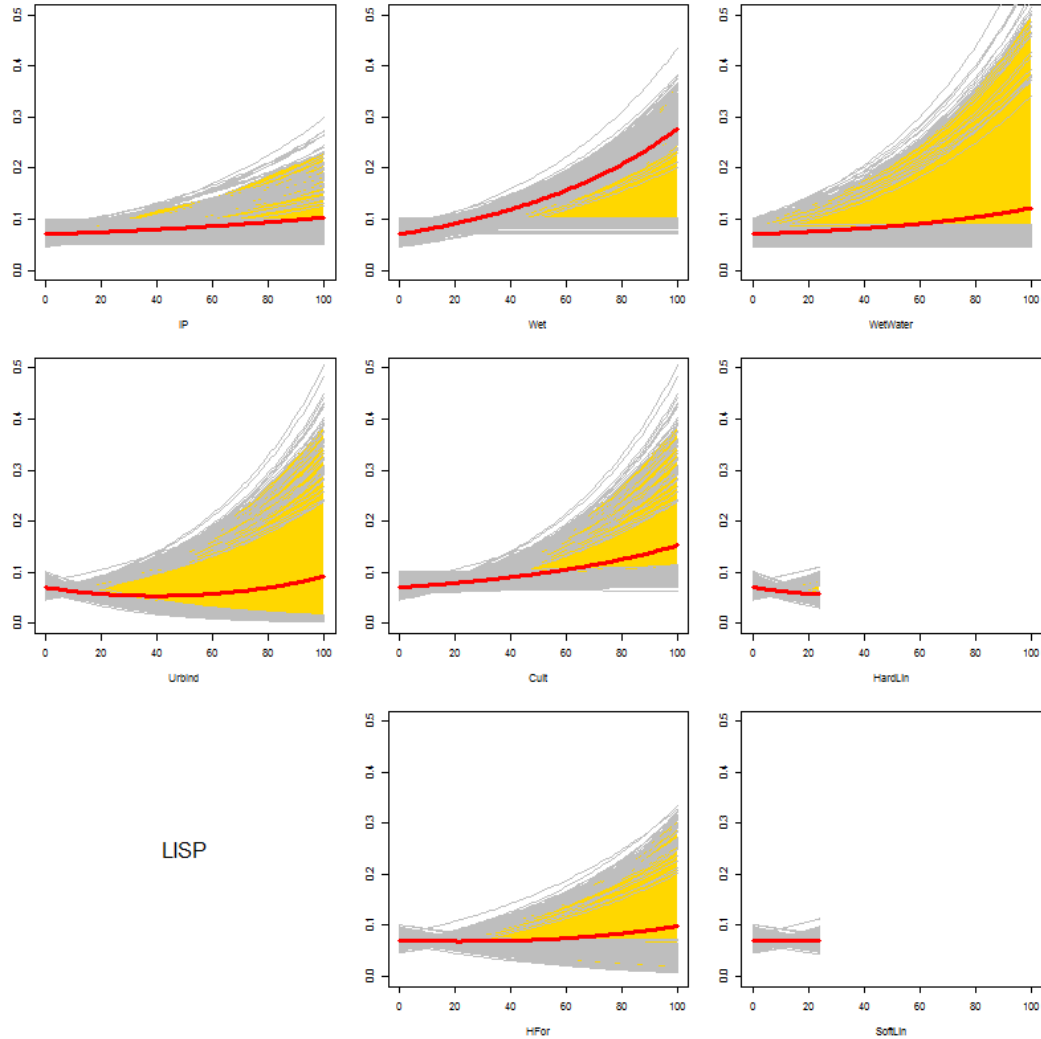


5.37.7 Relative habitat selection



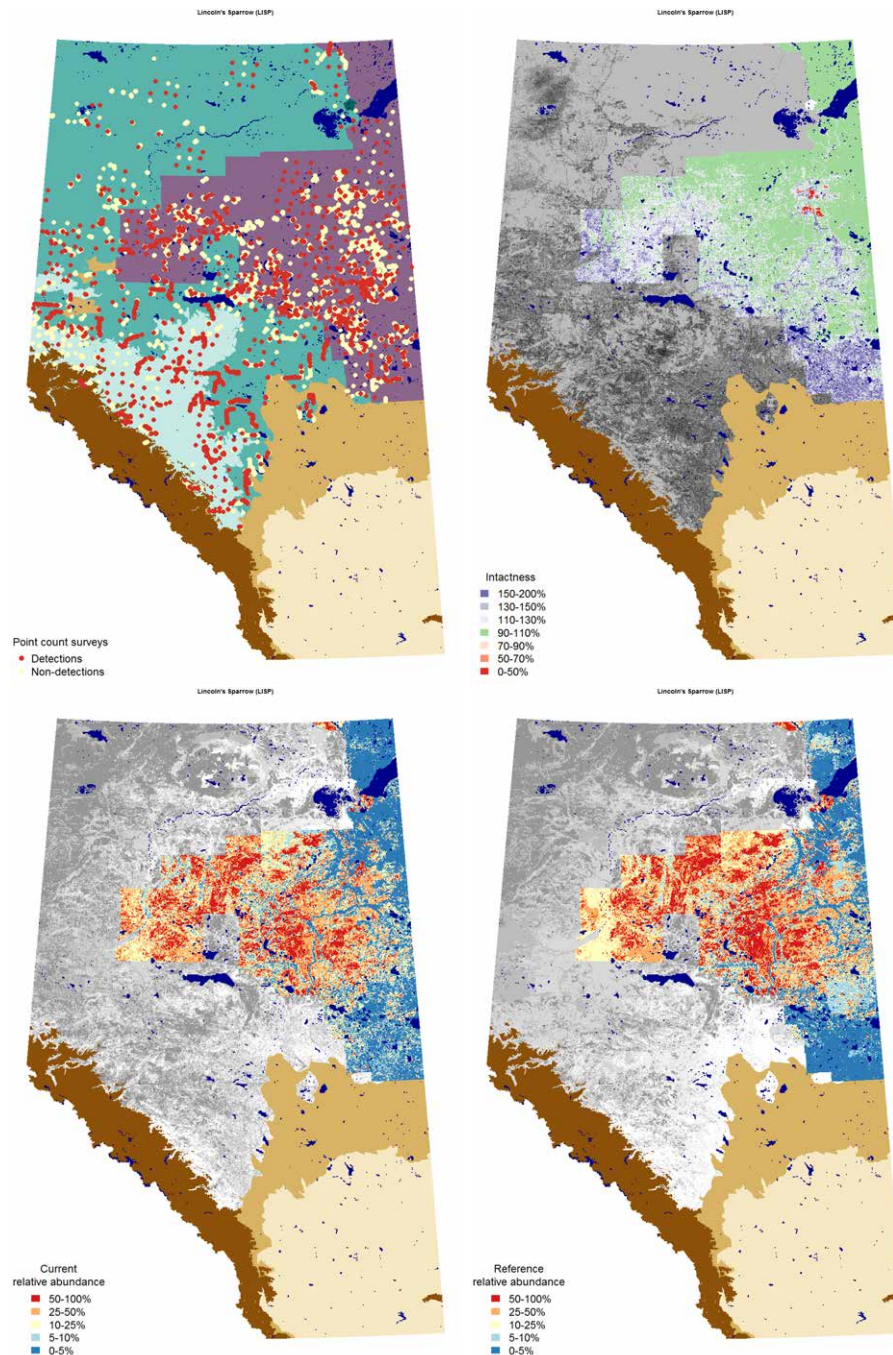
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.37.8 Quarter-section level responses



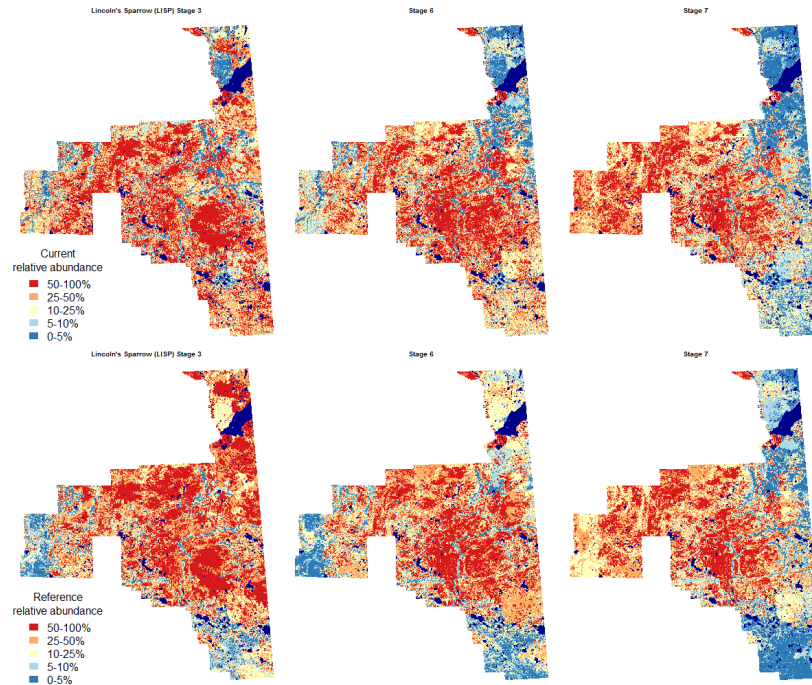
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.37.9 Maps



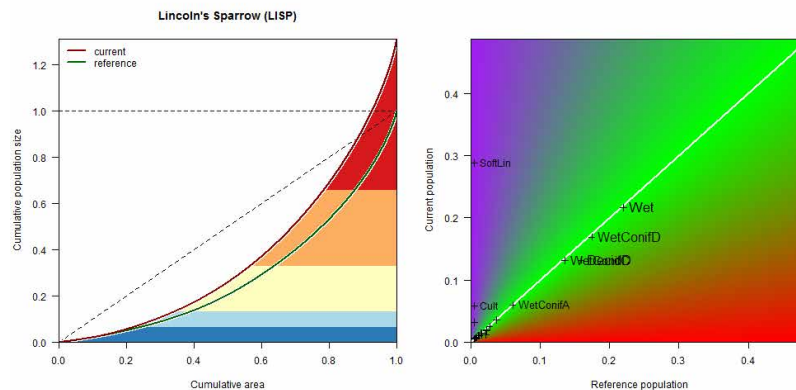
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.37.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.37.11 Population concentration



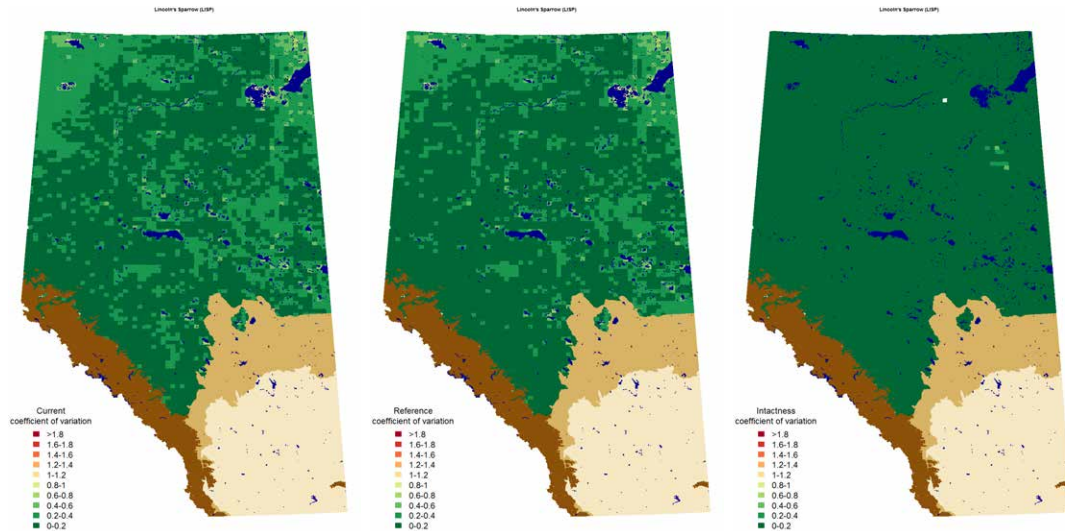
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.37.12 Potential population size

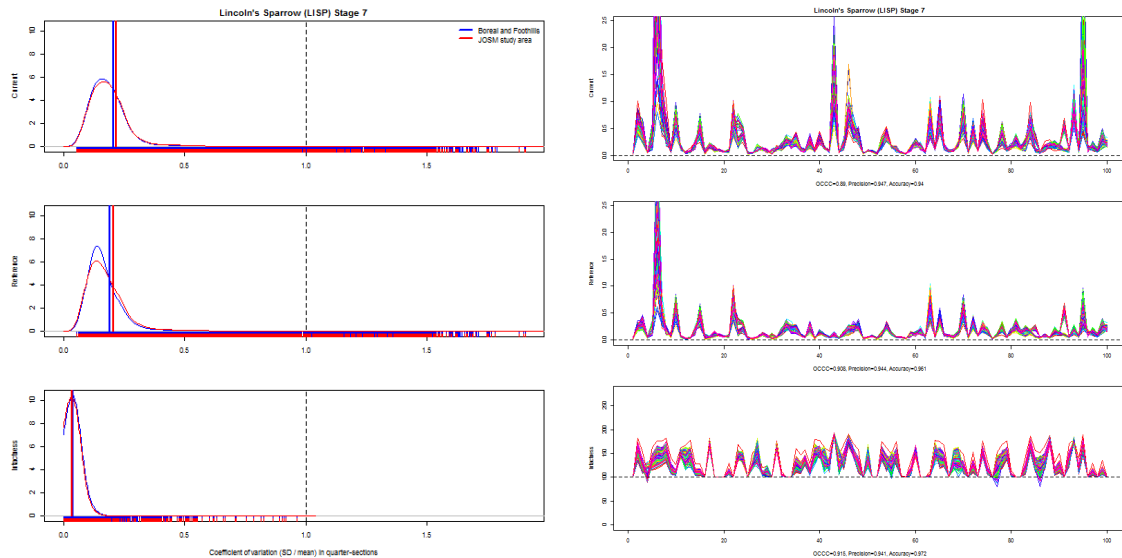
Estimated potential population size of Lincoln's Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.3612	0.2808	0.4024	0.3659	0.2893	0.3973
WetConifD	0.2819	0.2191	0.3140	0.2899	0.2292	0.3147
DecidD	0.2202	0.1712	0.2453	0.2643	0.2090	0.2870
WetConifC	0.2187	0.1700	0.2436	0.2257	0.1785	0.2451
WetConifA	0.0996	0.0774	0.1109	0.1008	0.0797	0.1094
WetConifB	0.0602	0.0468	0.0670	0.0624	0.0494	0.0678
ConifD	0.0415	0.0323	0.0463	0.0454	0.0359	0.0493
Shrub	0.0310	0.0241	0.0345	0.0388	0.0307	0.0421
MixedD	0.0338	0.0263	0.0377	0.0375	0.0297	0.0408
Grass	0.0201	0.0157	0.0224	0.0358	0.0283	0.0389
ConifC	0.0247	0.0192	0.0275	0.0273	0.0216	0.0297
DecidC	0.0207	0.0161	0.0231	0.0260	0.0206	0.0282
PineC	0.0241	0.0187	0.0268	0.0254	0.0201	0.0275
PineB	0.0242	0.0188	0.0269	0.0244	0.0193	0.0265
ConifA	0.0184	0.0143	0.0205	0.0215	0.0170	0.0233
PineD	0.0181	0.0141	0.0202	0.0194	0.0154	0.0211
DecidB	0.0123	0.0096	0.0137	0.0153	0.0121	0.0166
PineA	0.0130	0.0101	0.0145	0.0134	0.0106	0.0145
ConifB	0.0082	0.0064	0.0092	0.0102	0.0081	0.0111
DecidA	0.0031	0.0024	0.0034	0.0041	0.0032	0.0044
MixedB	0.0027	0.0021	0.0030	0.0030	0.0024	0.0033
MixedA	0.0021	0.0016	0.0023	0.0027	0.0021	0.0029
MixedC	0.0023	0.0018	0.0026	0.0027	0.0021	0.0029
Cult	0.0973	0.0756	0.1084	0.0000	0.0000	0.0000
UrbInd	0.0101	0.0079	0.0113	0.0000	0.0000	0.0000
HardLin	0.0020	0.0015	0.0022	0.0000	0.0000	0.0000
SoftLin	0.4795	0.3728	0.5342	0.0000	0.0000	0.0000
HFor	0.0534	0.0415	0.0595	0.0000	0.0000	0.0000
Total	2.1844	1.6982	2.4334	1.6619	1.3141	1.8044
Loss	0.0044	0.0025	0.0058			
Gain	0.5091	0.3089	0.7415			

5.37.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.37.14 Variable selection frequencies

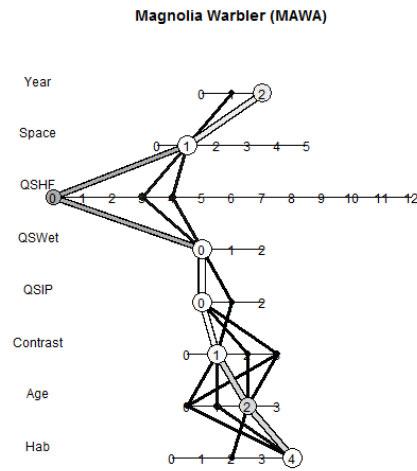
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	24.5	49	. + Habitat
1.2	4.5	9	. + HabitatB
1.3	65.0	130	. + Habitat + isHForC
1.4	6.0	12	. + HabitatB + isHForC
2.0	0.5	1	NULL
2.1	6.5	13	. + Age
2.2	2.0	4	. + Age + Age2
			. + Age + Age2 + Age:isMix + Age:isPine
2.3	91.0	182	+ Age:isUplConif + Age:isWetConif +
			Age2:isMix + Age2:isPine + Age2:isUplConif
			+ Age2:isWetConif
3.2	100.0	200	. + SoftLin_PC
4.0	71.5	143	NULL
4.1	3.5	7	. + Remn_QS
4.2	25.0	50	. + Remn_QS + Remn2_QS
5.1	87.0	174	. + pWet_QS
5.2	13.0	26	. + pWetWater_QS
6.4	69.0	138	. + Succ_QS + Noncult_QS + Cult_QS
6.8	1.0	2	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	24.5	49	. + Succ_QS + Alien_QS + Alien2_QS
6.10	5.5	11	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
7.2	10.5	21	. + xlat + xlong
7.3	89.5	179	. + xlat + xlong + xlat:xlong
8.0	9.5	19	NULL
8.1	44.0	88	. + xYEAR
8.2	46.5	93	. + YR5F

5.38 Magnolia Warbler (*Setophaga magnolia*)

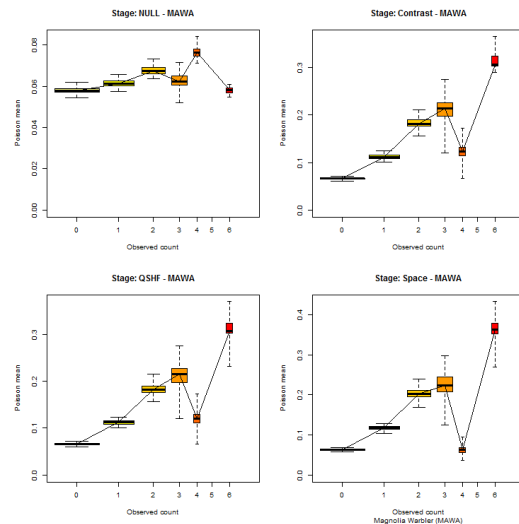
5.38.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

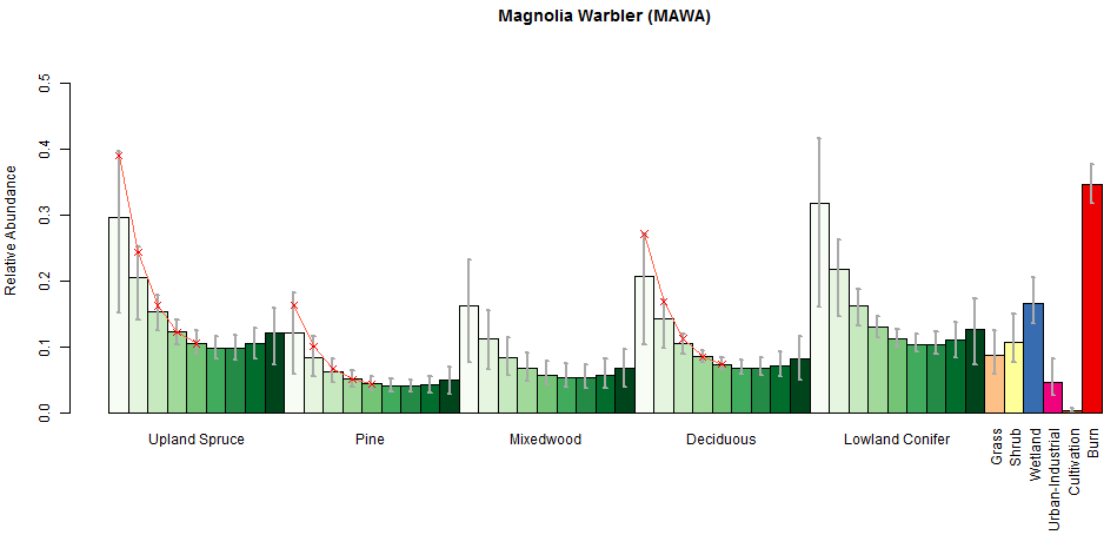


5.38.2 Cross validation

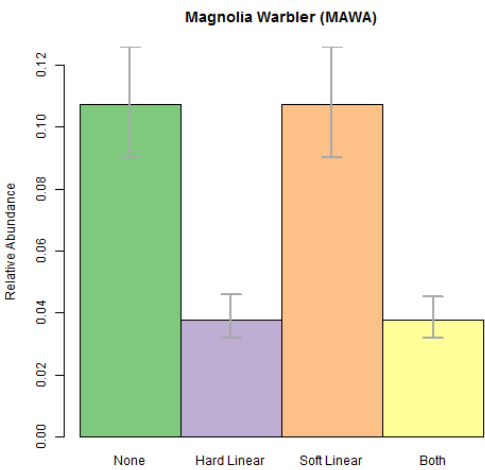
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.38.3 Point level habitat associations

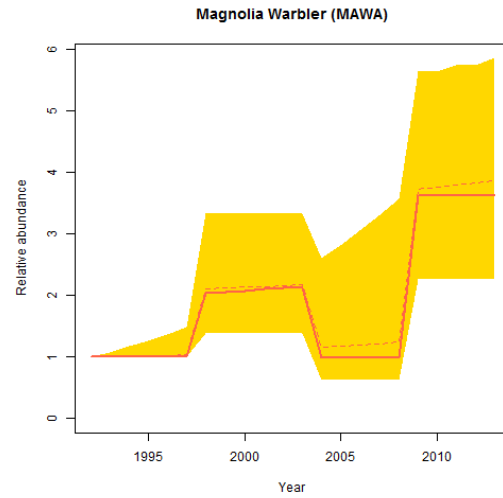


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

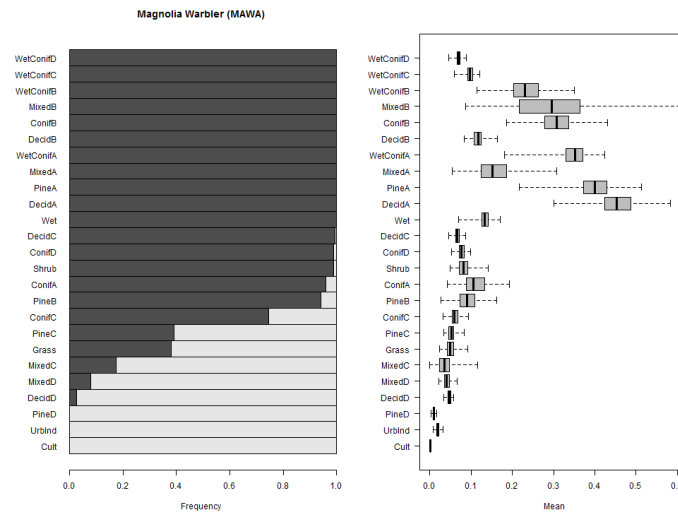


5.38.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



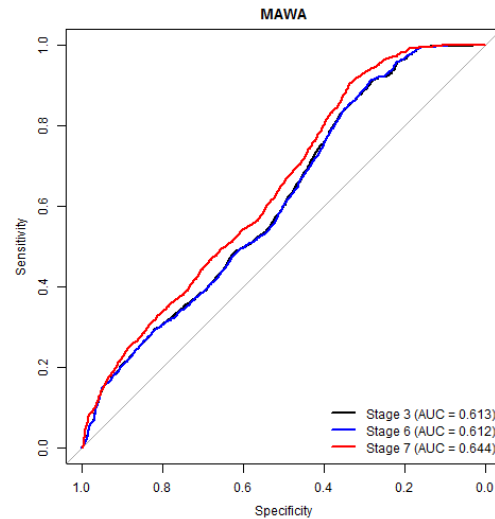
5.38.5 Habitat suitability ranking for patch delineation



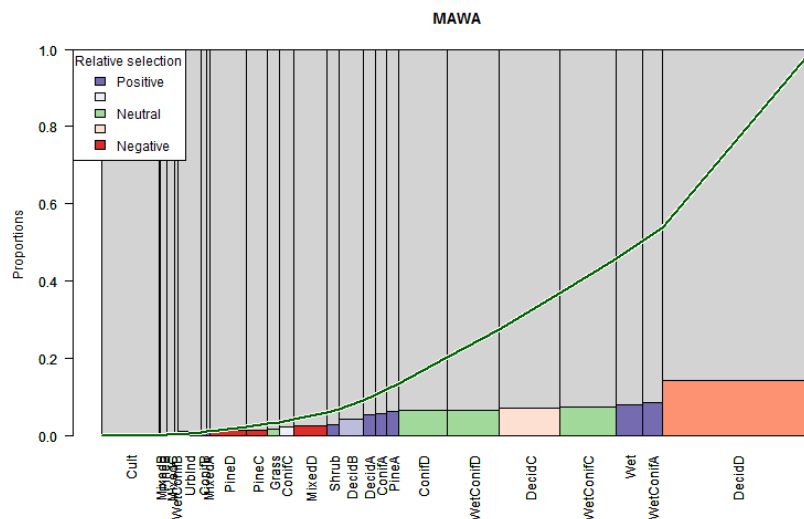
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.38.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

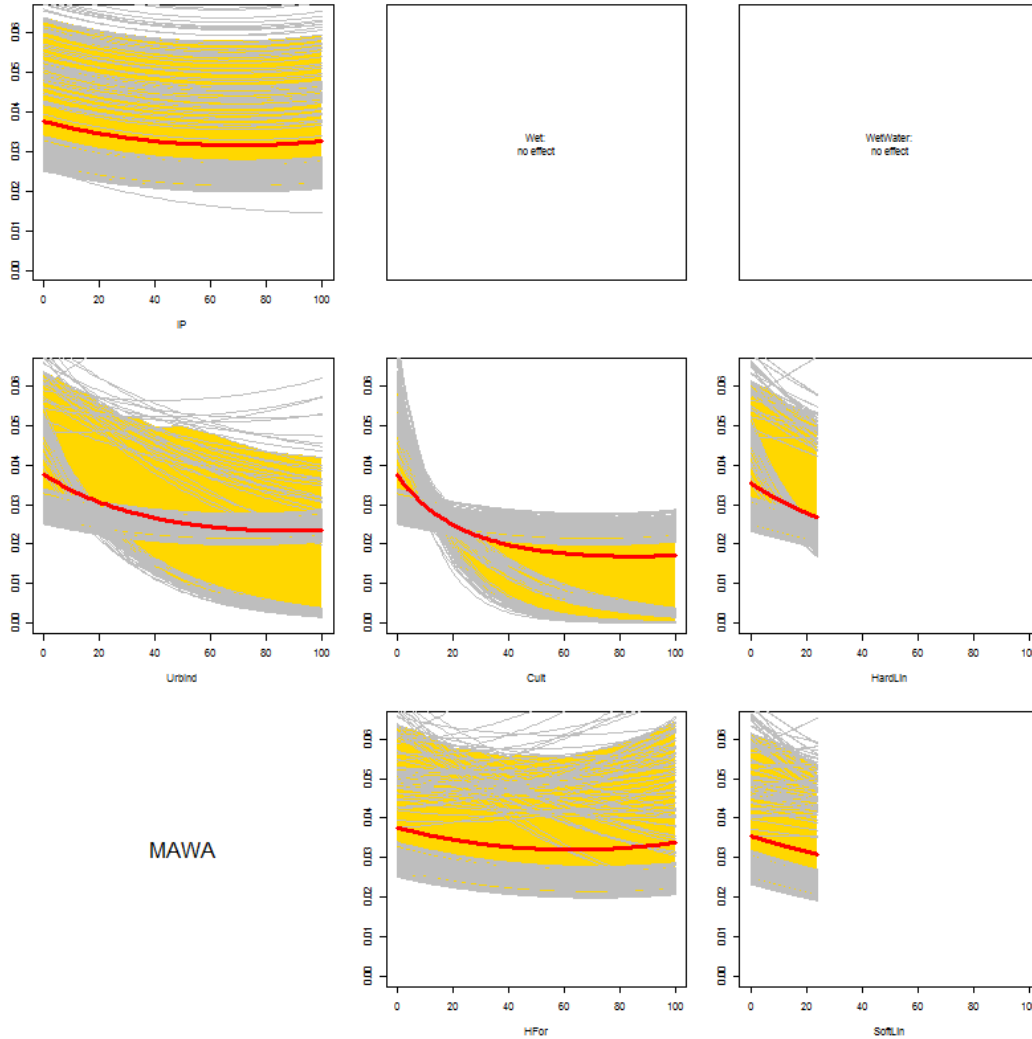


5.38.7 Relative habitat selection



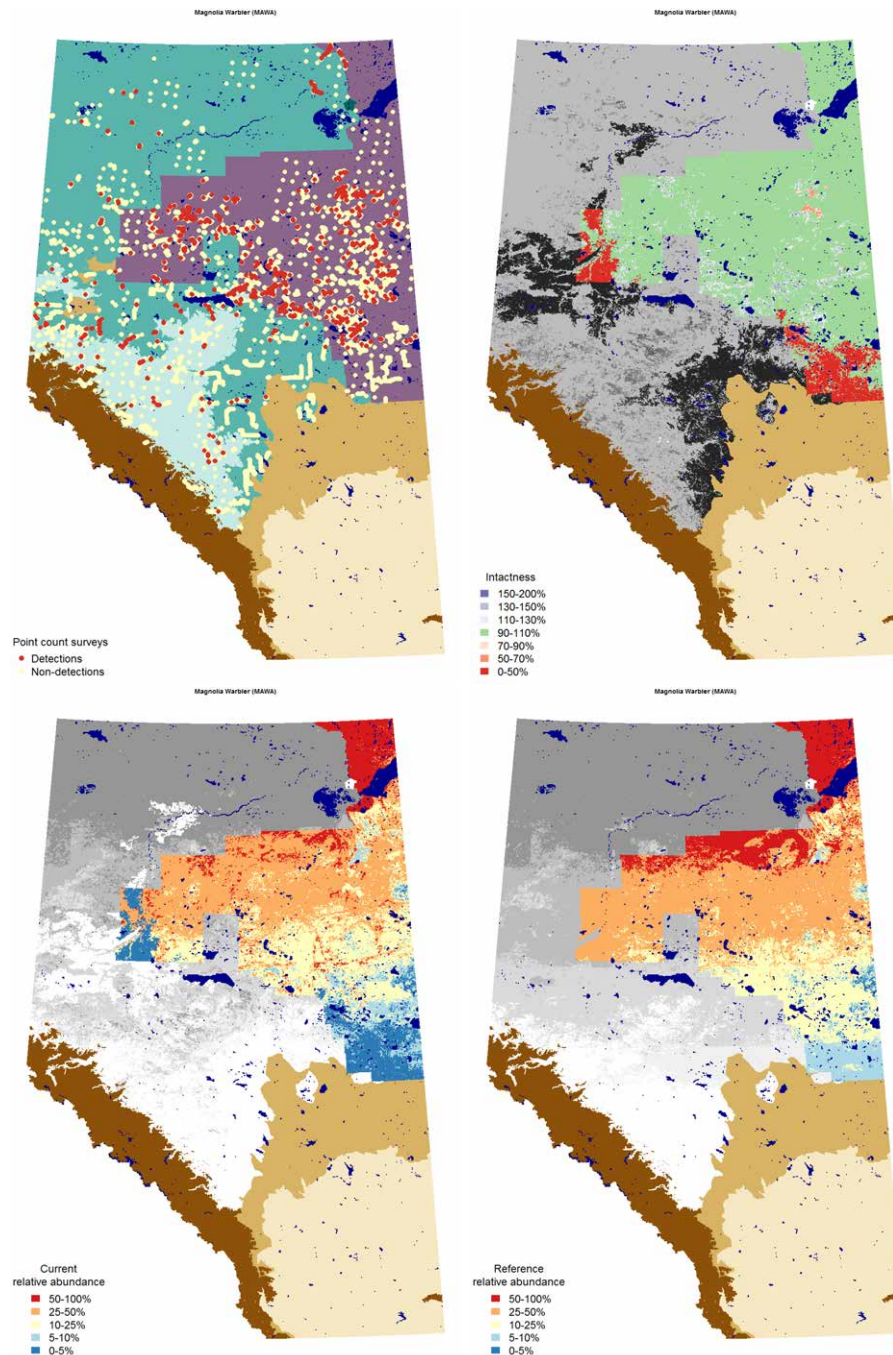
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.38.8 Quarter-section level responses



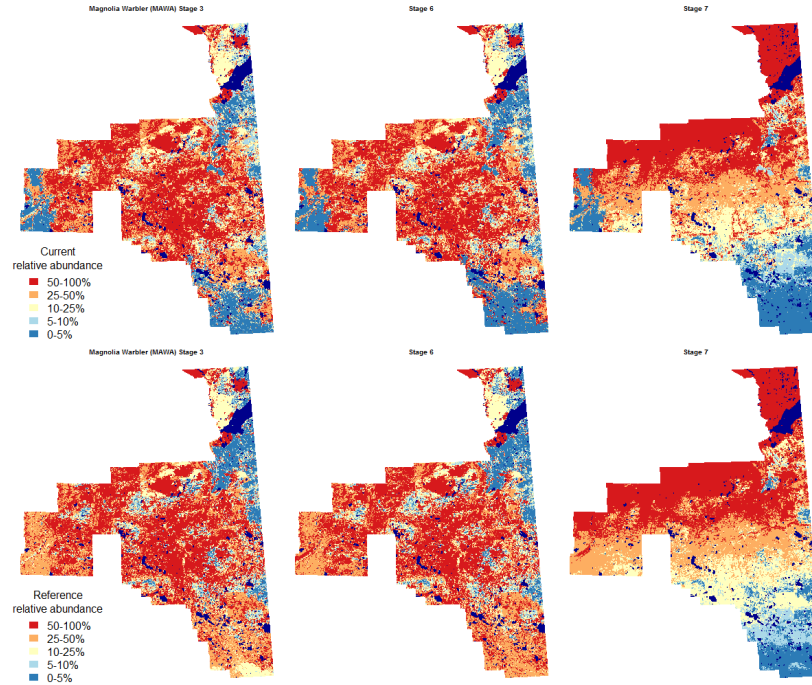
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.38.9 Maps



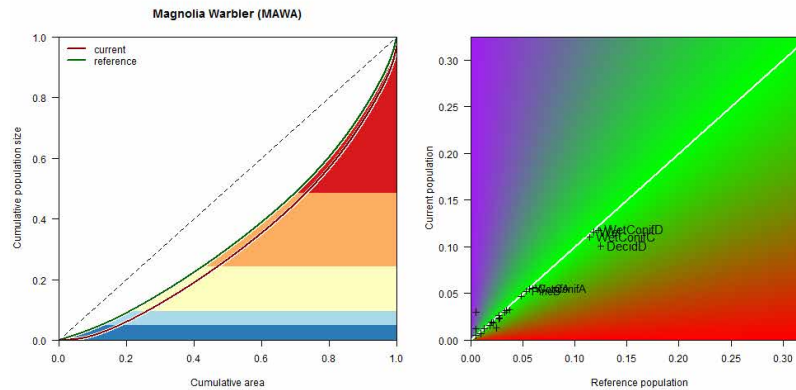
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on "Space" stage of the variable selection procedure (no year effect).

5.38.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.38.11 Population concentration



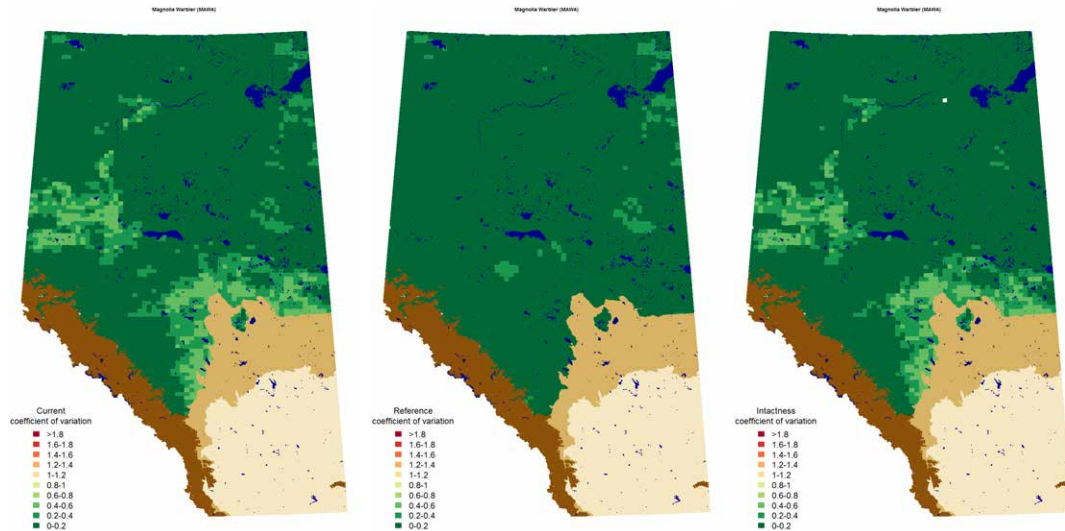
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.38.12 Potential population size

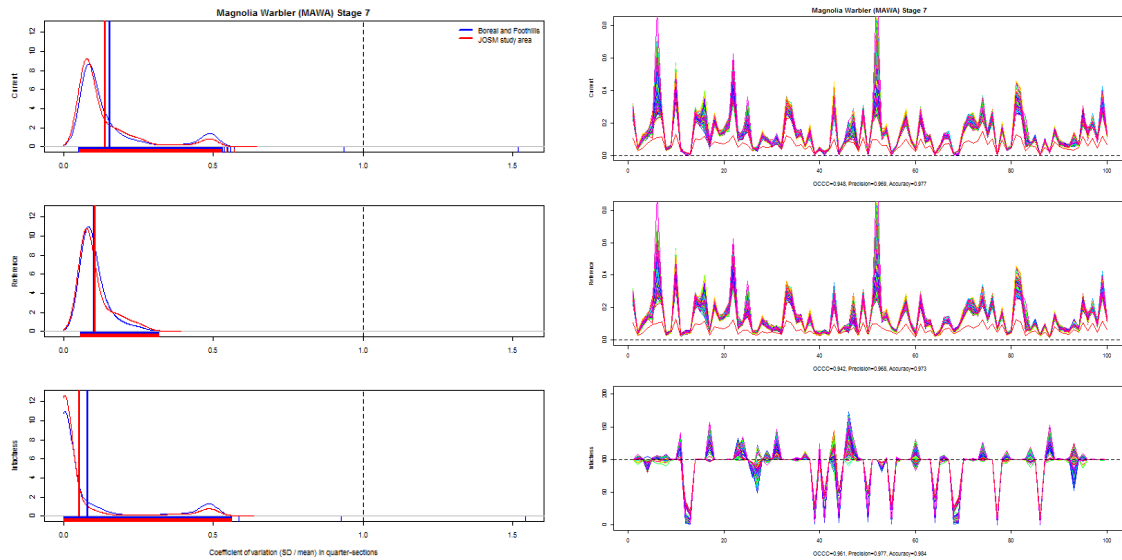
Estimated potential population size of Magnolia Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.2259	0.1915	0.2506	0.2793	0.2390	0.3107
WetConifD	0.2643	0.2241	0.2932	0.2749	0.2352	0.3057
Wet	0.2597	0.2202	0.2881	0.2646	0.2264	0.2943
WetConifC	0.2470	0.2094	0.2740	0.2564	0.2194	0.2852
ConifA	0.1241	0.1052	0.1377	0.1336	0.1144	0.1486
WetConifA	0.1235	0.1047	0.1370	0.1265	0.1083	0.1407
PineB	0.1179	0.1000	0.1308	0.1185	0.1014	0.1318
WetConifB	0.1058	0.0897	0.1173	0.1084	0.0928	0.1206
ConifD	0.0727	0.0616	0.0806	0.0832	0.0712	0.0925
ConifB	0.0717	0.0608	0.0795	0.0767	0.0657	0.0854
ConifC	0.0669	0.0567	0.0742	0.0738	0.0632	0.0821
DecidC	0.0529	0.0448	0.0587	0.0620	0.0530	0.0689
PineA	0.0599	0.0508	0.0665	0.0609	0.0521	0.0677
Shrub	0.0518	0.0439	0.0575	0.0607	0.0519	0.0675
Grass	0.0302	0.0256	0.0335	0.0549	0.0470	0.0610
DecidB	0.0414	0.0351	0.0459	0.0488	0.0418	0.0543
PineC	0.0430	0.0364	0.0477	0.0450	0.0385	0.0500
MixedD	0.0360	0.0305	0.0399	0.0410	0.0351	0.0457
PineD	0.0280	0.0237	0.0311	0.0296	0.0254	0.0330
DecidA	0.0155	0.0131	0.0172	0.0218	0.0186	0.0242
MixedB	0.0062	0.0053	0.0069	0.0067	0.0058	0.0075
MixedA	0.0051	0.0043	0.0056	0.0065	0.0056	0.0073
MixedC	0.0030	0.0025	0.0033	0.0033	0.0028	0.0037
Cult	0.0037	0.0032	0.0041	0.0000	0.0000	0.0000
UrbInd	0.0090	0.0076	0.0099	0.0000	0.0000	0.0000
HardLin	0.0008	0.0007	0.0009	0.0000	0.0000	0.0000
SoftLin	0.0272	0.0230	0.0301	0.0000	0.0000	0.0000
HFor	0.0673	0.0571	0.0747	0.0000	0.0000	0.0000
Total	2.1606	1.8316	2.3965	2.2370	1.9146	2.4885
Loss	0.0897	0.0752	0.1214			
Gain	0.0138	0.0046	0.0466			

5.38.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.38.14 Variable selection frequencies

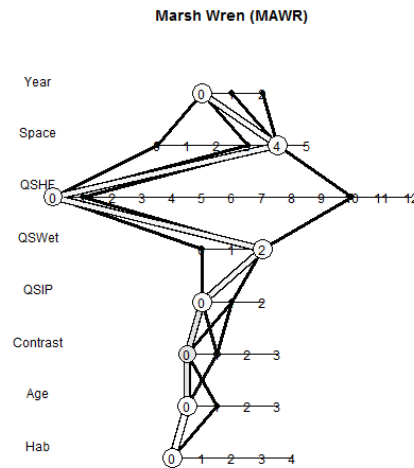
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	0.5	1	. + HabitatB
1.4	99.5	199	. + HabitatB + isHForC
2.0	5.0	10	NULL
2.1	10.0	20	. + Age
2.2	85.0	170	. + Age + Age2
3.1	97.5	195	. + ROAD
3.2	0.5	1	. + SoftLin_PC
3.3	2.0	4	. + ROAD + SoftLin_PC
4.0	99.5	199	NULL
4.1	0.5	1	. + Remn_QS
5.0	100.0	200	NULL
6.0	68.0	136	NULL
6.3	16.5	33	. + Succ_QS + Alien_QS
6.4	15.5	31	. + Succ_QS + Noncult_QS + Cult_QS
7.1	100.0	200	. + xlat
8.1	7.5	15	. + xYEAR
8.2	92.5	185	. + YR5F

5.39 Marsh Wren (*Cistothorus palustris*)

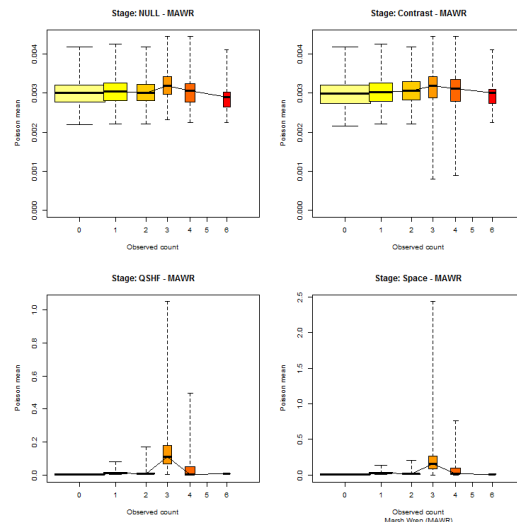
5.39.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

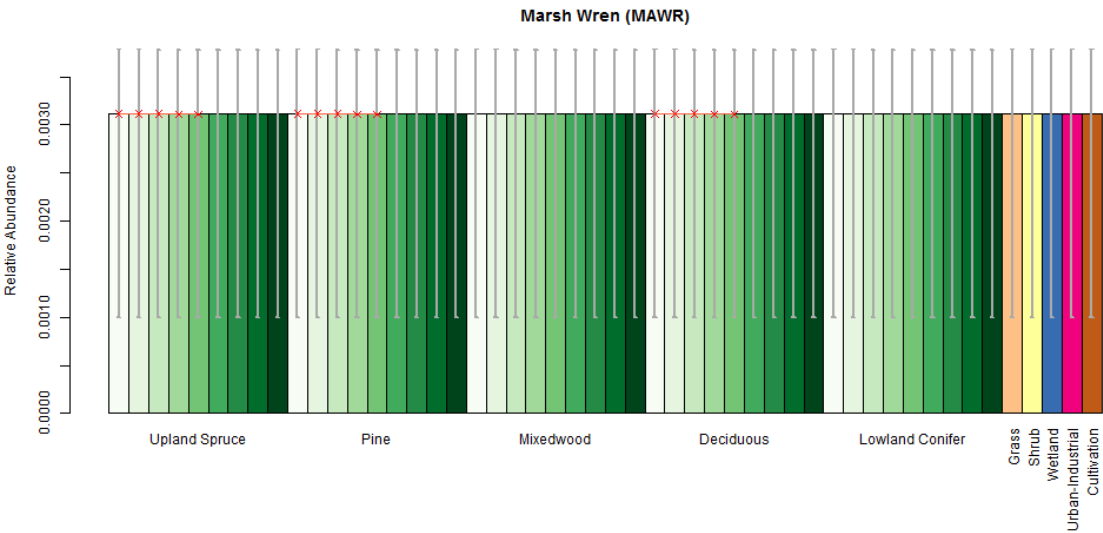


5.39.2 Cross validation

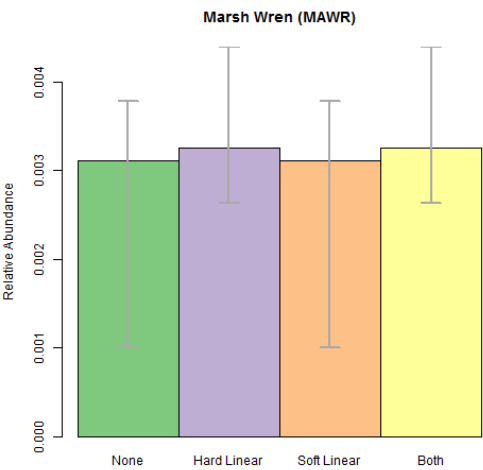
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.39.3 Point level habitat associations

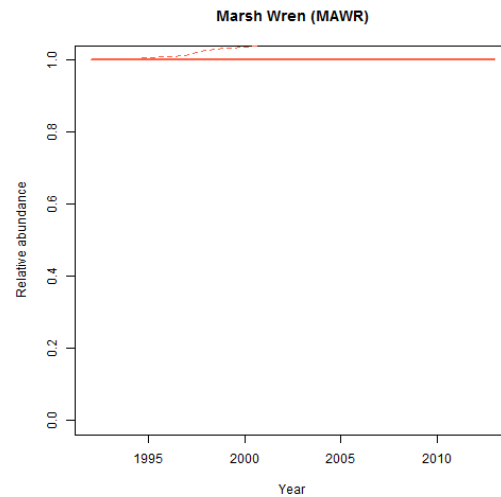


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

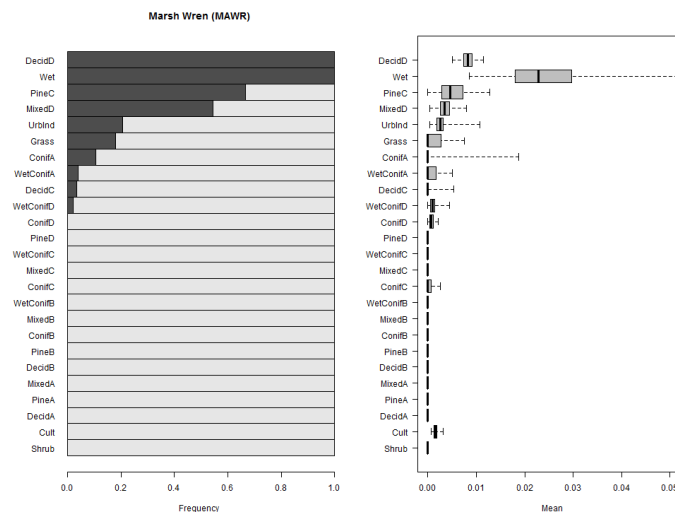


5.39.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



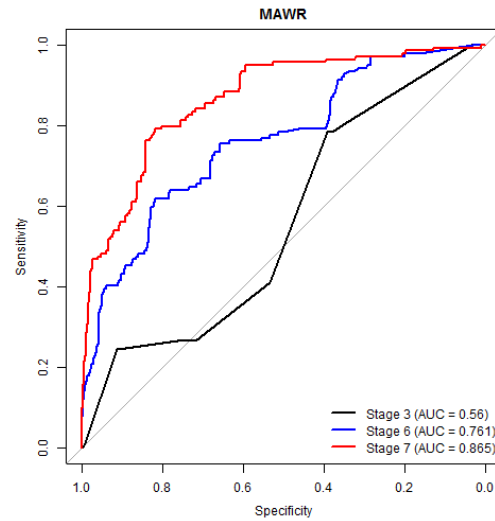
5.39.5 Habitat suitability ranking for patch delineation



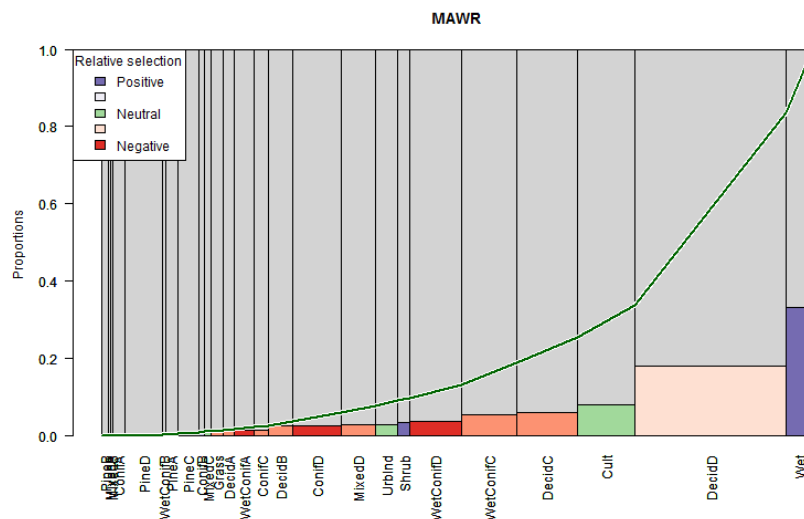
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.39.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

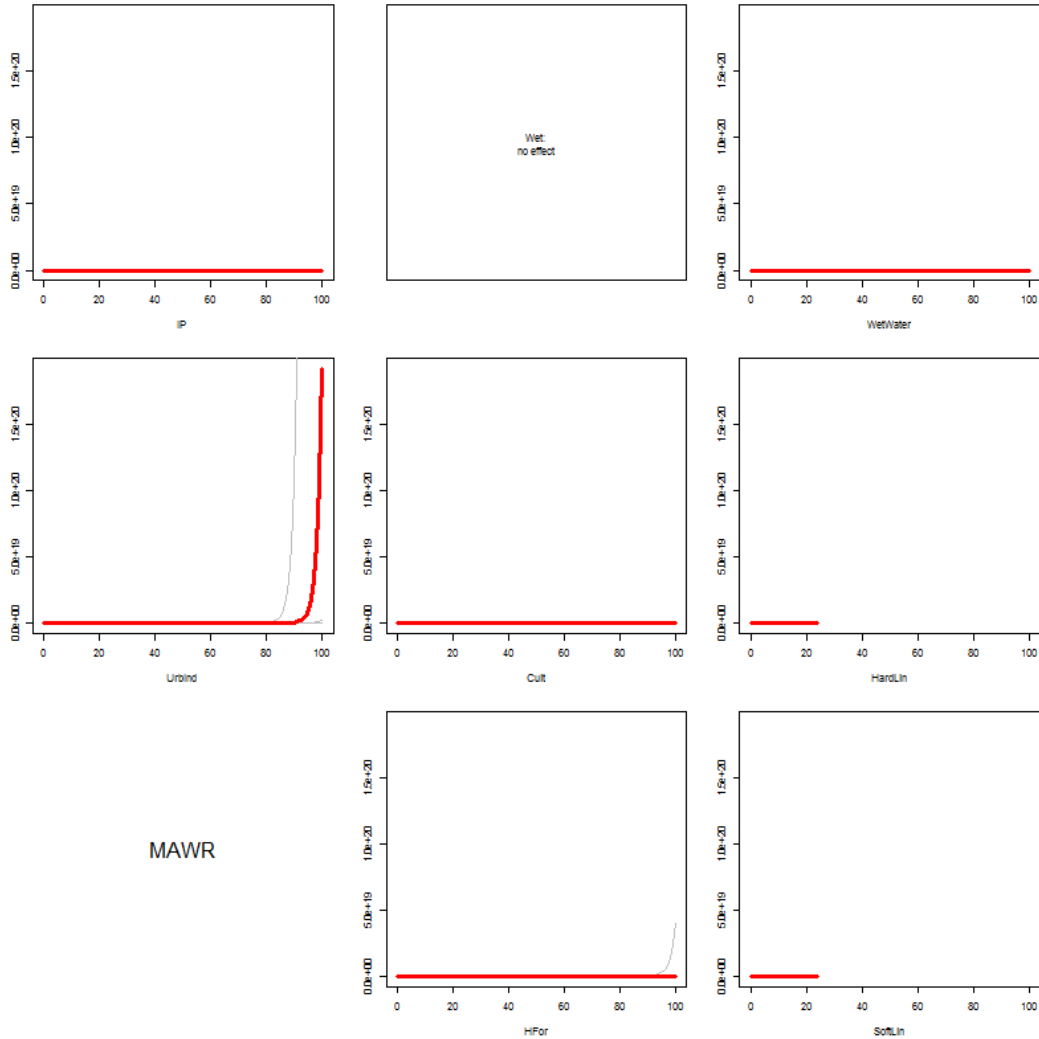


5.39.7 Relative habitat selection



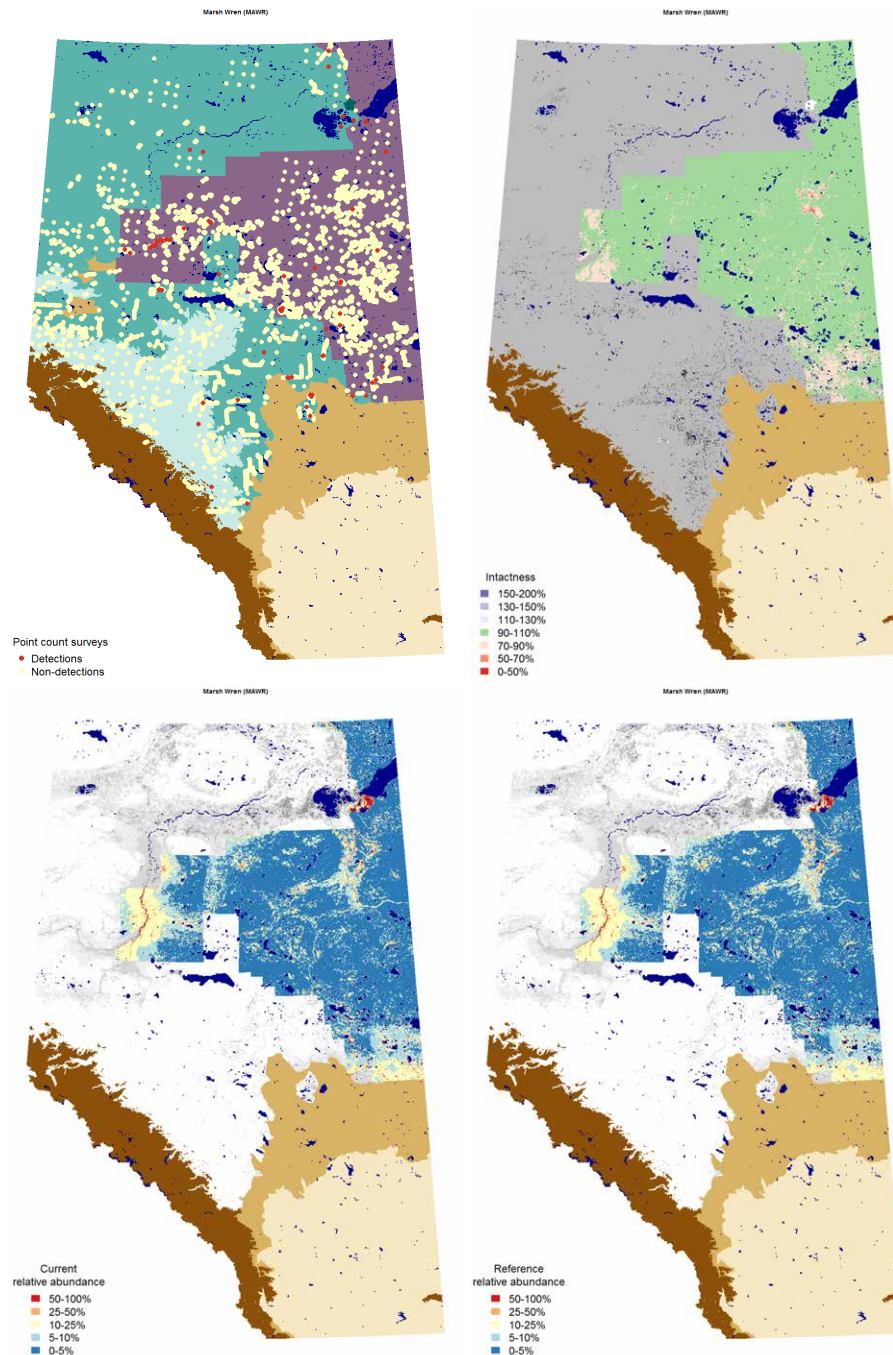
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.39.8 Quarter-section level responses



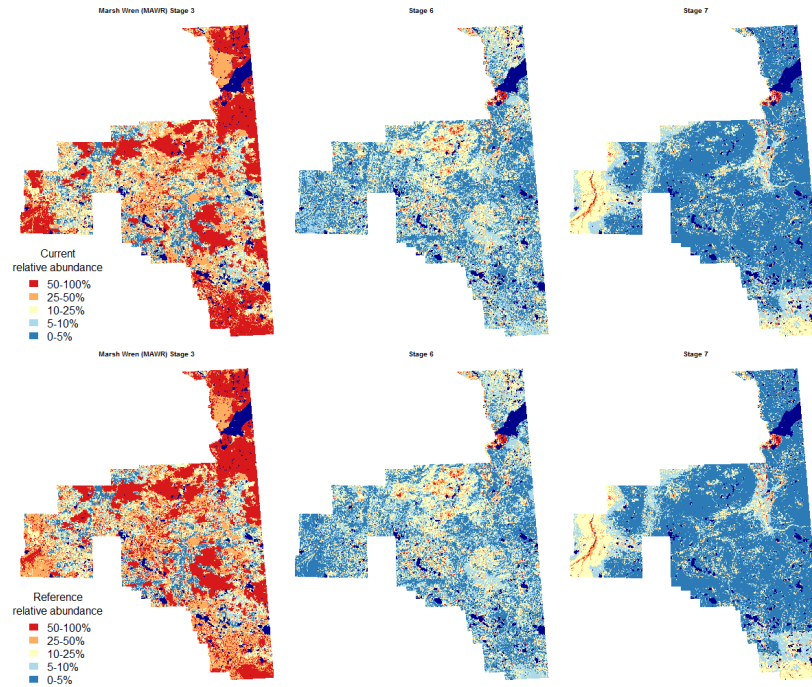
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.39.9 Maps



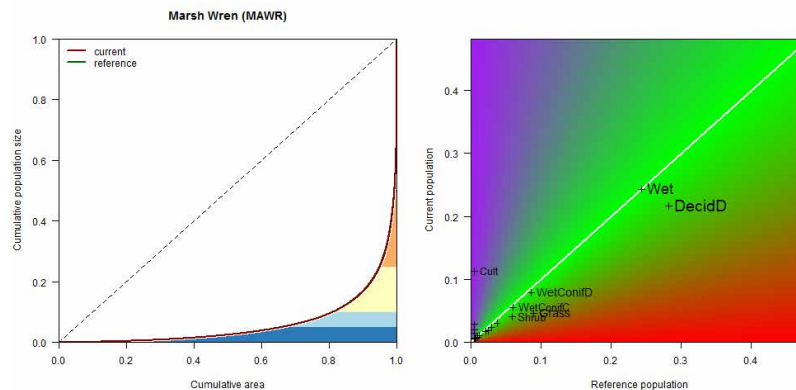
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.39.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.39.11 Population concentration



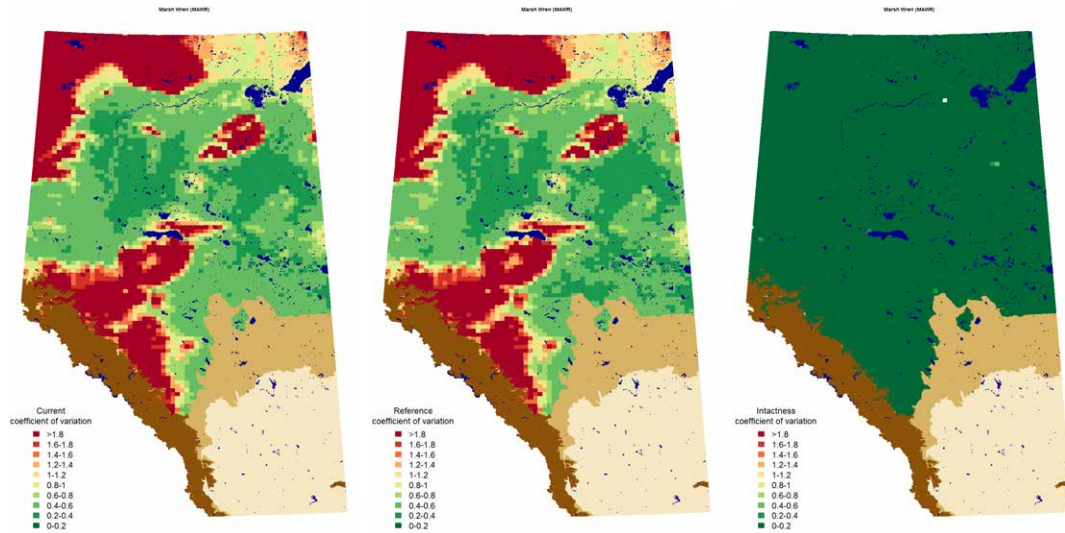
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.39.12 Potential population size

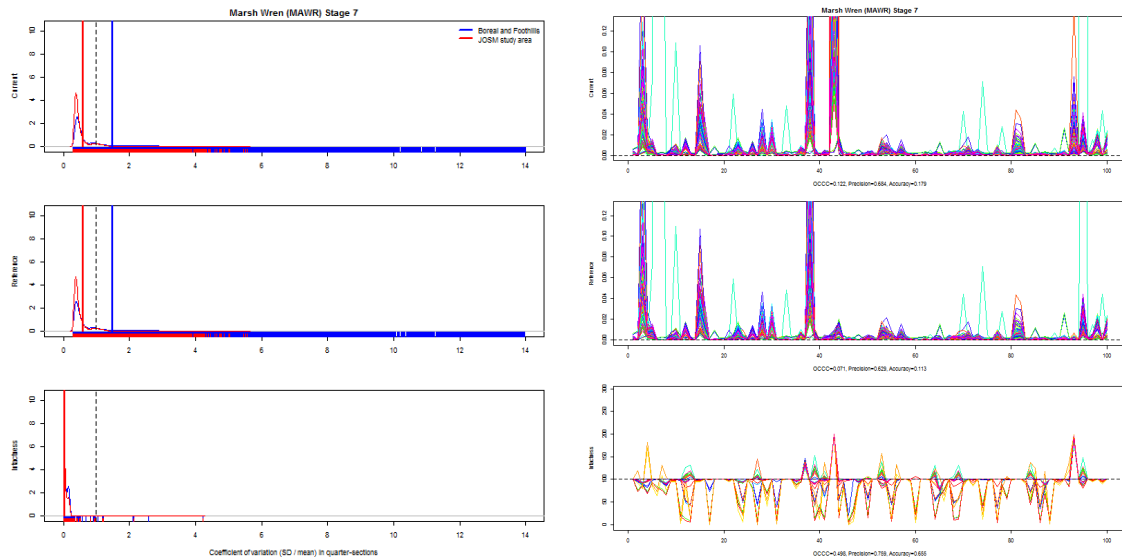
Estimated potential population size of Marsh Wren in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0451	0.0129	0.0831	0.0591	0.0167	0.1094
Wet	0.0506	0.0145	0.0933	0.0510	0.0144	0.0944
Grass	0.0096	0.0028	0.0178	0.0188	0.0053	0.0347
WetConifD	0.0164	0.0047	0.0303	0.0181	0.0051	0.0334
WetConifC	0.0115	0.0033	0.0212	0.0126	0.0035	0.0233
Shrub	0.0084	0.0024	0.0155	0.0124	0.0035	0.0229
DecidC	0.0062	0.0018	0.0115	0.0079	0.0022	0.0146
ConifD	0.0049	0.0014	0.0091	0.0063	0.0018	0.0116
MixedD	0.0039	0.0011	0.0072	0.0054	0.0015	0.0099
ConifC	0.0036	0.0010	0.0067	0.0045	0.0013	0.0082
PineC	0.0021	0.0006	0.0039	0.0027	0.0007	0.0049
PineD	0.0017	0.0005	0.0031	0.0021	0.0006	0.0039
WetConifA	0.0015	0.0004	0.0028	0.0016	0.0005	0.0030
DecidB	0.0008	0.0002	0.0015	0.0016	0.0005	0.0030
WetConifB	0.0014	0.0004	0.0025	0.0016	0.0004	0.0029
PineB	0.0013	0.0004	0.0024	0.0014	0.0004	0.0025
DecidA	0.0005	0.0002	0.0010	0.0009	0.0002	0.0016
ConifB	0.0004	0.0001	0.0008	0.0006	0.0002	0.0011
ConifA	0.0004	0.0001	0.0007	0.0005	0.0001	0.0009
PineA	0.0003	0.0001	0.0006	0.0003	0.0001	0.0006
MixedC	0.0002	0.0000	0.0003	0.0002	0.0001	0.0004
MixedB	0.0001	0.0000	0.0001	0.0001	0.0000	0.0002
MixedA	0.0000	0.0000	0.0001	0.0001	0.0000	0.0002
Cult	0.0235	0.0067	0.0433	0.0000	0.0000	0.0000
UrbInd	0.0059	0.0017	0.0109	0.0000	0.0000	0.0000
HardLin	0.0011	0.0003	0.0020	0.0000	0.0000	0.0000
SoftLin	0.0040	0.0012	0.0074	0.0000	0.0000	0.0000
HFor	0.0030	0.0009	0.0055	0.0000	0.0000	0.0000
Total	0.2085	0.0598	0.3846	0.2096	0.0591	0.3879
Loss	0.0060	0.0015	0.0139			
Gain	0.0044	0.0013	0.0092			

5.39.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.39.14 Variable selection frequencies

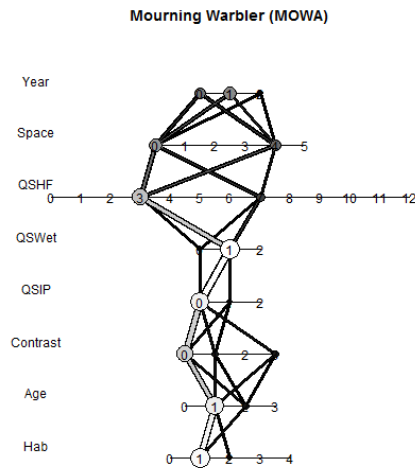
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	200	NULL
2.0	99.5	199	NULL
2.1	0.5	1	. + Age
3.0	89.5	179	NULL
3.1	10.5	21	. + ROAD
4.0	98.0	196	NULL
4.1	2.0	4	. + Remn_QS
5.0	2.0	4	NULL
5.2	98.0	196	. + pWetWater_QS
6.0	97.0	194	NULL
6.1	2.0	4	. + THF_QS
6.10	1.0	2	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
7.0	1.0	2	NULL
7.3	0.5	1	. + xlat + xlong + xlat:xlong
7.4	98.5	197	. + xMAP + xPET + xMAT + xCMD
8.0	98.5	197	NULL
8.1	1.0	2	. + xYEAR
8.2	0.5	1	. + YR5F

5.40 Mourning Warbler (*Geothlypis philadelphia*)

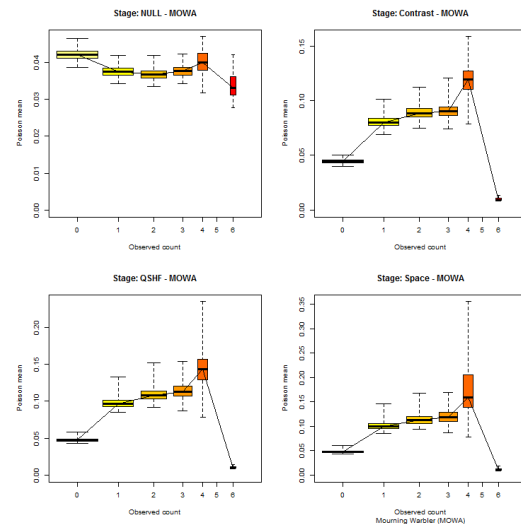
5.40.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

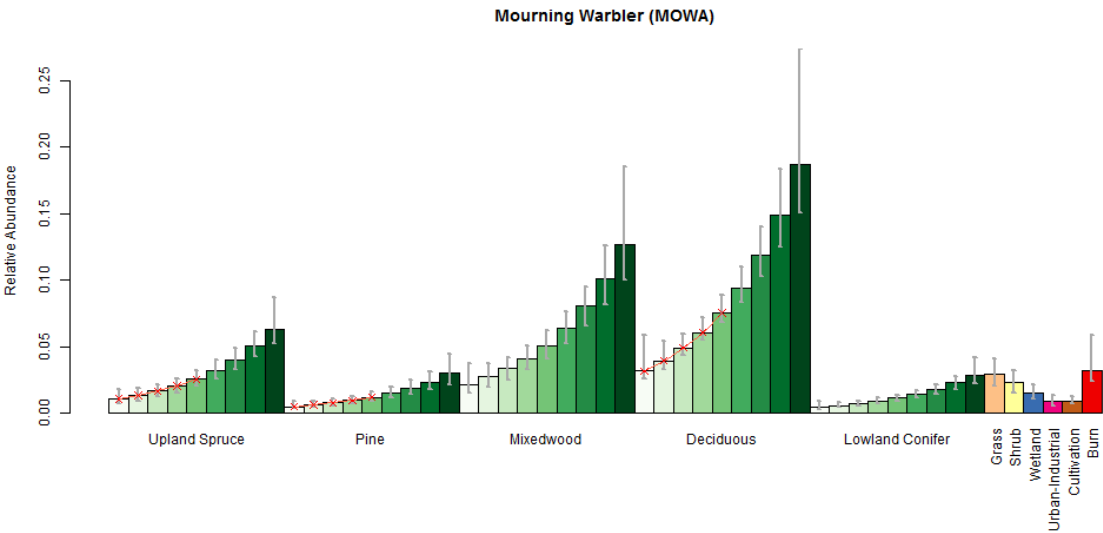


5.40.2 Cross validation

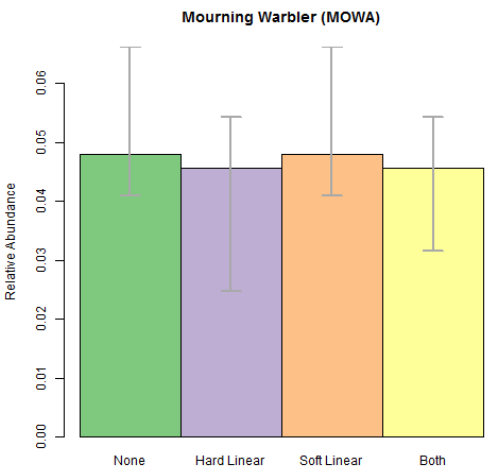
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.40.3 Point level habitat associations

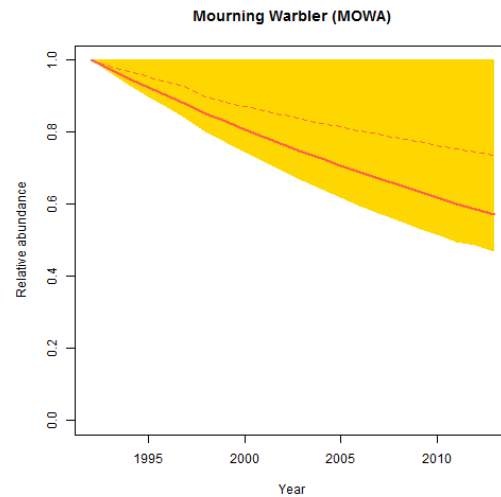


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

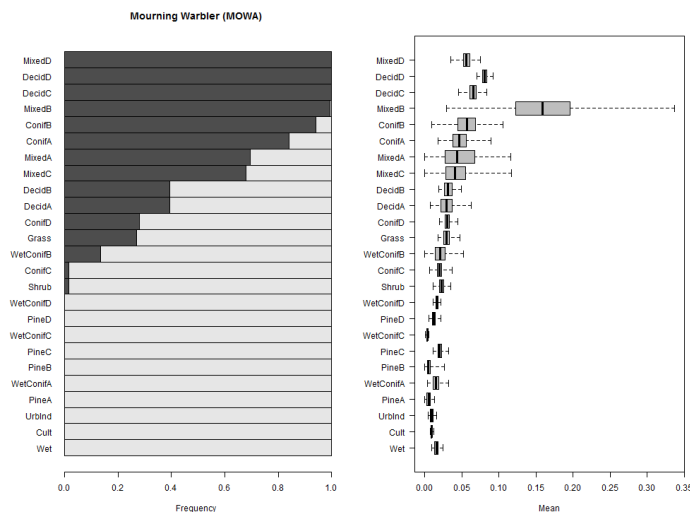


5.40.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



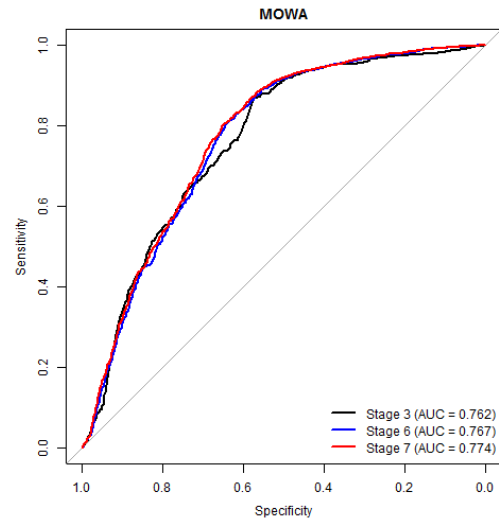
5.40.5 Habitat suitability ranking for patch delineation



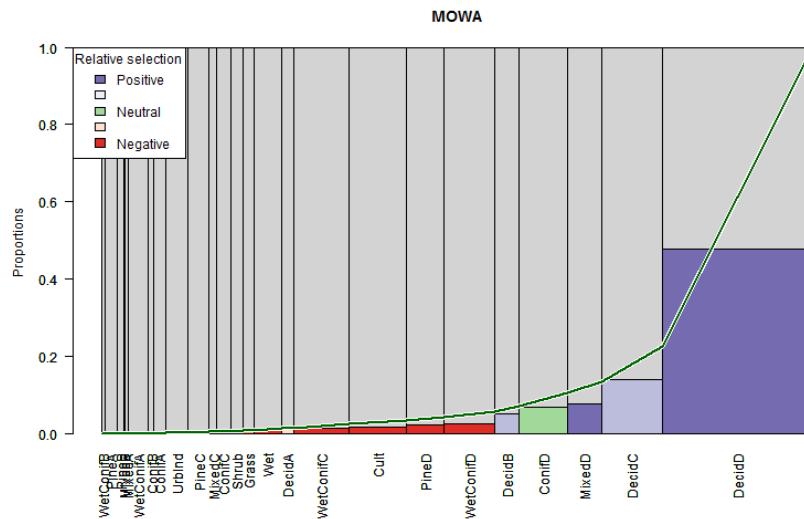
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.40.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

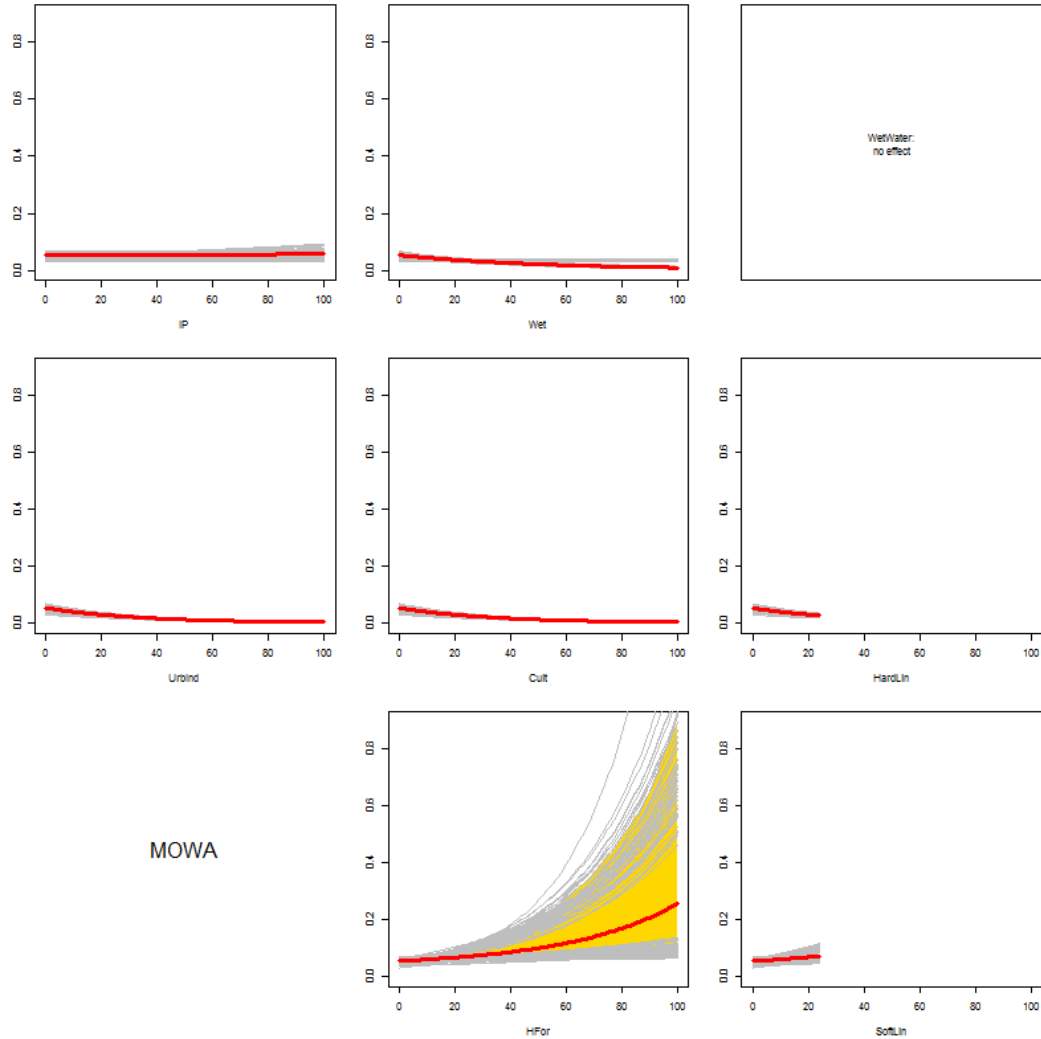


5.40.7 Relative habitat selection



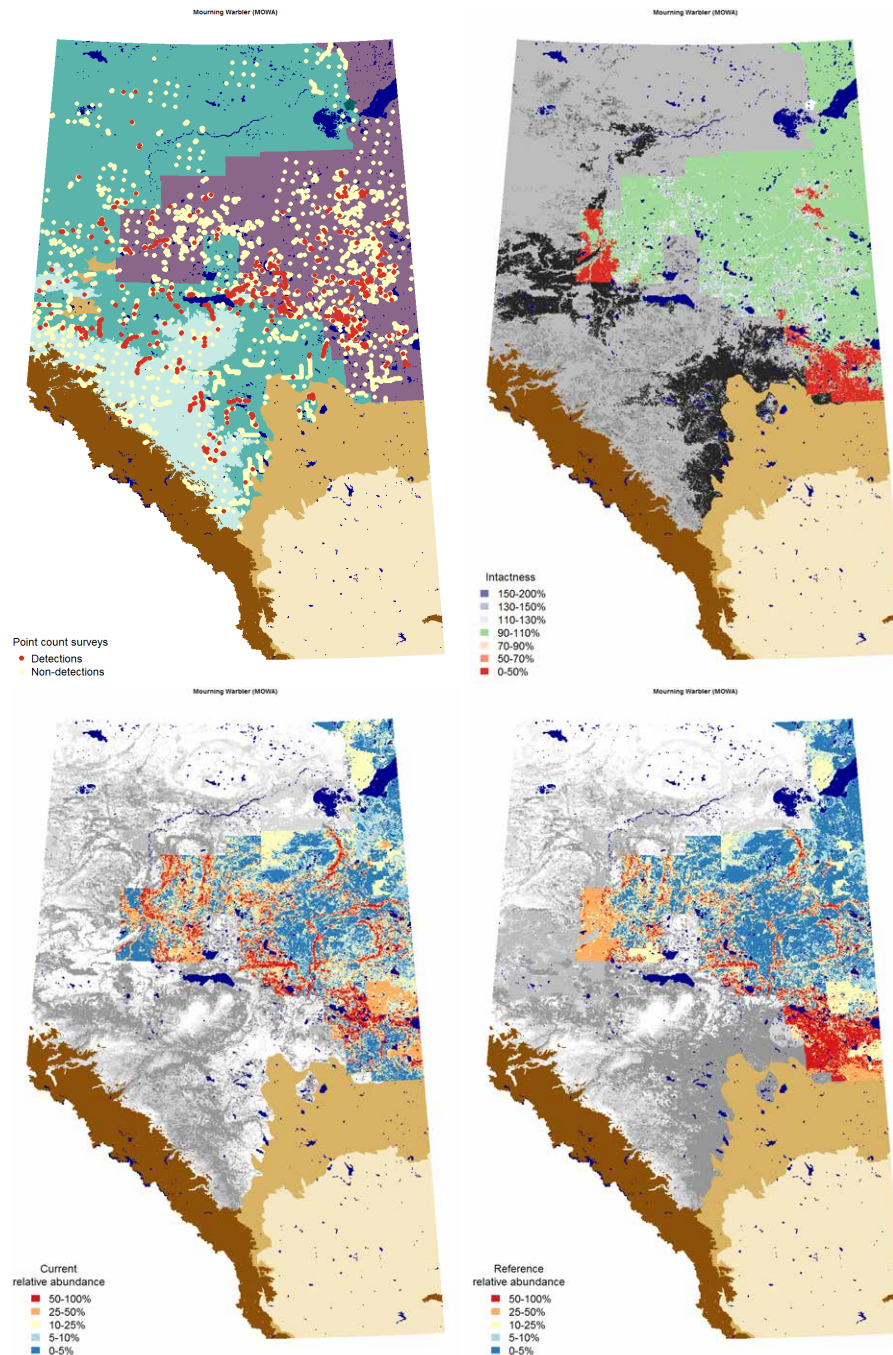
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.40.8 Quarter-section level responses



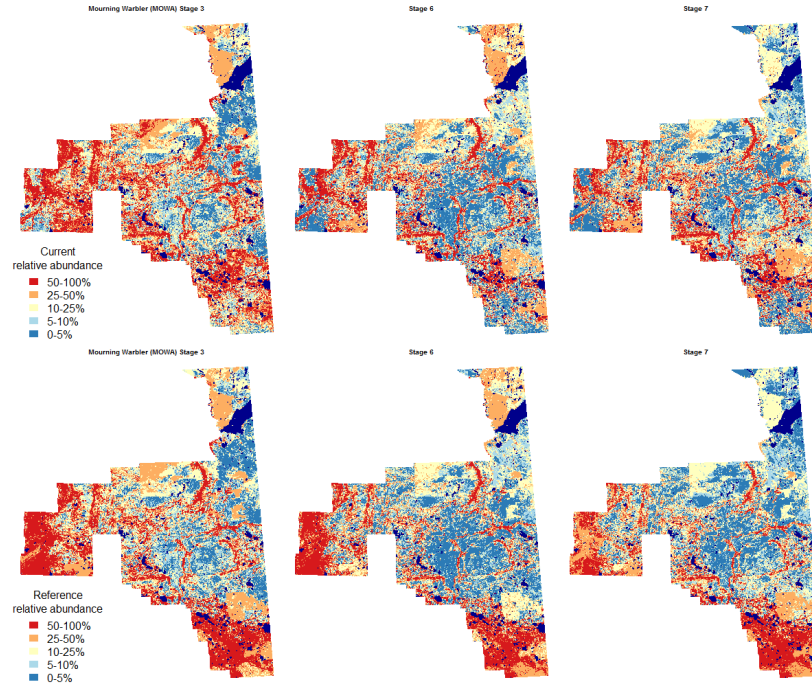
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.40.9 Maps



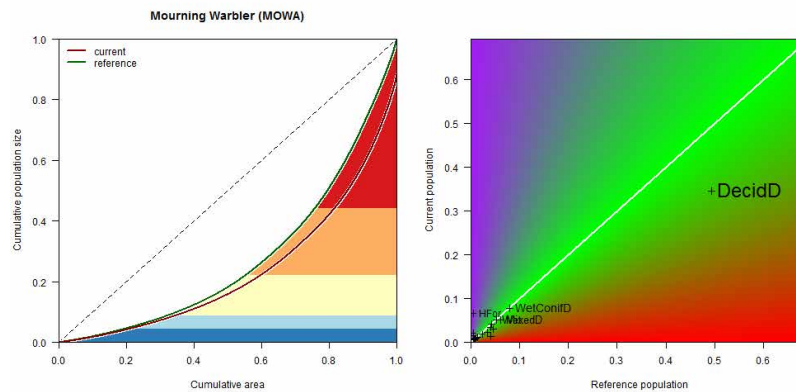
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.40.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.40.11 Population concentration



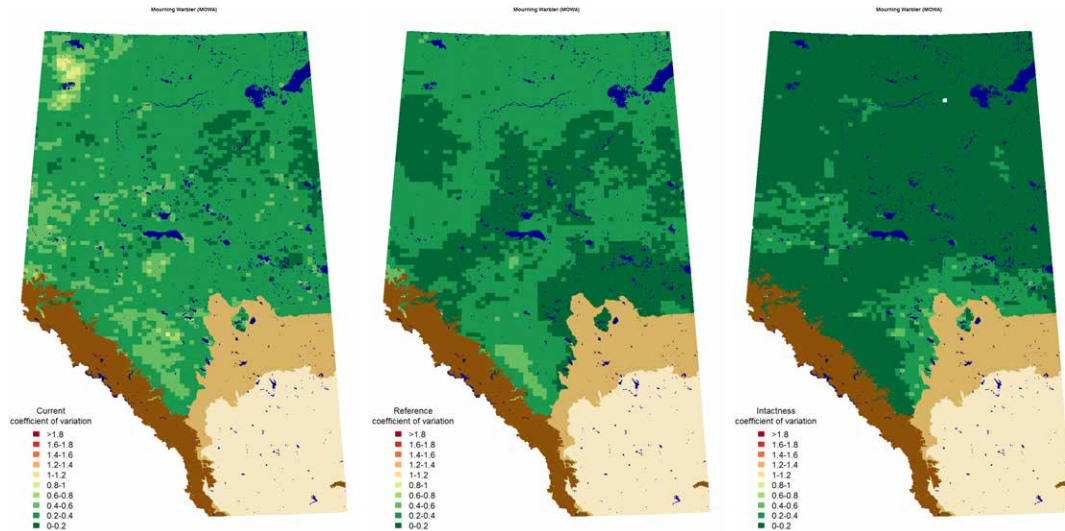
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.40.12 Potential population size

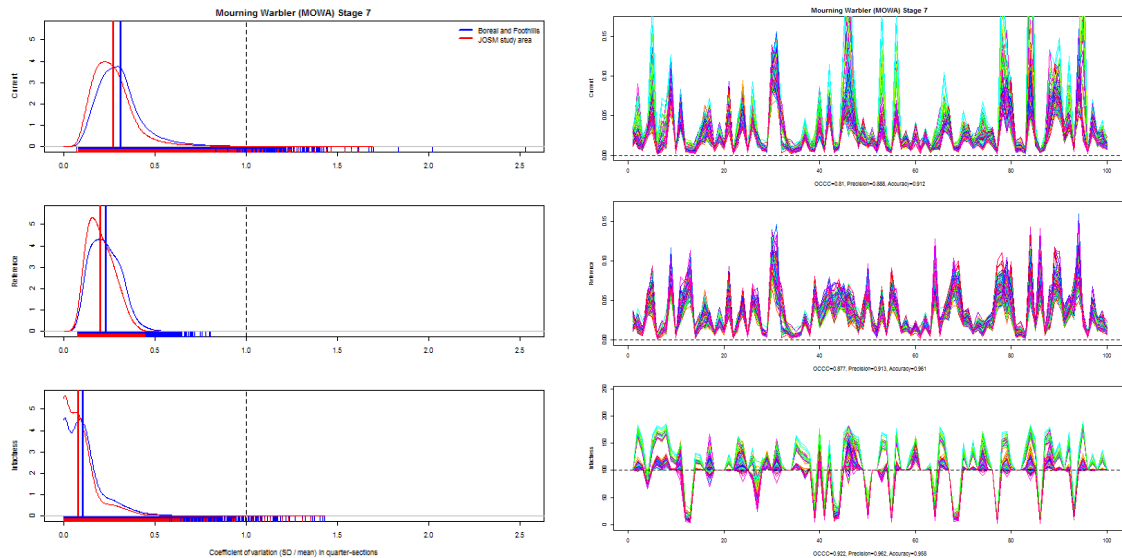
Estimated potential population size of Mourning Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1420	0.1210	0.2080	0.1987	0.1670	0.2311
WetConifD	0.0319	0.0271	0.0467	0.0323	0.0271	0.0376
MixedD	0.0211	0.0180	0.0310	0.0247	0.0208	0.0287
Wet	0.0210	0.0178	0.0307	0.0212	0.0178	0.0247
DecidC	0.0127	0.0108	0.0186	0.0186	0.0157	0.0217
WetConifC	0.0171	0.0146	0.0251	0.0174	0.0146	0.0202
Grass	0.0055	0.0047	0.0081	0.0168	0.0141	0.0195
ConifD	0.0141	0.0120	0.0206	0.0164	0.0138	0.0191
Shrub	0.0095	0.0081	0.0139	0.0141	0.0119	0.0164
DecidB	0.0075	0.0064	0.0110	0.0095	0.0080	0.0111
ConifC	0.0049	0.0042	0.0072	0.0058	0.0049	0.0068
PineB	0.0043	0.0036	0.0062	0.0042	0.0035	0.0049
PineD	0.0032	0.0027	0.0047	0.0035	0.0030	0.0041
PineC	0.0030	0.0025	0.0044	0.0032	0.0027	0.0037
WetConifB	0.0032	0.0027	0.0047	0.0032	0.0027	0.0037
ConifB	0.0025	0.0021	0.0037	0.0027	0.0023	0.0031
ConifA	0.0024	0.0020	0.0035	0.0026	0.0022	0.0030
DecidA	0.0014	0.0012	0.0021	0.0025	0.0021	0.0029
WetConifA	0.0022	0.0018	0.0032	0.0021	0.0018	0.0025
PineA	0.0012	0.0010	0.0017	0.0012	0.0010	0.0014
MixedB	0.0008	0.0007	0.0012	0.0009	0.0008	0.0011
MixedC	0.0005	0.0005	0.0008	0.0007	0.0006	0.0008
MixedA	0.0005	0.0004	0.0007	0.0007	0.0006	0.0008
Cult	0.0089	0.0076	0.0130	0.0000	0.0000	0.0000
UrbInd	0.0019	0.0016	0.0028	0.0000	0.0000	0.0000
HardLin	0.0005	0.0004	0.0007	0.0000	0.0000	0.0000
SoftLin	0.0063	0.0054	0.0093	0.0000	0.0000	0.0000
HFor	0.0273	0.0232	0.0399	0.0000	0.0000	0.0000
Total	0.3575	0.3044	0.5233	0.4029	0.3387	0.4688
Loss	0.0704	0.0526	0.0920			
Gain	0.0195	0.0109	0.1660			

5.40.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.40.14 Variable selection frequencies

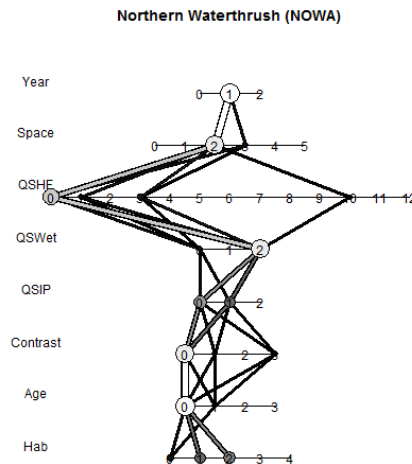
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	96.5	193	. + Habitat
1.2	3.5	7	. + HabitatB
2.1	91.5	183	. + Age
2.2	8.5	17	. + Age + Age2
3.0	80.5	161	NULL
3.1	9.5	19	. + ROAD
3.3	10.0	20	. + ROAD + SoftLin_PC
4.0	93.5	187	NULL
4.1	6.5	13	. + Remn_QS
5.0	1.5	3	NULL
5.1	98.5	197	. + pWet_QS
6.3	74.5	149	. + Succ_QS + Alien_QS
6.7	25.5	51	. + Succ_QS + Alien_QS + Succ2_QS
7.0	59.0	118	NULL
7.4	41.0	82	. + xMAP + xPET + xMAT + xCMD
8.0	44.5	89	NULL
8.1	53.0	106	. + xYEAR
8.2	2.5	5	. + YR5F

5.41 Northern Waterthrush (*Parkesia noveboracensis*)

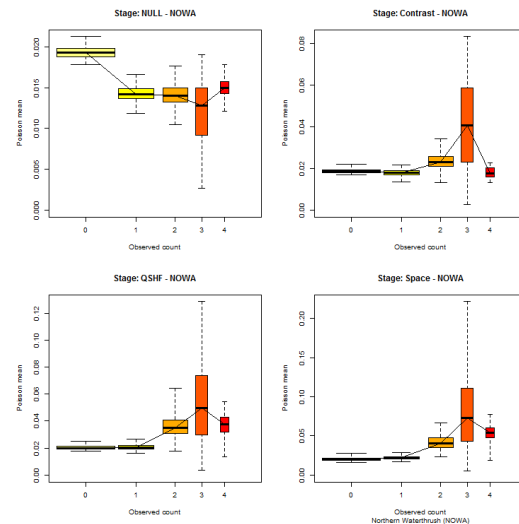
5.41.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

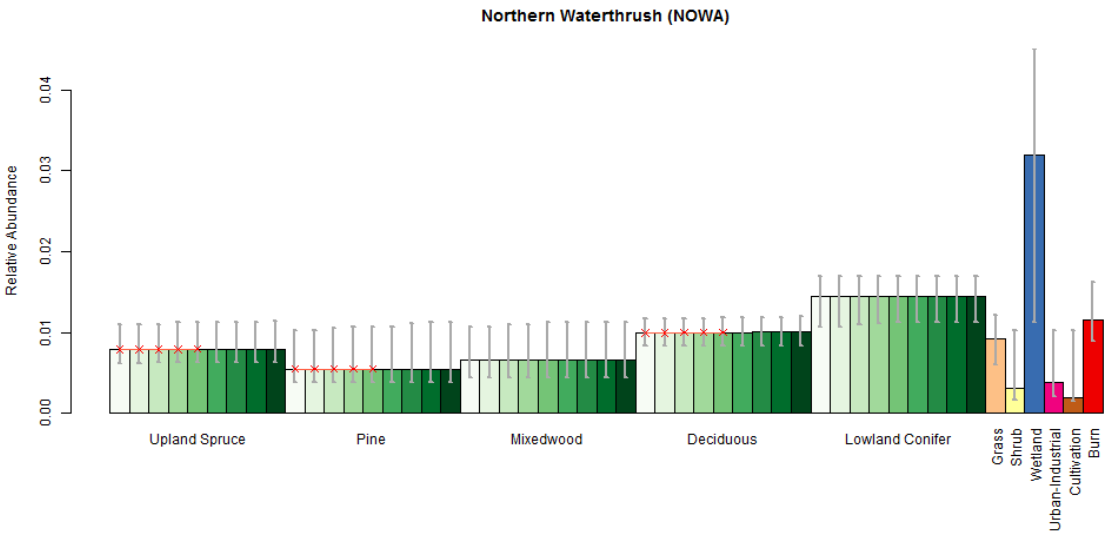


5.41.2 Cross validation

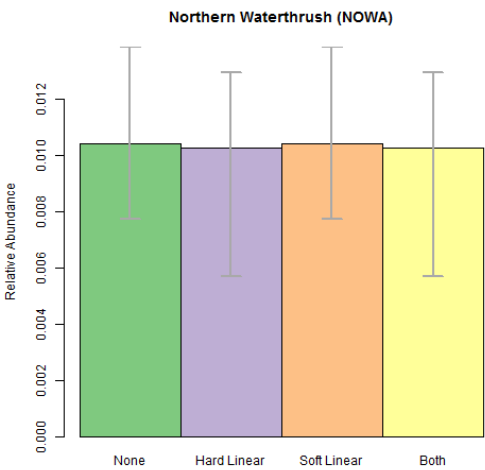
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.41.3 Point level habitat associations

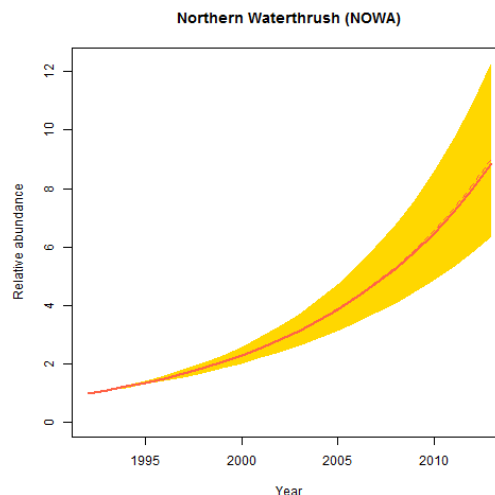


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

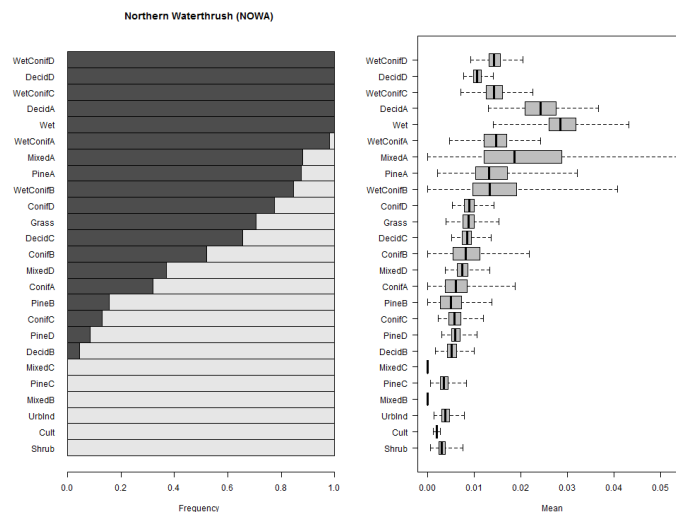


5.41.4 Year effect

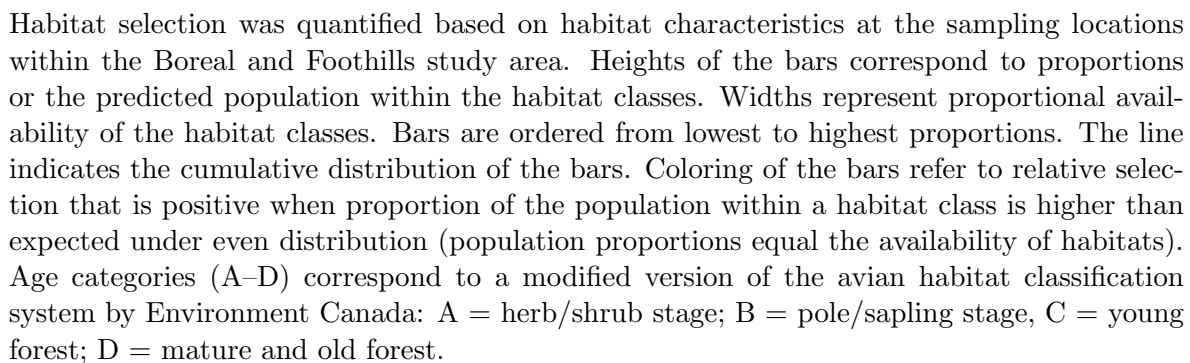
Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



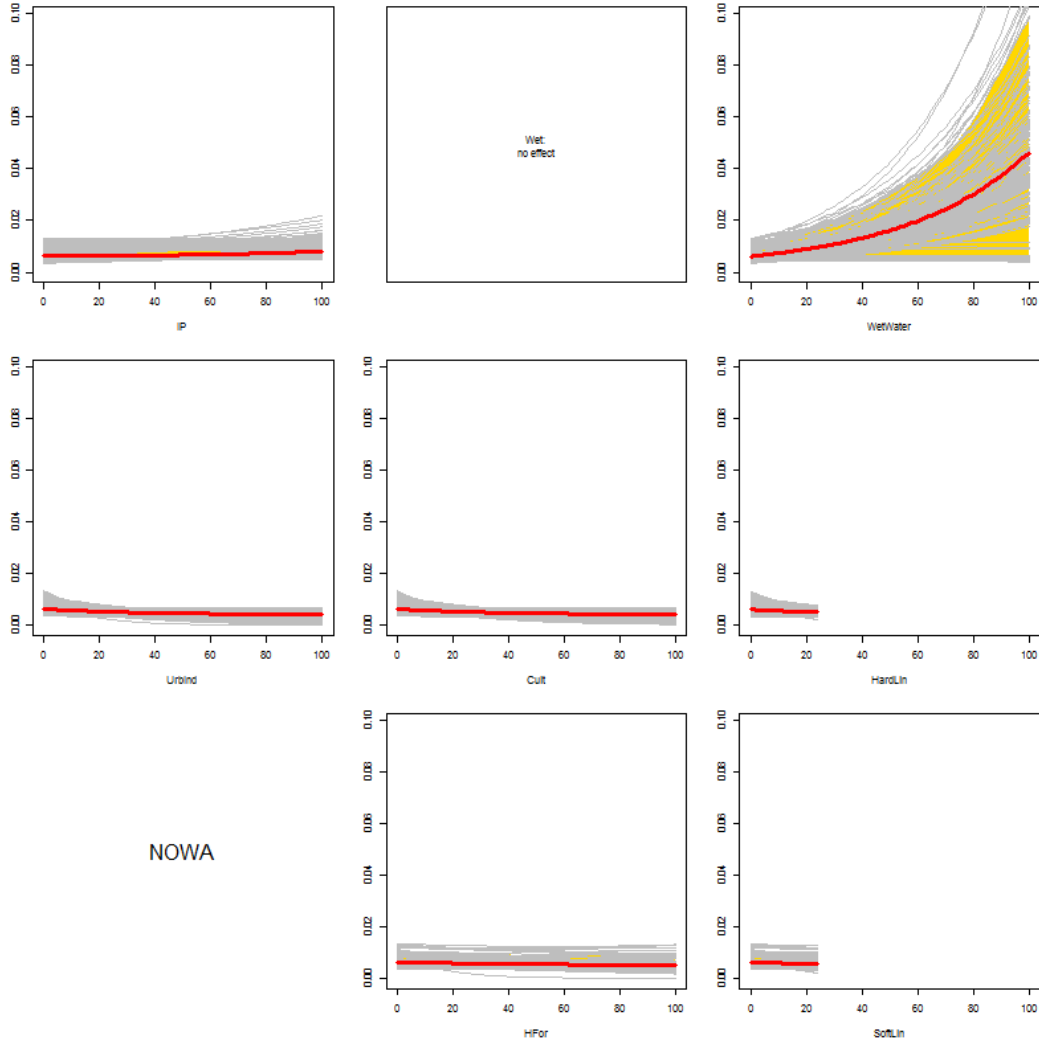
5.41.5 Habitat suitability ranking for patch delineation



Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

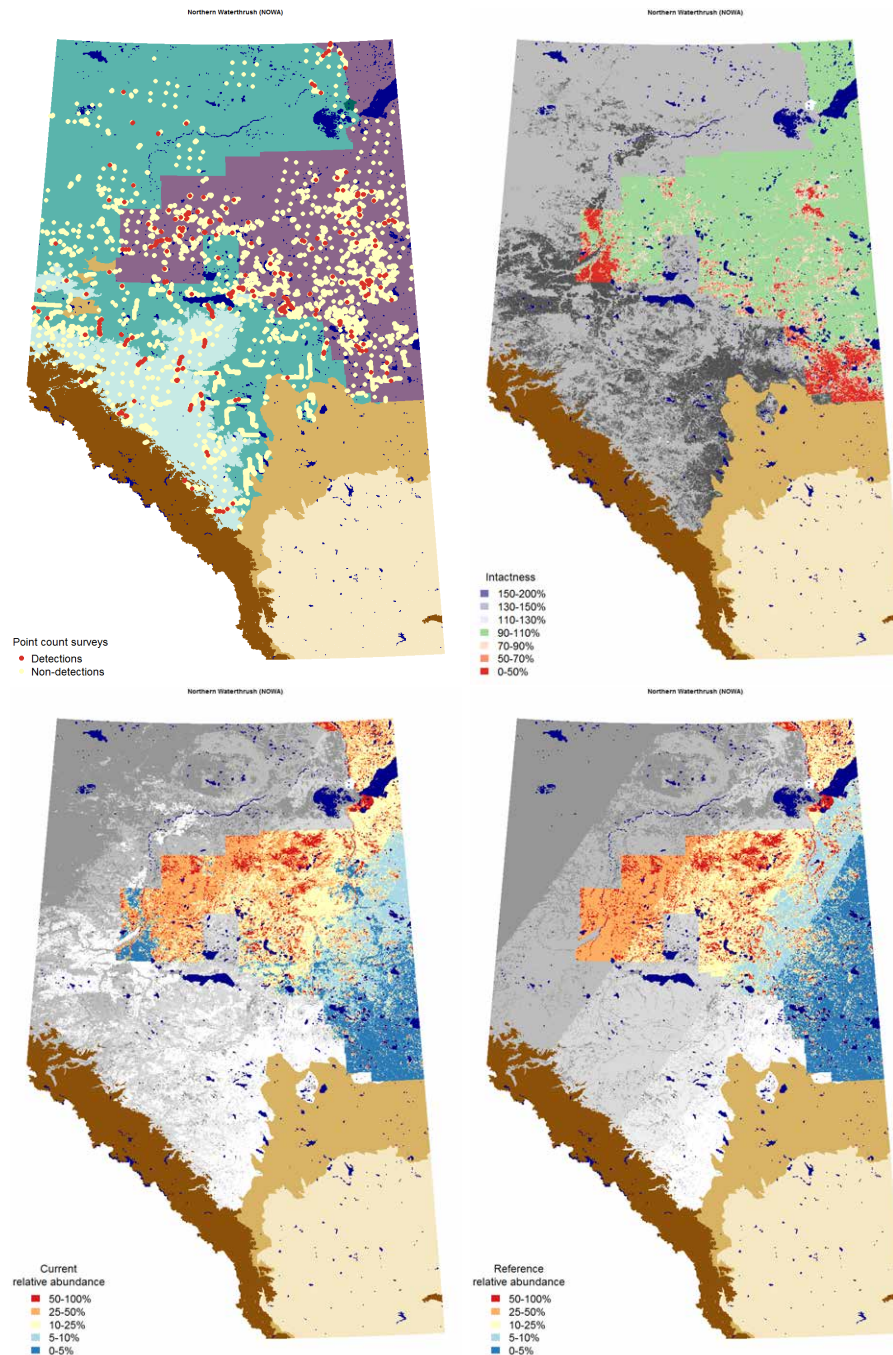


5.41.8 Quarter-section level responses



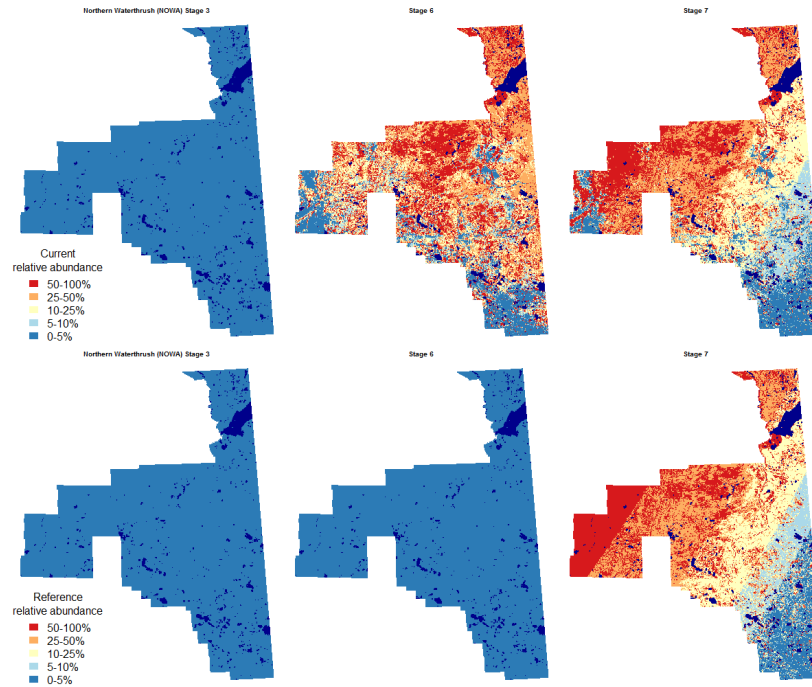
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.41.9 Maps



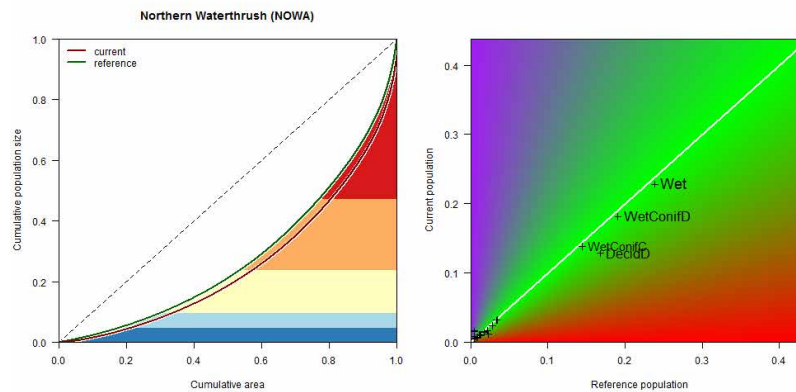
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.41.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.41.11 Population concentration



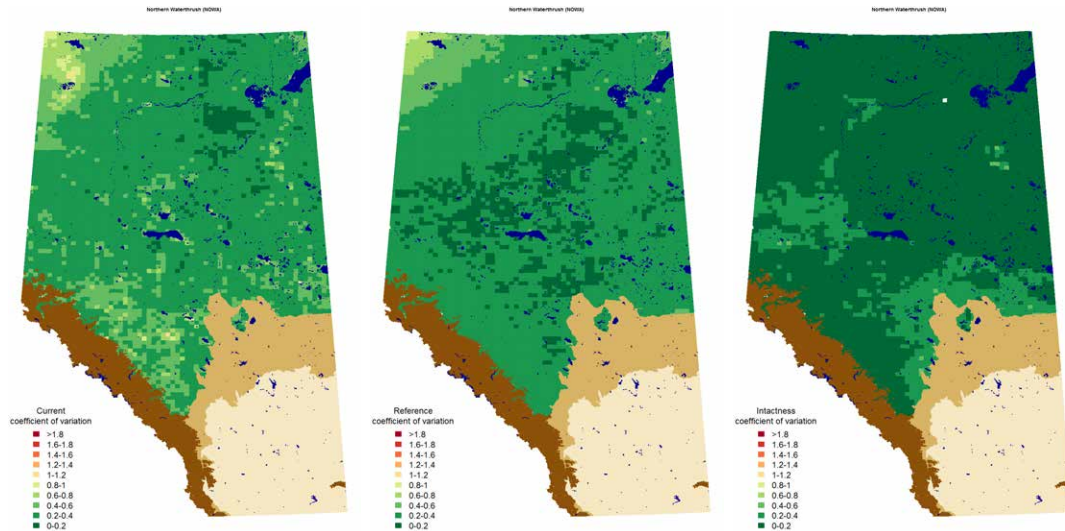
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.41.12 Potential population size

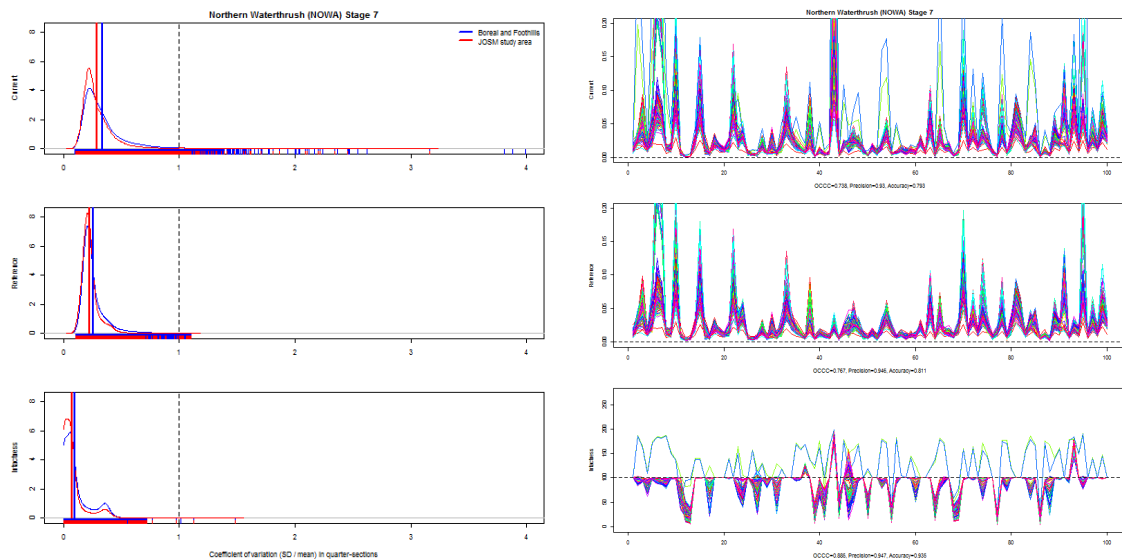
Estimated potential population size of Northern Waterthrush in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.0556	0.0459	0.0697	0.0580	0.0469	0.0734
WetConifD	0.0441	0.0364	0.0553	0.0465	0.0376	0.0588
DecidD	0.0313	0.0258	0.0392	0.0409	0.0331	0.0517
WetConifC	0.0337	0.0277	0.0422	0.0353	0.0285	0.0446
WetConifB	0.0079	0.0065	0.0099	0.0083	0.0067	0.0105
WetConifA	0.0078	0.0064	0.0097	0.0081	0.0066	0.0103
ConifD	0.0058	0.0048	0.0072	0.0069	0.0056	0.0088
Grass	0.0029	0.0024	0.0037	0.0056	0.0046	0.0071
DecidC	0.0040	0.0033	0.0050	0.0053	0.0043	0.0067
ConifC	0.0037	0.0030	0.0046	0.0043	0.0034	0.0054
MixedD	0.0035	0.0029	0.0044	0.0042	0.0034	0.0053
DecidB	0.0025	0.0020	0.0031	0.0032	0.0026	0.0040
PineC	0.0027	0.0022	0.0034	0.0029	0.0024	0.0037
PineB	0.0027	0.0022	0.0034	0.0028	0.0022	0.0035
Shrub	0.0018	0.0015	0.0023	0.0023	0.0019	0.0029
ConifA	0.0018	0.0015	0.0023	0.0021	0.0017	0.0027
PineD	0.0019	0.0016	0.0024	0.0021	0.0017	0.0027
ConifB	0.0014	0.0012	0.0018	0.0016	0.0013	0.0021
DecidA	0.0009	0.0007	0.0011	0.0012	0.0010	0.0016
PineA	0.0011	0.0009	0.0014	0.0012	0.0009	0.0015
MixedB	0.0002	0.0002	0.0003	0.0003	0.0002	0.0003
MixedC	0.0002	0.0001	0.0002	0.0002	0.0002	0.0003
MixedA	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003
Cult	0.0022	0.0018	0.0027	0.0000	0.0000	0.0000
UrbInd	0.0008	0.0007	0.0010	0.0000	0.0000	0.0000
HardLin	0.0003	0.0002	0.0003	0.0000	0.0000	0.0000
SoftLin	0.0037	0.0030	0.0046	0.0000	0.0000	0.0000
HFor	0.0040	0.0033	0.0050	0.0000	0.0000	0.0000
Total	0.2287	0.1885	0.2866	0.2436	0.1969	0.3082
Loss	0.0155	0.0086	0.0290			
Gain	0.0007	0.0004	0.0011			

5.41.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.41.14 Variable selection frequencies

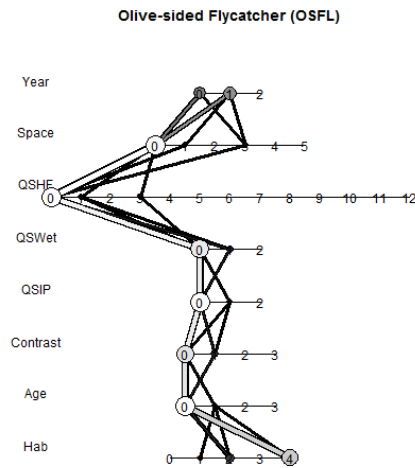
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	8.5	17	NULL
1.1	41.5	83	. + Habitat
1.2	50.0	100	. + HabitatB
2.0	98.0	196	NULL
2.1	2.0	4	. + Age
3.0	93.0	186	NULL
3.1	6.0	12	. + ROAD
3.3	1.0	2	. + ROAD + SoftLin_PC
4.0	59.5	119	NULL
4.1	40.5	81	. + Remn_QS
5.0	8.0	16	NULL
5.2	92.0	184	. + pWetWater_QS
6.0	79.5	159	NULL
6.1	7.5	15	. + THF_QS
6.3	12.5	25	. + Succ_QS + Alien_QS
6.10	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
7.2	92.0	184	. + xlat + xlong
7.3	8.0	16	. + xlat + xlong + xlat:xlong
8.1	100.0	200	. + xYEAR

5.42 Olive-sided Flycatcher (*Contopus cooperi*)

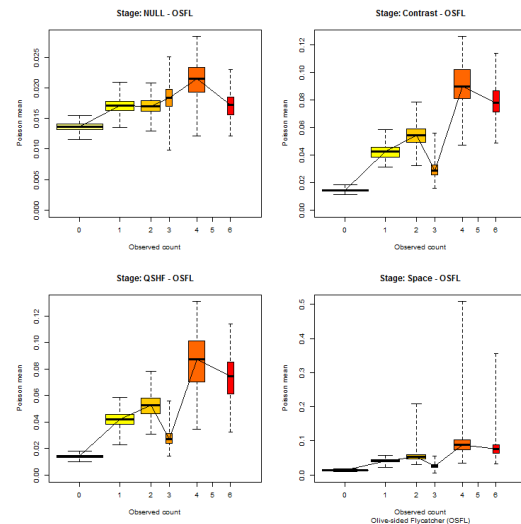
5.42.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

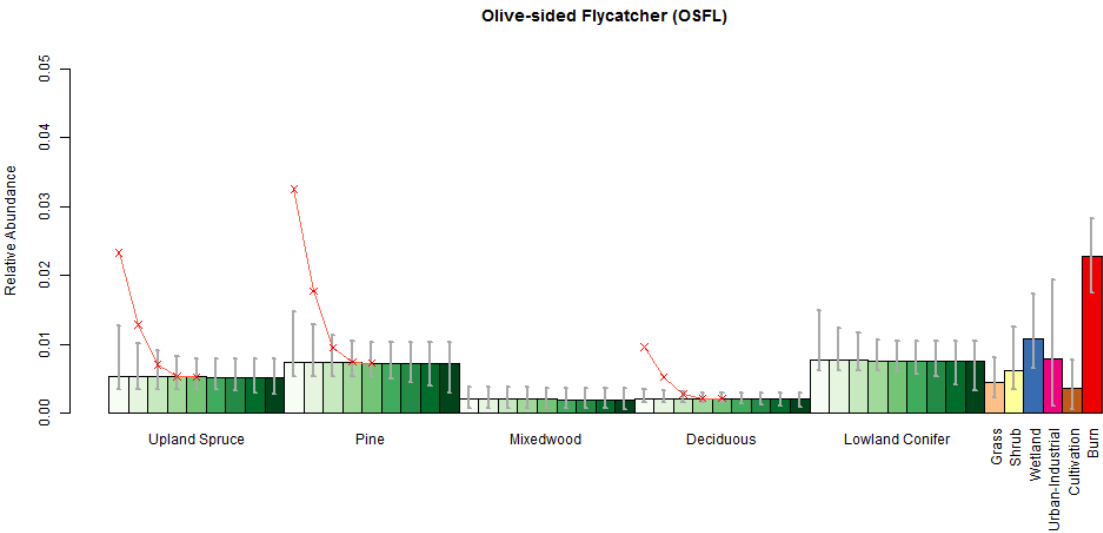


5.42.2 Cross validation

Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.42.3 Point level habitat associations

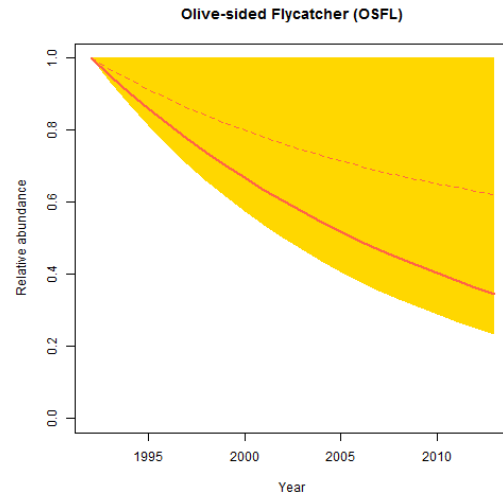


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

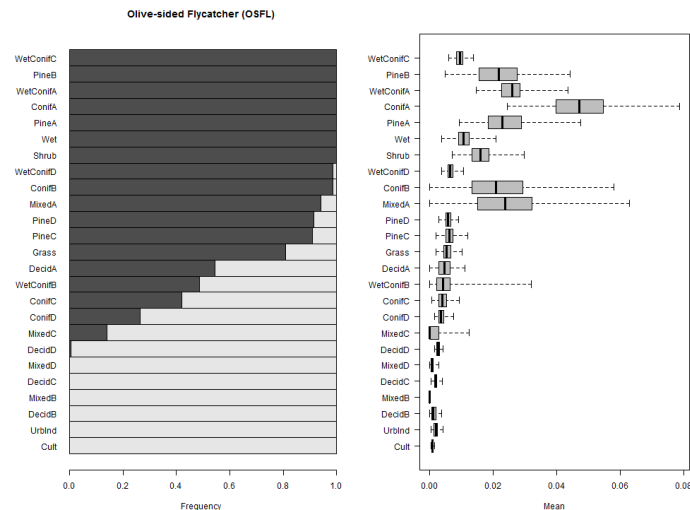


5.42.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



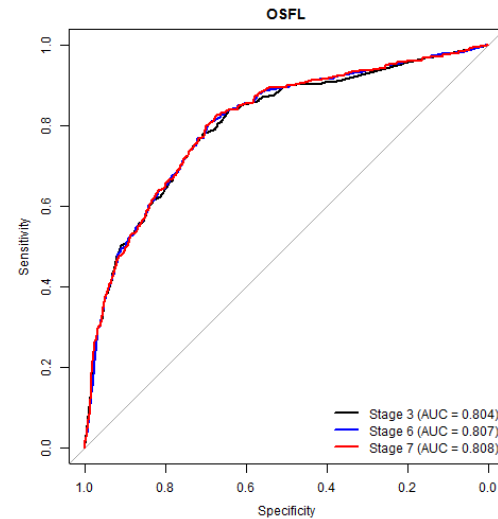
5.42.5 Habitat suitability ranking for patch delineation



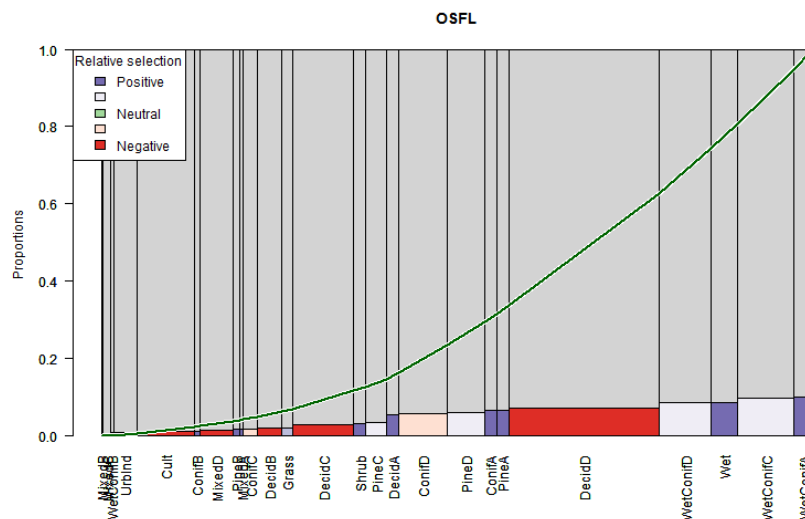
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.42.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

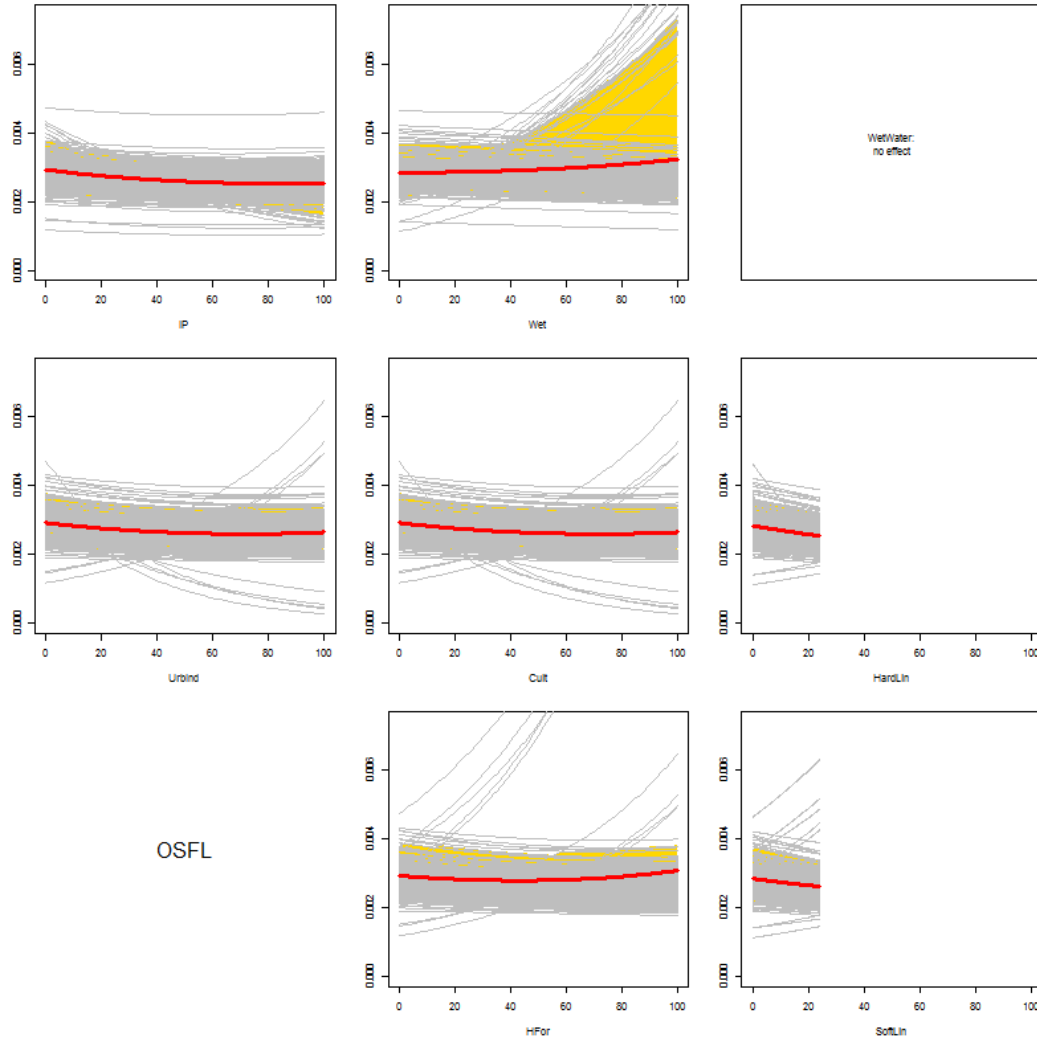


5.42.7 Relative habitat selection



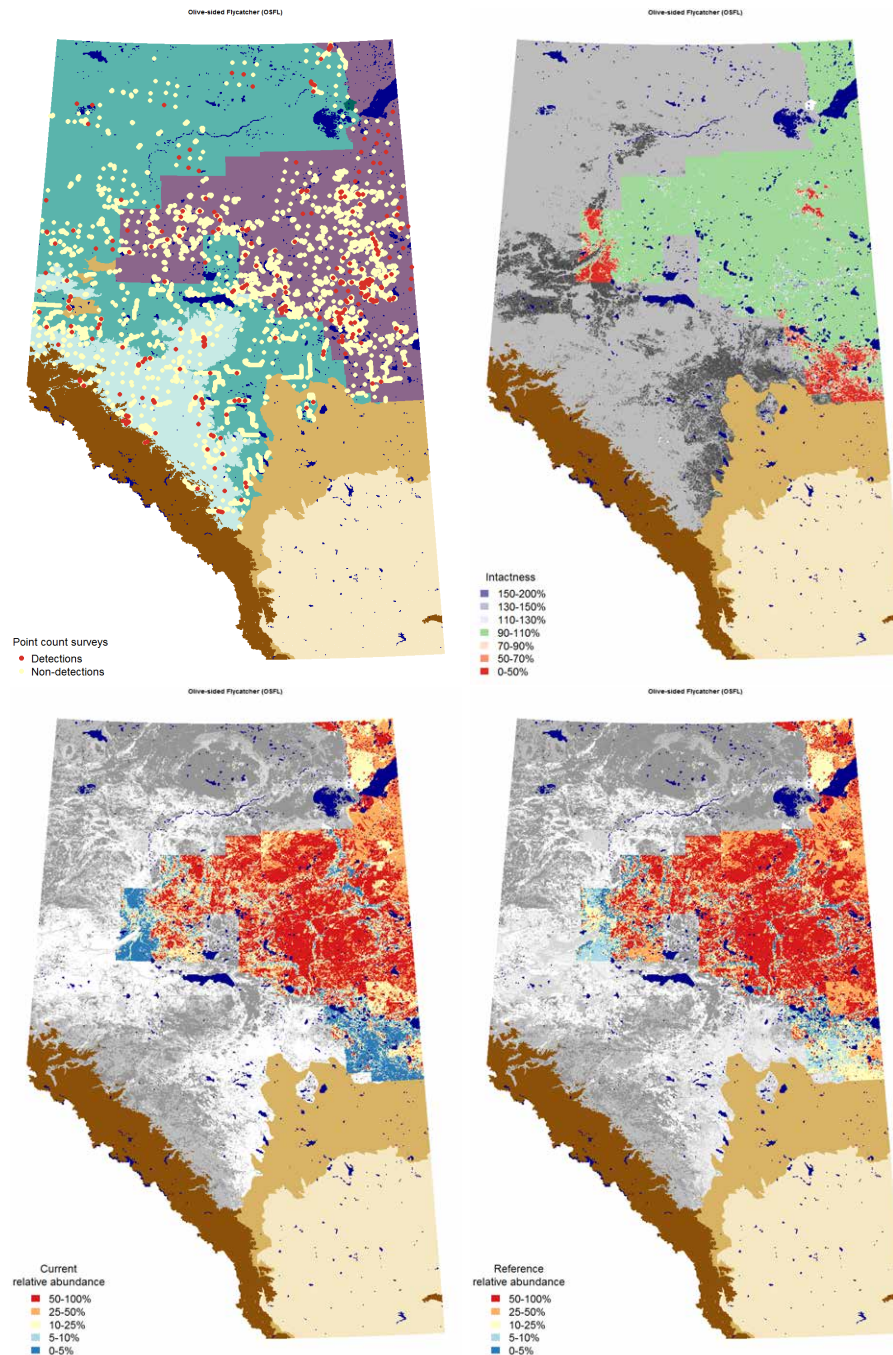
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.42.8 Quarter-section level responses



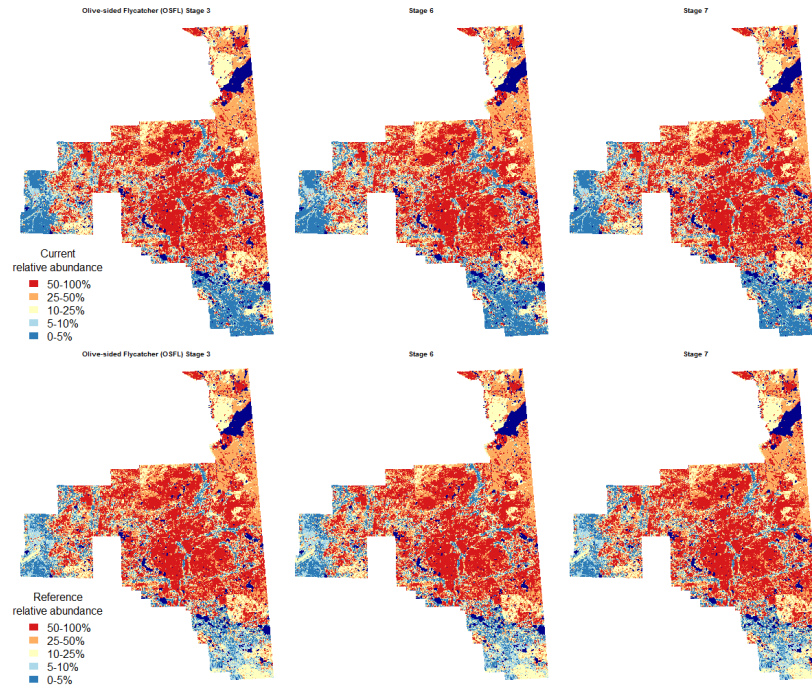
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.42.9 Maps



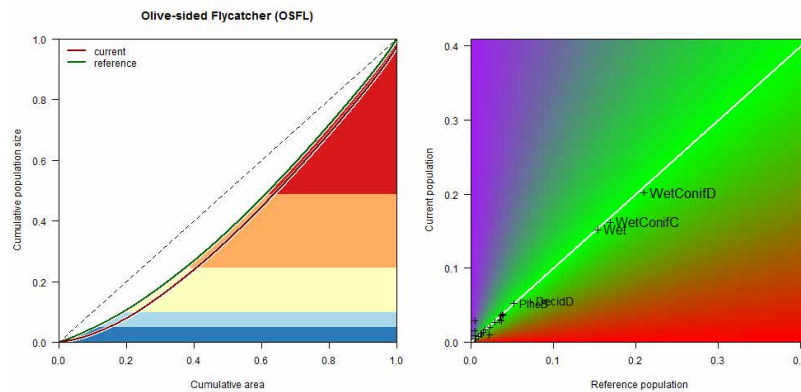
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.42.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.42.11 Population concentration



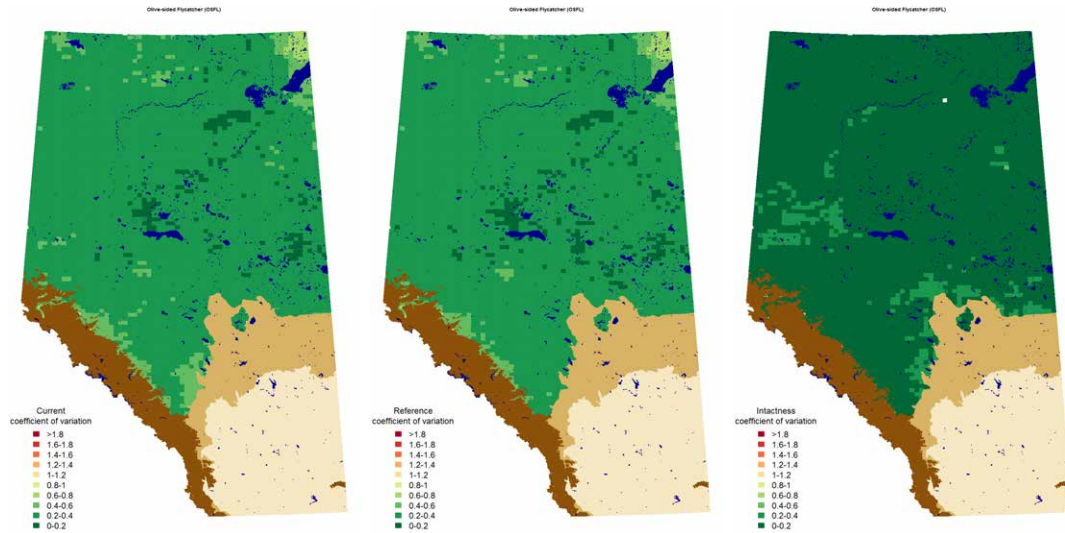
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.42.12 Potential population size

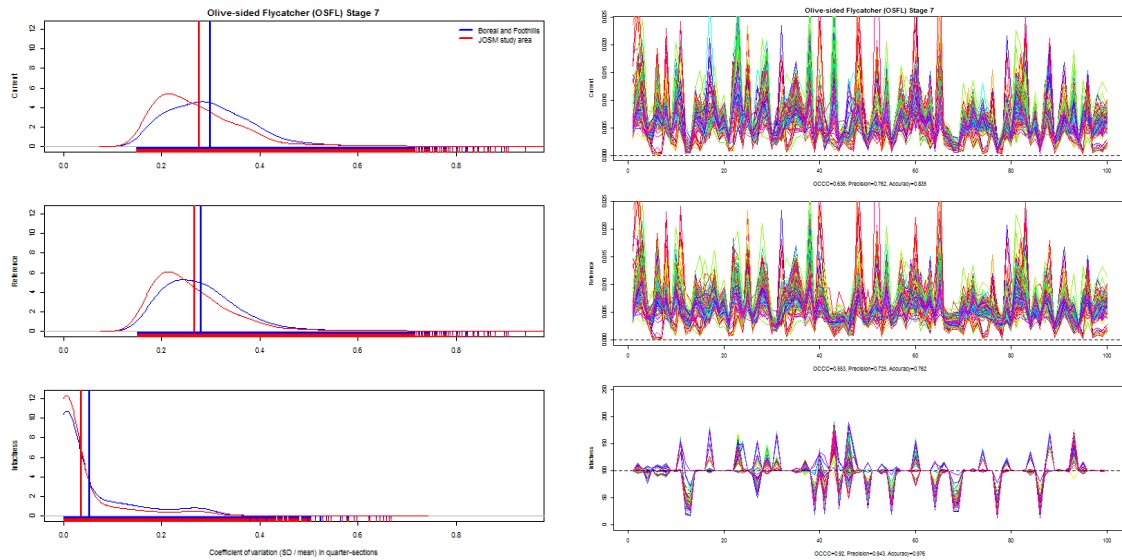
Estimated potential population size of Olive-sided Flycatcher in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.0194	0.0147	0.0262	0.0202	0.0151	0.0274
WetConifC	0.0156	0.0118	0.0211	0.0163	0.0122	0.0220
Wet	0.0146	0.0111	0.0198	0.0148	0.0111	0.0201
DecidD	0.0053	0.0040	0.0071	0.0069	0.0052	0.0094
PineB	0.0050	0.0038	0.0068	0.0051	0.0038	0.0069
PineC	0.0035	0.0027	0.0047	0.0038	0.0028	0.0051
WetConifB	0.0036	0.0027	0.0049	0.0037	0.0028	0.0050
Shrub	0.0028	0.0021	0.0037	0.0036	0.0027	0.0048
WetConifA	0.0034	0.0026	0.0046	0.0035	0.0027	0.0048
ConifD	0.0029	0.0022	0.0039	0.0034	0.0026	0.0047
PineD	0.0026	0.0020	0.0036	0.0028	0.0021	0.0038
ConifC	0.0020	0.0015	0.0027	0.0023	0.0017	0.0031
Grass	0.0010	0.0008	0.0013	0.0022	0.0016	0.0030
PineA	0.0017	0.0013	0.0022	0.0017	0.0013	0.0023
ConifA	0.0013	0.0010	0.0017	0.0015	0.0011	0.0020
MixedD	0.0011	0.0008	0.0014	0.0012	0.0009	0.0017
ConifB	0.0011	0.0008	0.0014	0.0012	0.0009	0.0016
DecidC	0.0007	0.0006	0.0010	0.0009	0.0007	0.0013
DecidB	0.0005	0.0004	0.0006	0.0006	0.0004	0.0008
DecidA	0.0001	0.0001	0.0002	0.0002	0.0001	0.0003
MixedB	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
MixedA	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
MixedC	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
Cult	0.0009	0.0007	0.0012	0.0000	0.0000	0.0000
UrbInd	0.0004	0.0003	0.0005	0.0000	0.0000	0.0000
HardLin	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0015	0.0011	0.0020	0.0000	0.0000	0.0000
HFor	0.0028	0.0021	0.0038	0.0000	0.0000	0.0000
Total	0.0940	0.0712	0.1270	0.0961	0.0721	0.1303
Loss	0.0037	0.0021	0.0055			
Gain	0.0012	0.0001	0.0030			

5.42.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.42.14 Variable selection frequencies

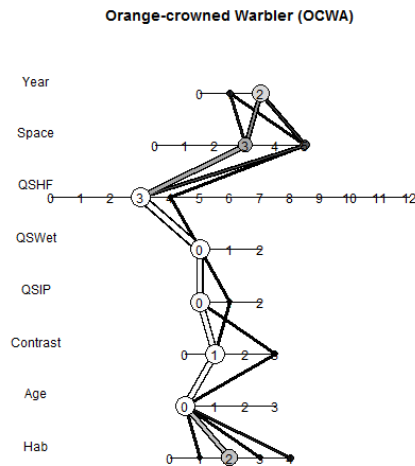
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	0.5	1	. + Habitat
1.2	23.5	47	. + HabitatB
1.4	76.0	152	. + HabitatB + isHForC
2.0	94.5	189	NULL
2.1	5.5	11	. + Age
3.0	85.0	170	NULL
3.1	15.0	30	. + ROAD
4.0	94.5	189	NULL
4.1	5.5	11	. + Remn_QS
5.0	88.0	176	NULL
5.1	12.0	24	. + pWet_QS
6.0	95.5	191	NULL
6.1	2.0	4	. + THF_QS
6.3	2.5	5	. + Succ_QS + Alien_QS
7.0	93.0	186	NULL
7.1	1.0	2	. + xlat
7.3	6.0	12	. + xlat + xlong + xlat:xlong
8.0	46.5	93	NULL
8.1	53.5	107	. + xYEAR

5.43 Orange-crowned Warbler (*Oreothlypis celata*)

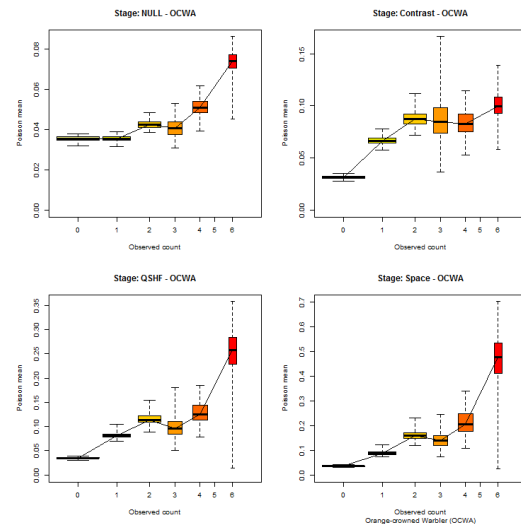
5.43.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

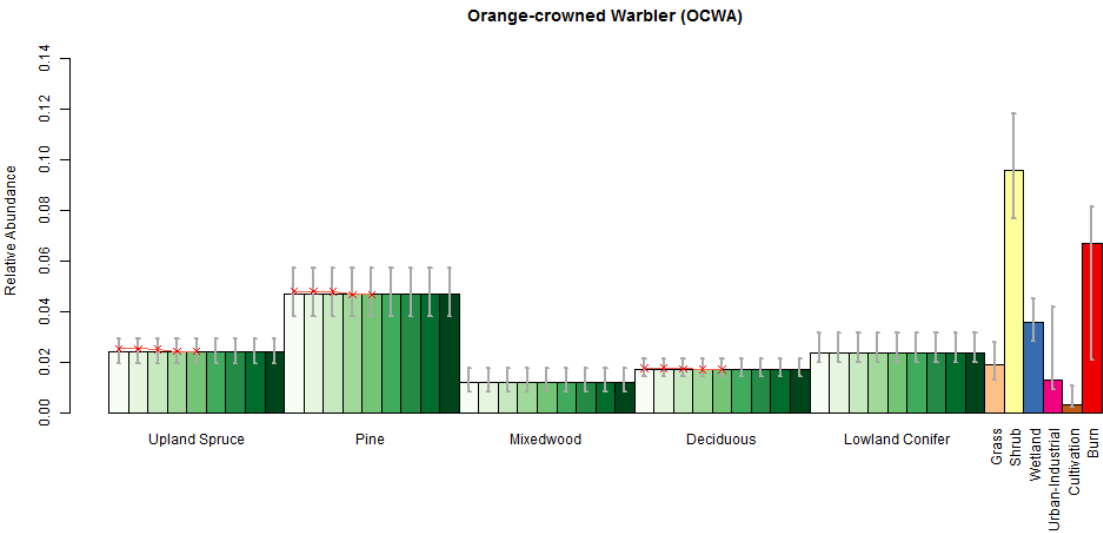


5.43.2 Cross validation

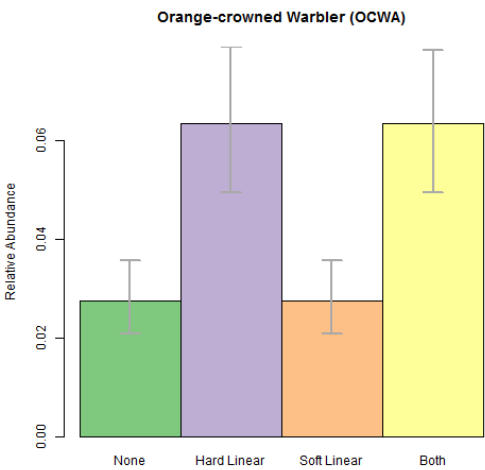
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.43.3 Point level habitat associations

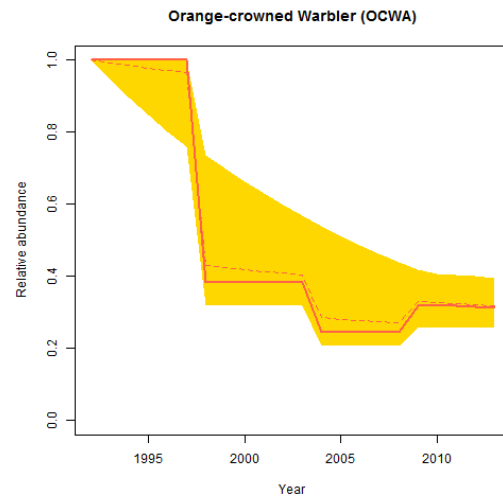


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

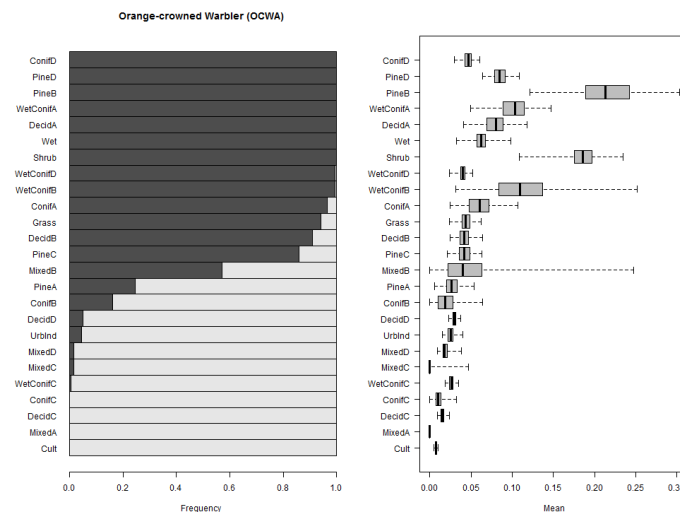


5.43.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



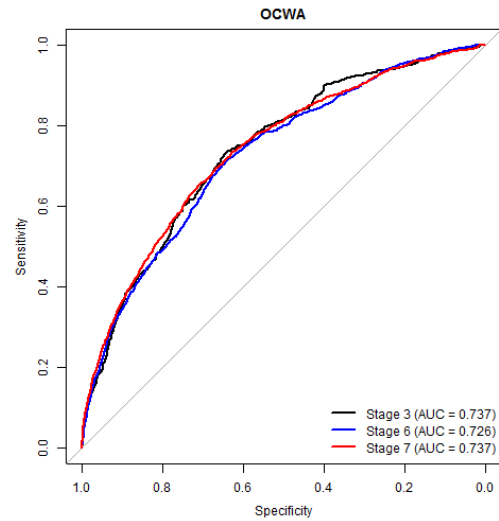
5.43.5 Habitat suitability ranking for patch delineation



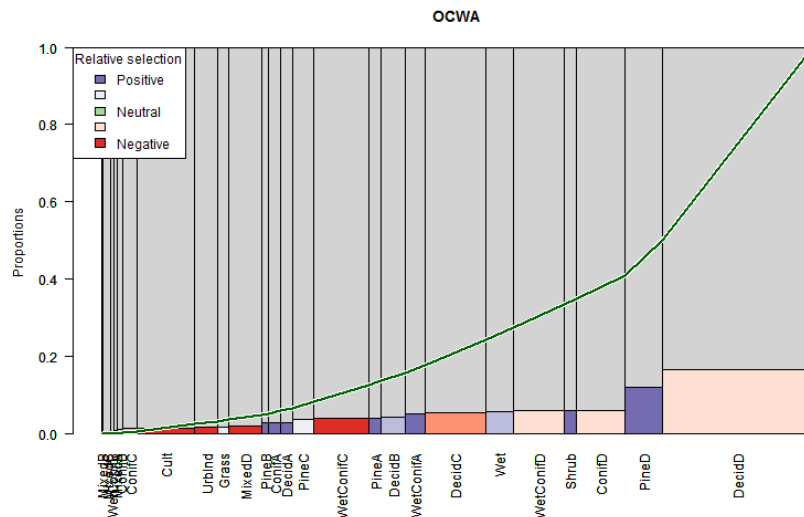
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.43.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

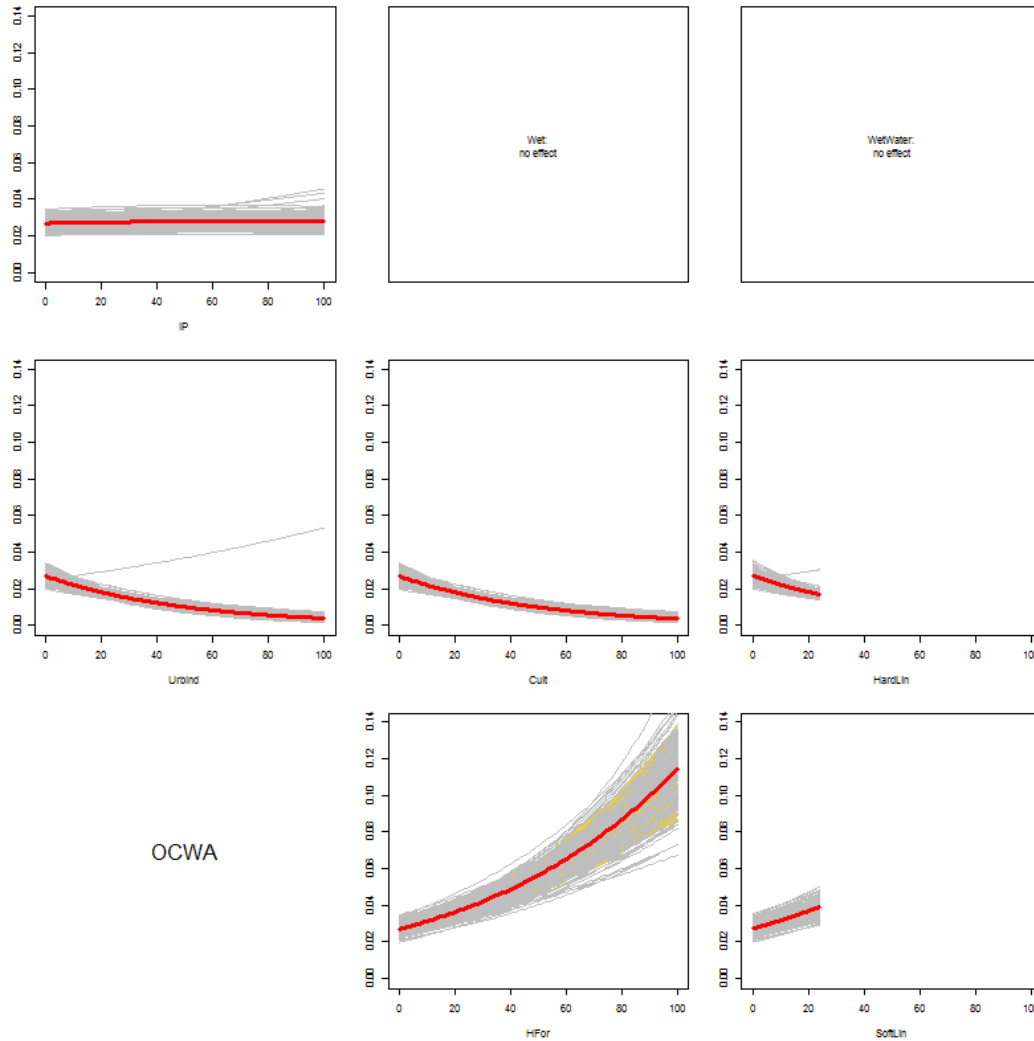


5.43.7 Relative habitat selection



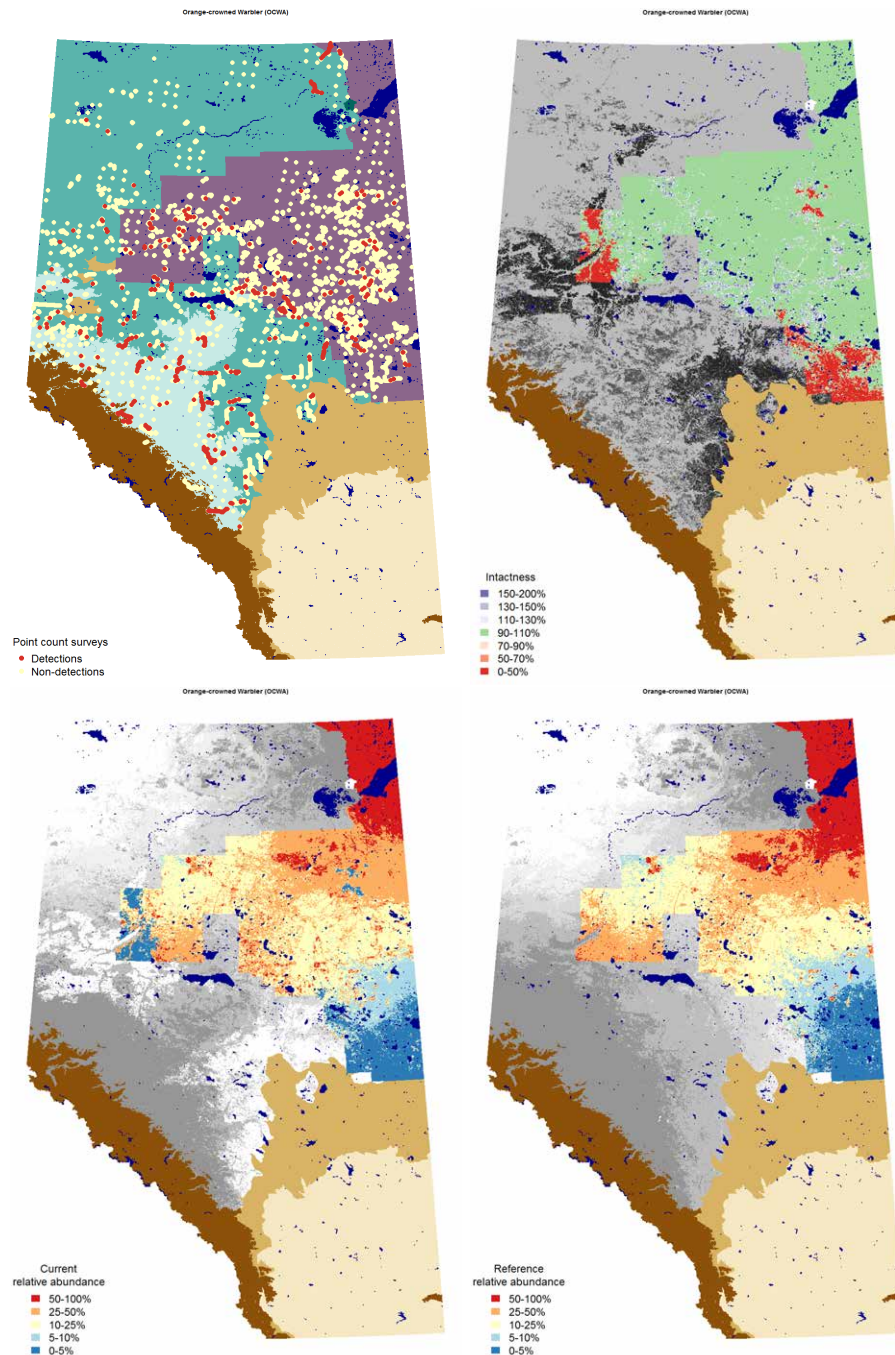
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.43.8 Quarter-section level responses



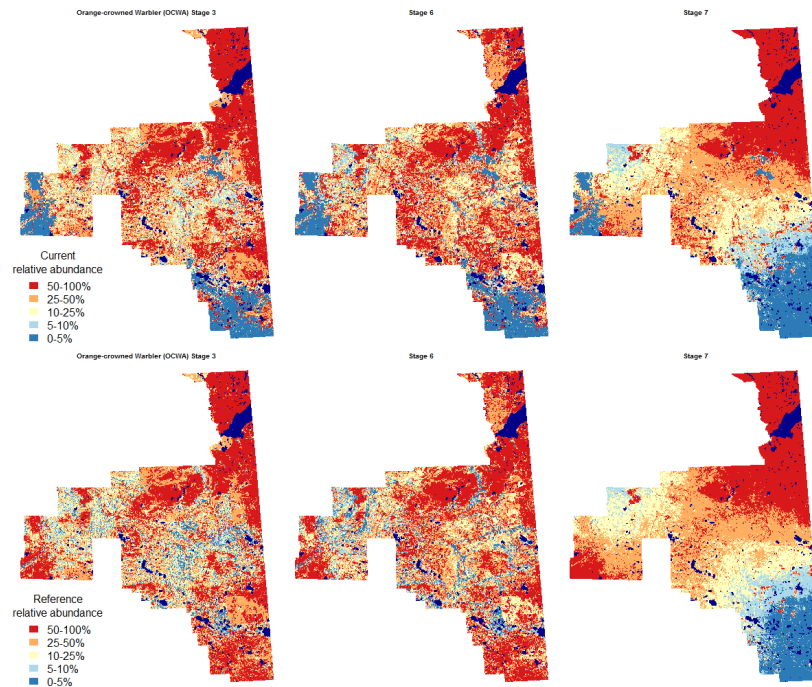
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.43.9 Maps



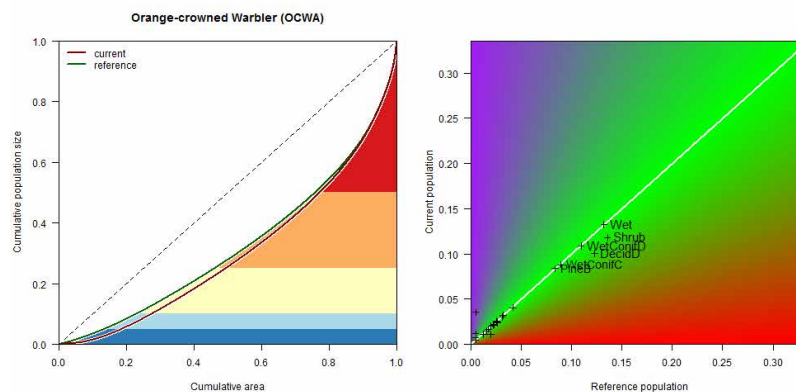
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.43.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.43.11 Population concentration



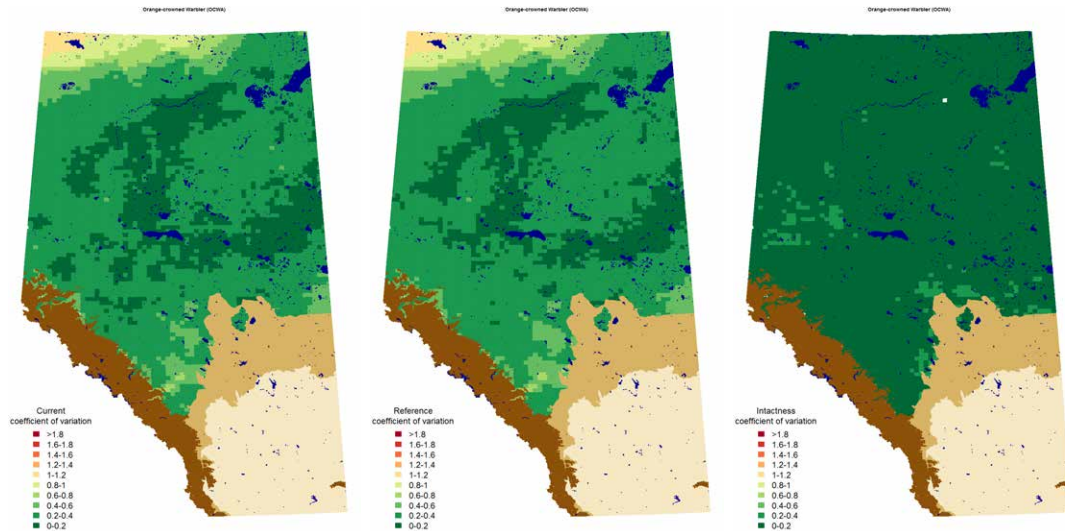
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.43.12 Potential population size

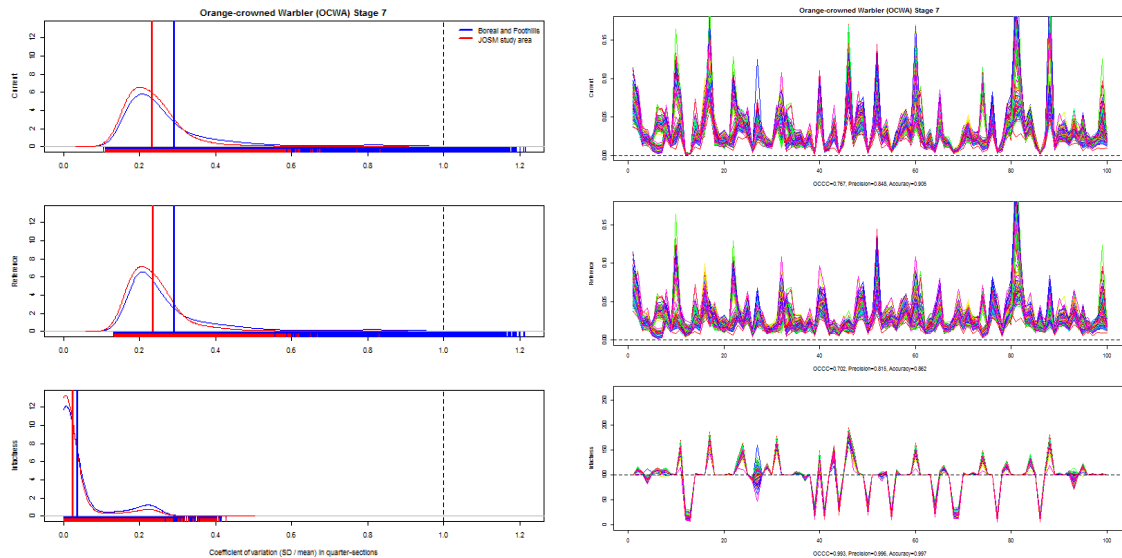
Estimated potential population size of Orange-crowned Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Shrub	0.0448	0.0374	0.0578	0.0512	0.0425	0.0672
Wet	0.0503	0.0419	0.0648	0.0500	0.0414	0.0656
DecidD	0.0380	0.0317	0.0490	0.0464	0.0385	0.0609
WetConifD	0.0413	0.0344	0.0532	0.0414	0.0343	0.0543
WetConifC	0.0334	0.0278	0.0430	0.0338	0.0280	0.0443
PineB	0.0317	0.0264	0.0409	0.0316	0.0262	0.0415
PineC	0.0154	0.0128	0.0199	0.0159	0.0131	0.0208
PineA	0.0122	0.0102	0.0157	0.0123	0.0102	0.0161
PineD	0.0115	0.0096	0.0148	0.0120	0.0100	0.0158
DecidC	0.0089	0.0074	0.0114	0.0101	0.0084	0.0133
ConifD	0.0094	0.0079	0.0122	0.0100	0.0083	0.0131
WetConifB	0.0097	0.0081	0.0125	0.0098	0.0081	0.0128
ConifA	0.0084	0.0070	0.0109	0.0088	0.0073	0.0115
ConifC	0.0079	0.0066	0.0102	0.0085	0.0070	0.0112
WetConifA	0.0077	0.0064	0.0100	0.0077	0.0063	0.0100
Grass	0.0040	0.0033	0.0052	0.0075	0.0062	0.0098
ConifB	0.0064	0.0053	0.0082	0.0067	0.0055	0.0088
MixedD	0.0057	0.0047	0.0073	0.0062	0.0051	0.0081
DecidB	0.0041	0.0034	0.0053	0.0047	0.0039	0.0062
DecidA	0.0011	0.0009	0.0015	0.0015	0.0013	0.0020
MixedB	0.0007	0.0005	0.0008	0.0007	0.0006	0.0009
MixedC	0.0004	0.0003	0.0005	0.0004	0.0004	0.0006
MixedA	0.0004	0.0003	0.0005	0.0004	0.0004	0.0006
Cult	0.0028	0.0023	0.0036	0.0000	0.0000	0.0000
UrbInd	0.0028	0.0023	0.0036	0.0000	0.0000	0.0000
HardLin	0.0005	0.0004	0.0007	0.0000	0.0000	0.0000
SoftLin	0.0044	0.0036	0.0056	0.0000	0.0000	0.0000
HFor	0.0134	0.0112	0.0173	0.0000	0.0000	0.0000
Total	0.3771	0.3144	0.4863	0.3775	0.3129	0.4953
Loss	0.0182	0.0135	0.0263			
Gain	0.0175	0.0132	0.0226			

5.43.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.43.14 Variable selection frequencies

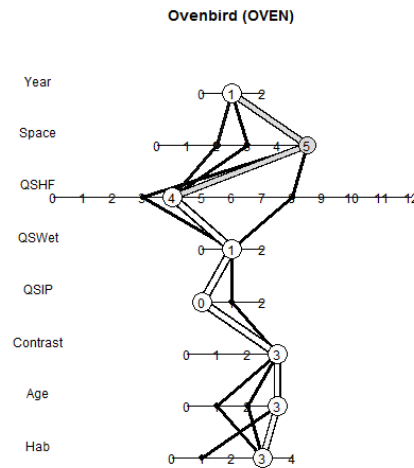
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	6.5	13	. + Habitat
1.2	77.0	154	. + HabitatB
1.3	4.0	8	. + Habitat + isHForC
1.4	12.5	25	. + HabitatB + isHForC
2.0	100.0	200	NULL
3.1	98.5	197	. + ROAD
3.3	1.5	3	. + ROAD + SoftLin_PC
4.0	97.5	195	NULL
4.1	2.5	5	. + Remn_QS
5.0	100.0	200	NULL
6.3	99.5	199	. + Succ_QS + Alien_QS
6.4	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS
7.3	66.5	133	. + xlat + xlong + xlat:xlong
7.5	33.5	67	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	15.0	30	. + xYEAR
8.2	85.0	170	. + YR5F

5.44 Ovenbird (*Seiurus aurocapilla*)

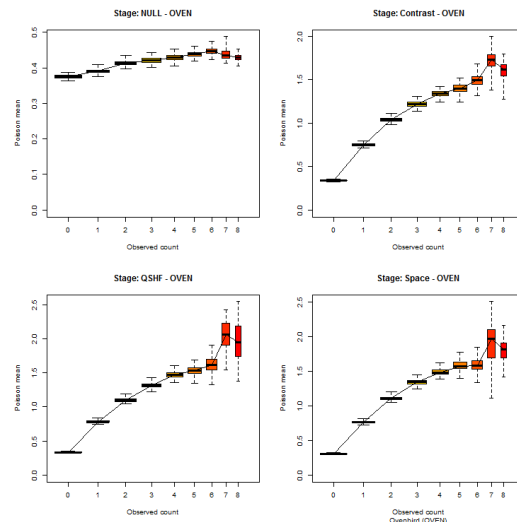
5.44.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

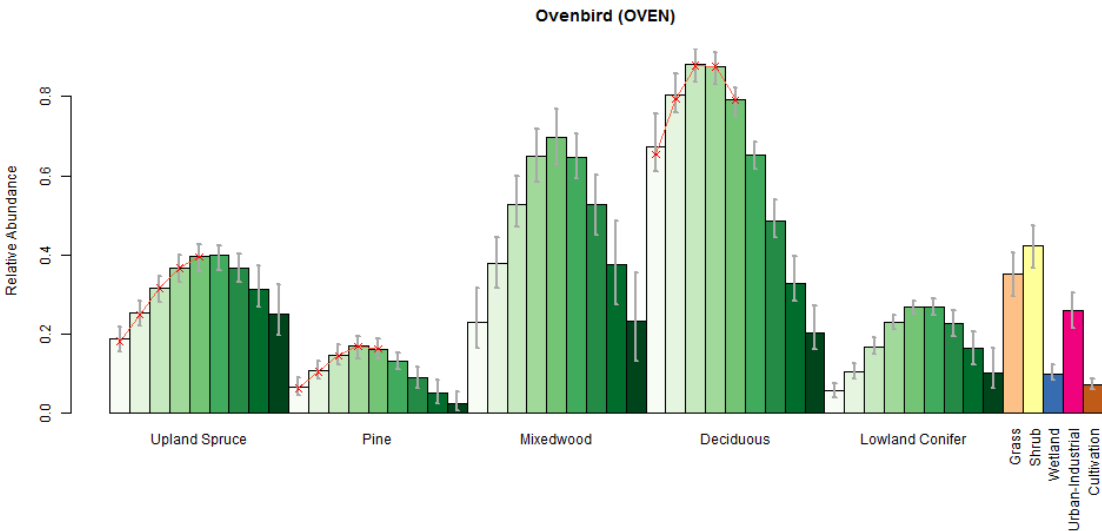


5.44.2 Cross validation

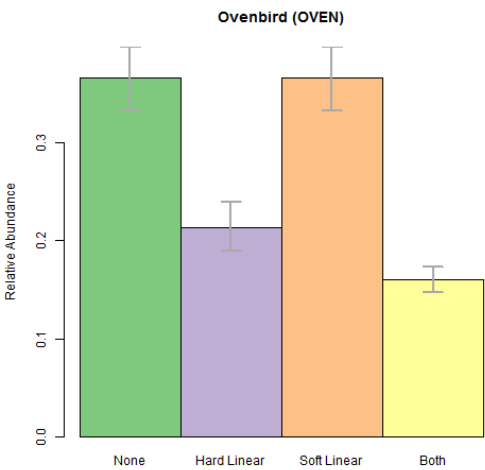
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.44.3 Point level habitat associations

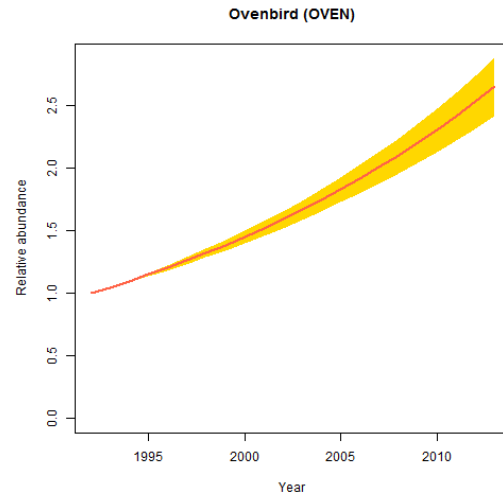


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

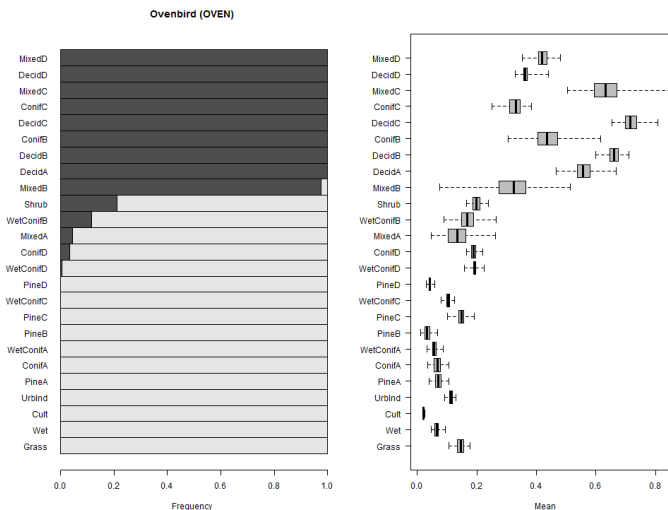


5.44.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



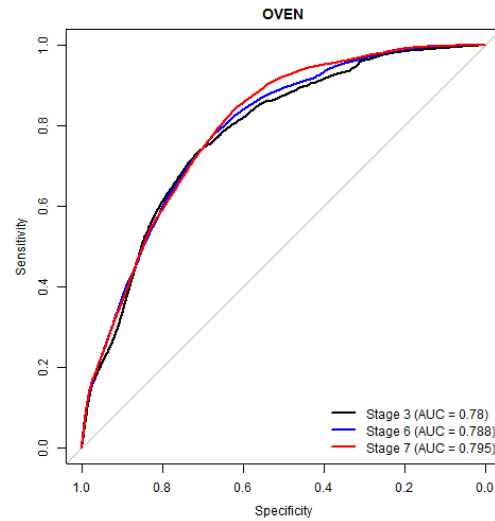
5.44.5 Habitat suitability ranking for patch delineation



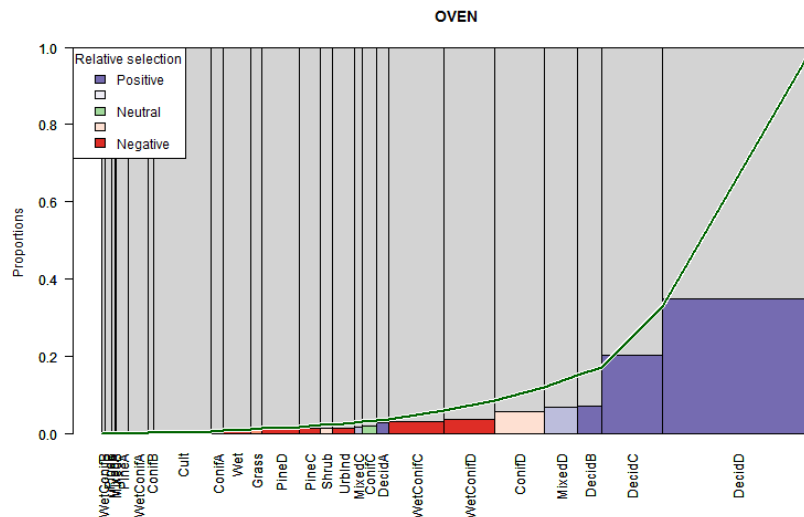
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.44.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

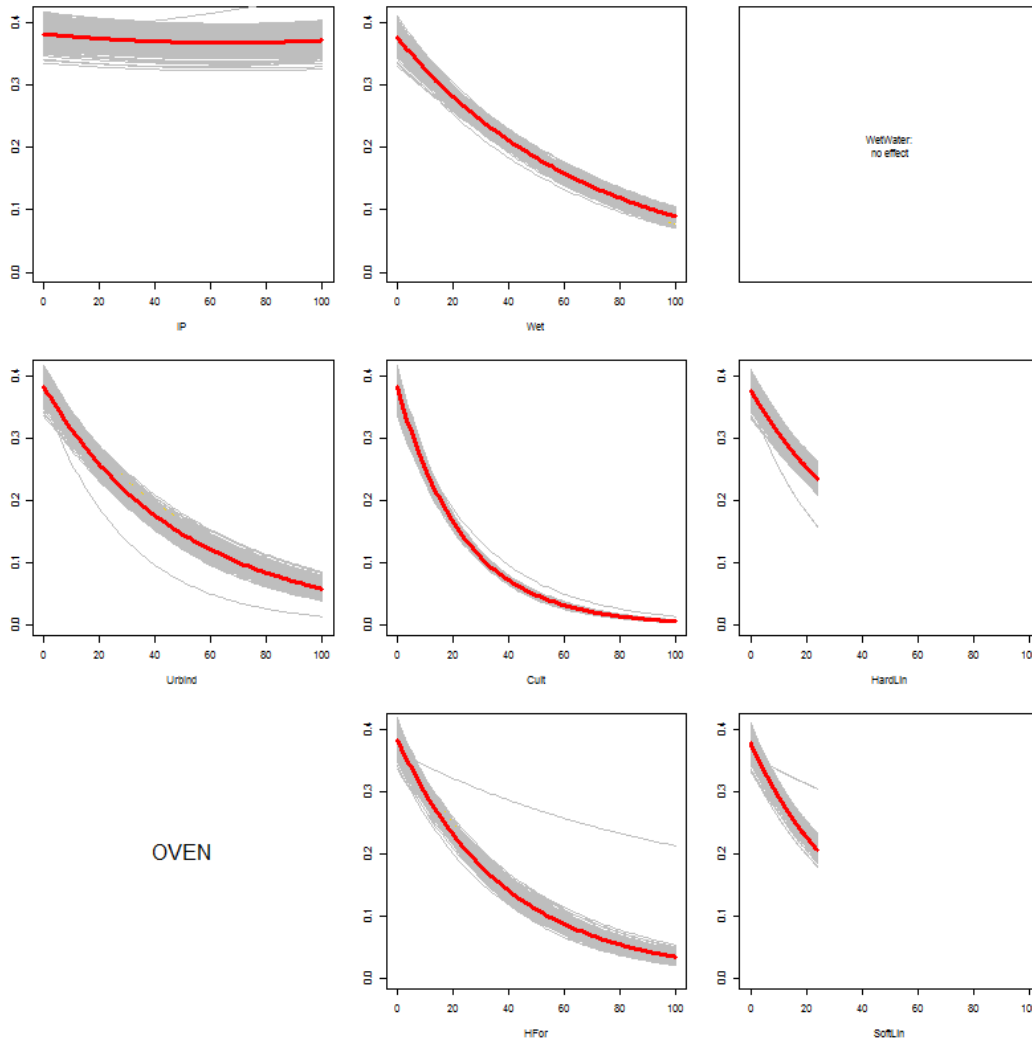


5.44.7 Relative habitat selection



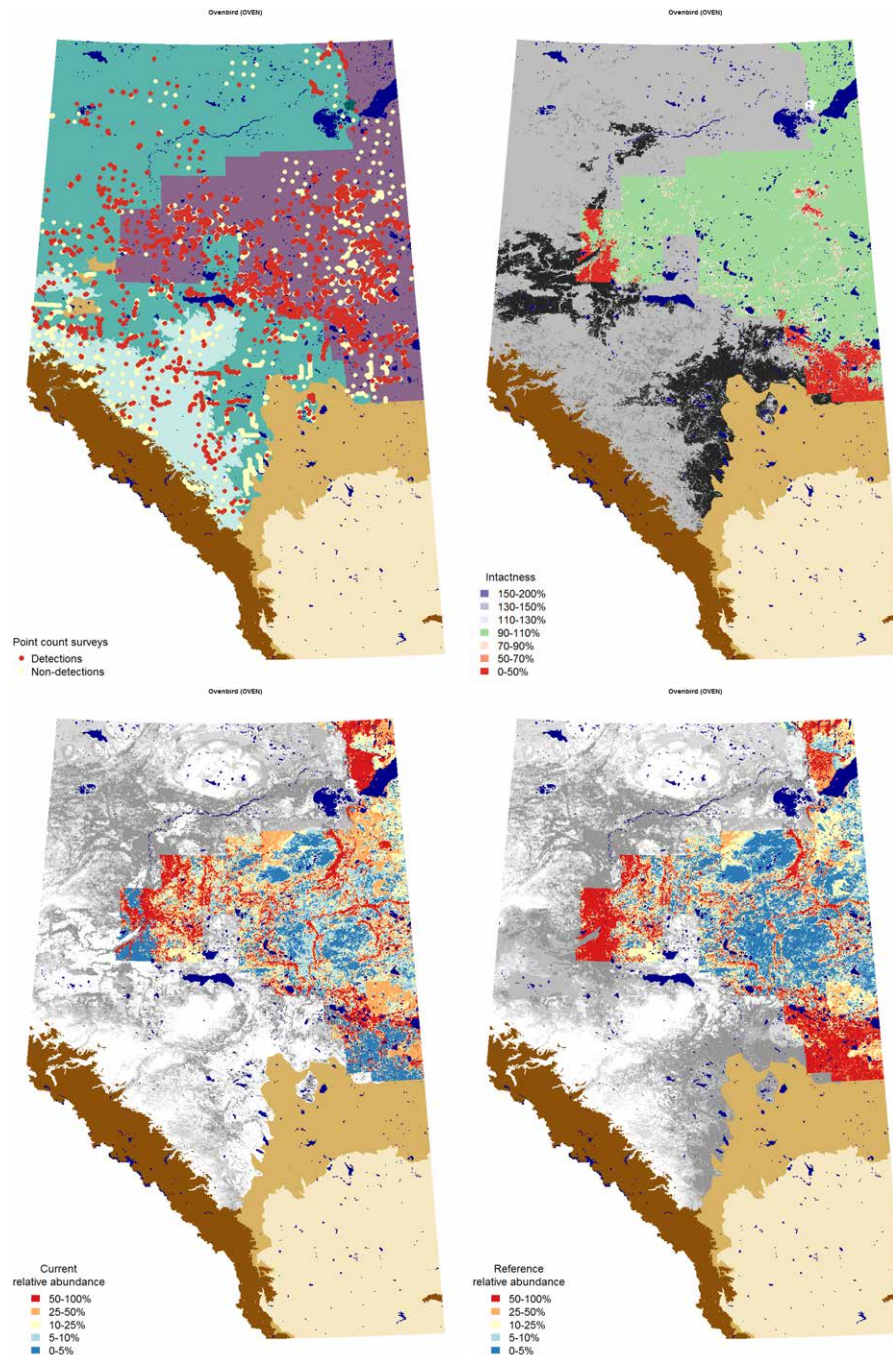
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.44.8 Quarter-section level responses



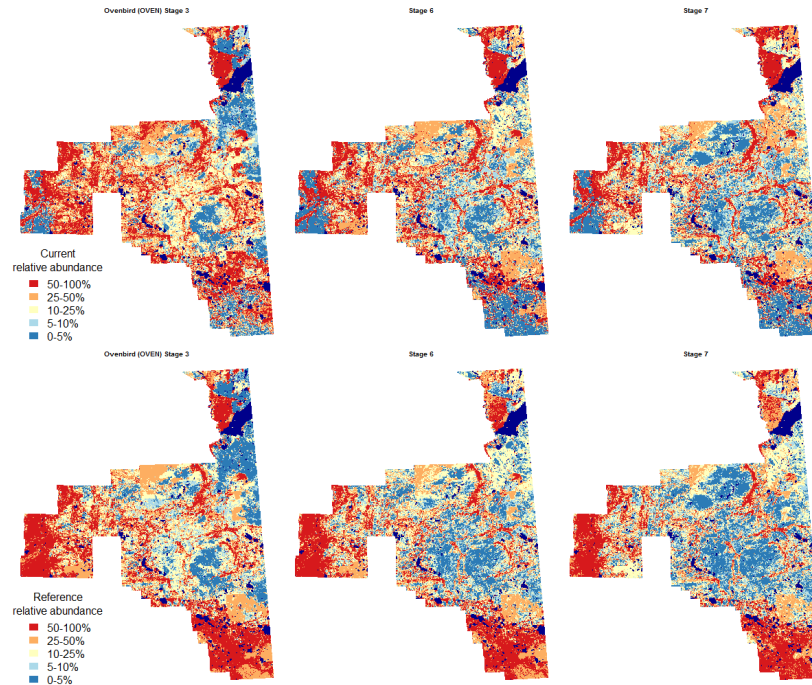
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.44.9 Maps



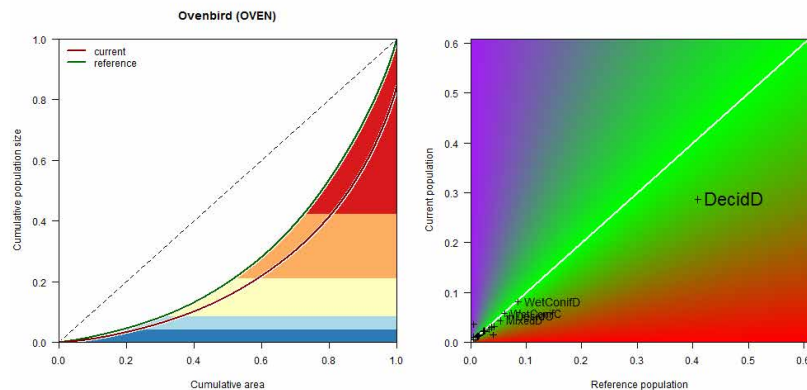
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.44.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSH study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSH area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.44.11 Population concentration



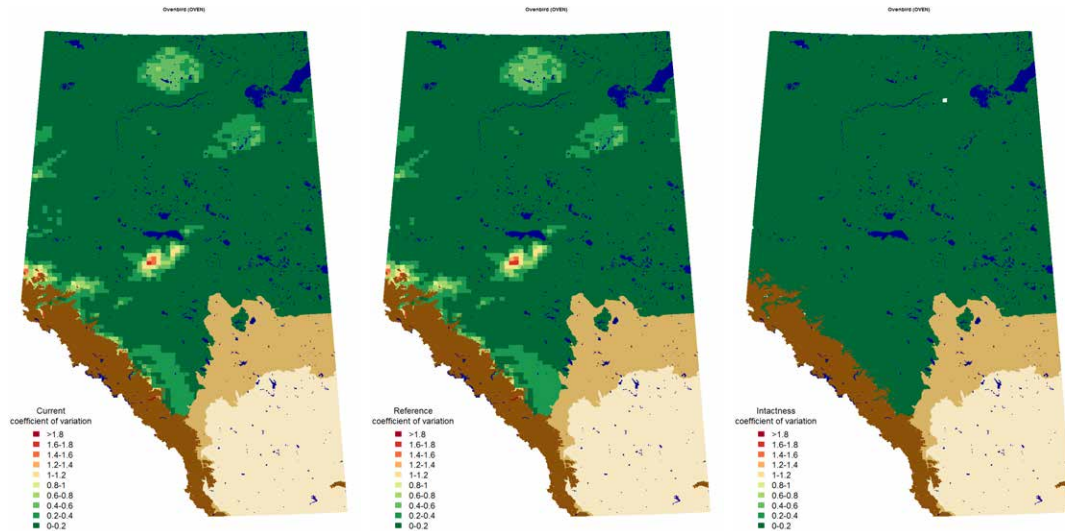
Lorenz curves (left) based on 10% of the quarter-sections in the JOSH study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.44.12 Potential population size

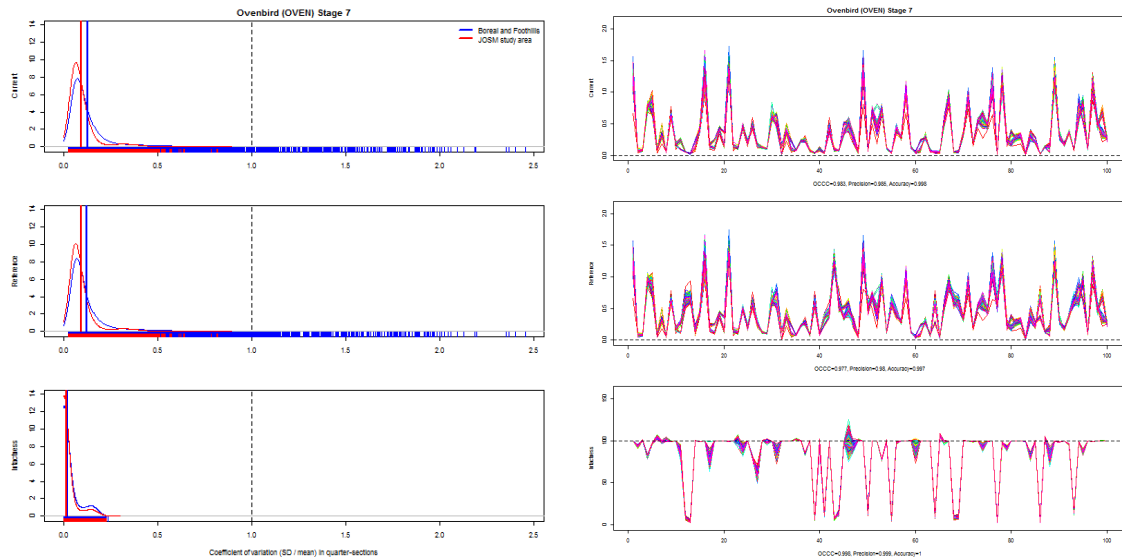
Estimated potential population size of Ovenbird in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	1.8859	1.8089	1.9730	2.6575	2.5393	2.7783
WetConifD	0.5288	0.5072	0.5532	0.5575	0.5327	0.5828
DecidC	0.3468	0.3326	0.3628	0.4576	0.4372	0.4784
WetConifC	0.3765	0.3611	0.3939	0.3961	0.3785	0.4141
MixedD	0.2833	0.2717	0.2964	0.3481	0.3326	0.3639
Shrub	0.2094	0.2009	0.2191	0.2740	0.2618	0.2864
Grass	0.0939	0.0900	0.0982	0.2665	0.2546	0.2786
ConifD	0.1983	0.1902	0.2075	0.2439	0.2331	0.2550
DecidB	0.1766	0.1694	0.1847	0.2211	0.2113	0.2311
ConifC	0.1474	0.1414	0.1542	0.1702	0.1626	0.1779
Wet	0.1532	0.1470	0.1603	0.1591	0.1520	0.1663
PineB	0.1448	0.1389	0.1515	0.1442	0.1378	0.1508
PineC	0.0929	0.0891	0.0972	0.1003	0.0959	0.1049
ConifB	0.0945	0.0907	0.0989	0.0998	0.0953	0.1043
ConifA	0.0824	0.0790	0.0862	0.0877	0.0838	0.0917
PineD	0.0740	0.0710	0.0774	0.0808	0.0772	0.0844
WetConifB	0.0672	0.0645	0.0703	0.0683	0.0652	0.0714
DecidA	0.0329	0.0316	0.0345	0.0526	0.0503	0.0550
WetConifA	0.0339	0.0325	0.0354	0.0346	0.0330	0.0361
PineA	0.0324	0.0310	0.0339	0.0326	0.0311	0.0341
MixedB	0.0186	0.0179	0.0195	0.0204	0.0195	0.0213
MixedC	0.0145	0.0139	0.0152	0.0170	0.0162	0.0177
MixedA	0.0061	0.0059	0.0064	0.0081	0.0078	0.0085
Cult	0.0713	0.0684	0.0746	0.0000	0.0000	0.0000
UrbInd	0.0661	0.0634	0.0692	0.0000	0.0000	0.0000
HardLin	0.0024	0.0023	0.0025	0.0000	0.0000	0.0000
SoftLin	0.0160	0.0154	0.0168	0.0000	0.0000	0.0000
HFor	0.2361	0.2264	0.2469	0.0000	0.0000	0.0000
Total	5.4864	5.2623	5.7396	6.4977	6.2087	6.7931
Loss	1.0541	0.9155	1.1492			
Gain	0.0399	0.0313	0.0500			

5.44.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.44.14 Variable selection frequencies

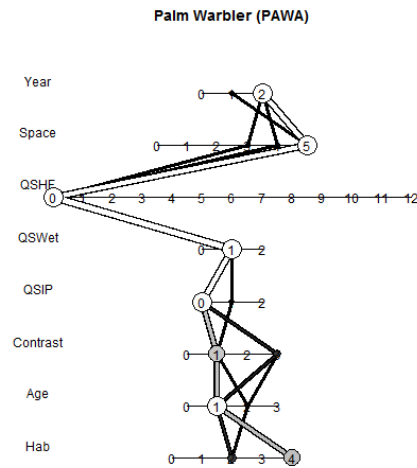
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	2.5	5	. + Habitat
1.3	97.5	195	. + Habitat + isHForC
2.1	1.5	3	. + Age
2.2	0.5	1	. + Age + Age2
			. + Age + Age2 + Age:isMix + Age:isPine
2.3	98.0	196	+ Age:isUplConif + Age:isWetConif +
			Age2:isMix + Age2:isPine + Age2:isUplConif
			+ Age2:isWetConif
3.3	100.0	200	. + ROAD + SoftLin_PC
4.0	99.0	198	NULL
4.1	1.0	2	. + Remn_QS
5.1	100.0	200	. + pWet_QS
6.3	0.5	1	. + Succ_QS + Alien_QS
6.4	99.0	198	. + Succ_QS + Noncult_QS + Cult_QS
6.8	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
7.2	13.0	26	. + xlat + xlong
7.3	1.0	2	. + xlat + xlong + xlat:xlong
7.5	86.0	172	. + xMAP + xPET + xMAT + xCMD +
			xMAP:xPET + xMAT:xCMD
8.1	100.0	200	. + xYEAR

5.45 Palm Warbler (*Setophaga palmarum*)

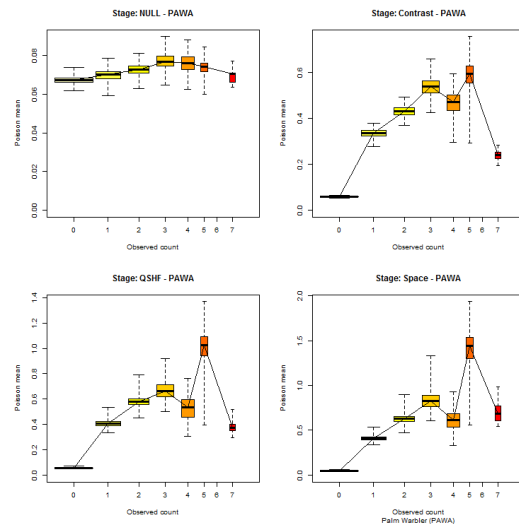
5.45.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

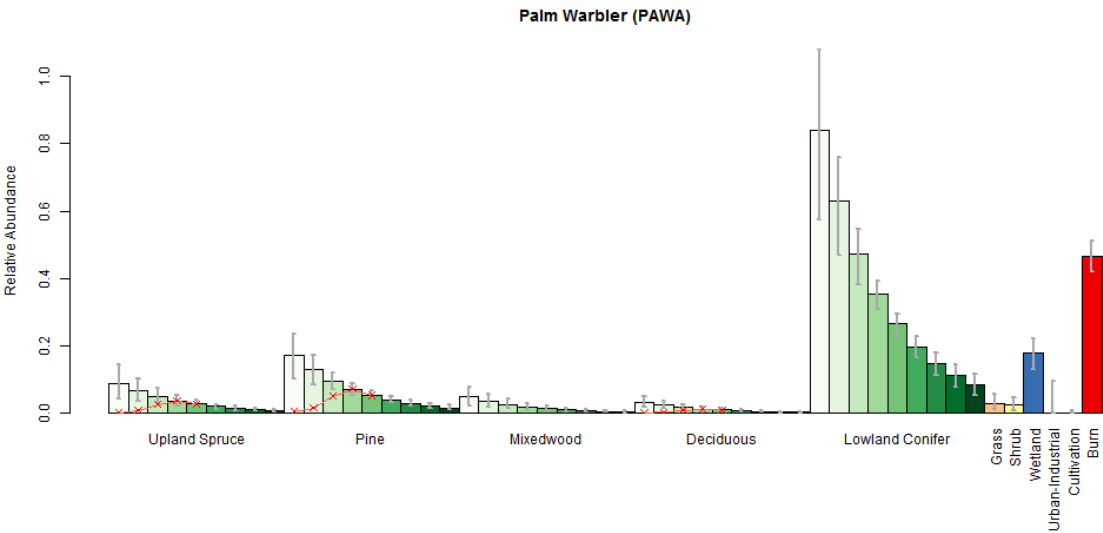


5.45.2 Cross validation

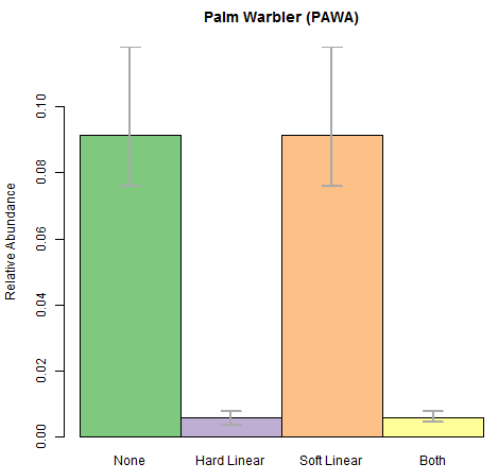
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.45.3 Point level habitat associations

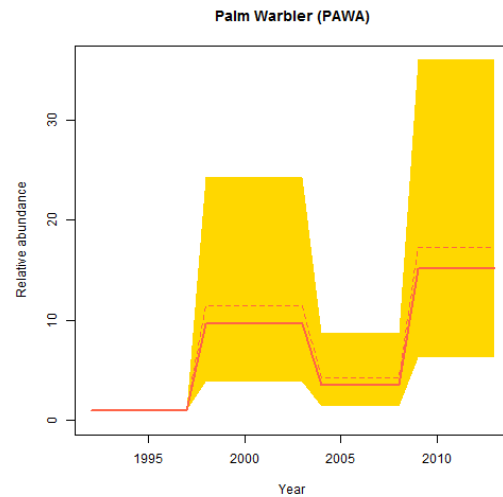


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

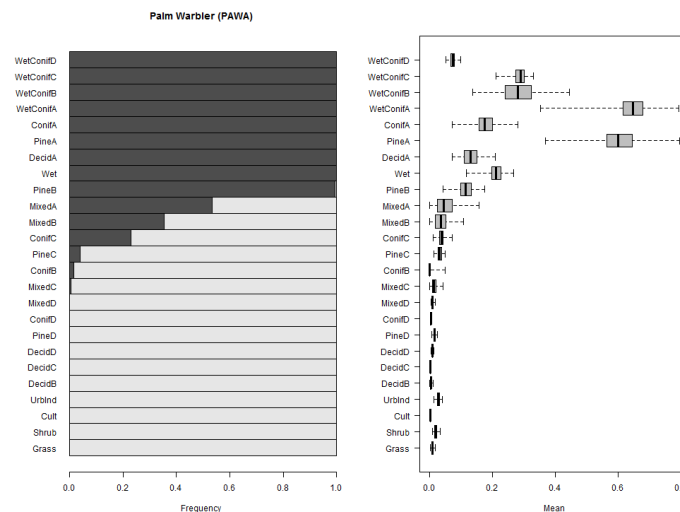


5.45.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



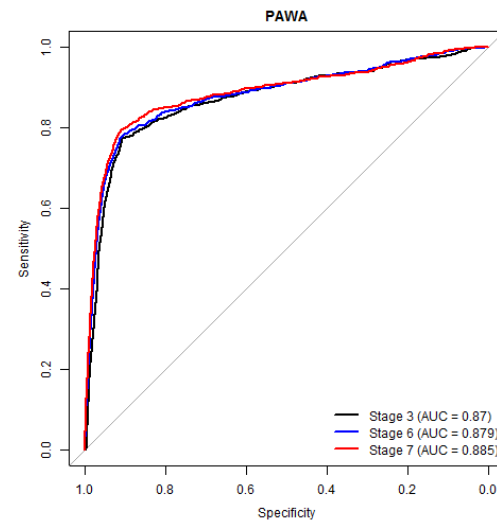
5.45.5 Habitat suitability ranking for patch delineation



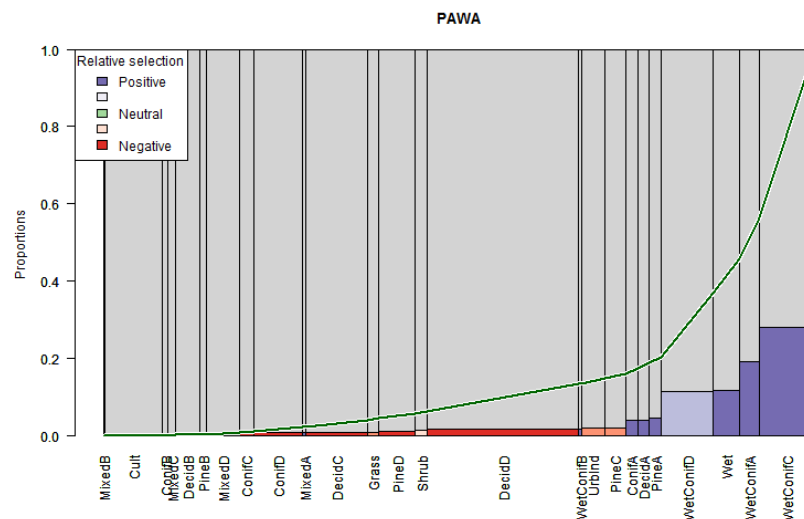
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.45.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

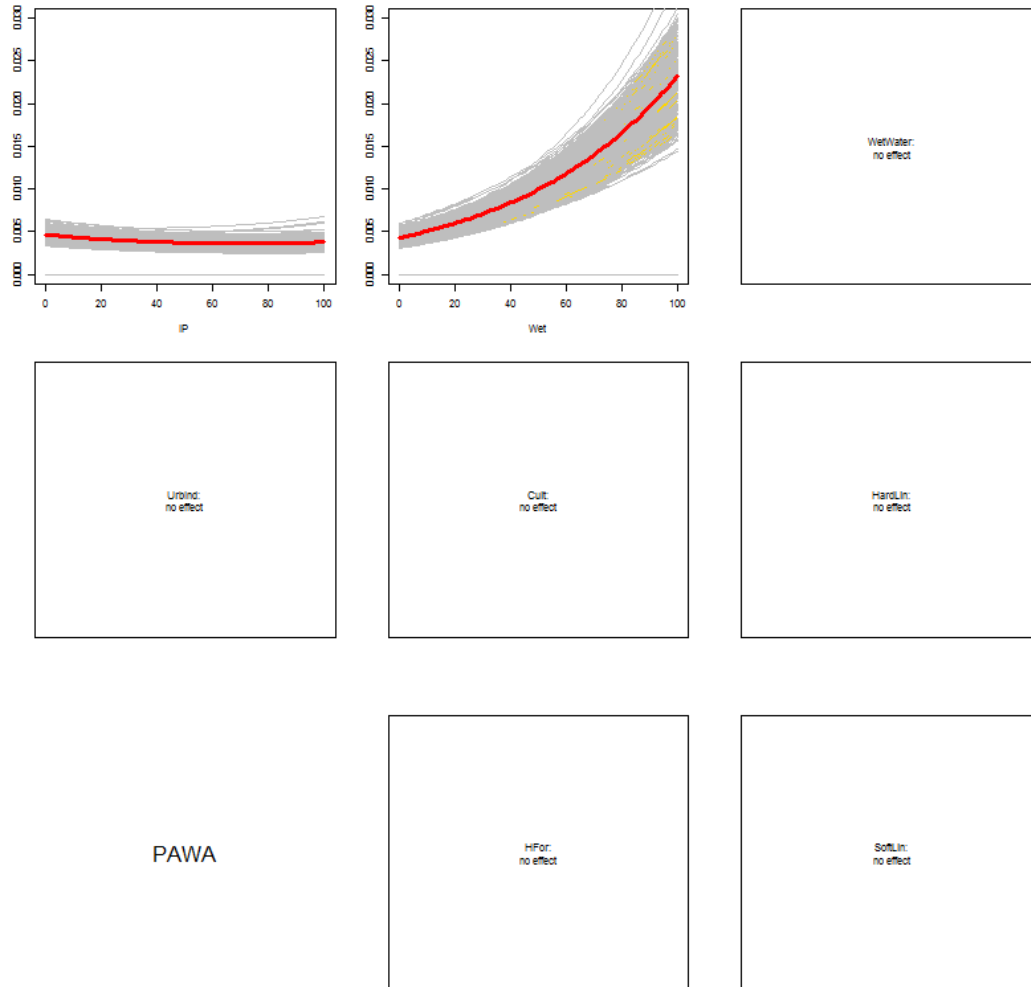


5.45.7 Relative habitat selection



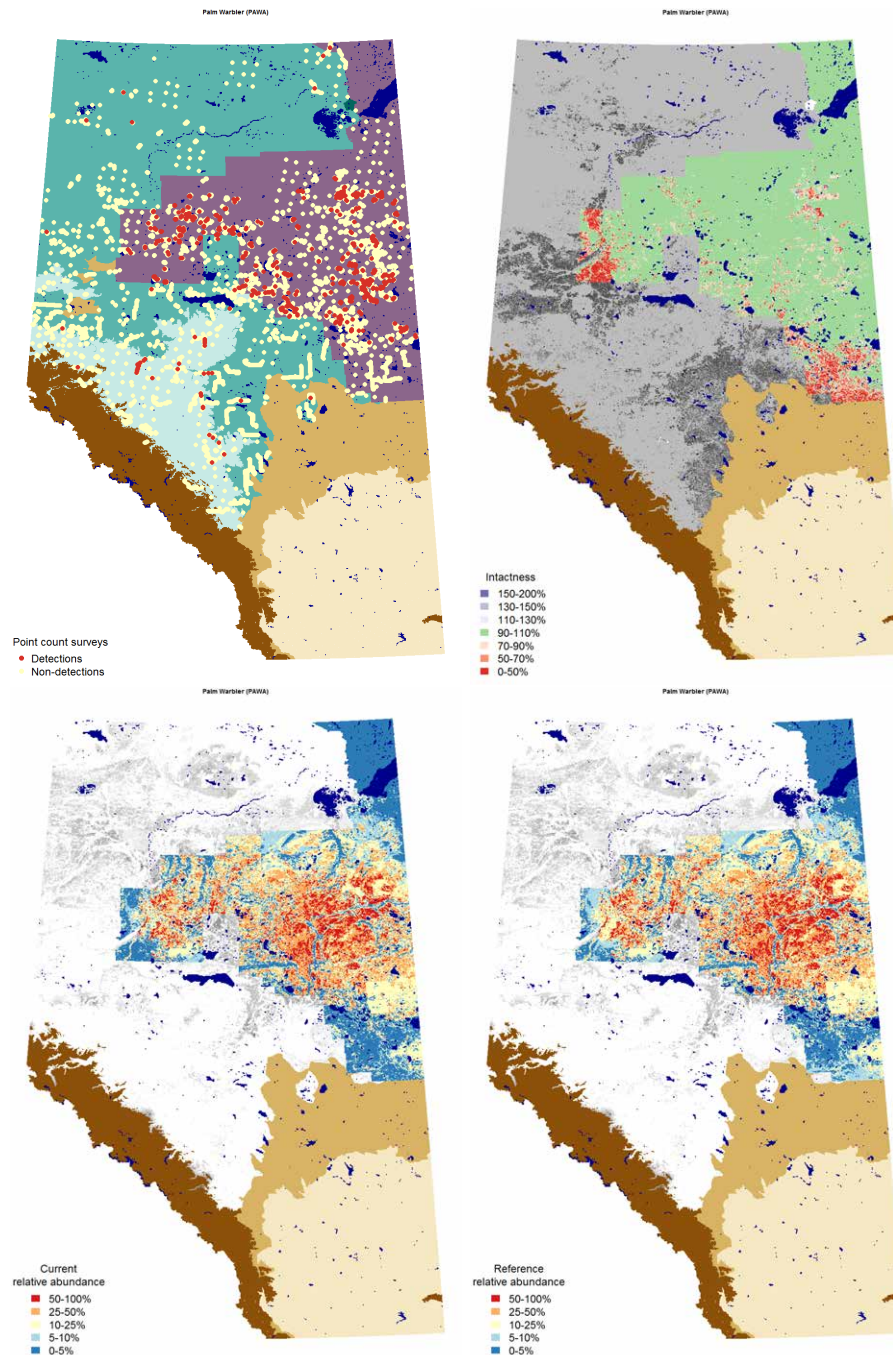
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.45.8 Quarter-section level responses



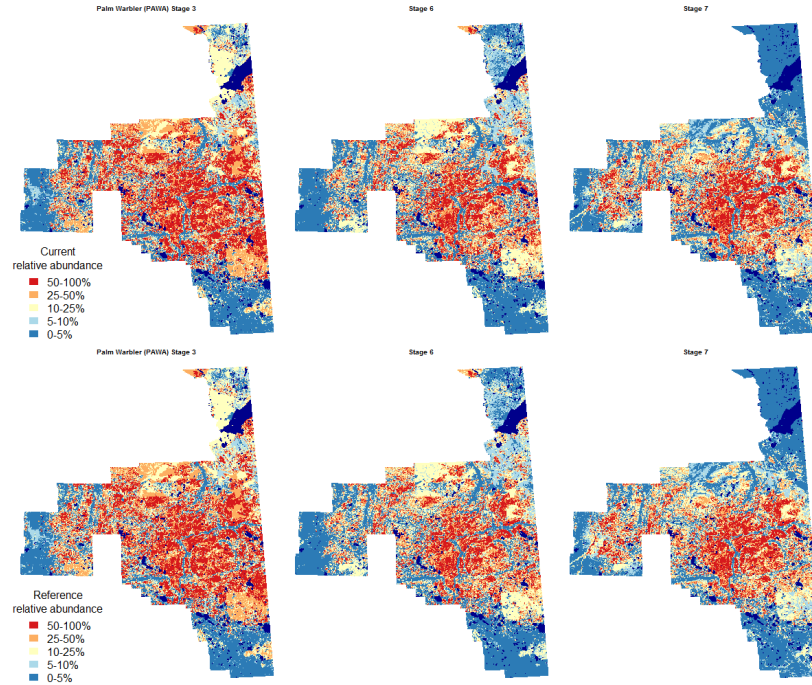
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.45.9 Maps



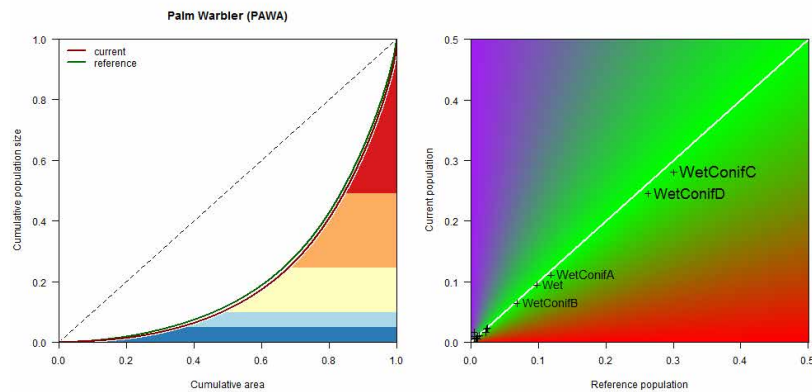
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.45.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.45.11 Population concentration



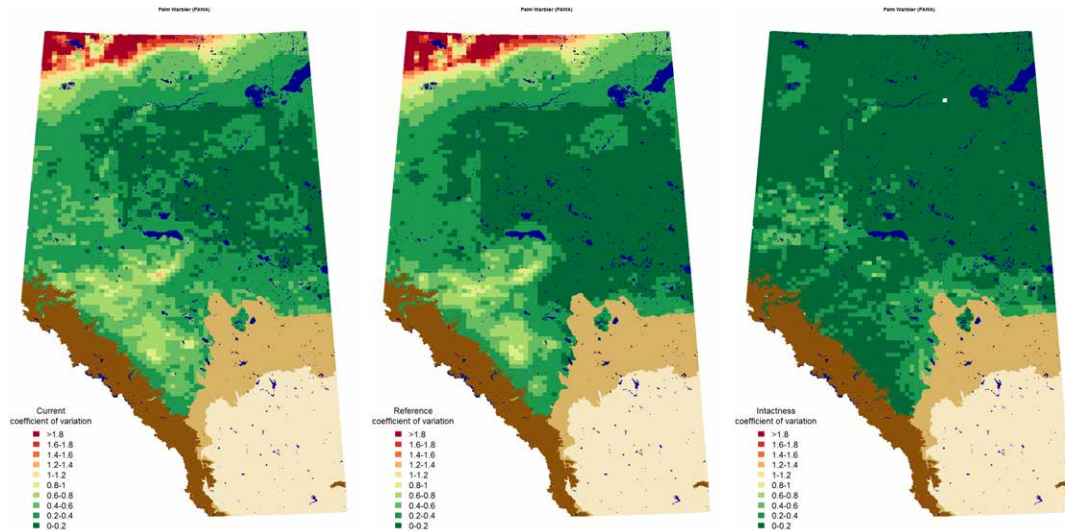
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.45.12 Potential population size

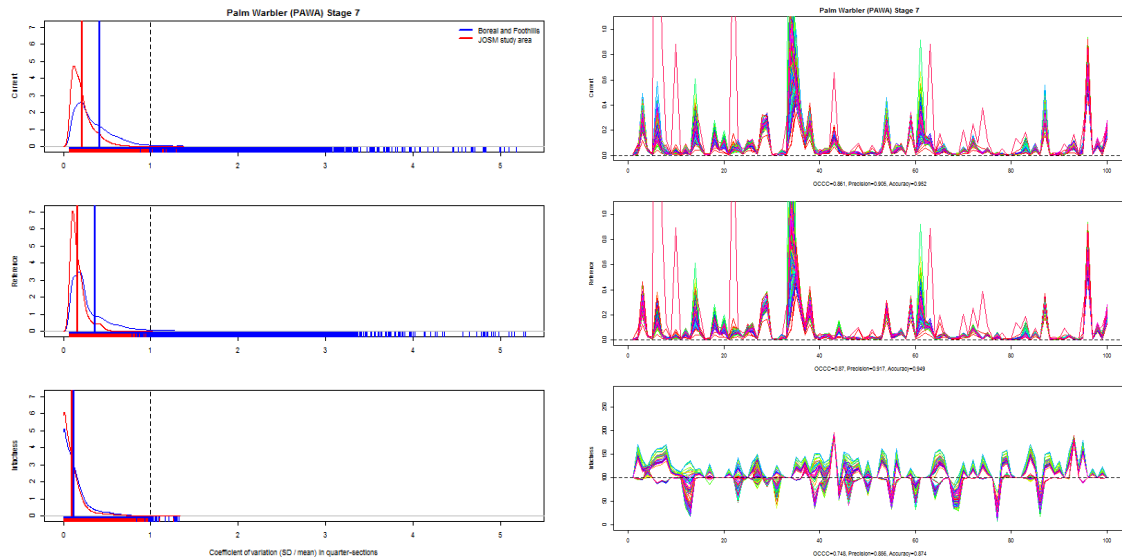
Estimated potential population size of Palm Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifC	0.7128	0.6290	0.8895	0.7451	0.6473	0.8397
WetConifD	0.6230	0.5497	0.7774	0.6496	0.5644	0.7322
WetConifA	0.2824	0.2492	0.3524	0.2942	0.2556	0.3316
Wet	0.2408	0.2124	0.3004	0.2432	0.2113	0.2741
WetConifB	0.1638	0.1445	0.2044	0.1694	0.1472	0.1909
PineC	0.0581	0.0513	0.0725	0.0632	0.0549	0.0712
PineB	0.0573	0.0506	0.0715	0.0573	0.0498	0.0645
DecidD	0.0417	0.0368	0.0521	0.0556	0.0483	0.0627
PineD	0.0293	0.0259	0.0366	0.0320	0.0278	0.0360
Grass	0.0115	0.0102	0.0144	0.0265	0.0230	0.0298
PineA	0.0237	0.0209	0.0296	0.0251	0.0218	0.0282
Shrub	0.0142	0.0126	0.0178	0.0215	0.0186	0.0242
ConifC	0.0166	0.0147	0.0208	0.0196	0.0171	0.0221
ConifD	0.0154	0.0136	0.0192	0.0185	0.0160	0.0208
ConifA	0.0117	0.0103	0.0146	0.0145	0.0126	0.0164
MixedD	0.0101	0.0089	0.0126	0.0123	0.0107	0.0139
DecidC	0.0069	0.0061	0.0086	0.0094	0.0082	0.0106
ConifB	0.0056	0.0050	0.0070	0.0070	0.0061	0.0079
DecidB	0.0044	0.0039	0.0055	0.0061	0.0053	0.0068
DecidA	0.0018	0.0016	0.0022	0.0027	0.0024	0.0031
MixedA	0.0010	0.0009	0.0013	0.0015	0.0013	0.0017
MixedB	0.0007	0.0006	0.0009	0.0009	0.0008	0.0010
MixedC	0.0005	0.0005	0.0007	0.0007	0.0006	0.0008
Cult	0.0054	0.0047	0.0067	0.0000	0.0000	0.0000
UrbInd	0.0257	0.0227	0.0321	0.0000	0.0000	0.0000
HardLin	0.0003	0.0003	0.0004	0.0000	0.0000	0.0000
SoftLin	0.0409	0.0361	0.0511	0.0000	0.0000	0.0000
HFor	0.0083	0.0074	0.0104	0.0000	0.0000	0.0000
Total	2.4143	2.1303	3.0126	2.4758	2.1510	2.7903
Loss	0.1303	0.0317	0.1636			
Gain	0.0107	0.0063	0.5888			

5.45.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.45.14 Variable selection frequencies

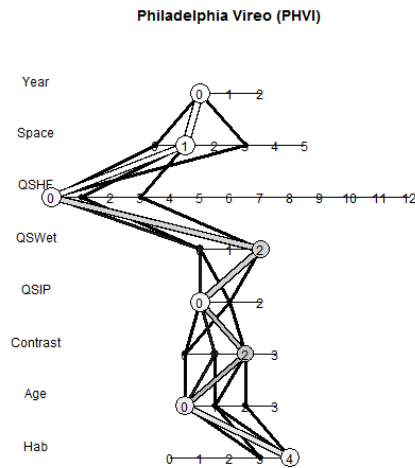
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	25.0	50	. + HabitatB
1.4	75.0	150	. + HabitatB + isHForC
2.1	97.5	195	. + Age
2.2	2.5	5	. + Age + Age2
3.1	78.0	156	. + ROAD
3.3	22.0	44	. + ROAD + SoftLin_PC
4.0	98.0	196	NULL
4.1	2.0	4	. + Remn_QS
5.1	100.0	200	. + pWet_QS
6.0	100.0	200	NULL
7.3	0.5	1	. + xlat + xlong + xlat:xlong
7.4	0.5	1	. + xMAP + xPET + xMAT + xCMD
7.5	99.0	198	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	0.5	1	. + xYEAR
8.2	99.5	199	. + YR5F

5.46 Philadelphia Vireo (*Vireo philadelphicus*)

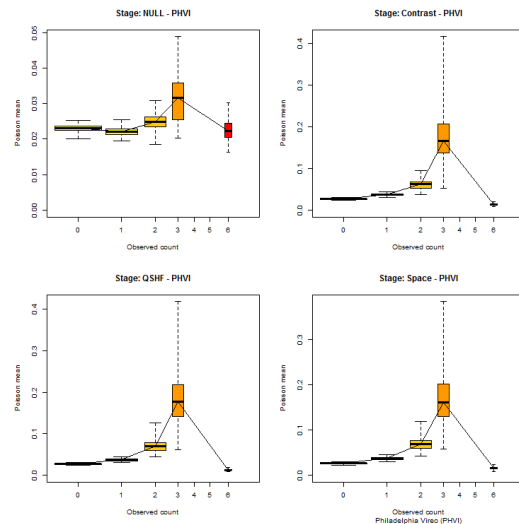
5.46.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

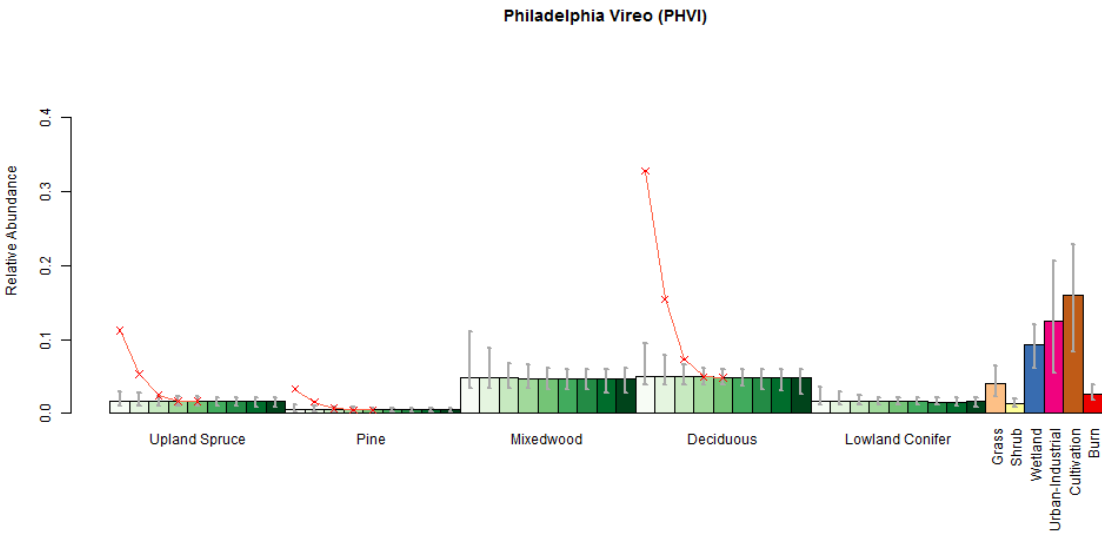


5.46.2 Cross validation

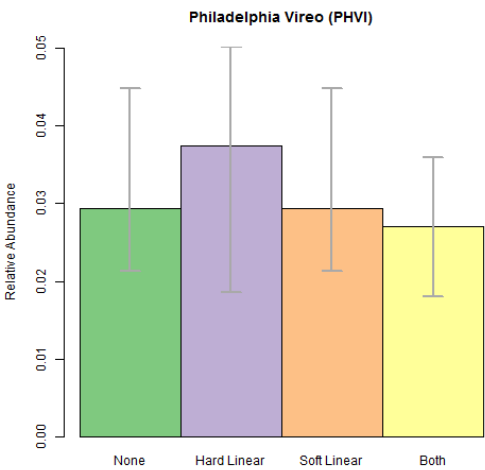
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.46.3 Point level habitat associations

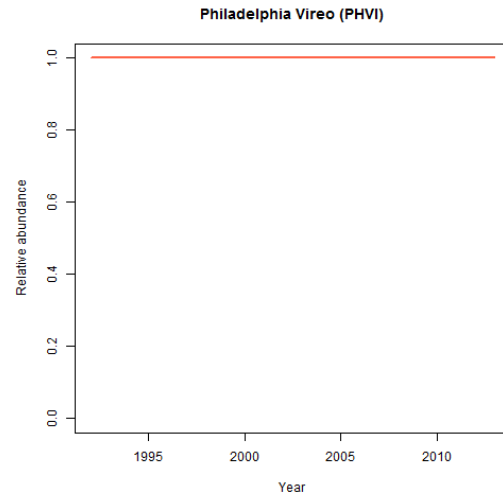


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

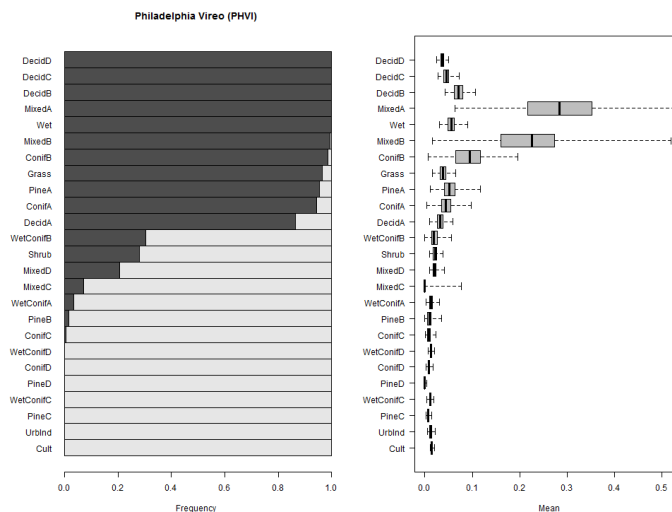


5.46.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



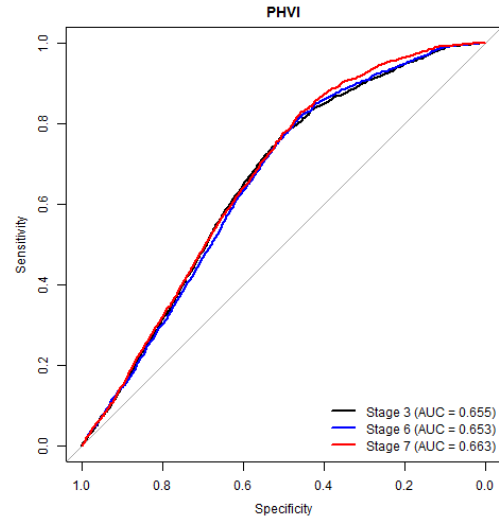
5.46.5 Habitat suitability ranking for patch delineation



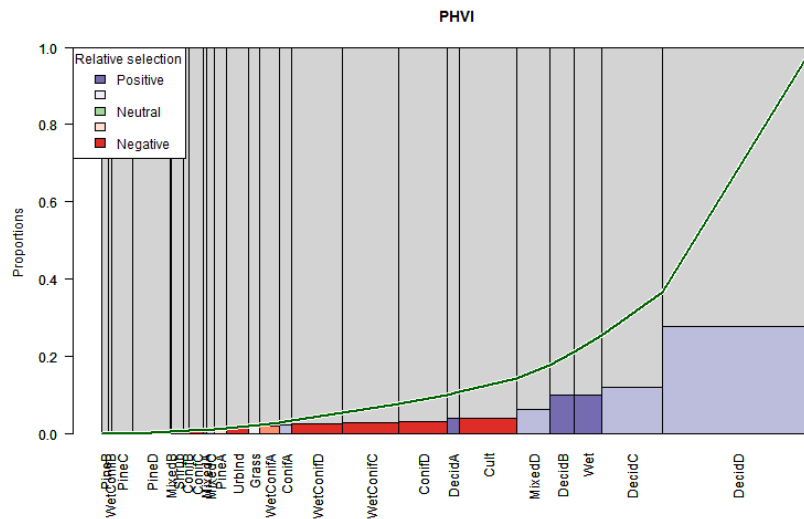
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.46.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

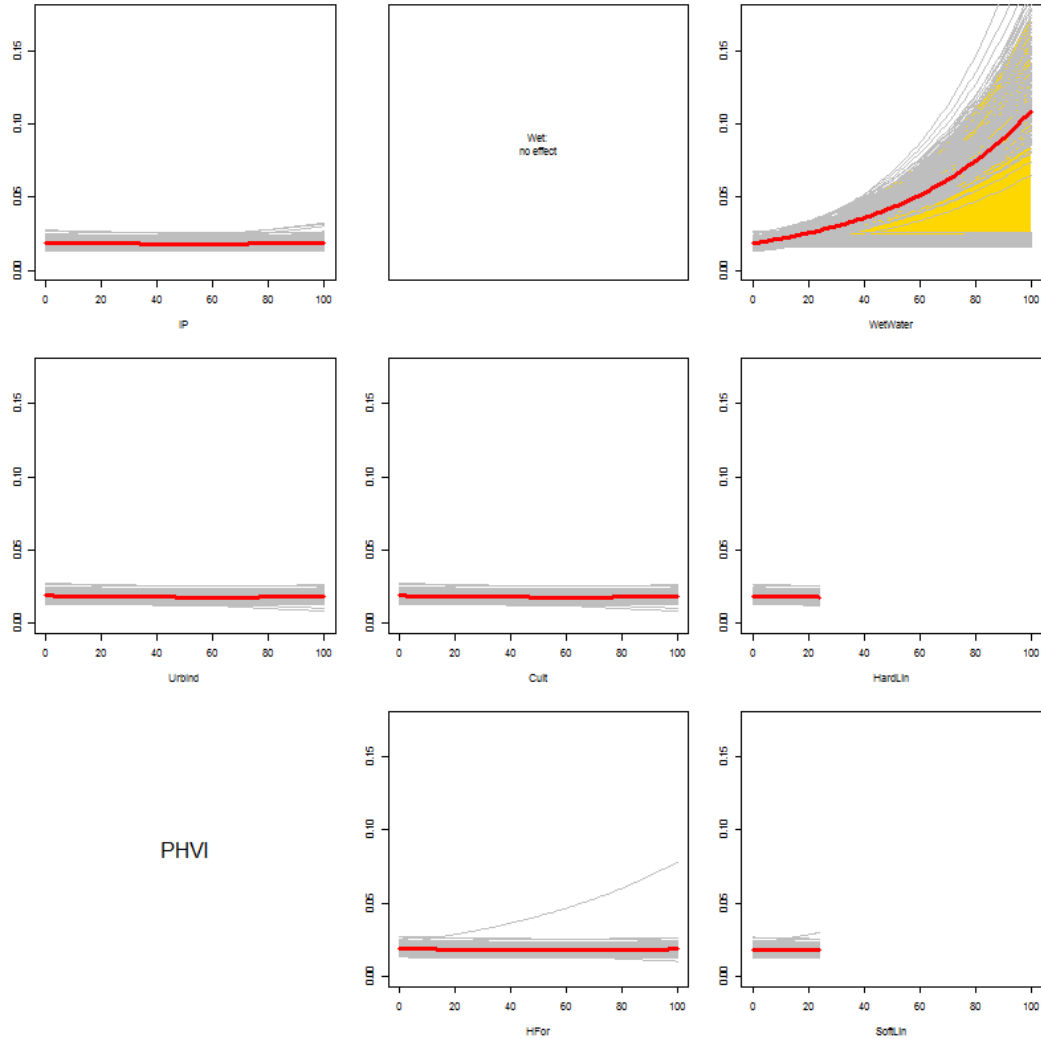


5.46.7 Relative habitat selection



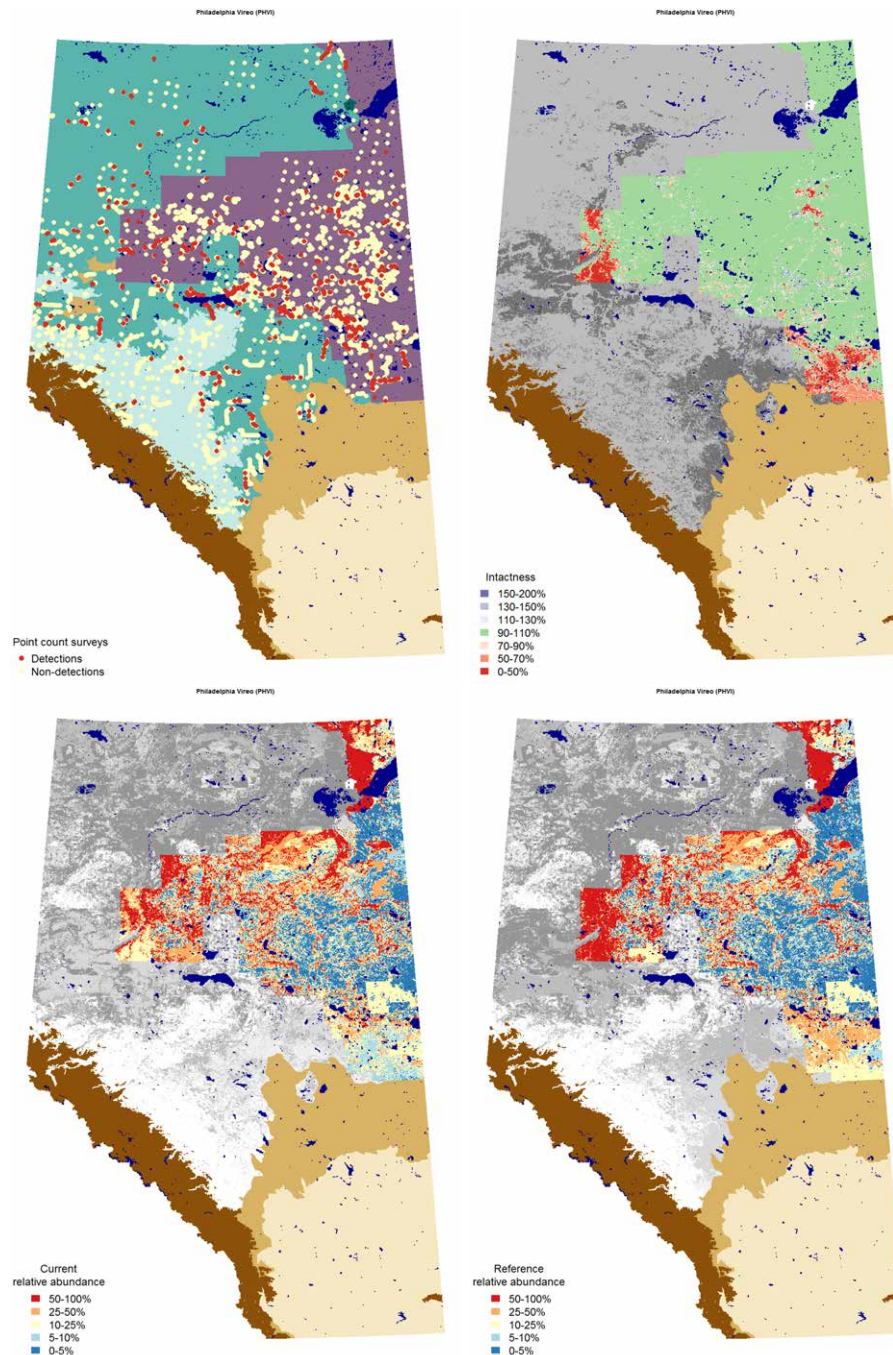
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.46.8 Quarter-section level responses



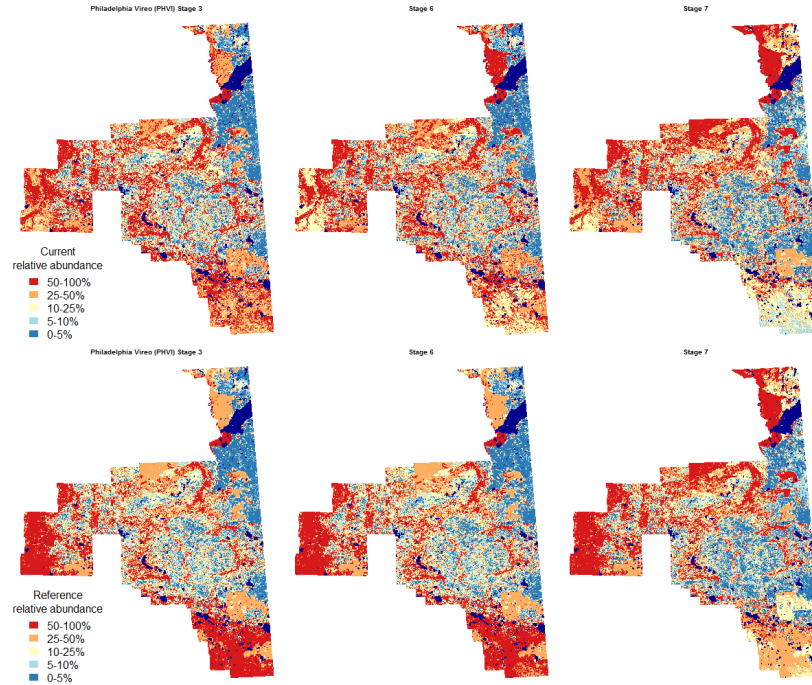
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.46.9 Maps



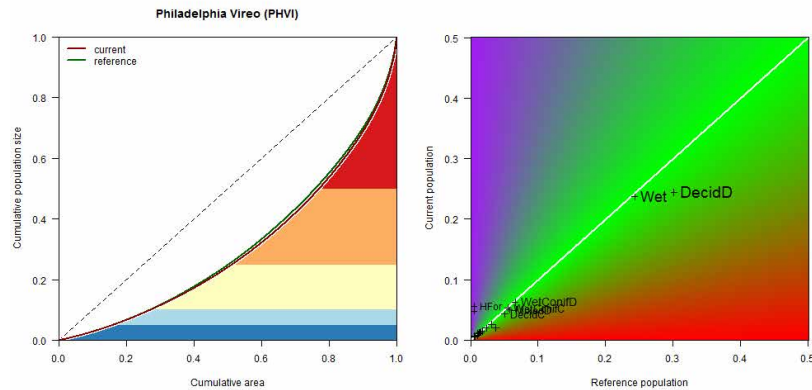
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.46.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.46.11 Population concentration



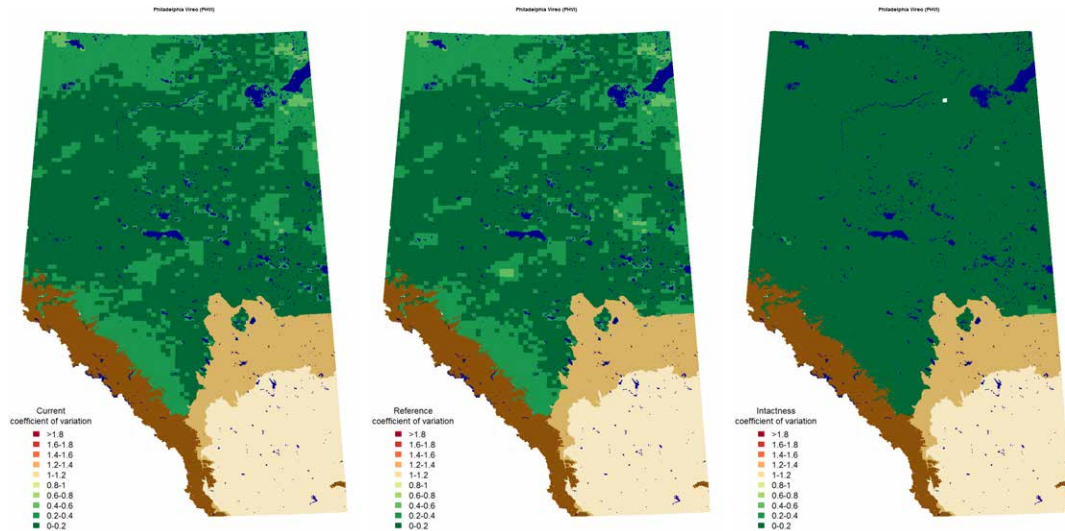
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.46.12 Potential population size

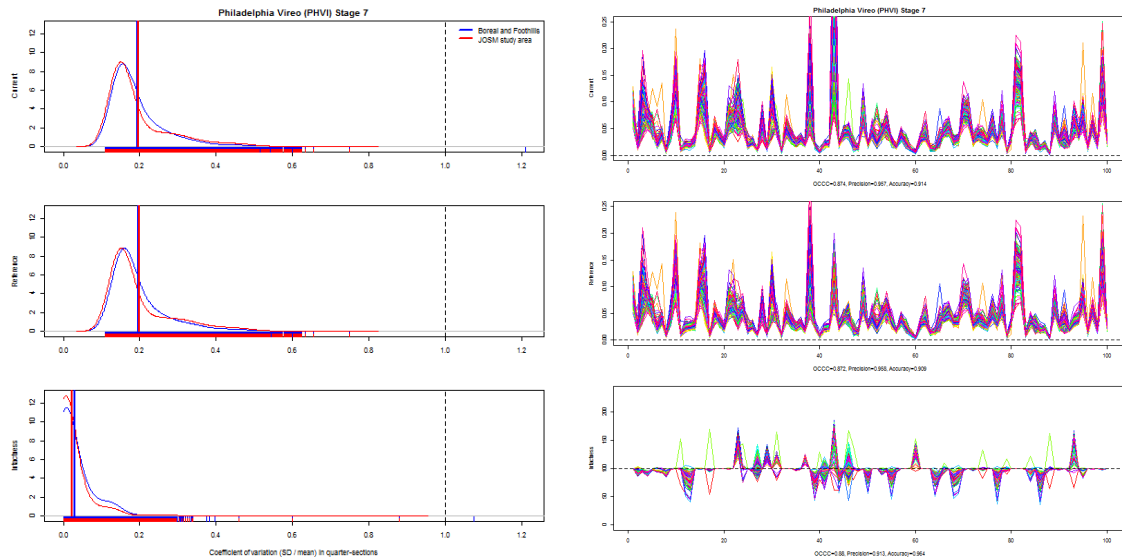
Estimated potential population size of Philadelphia Vireo in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1471	0.1166	0.1800	0.1803	0.1424	0.2234
Wet	0.1425	0.1130	0.1744	0.1453	0.1148	0.1800
WetConifD	0.0380	0.0301	0.0465	0.0395	0.0312	0.0489
MixedD	0.0301	0.0239	0.0368	0.0344	0.0271	0.0426
WetConifC	0.0318	0.0252	0.0389	0.0331	0.0261	0.0410
DecidC	0.0260	0.0206	0.0318	0.0305	0.0241	0.0378
Grass	0.0124	0.0099	0.0152	0.0222	0.0175	0.0275
DecidB	0.0155	0.0123	0.0190	0.0184	0.0146	0.0228
ConifD	0.0120	0.0095	0.0147	0.0139	0.0110	0.0173
ConifC	0.0093	0.0074	0.0114	0.0103	0.0081	0.0128
WetConifB	0.0088	0.0069	0.0107	0.0090	0.0071	0.0111
Shrub	0.0077	0.0061	0.0094	0.0089	0.0070	0.0110
ConifA	0.0078	0.0062	0.0095	0.0084	0.0066	0.0104
WetConifA	0.0075	0.0060	0.0092	0.0078	0.0061	0.0096
ConifB	0.0063	0.0050	0.0078	0.0068	0.0054	0.0084
DecidA	0.0047	0.0037	0.0058	0.0064	0.0051	0.0080
PineB	0.0064	0.0051	0.0078	0.0064	0.0051	0.0079
PineC	0.0039	0.0031	0.0047	0.0041	0.0032	0.0050
MixedB	0.0029	0.0023	0.0035	0.0031	0.0025	0.0039
PineD	0.0029	0.0023	0.0035	0.0031	0.0024	0.0038
PineA	0.0023	0.0018	0.0028	0.0024	0.0019	0.0029
MixedA	0.0017	0.0013	0.0021	0.0022	0.0017	0.0027
MixedC	0.0018	0.0014	0.0022	0.0020	0.0016	0.0025
Cult	0.0292	0.0231	0.0357	0.0000	0.0000	0.0000
UrbInd	0.0045	0.0035	0.0055	0.0000	0.0000	0.0000
HardLin	0.0009	0.0007	0.0010	0.0000	0.0000	0.0000
SoftLin	0.0005	0.0004	0.0006	0.0000	0.0000	0.0000
HFor	0.0337	0.0267	0.0412	0.0000	0.0000	0.0000
Total	0.5982	0.4741	0.7319	0.5984	0.4727	0.7413
Loss	0.0201	0.0094	0.0327			
Gain	0.0172	0.0108	0.0252			

5.46.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.46.14 Variable selection frequencies

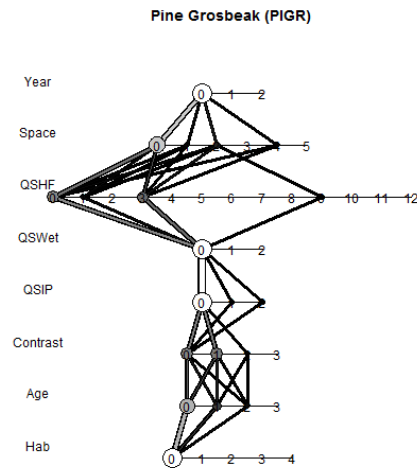
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.3	3.0	6	. + Habitat + isHForC
1.4	97.0	194	. + HabitatB + isHForC
2.0	92.5	185	NULL
2.1	6.0	12	. + Age
2.2	1.5	3	. + Age + Age2
3.0	2.5	5	NULL
3.1	19.0	38	. + ROAD
3.2	78.5	157	. + SoftLin_PC
4.0	97.5	195	NULL
4.1	2.5	5	. + Remn_QS
5.0	16.5	33	NULL
5.2	83.5	167	. + pWetWater_QS
6.0	99.0	198	NULL
6.1	0.5	1	. + THF_QS
6.3	0.5	1	. + Succ_QS + Alien_QS
7.0	0.5	1	NULL
7.1	99.0	198	. + xlat
7.3	0.5	1	. + xlat + xlong + xlat:xlong
8.0	100.0	200	NULL

5.47 Pine Grosbeak (*Pinicola enucleator*)

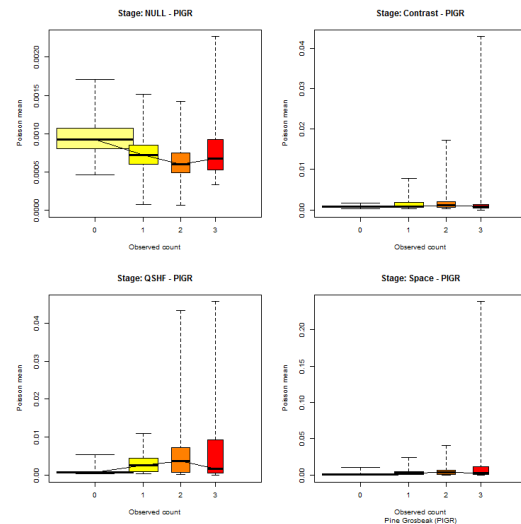
5.47.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

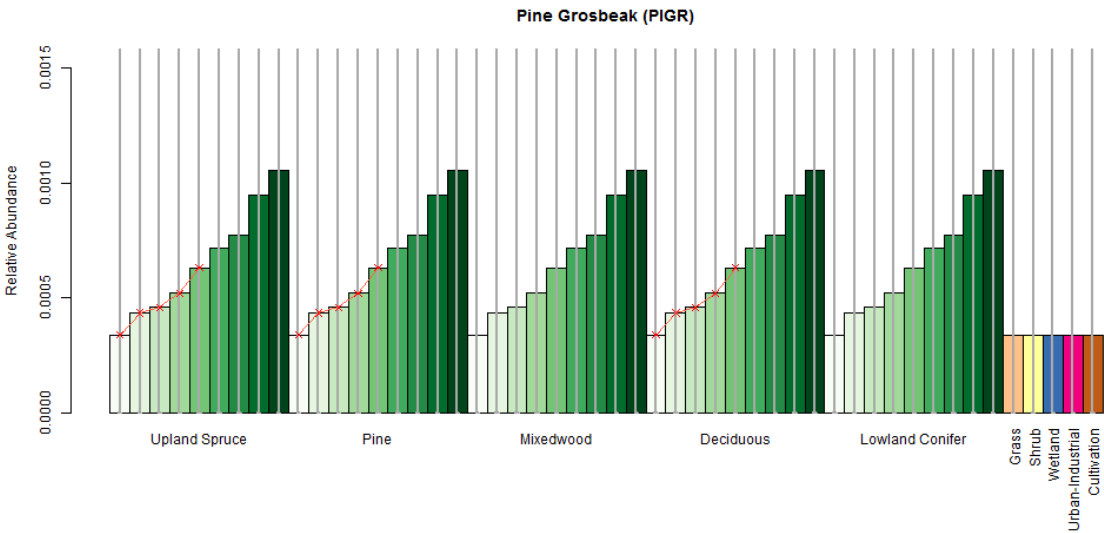


5.47.2 Cross validation

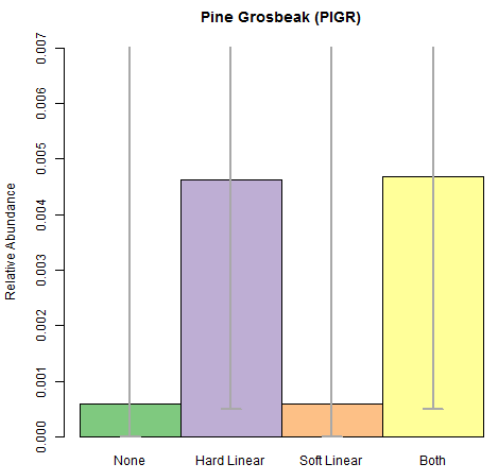
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.47.3 Point level habitat associations

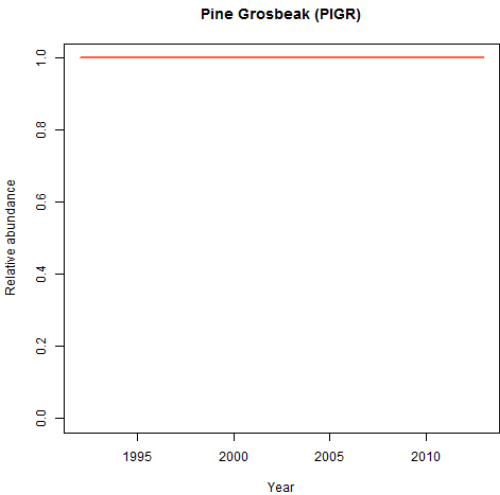


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

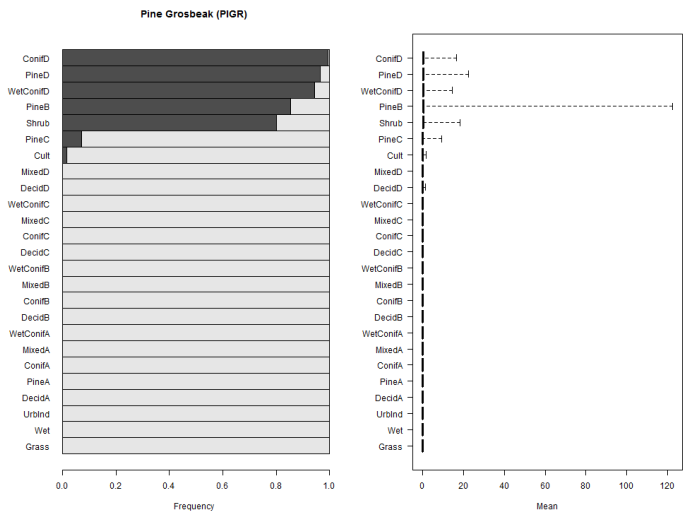


5.47.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



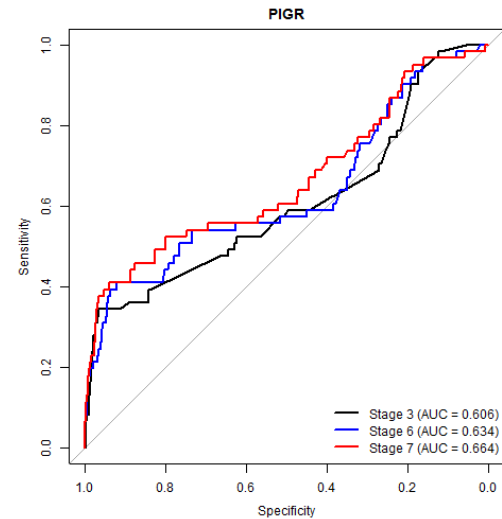
5.47.5 Habitat suitability ranking for patch delineation



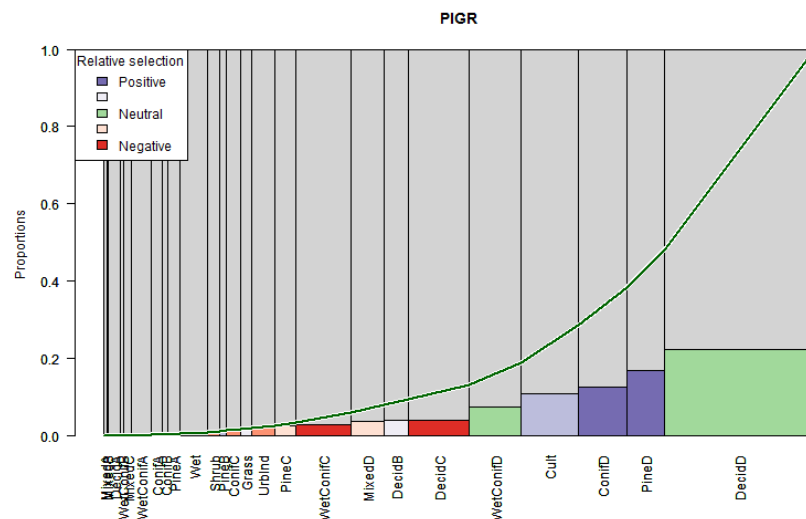
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.47.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

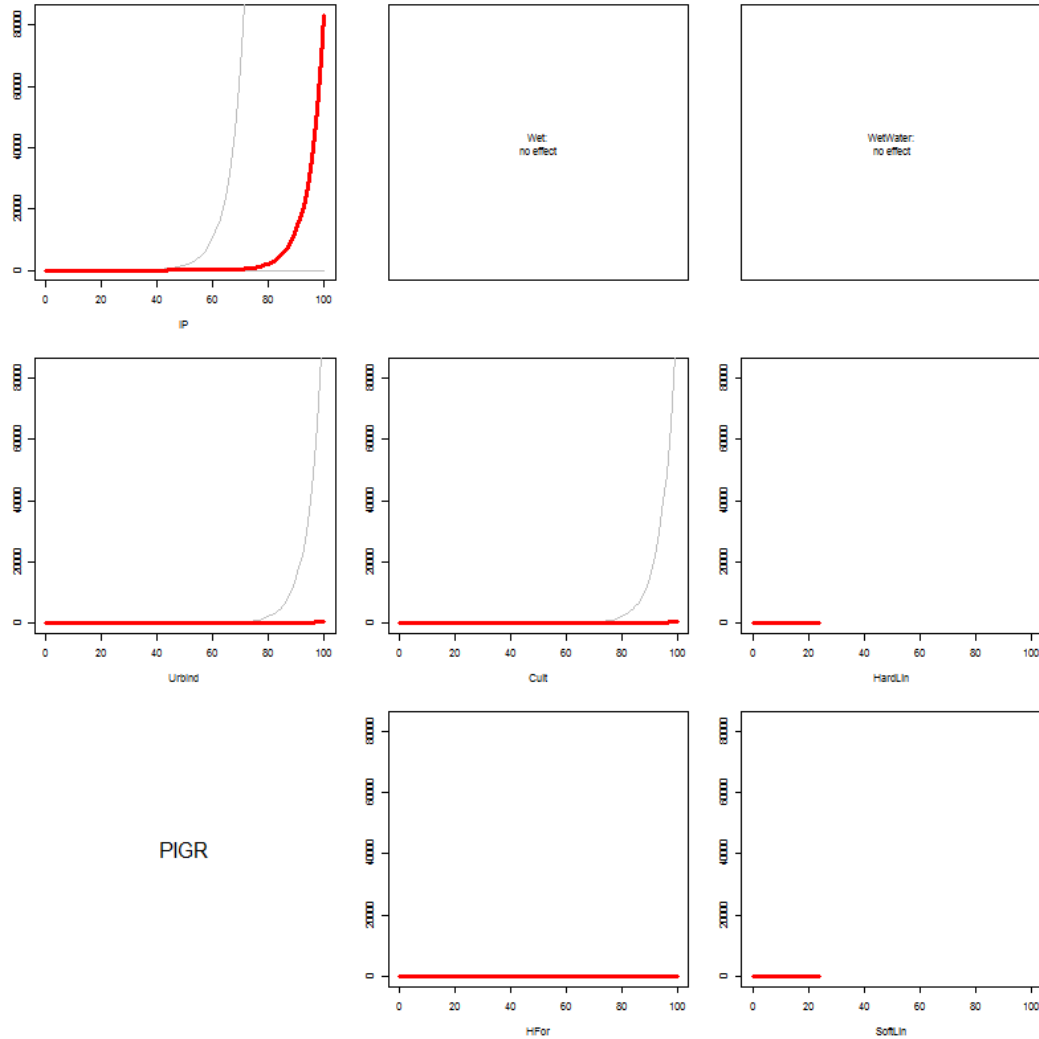


5.47.7 Relative habitat selection



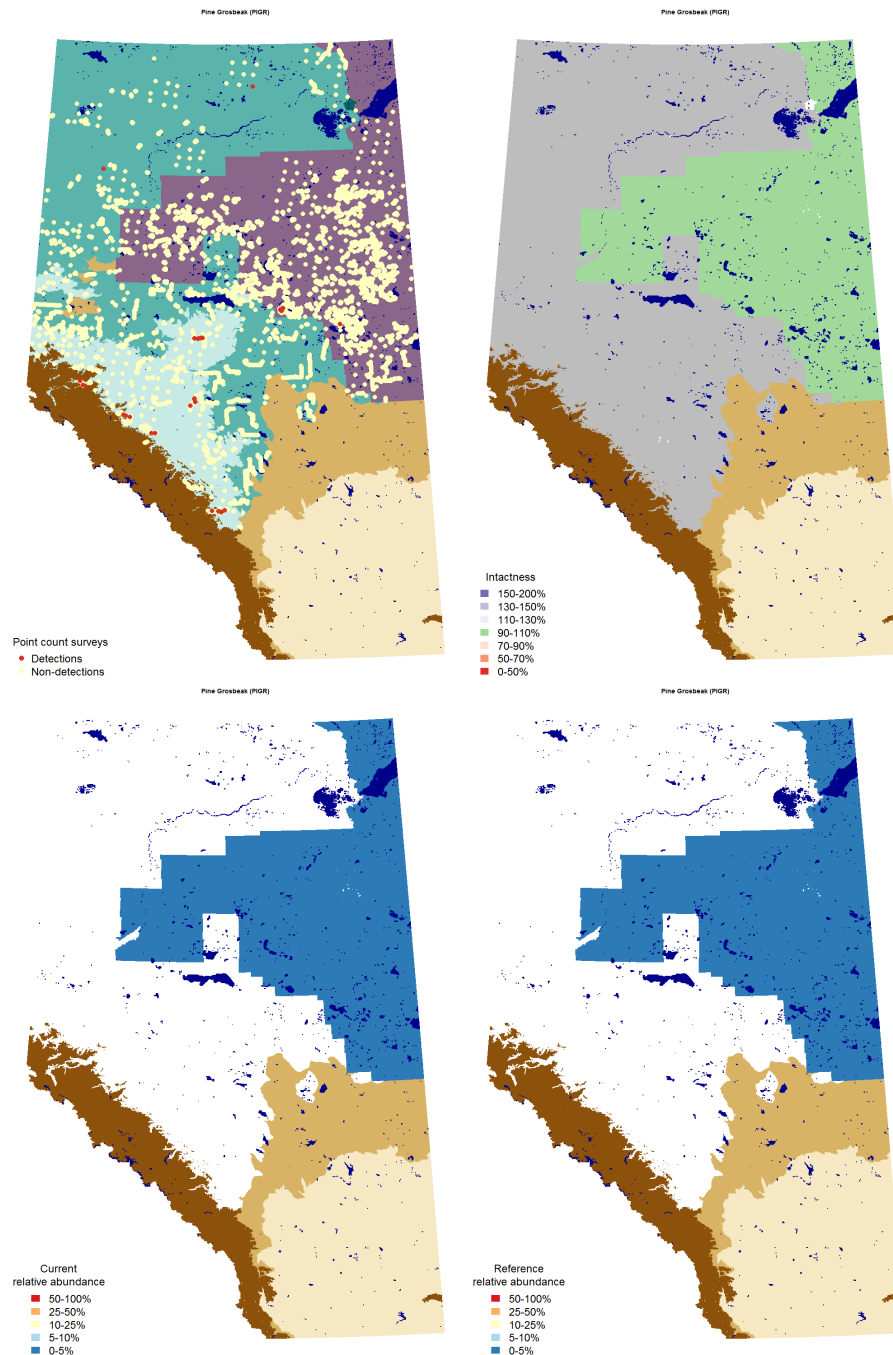
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.47.8 Quarter-section level responses



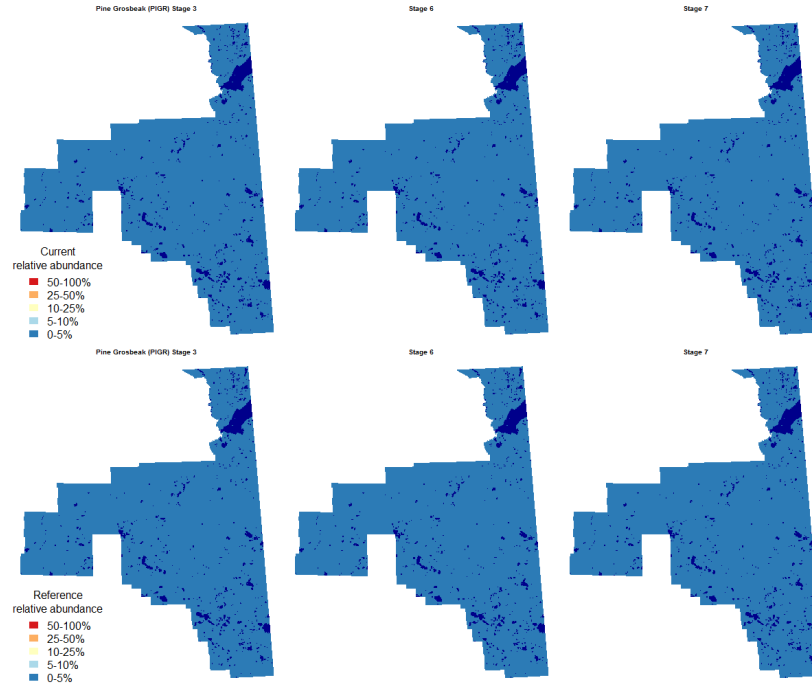
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.47.9 Maps



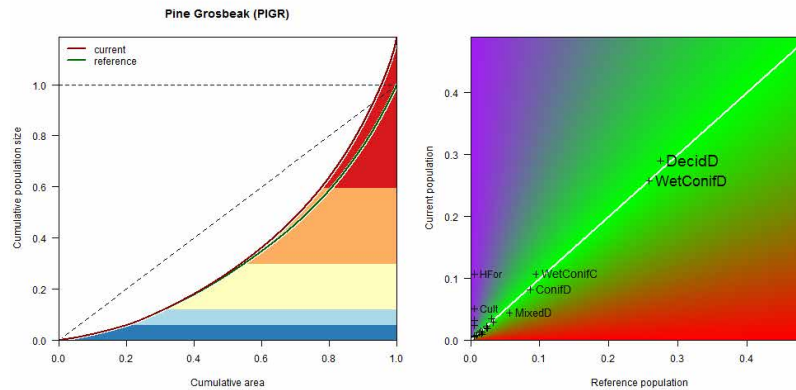
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.47.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.47.11 Population concentration



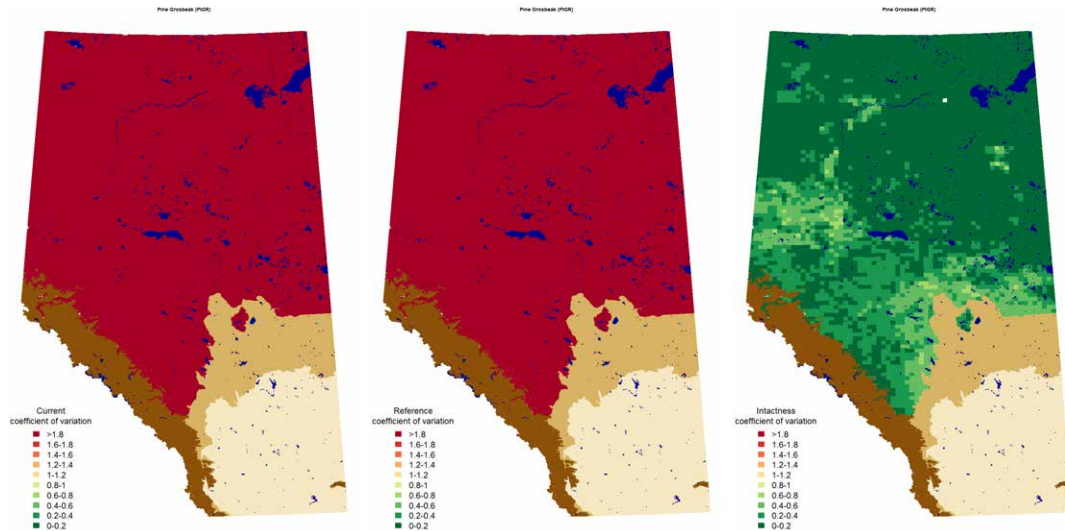
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.47.12 Potential population size

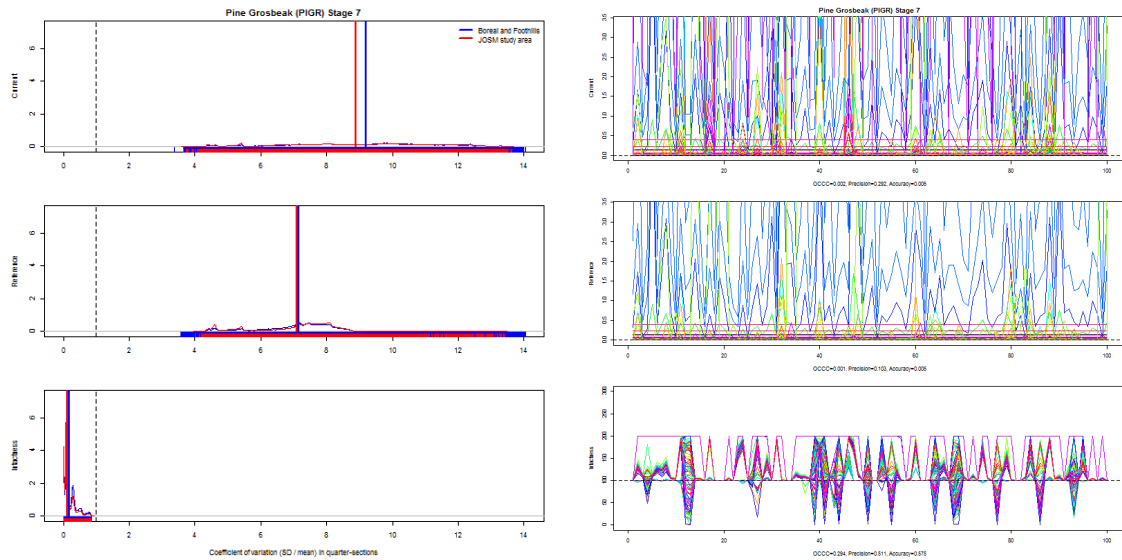
Estimated potential population size of Pine Grosbeak in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0011	0.0000	0.5120	0.0008	0.0000	0.2778
WetConifD	0.0010	0.0000	0.4542	0.0007	0.0000	0.2611
WetConifC	0.0004	0.0000	0.1887	0.0003	0.0000	0.0951
ConifD	0.0003	0.0000	0.1439	0.0002	0.0000	0.0873
MixedD	0.0002	0.0000	0.0783	0.0002	0.0000	0.0567
PineD	0.0001	0.0000	0.0513	0.0001	0.0000	0.0327
Wet	0.0001	0.0000	0.0608	0.0001	0.0000	0.0306
DecidC	0.0001	0.0000	0.0339	0.0001	0.0000	0.0246
ConifC	0.0001	0.0000	0.0410	0.0001	0.0000	0.0235
PineC	0.0001	0.0000	0.0360	0.0001	0.0000	0.0229
Shrub	0.0000	0.0000	0.0223	0.0000	0.0000	0.0168
Grass	0.0000	0.0000	0.0174	0.0000	0.0000	0.0165
PineB	0.0001	0.0000	0.0266	0.0000	0.0000	0.0154
WetConifB	0.0000	0.0000	0.0221	0.0000	0.0000	0.0129
DecidB	0.0000	0.0000	0.0132	0.0000	0.0000	0.0091
WetConifA	0.0000	0.0000	0.0154	0.0000	0.0000	0.0087
ConifA	0.0000	0.0000	0.0081	0.0000	0.0000	0.0051
ConifB	0.0000	0.0000	0.0077	0.0000	0.0000	0.0049
PineA	0.0000	0.0000	0.0058	0.0000	0.0000	0.0032
DecidA	0.0000	0.0000	0.0024	0.0000	0.0000	0.0020
MixedB	0.0000	0.0000	0.0016	0.0000	0.0000	0.0011
MixedC	0.0000	0.0000	0.0018	0.0000	0.0000	0.0010
MixedA	0.0000	0.0000	0.0009	0.0000	0.0000	0.0007
Cult	0.0002	0.0000	0.0905	0.0000	0.0000	0.0000
UrbInd	0.0000	0.0000	0.0126	0.0000	0.0000	0.0000
HardLin	0.0001	0.0000	0.0429	0.0000	0.0000	0.0000
SoftLin	0.0001	0.0000	0.0567	0.0000	0.0000	0.0000
HFor	0.0004	0.0000	0.1883	0.0000	0.0000	0.0000
Total	0.0047	0.0000	2.1360	0.0028	0.0000	1.0098
Loss	0.0000	0.0000	0.0057			
Gain	0.0001	0.0000	0.1421			

5.47.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.47.14 Variable selection frequencies

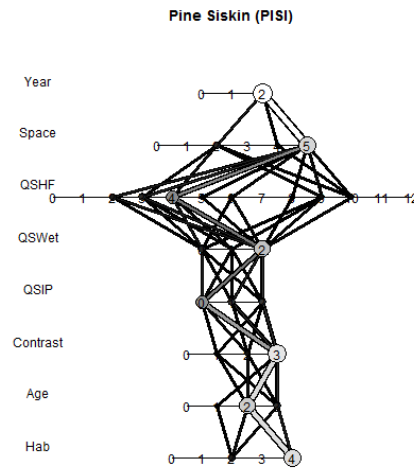
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	200	NULL
2.0	69.5	139	NULL
2.1	25.5	51	. + Age
2.2	5.0	10	. + Age + Age2
3.0	50.0	100	NULL
3.1	49.0	98	. + ROAD
3.2	1.0	2	. + SoftLin_PC
4.0	99.0	198	NULL
4.1	0.5	1	. + Remn_QS
4.2	0.5	1	. + Remn_QS + Remn2_QS
5.0	100.0	200	NULL
6.0	52.0	104	NULL
6.1	5.0	10	. + THF_QS
6.3	42.5	85	. + Succ_QS + Alien_QS
6.9	0.5	1	. + Succ_QS + Alien_QS + Alien2_QS
7.0	79.0	158	NULL
7.1	4.0	8	. + xlat
7.2	14.5	29	. + xlat + xlong
7.4	2.5	5	. + xMAP + xPET + xMAT + xCMD
8.0	100.0	200	NULL

5.48 Pine Siskin (*Spinus pinus*)

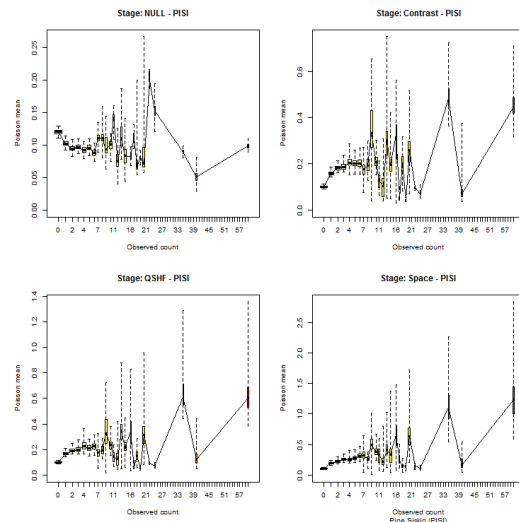
5.48.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

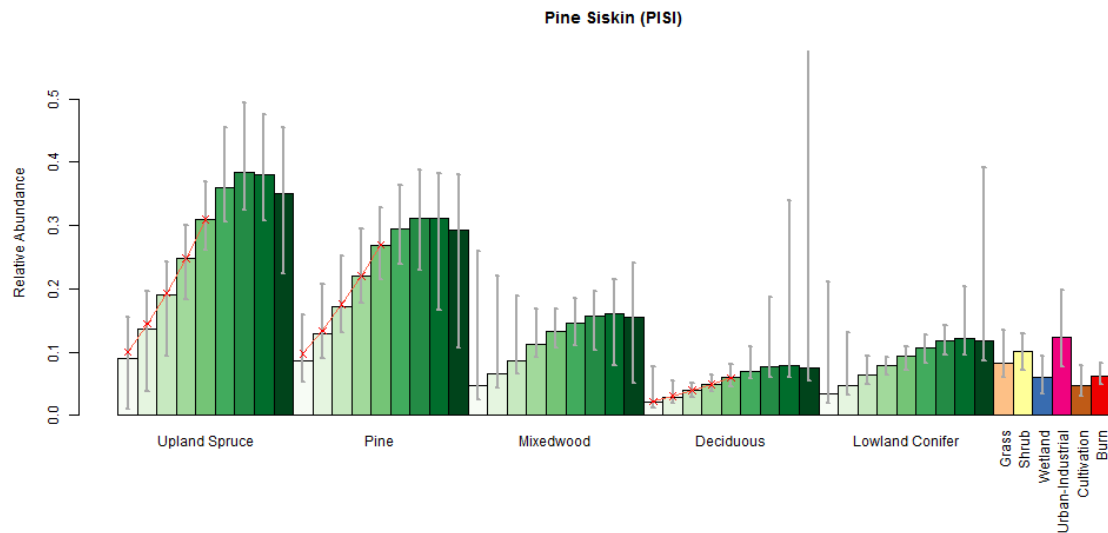


5.48.2 Cross validation

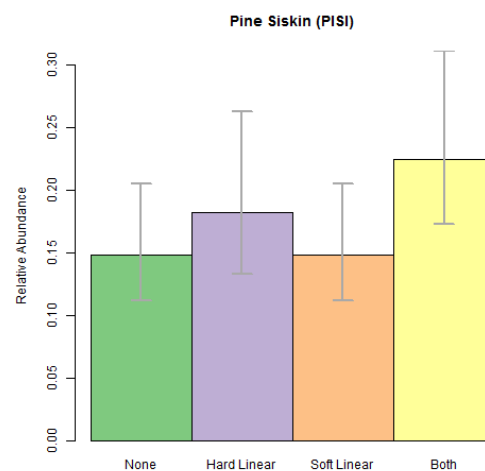
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.48.3 Point level habitat associations

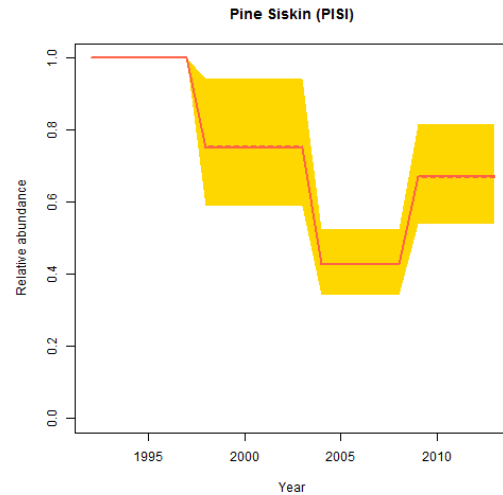


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

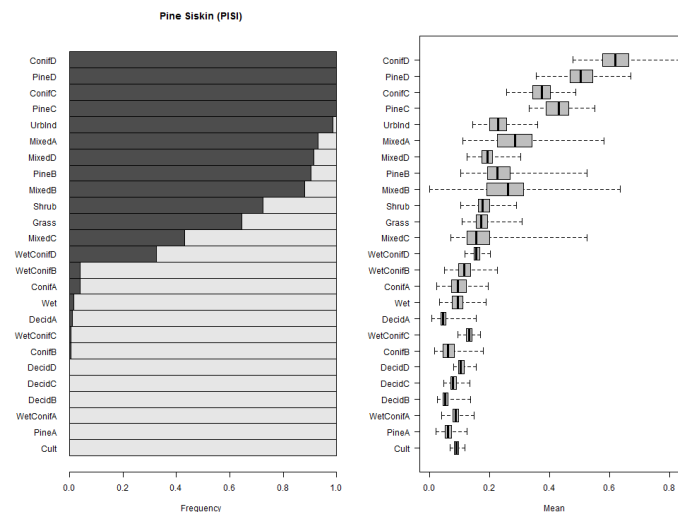


5.48.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



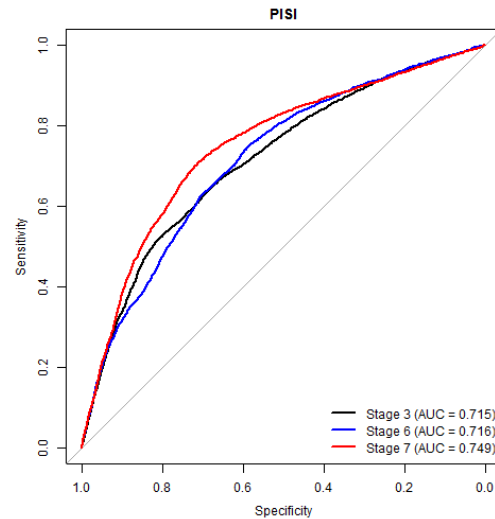
5.48.5 Habitat suitability ranking for patch delineation



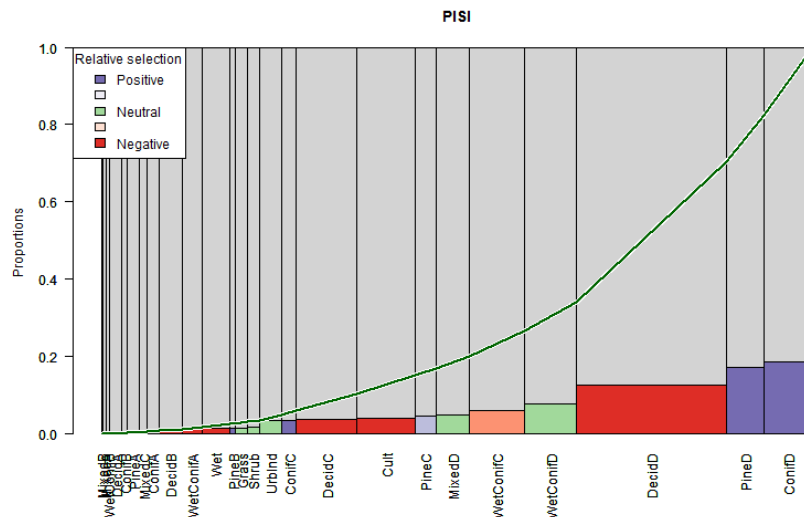
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.48.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

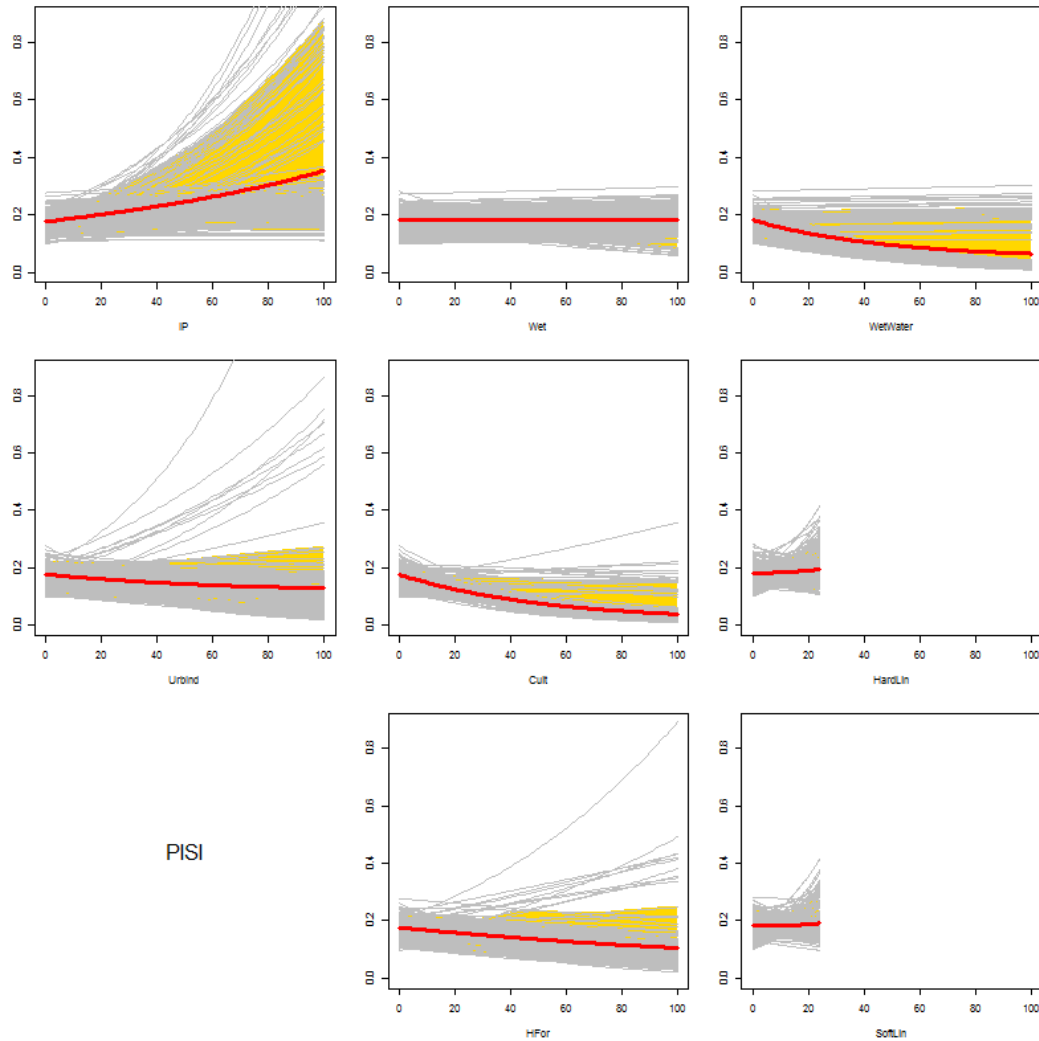


5.48.7 Relative habitat selection



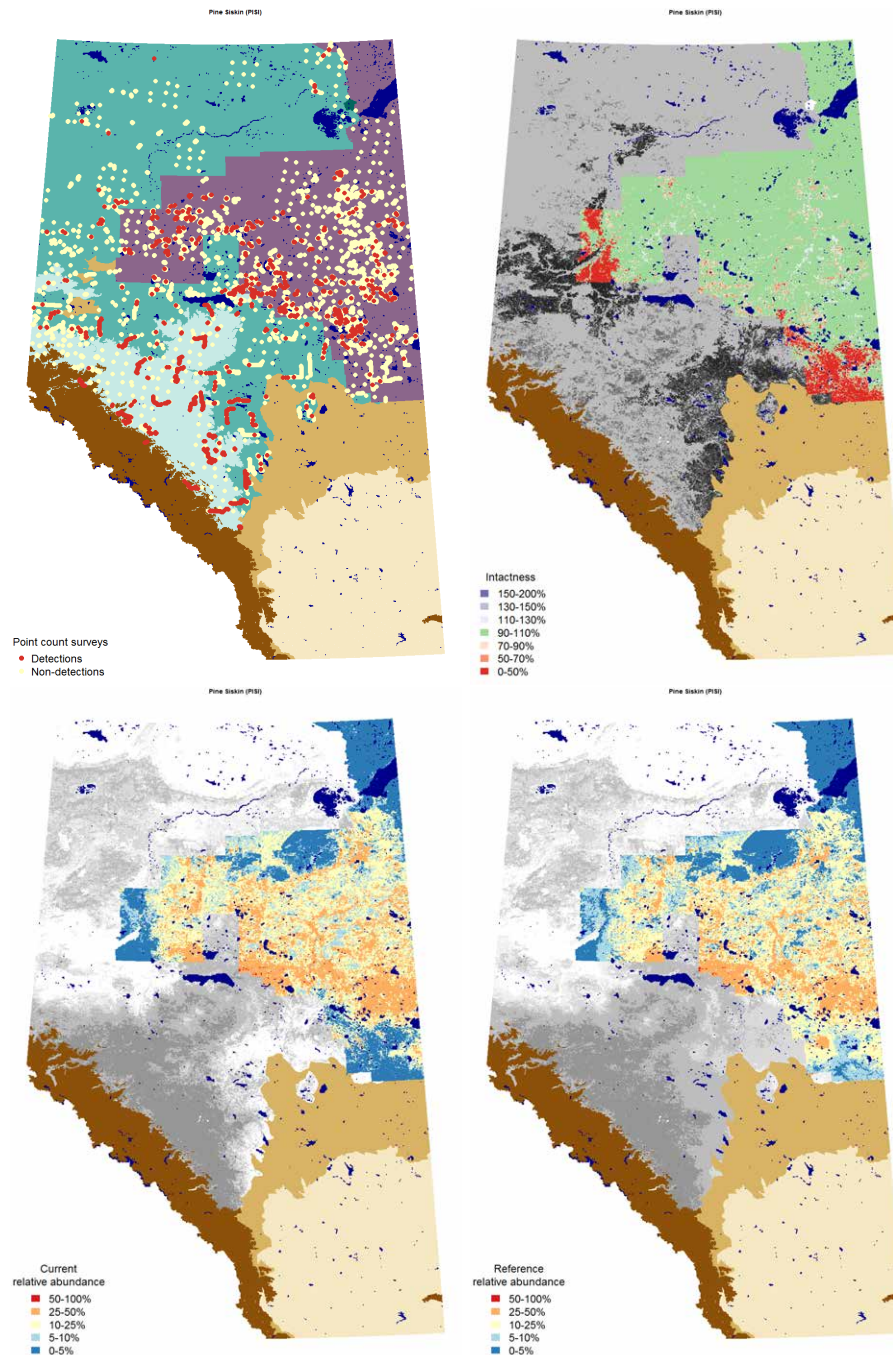
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.48.8 Quarter-section level responses



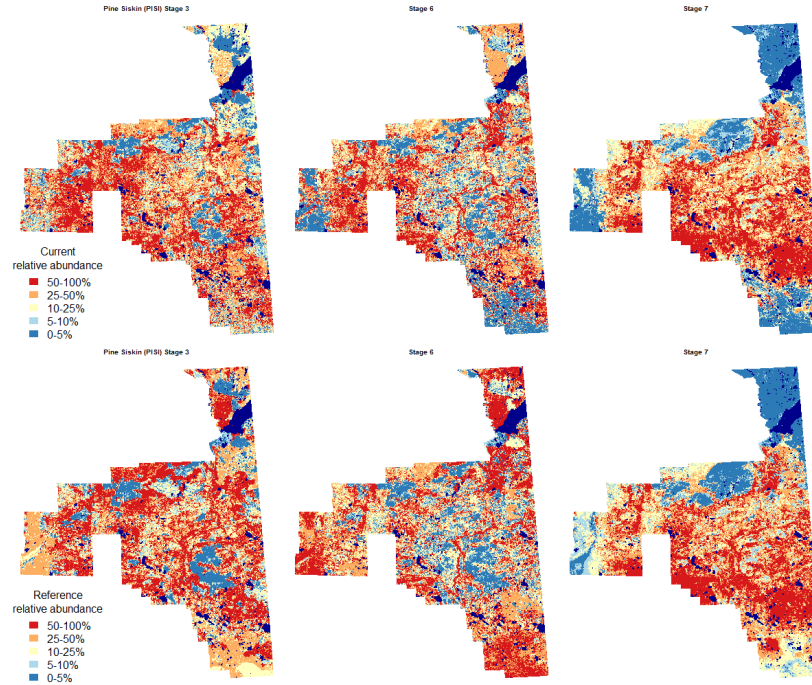
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.48.9 Maps



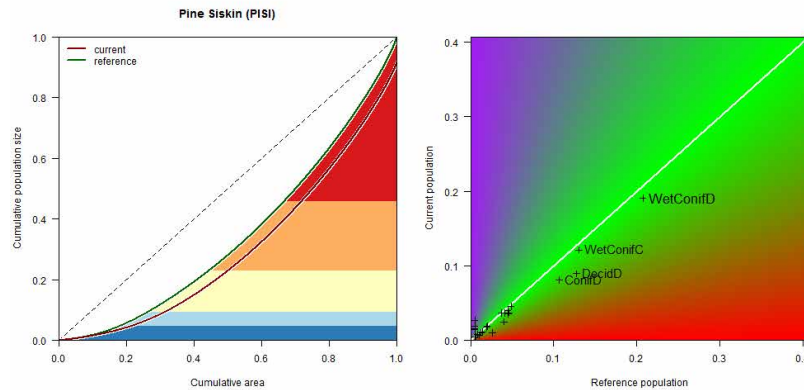
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.48.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.48.11 Population concentration



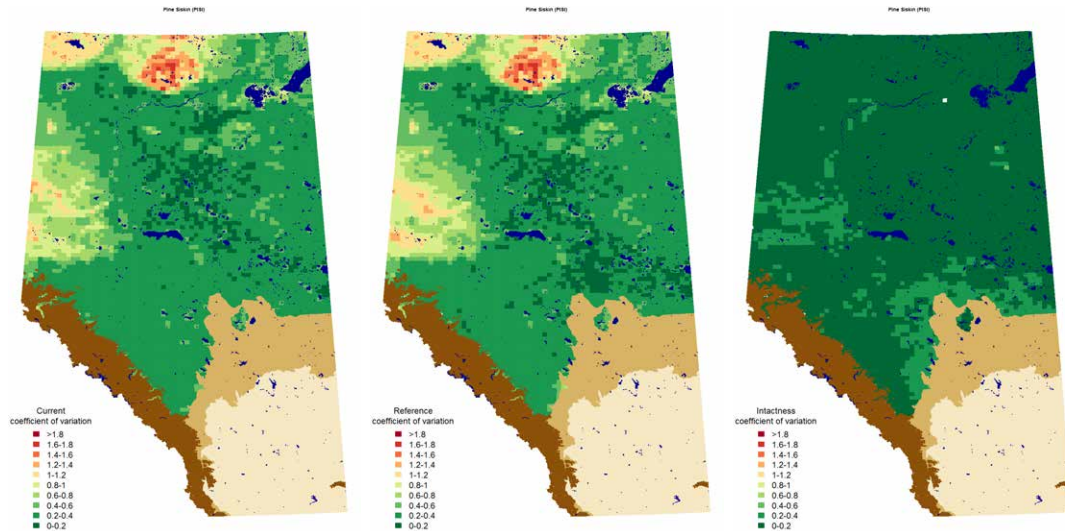
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.48.12 Potential population size

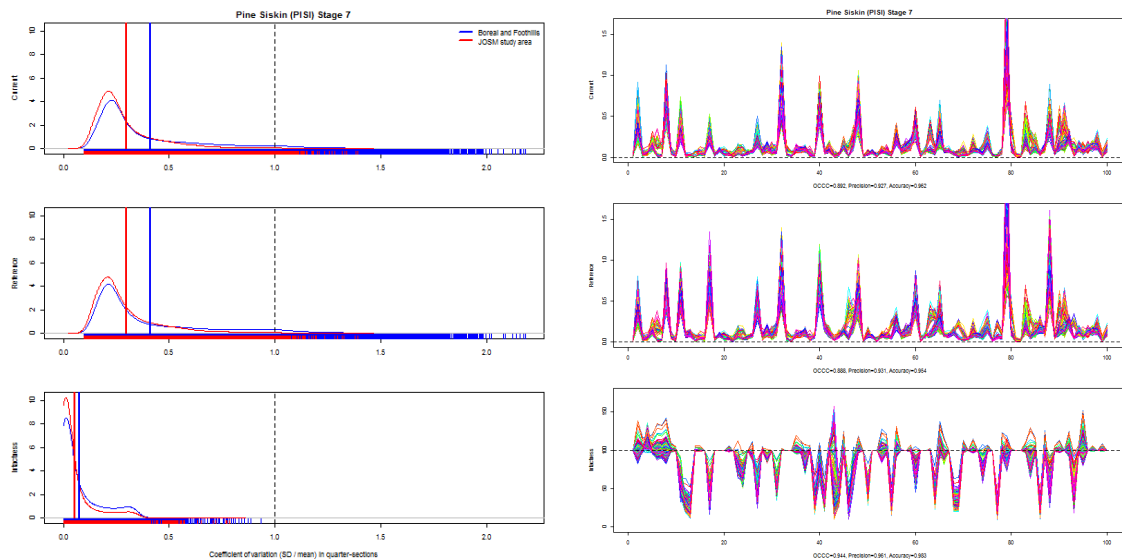
Estimated potential population size of Pine Siskin in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.2958	0.2517	0.3444	0.3180	0.2727	0.3652
WetConifC	0.1885	0.1604	0.2195	0.2002	0.1717	0.2299
DecidD	0.1389	0.1182	0.1617	0.1958	0.1679	0.2249
ConifD	0.1258	0.1070	0.1464	0.1639	0.1406	0.1882
Wet	0.0703	0.0599	0.0819	0.0745	0.0639	0.0856
ConifC	0.0578	0.0492	0.0673	0.0706	0.0606	0.0811
MixedD	0.0553	0.0470	0.0643	0.0689	0.0591	0.0791
PineC	0.0620	0.0528	0.0722	0.0685	0.0587	0.0786
PineD	0.0565	0.0481	0.0658	0.0636	0.0545	0.0730
Shrub	0.0386	0.0328	0.0449	0.0611	0.0524	0.0702
PineB	0.0569	0.0484	0.0663	0.0574	0.0492	0.0659
Grass	0.0157	0.0134	0.0183	0.0403	0.0345	0.0462
WetConifB	0.0294	0.0250	0.0342	0.0306	0.0263	0.0352
WetConifA	0.0280	0.0238	0.0326	0.0299	0.0256	0.0343
ConifA	0.0178	0.0152	0.0208	0.0227	0.0194	0.0260
ConifB	0.0158	0.0135	0.0184	0.0192	0.0164	0.0220
DecidC	0.0106	0.0090	0.0123	0.0165	0.0142	0.0190
PineA	0.0119	0.0102	0.0139	0.0127	0.0109	0.0146
DecidB	0.0075	0.0064	0.0087	0.0102	0.0088	0.0117
DecidA	0.0018	0.0015	0.0021	0.0034	0.0029	0.0039
MixedA	0.0017	0.0015	0.0020	0.0027	0.0024	0.0032
MixedB	0.0019	0.0016	0.0022	0.0023	0.0020	0.0027
MixedC	0.0014	0.0012	0.0016	0.0019	0.0016	0.0022
Cult	0.0287	0.0244	0.0334	0.0000	0.0000	0.0000
UrbInd	0.0218	0.0185	0.0254	0.0000	0.0000	0.0000
HardLin	0.0022	0.0018	0.0025	0.0000	0.0000	0.0000
SoftLin	0.0243	0.0207	0.0283	0.0000	0.0000	0.0000
HFor	0.0423	0.0360	0.0492	0.0000	0.0000	0.0000
Total	1.4088	1.1989	1.6402	1.5351	1.3162	1.7626
Loss	0.1433	0.0901	0.1985			
Gain	0.0049	0.0010	0.0421			

5.48.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.48.14 Variable selection frequencies

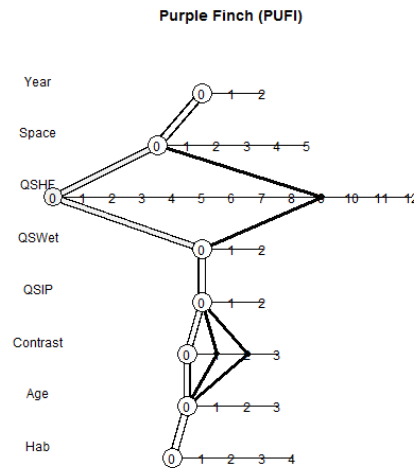
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	13.0	26	. + HabitatB
1.4	87.0	174	. + HabitatB + isHForC
2.1	0.5	1	. + Age
2.2	80.5	161	. + Age + Age2
			. + Age + Age2 + Age:isMix + Age:isPine
2.3	19.0	38	+ Age:isUplConif + Age:isWetConif +
			Age2:isMix + Age2:isPine + Age2:isUplConif
			+ Age2:isWetConif
3.1	2.5	5	. + ROAD
3.2	7.5	15	. + SoftLin_PC
3.3	90.0	180	. + ROAD + SoftLin_PC
4.0	57.0	114	NULL
4.1	21.0	42	. + Remn_QS
4.2	22.0	44	. + Remn_QS + Remn2_QS
5.0	16.0	32	NULL
5.1	8.0	16	. + pWet_QS
5.2	76.0	152	. + pWetWater_QS
6.2	12.0	24	. + Lin_QS + Nonlin_QS
6.3	17.5	35	. + Succ_QS + Alien_QS
6.4	54.5	109	. + Succ_QS + Noncult_QS + Cult_QS
6.5	0.5	1	. + THF_QS + THF2_QS
6.6	4.5	9	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.8	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	6.0	12	. + Succ_QS + Alien_QS + Alien2_QS
6.10	4.5	9	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
7.2	15.5	31	. + xlat + xlong
7.4	0.5	1	. + xMAP + xPET + xMAT + xCMD
7.5	84.0	168	. + xMAP + xPET + xMAT + xCMD +
			xMAP:xPET + xMAT:xCMD
8.2	100.0	200	. + YR5F

5.49 Purple Finch (*Carpodacus purpureus*)

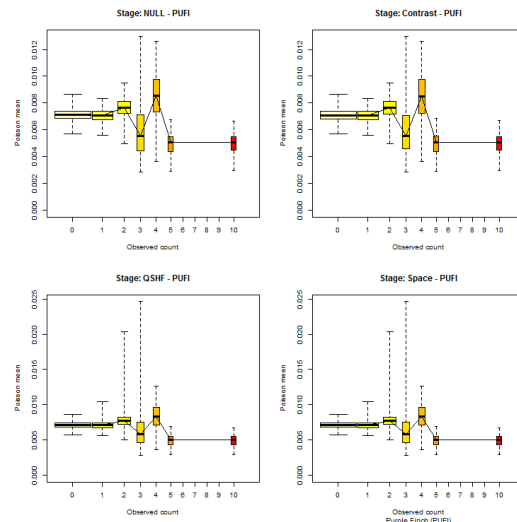
5.49.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

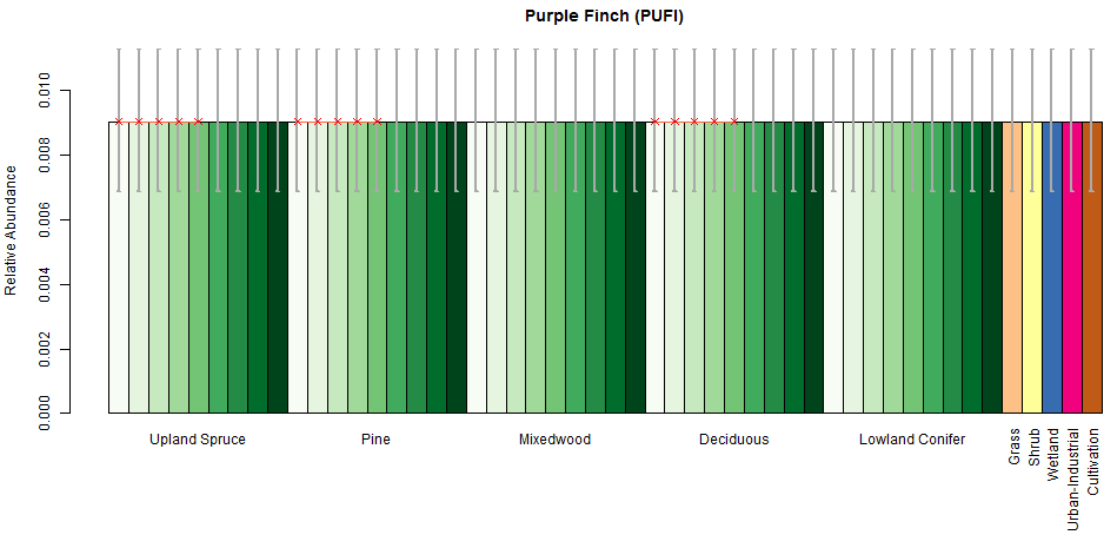


5.49.2 Cross validation

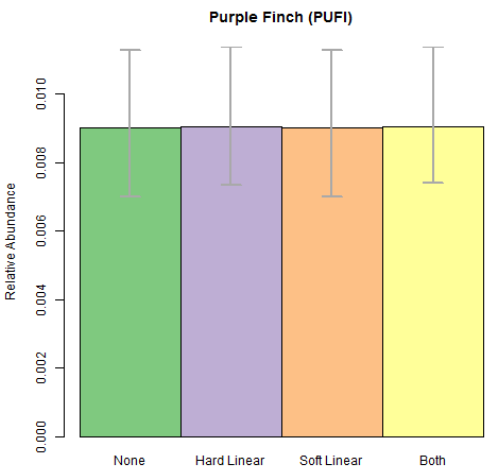
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.49.3 Point level habitat associations

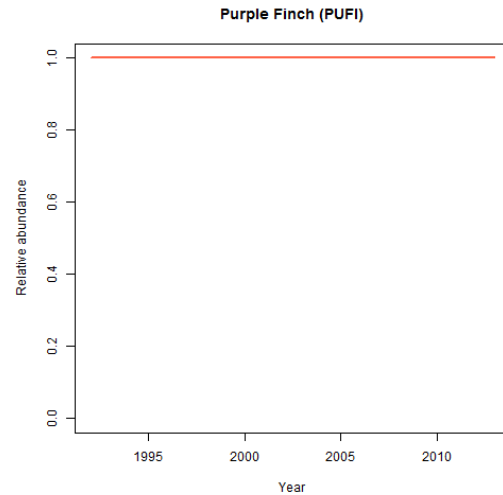


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

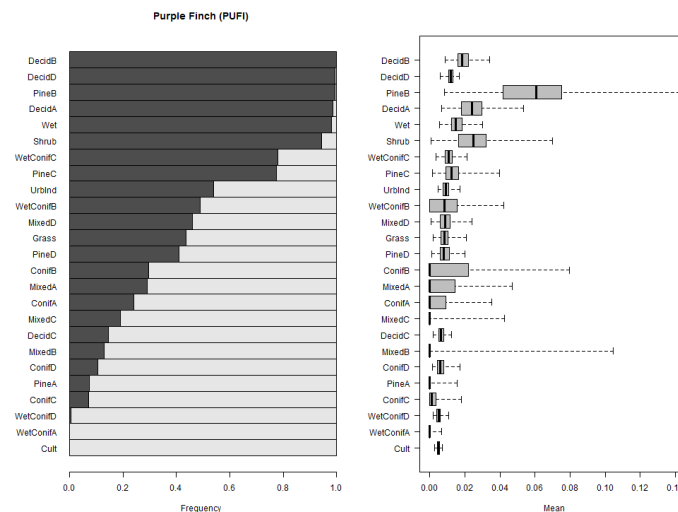


5.49.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).

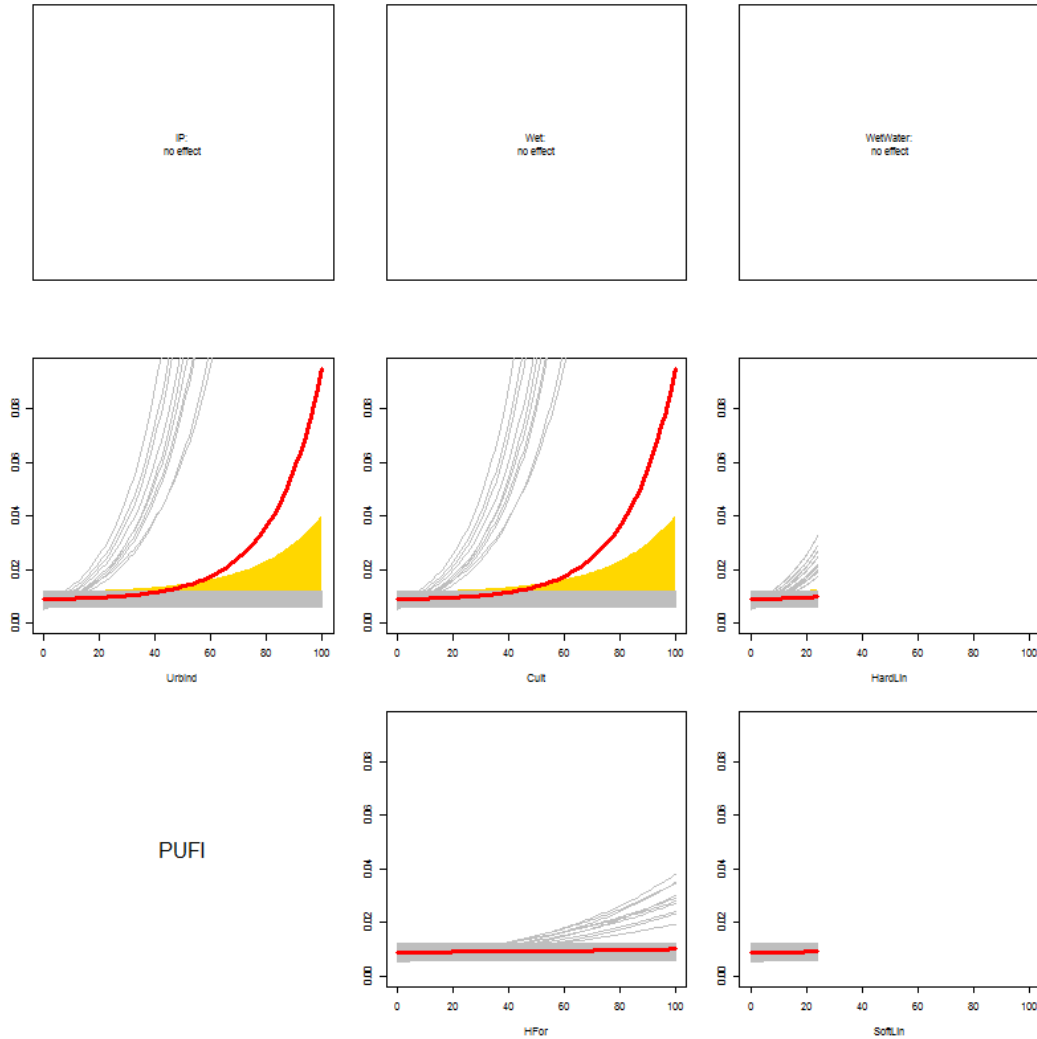


5.49.5 Habitat suitability ranking for patch delineation



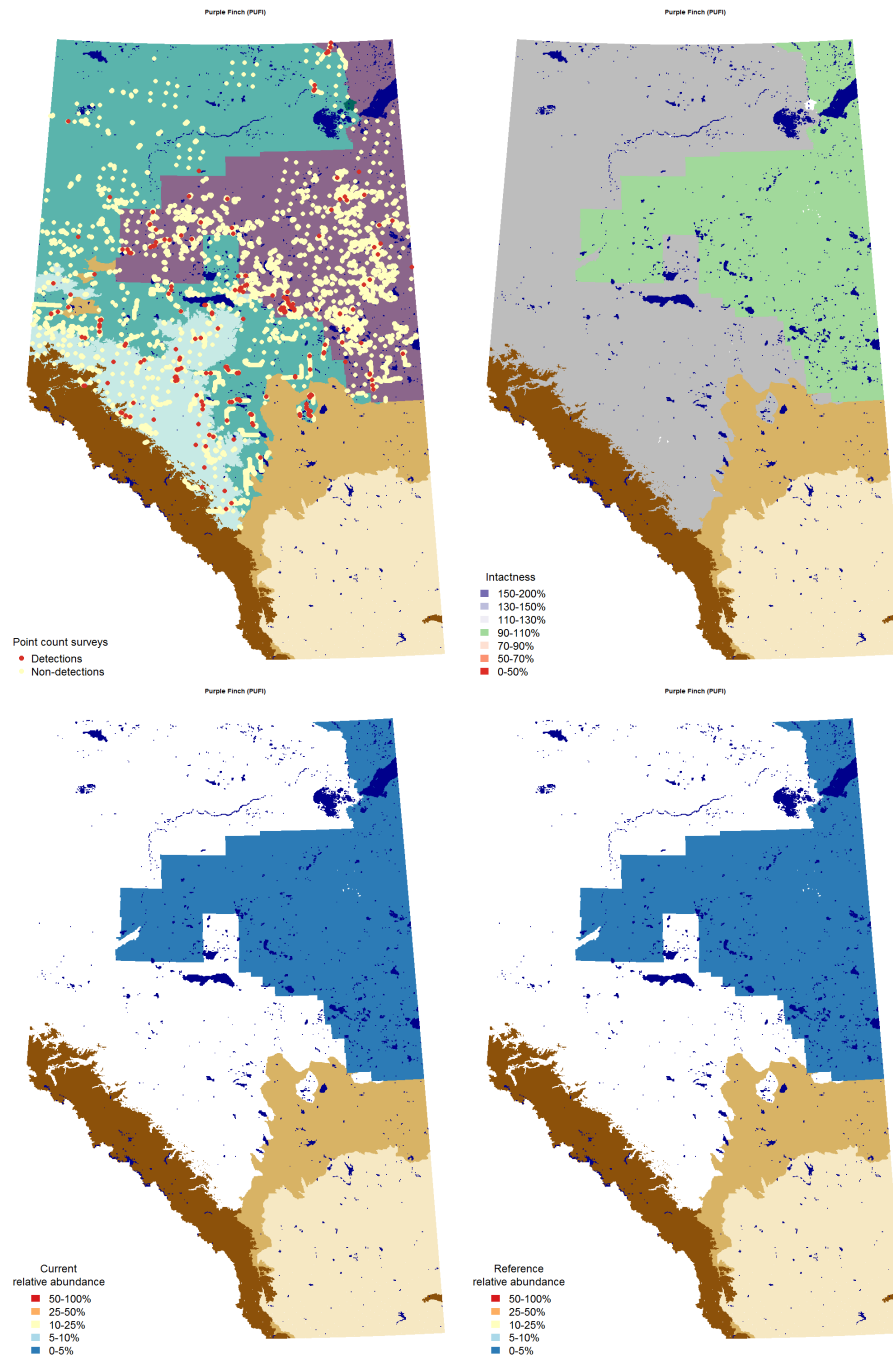
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.49.8 Quarter-section level responses



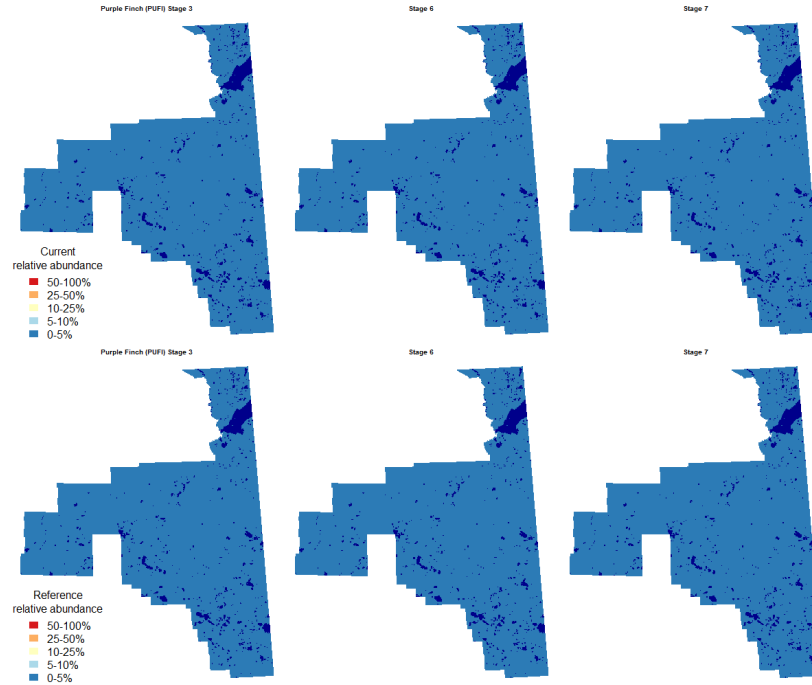
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.49.9 Maps



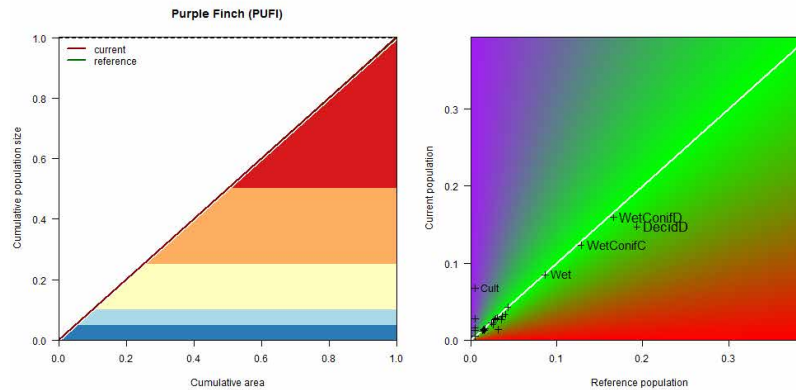
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.49.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.49.11 Population concentration



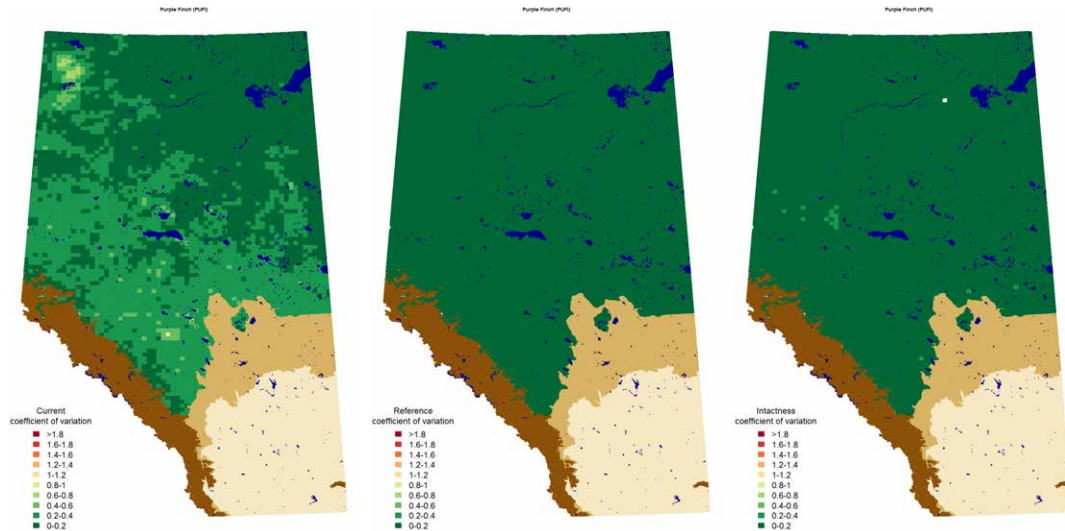
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.49.12 Potential population size

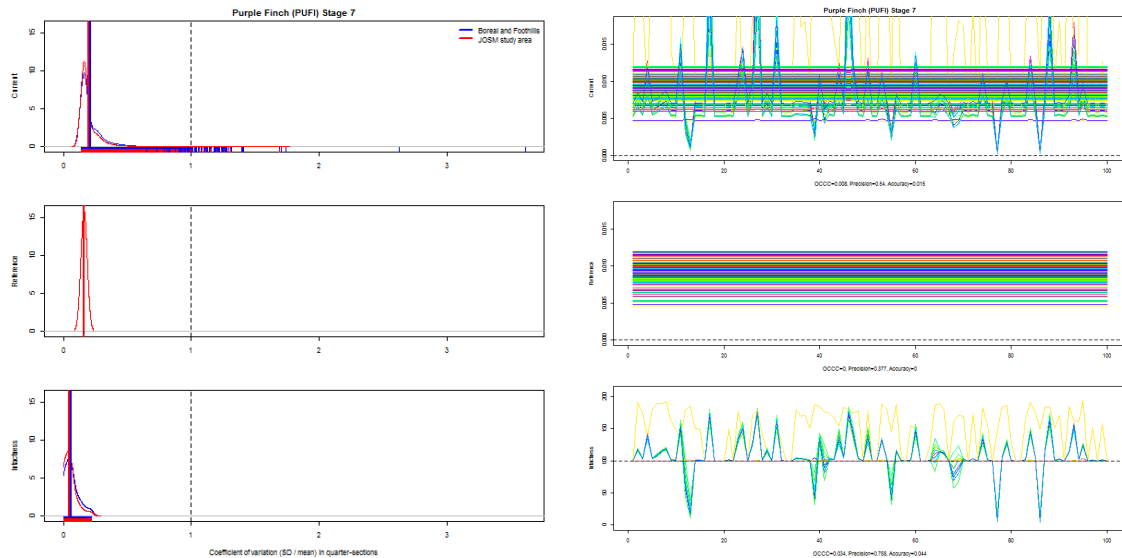
Estimated potential population size of Purple Finch in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0212	0.0158	0.0270	0.0279	0.0194	0.0351
WetConifD	0.0230	0.0171	0.0291	0.0239	0.0166	0.0301
WetConifC	0.0178	0.0132	0.0225	0.0185	0.0129	0.0233
Wet	0.0122	0.0091	0.0155	0.0125	0.0087	0.0157
PineB	0.0062	0.0046	0.0078	0.0062	0.0043	0.0078
ConifD	0.0048	0.0036	0.0061	0.0058	0.0040	0.0073
MixedD	0.0045	0.0033	0.0057	0.0053	0.0037	0.0066
Shrub	0.0039	0.0029	0.0049	0.0052	0.0036	0.0065
Grass	0.0021	0.0015	0.0026	0.0046	0.0032	0.0058
PineC	0.0042	0.0031	0.0054	0.0045	0.0032	0.0057
WetConifB	0.0041	0.0030	0.0052	0.0042	0.0029	0.0053
WetConifA	0.0039	0.0029	0.0049	0.0040	0.0028	0.0050
ConifC	0.0033	0.0024	0.0042	0.0038	0.0026	0.0048
DecidC	0.0029	0.0021	0.0036	0.0037	0.0026	0.0047
PineD	0.0033	0.0024	0.0041	0.0036	0.0025	0.0045
ConifA	0.0021	0.0016	0.0027	0.0024	0.0017	0.0031
DecidB	0.0018	0.0014	0.0023	0.0023	0.0016	0.0029
PineA	0.0020	0.0015	0.0026	0.0021	0.0015	0.0027
ConifB	0.0018	0.0013	0.0023	0.0020	0.0014	0.0025
DecidA	0.0005	0.0004	0.0006	0.0008	0.0005	0.0010
MixedB	0.0003	0.0002	0.0004	0.0003	0.0002	0.0004
MixedA	0.0002	0.0002	0.0003	0.0003	0.0002	0.0004
MixedC	0.0002	0.0001	0.0003	0.0002	0.0002	0.0003
Cult	0.0098	0.0073	0.0124	0.0000	0.0000	0.0000
UrbInd	0.0018	0.0014	0.0023	0.0000	0.0000	0.0000
HardLin	0.0002	0.0002	0.0003	0.0000	0.0000	0.0000
SoftLin	0.0023	0.0017	0.0030	0.0000	0.0000	0.0000
HFor	0.0040	0.0030	0.0051	0.0000	0.0000	0.0000
Total	0.1444	0.1076	0.1832	0.1442	0.1002	0.1817
Loss	0.0000	0.0000	0.0002			
Gain	0.0000	0.0000	0.0123			

5.49.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.49.14 Variable selection frequencies

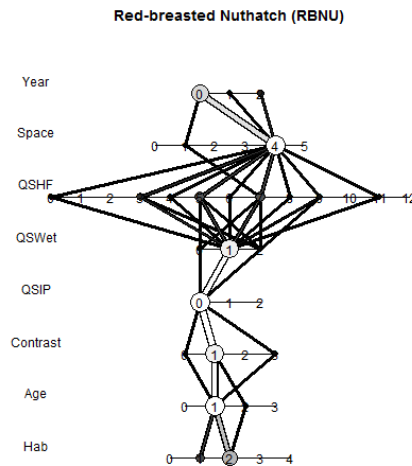
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	200	NULL
2.0	100.0	200	NULL
3.0	98.0	196	NULL
3.1	1.5	3	. + ROAD
3.2	0.5	1	. + SoftLin_PC
4.0	100.0	200	NULL
5.0	100.0	200	NULL
6.0	95.0	190	NULL
6.9	5.0	10	. + Succ_QS + Alien_QS + Alien2_QS
7.0	100.0	200	NULL
8.0	100.0	200	NULL

5.50 Red-breasted Nuthatch (*Sitta canadensis*)

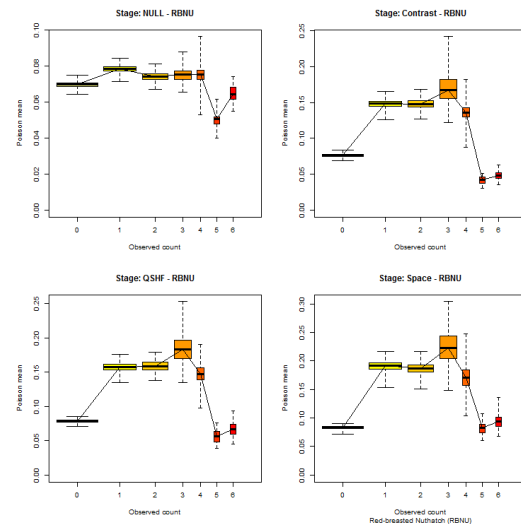
5.50.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

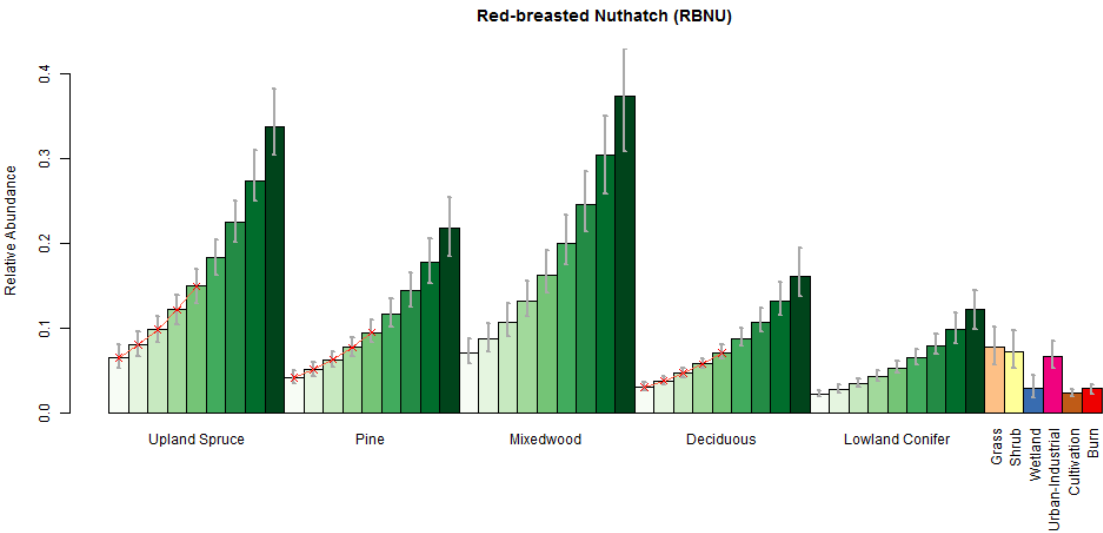


5.50.2 Cross validation

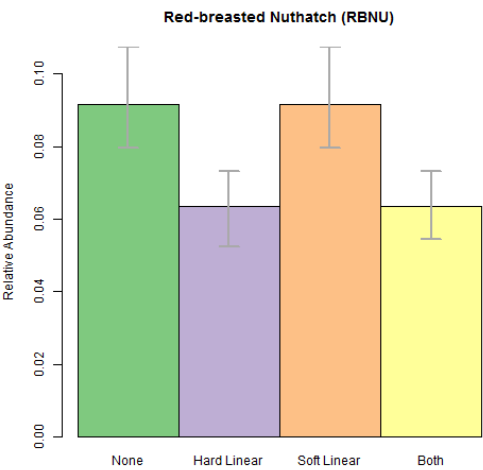
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.50.3 Point level habitat associations

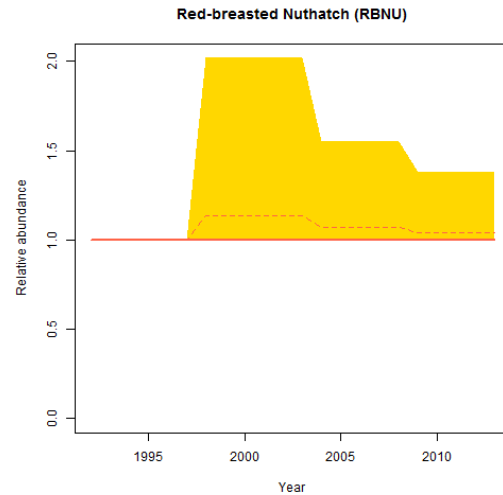


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

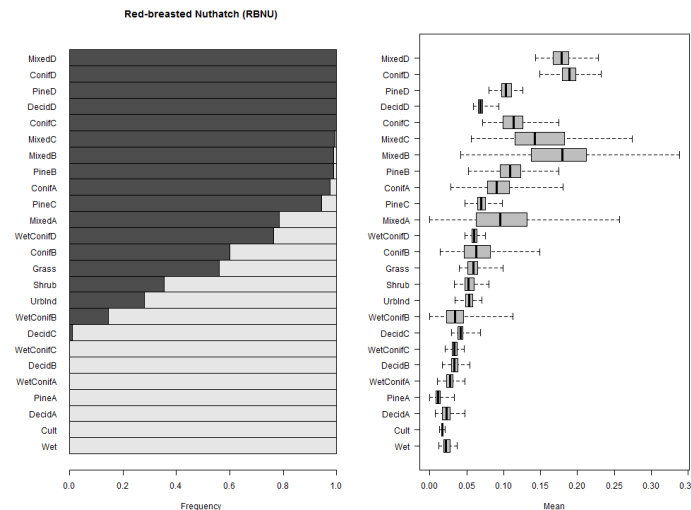


5.50.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



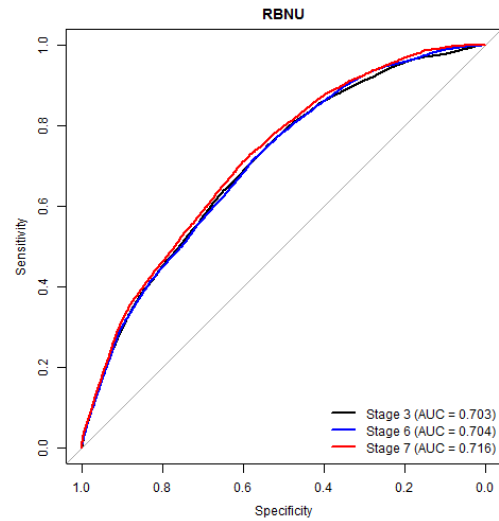
5.50.5 Habitat suitability ranking for patch delineation



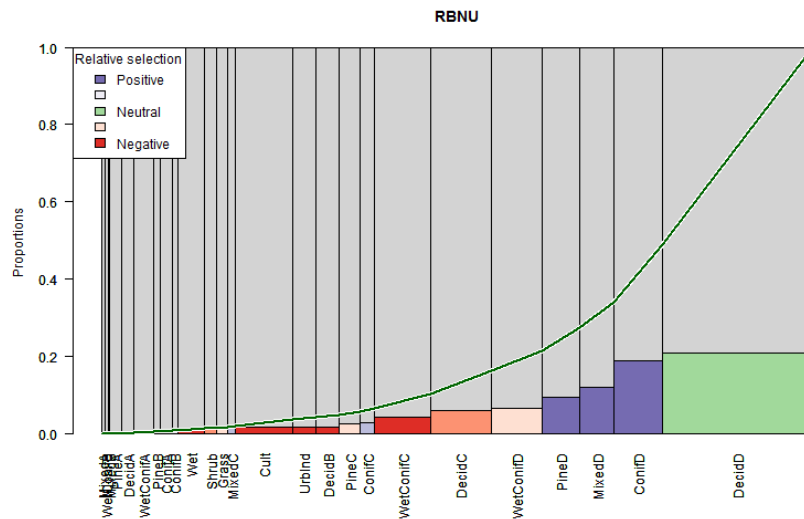
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.50.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

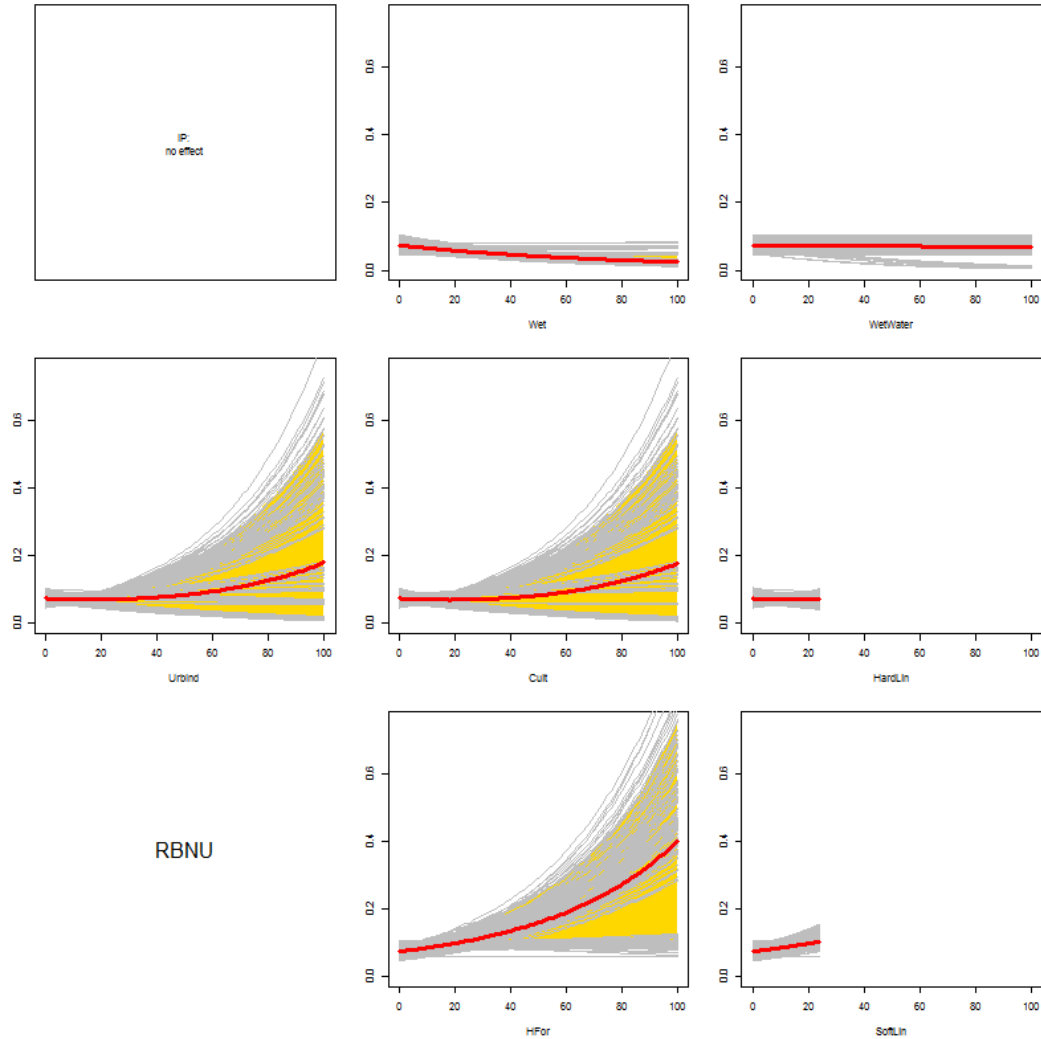


5.50.7 Relative habitat selection



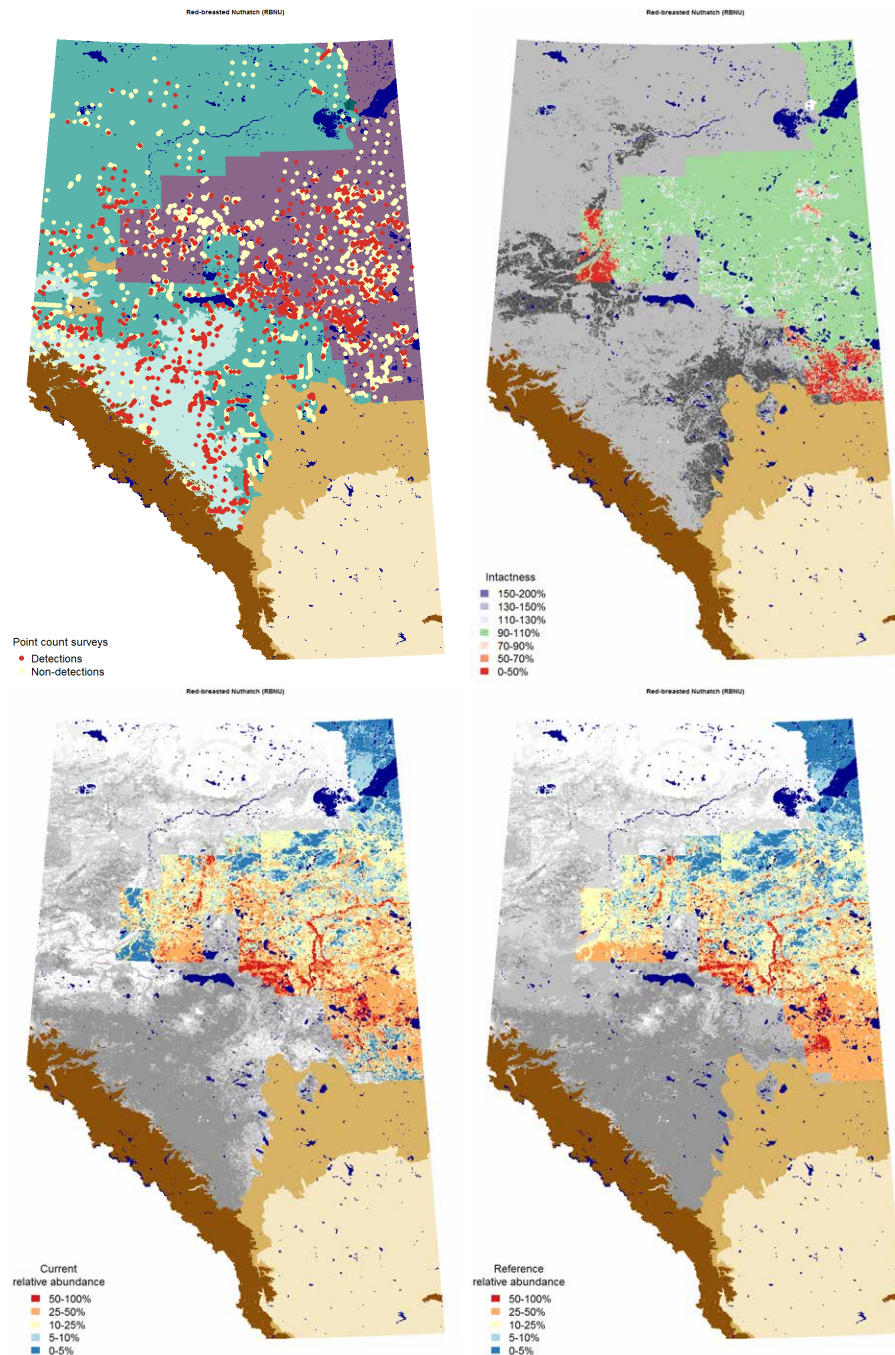
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.50.8 Quarter-section level responses



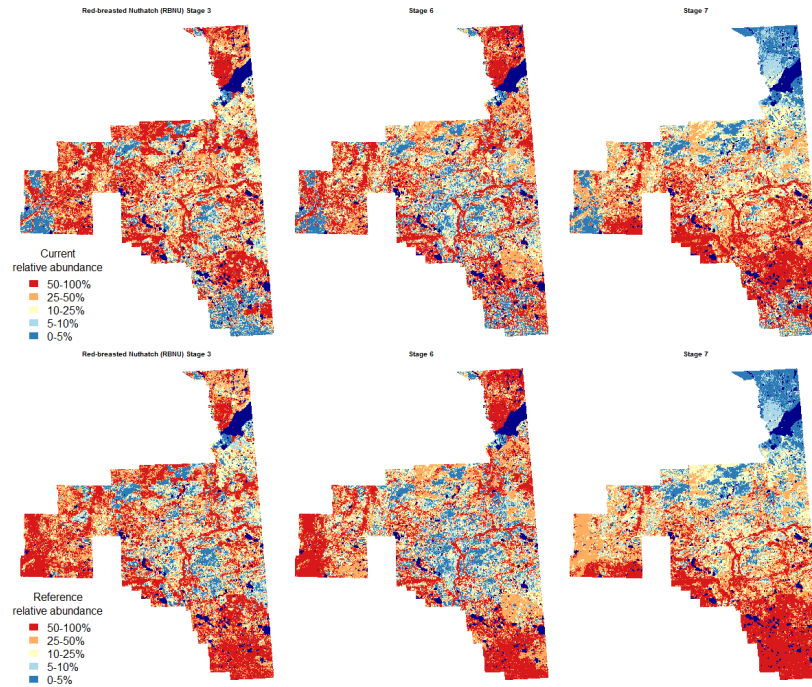
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.50.9 Maps



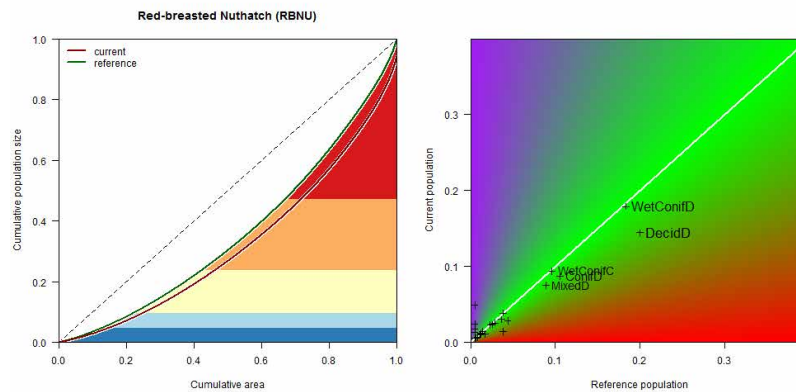
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.50.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.50.11 Population concentration



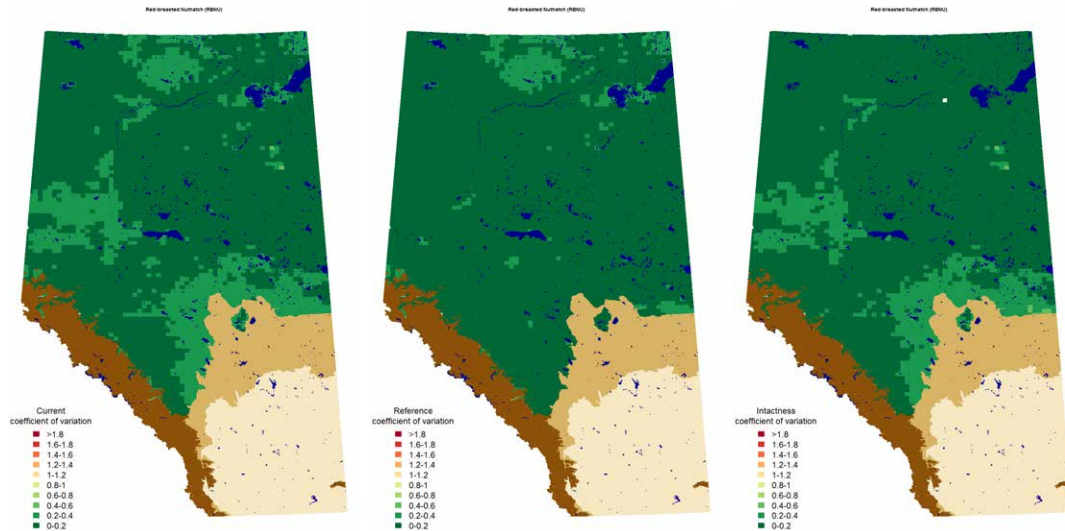
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.50.12 Potential population size

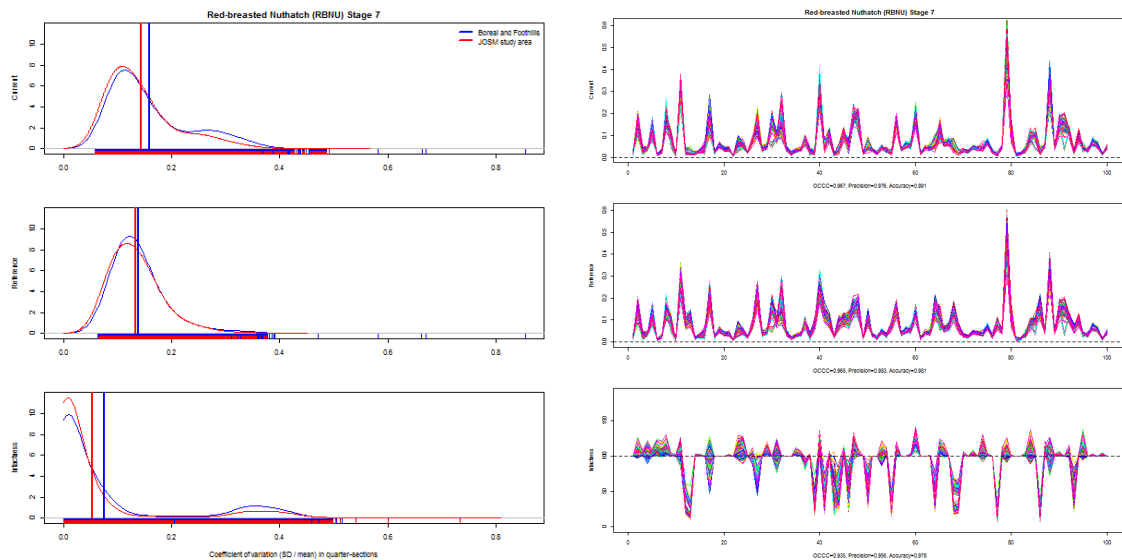
Estimated potential population size of Red-breasted Nuthatch in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1257	0.1172	0.1389	0.1738	0.1552	0.1976
WetConifD	0.1558	0.1454	0.1722	0.1593	0.1422	0.1811
ConifD	0.0758	0.0707	0.0838	0.0920	0.0821	0.1045
WetConifC	0.0815	0.0761	0.0901	0.0837	0.0748	0.0952
MixedD	0.0652	0.0608	0.0721	0.0775	0.0692	0.0881
Shrub	0.0248	0.0232	0.0274	0.0381	0.0340	0.0433
Wet	0.0336	0.0313	0.0371	0.0336	0.0300	0.0382
Grass	0.0122	0.0114	0.0135	0.0333	0.0298	0.0379
ConifC	0.0263	0.0245	0.0290	0.0315	0.0281	0.0358
PineD	0.0222	0.0207	0.0245	0.0248	0.0222	0.0282
PineC	0.0205	0.0191	0.0227	0.0221	0.0198	0.0252
PineB	0.0201	0.0187	0.0222	0.0202	0.0180	0.0230
DecidC	0.0097	0.0090	0.0107	0.0145	0.0130	0.0165
WetConifB	0.0121	0.0113	0.0134	0.0124	0.0111	0.0141
ConifA	0.0091	0.0085	0.0100	0.0106	0.0095	0.0121
WetConifA	0.0103	0.0096	0.0114	0.0104	0.0093	0.0118
ConifB	0.0086	0.0081	0.0096	0.0100	0.0089	0.0114
DecidB	0.0056	0.0053	0.0062	0.0074	0.0066	0.0084
PineA	0.0052	0.0049	0.0058	0.0054	0.0048	0.0061
DecidA	0.0013	0.0012	0.0014	0.0022	0.0020	0.0026
MixedB	0.0018	0.0016	0.0020	0.0021	0.0019	0.0024
MixedA	0.0014	0.0013	0.0015	0.0020	0.0018	0.0023
MixedC	0.0014	0.0013	0.0016	0.0018	0.0016	0.0021
Cult	0.0213	0.0199	0.0235	0.0000	0.0000	0.0000
UrbInd	0.0117	0.0109	0.0129	0.0000	0.0000	0.0000
HardLin	0.0006	0.0006	0.0007	0.0000	0.0000	0.0000
SoftLin	0.0151	0.0141	0.0167	0.0000	0.0000	0.0000
HFor	0.0429	0.0400	0.0474	0.0000	0.0000	0.0000
Total	0.8216	0.7666	0.9082	0.8691	0.7759	0.9879
Loss	0.0852	0.0414	0.1195			
Gain	0.0343	0.0096	0.0625			

5.50.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.50.14 Variable selection frequencies

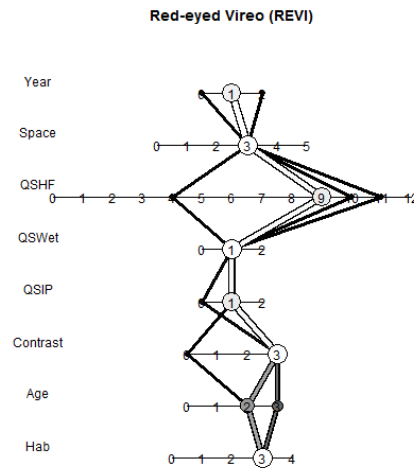
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	28.5	57	. + Habitat
1.2	71.5	143	. + HabitatB
2.1	99.5	199	. + Age
2.2	0.5	1	. + Age + Age2
3.0	0.5	1	NULL
3.1	95.0	190	. + ROAD
3.3	4.5	9	. + ROAD + SoftLin_PC
4.0	100.0	200	NULL
5.0	1.5	3	NULL
5.1	94.0	188	. + pWet_QS
5.2	4.5	9	. + pWetWater_QS
6.0	1.0	2	NULL
6.3	19.0	38	. + Succ_QS + Alien_QS
6.4	2.5	5	. + Succ_QS + Noncult_QS + Cult_QS
6.5	34.0	68	. + THF_QS + THF2_QS
6.6	0.5	1	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.7	33.5	67	. + Succ_QS + Alien_QS + Succ2_QS
6.8	1.0	2	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	6.5	13	. + Succ_QS + Alien_QS + Alien2_QS
6.11	2.0	4	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.1	0.5	1	. + xlat
7.4	99.5	199	. + xMAP + xPET + xMAT + xCMD
8.0	85.0	170	NULL
8.1	1.0	2	. + xYEAR
8.2	14.0	28	. + YR5F

5.51 Red-eyed Vireo (*Vireo olivaceus*)

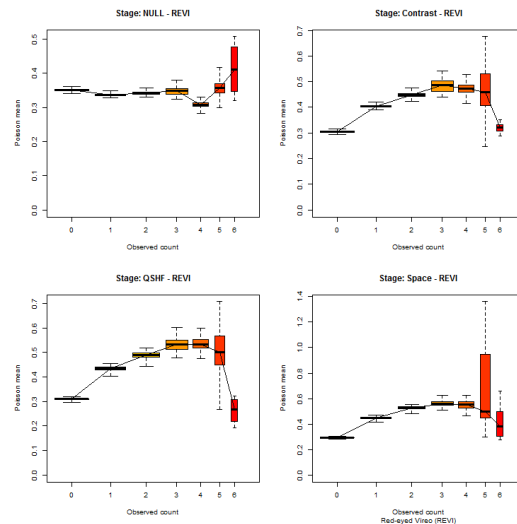
5.51.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

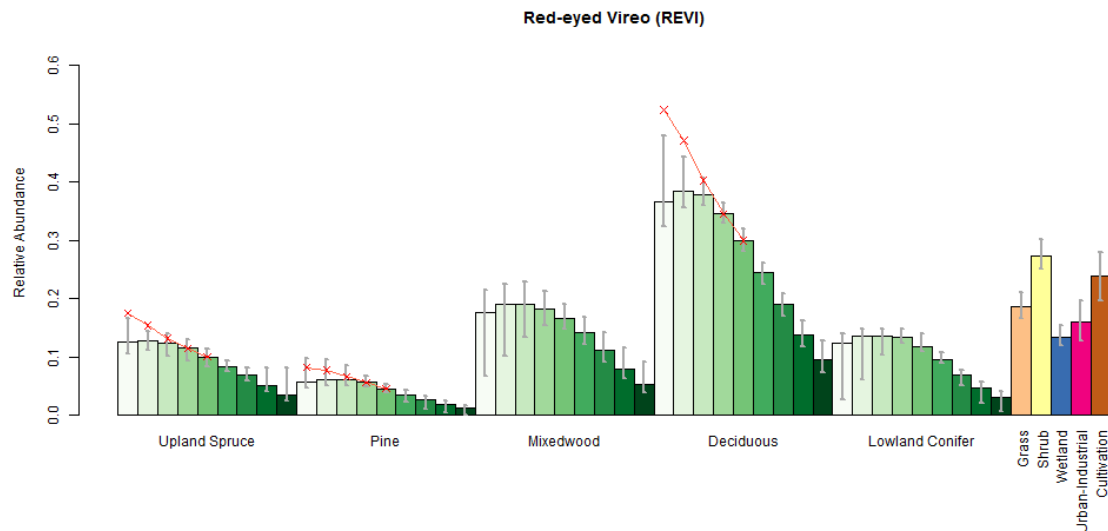


5.51.2 Cross validation

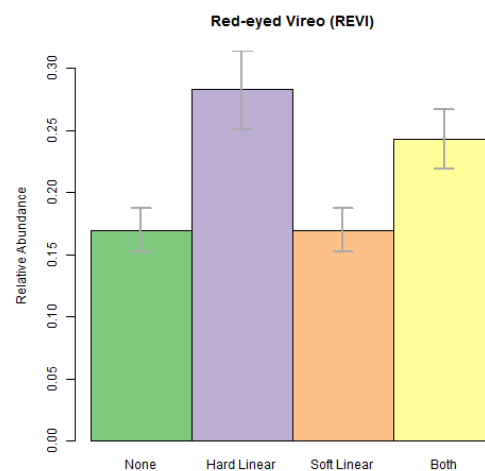
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.51.3 Point level habitat associations

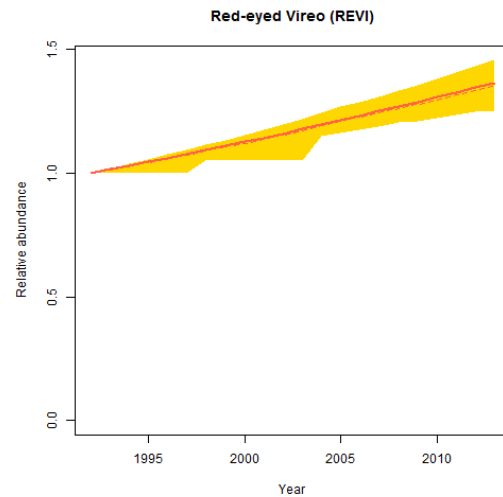


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

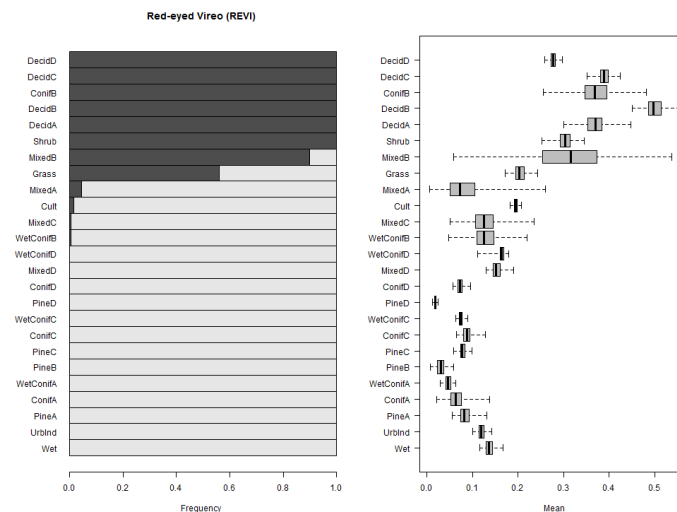


5.51.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



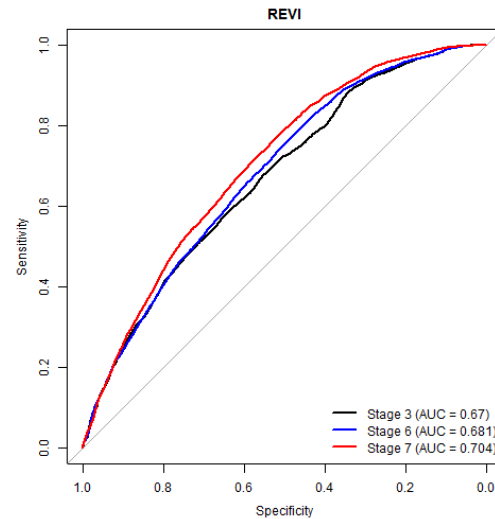
5.51.5 Habitat suitability ranking for patch delineation



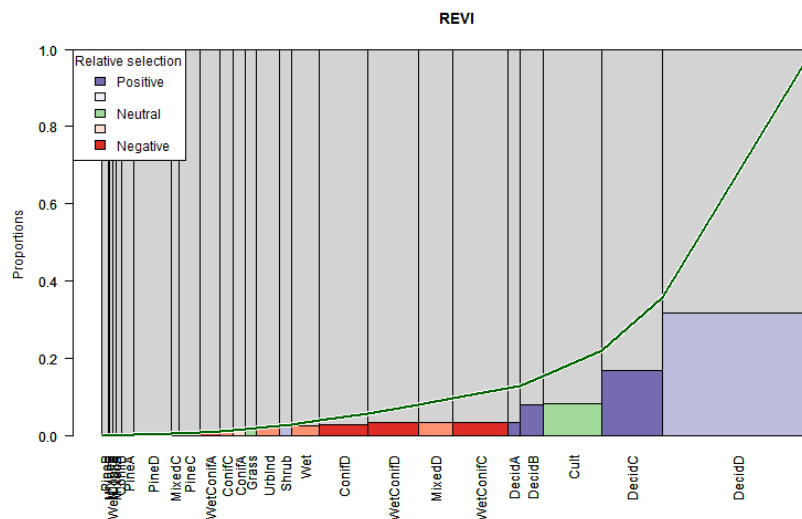
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.51.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

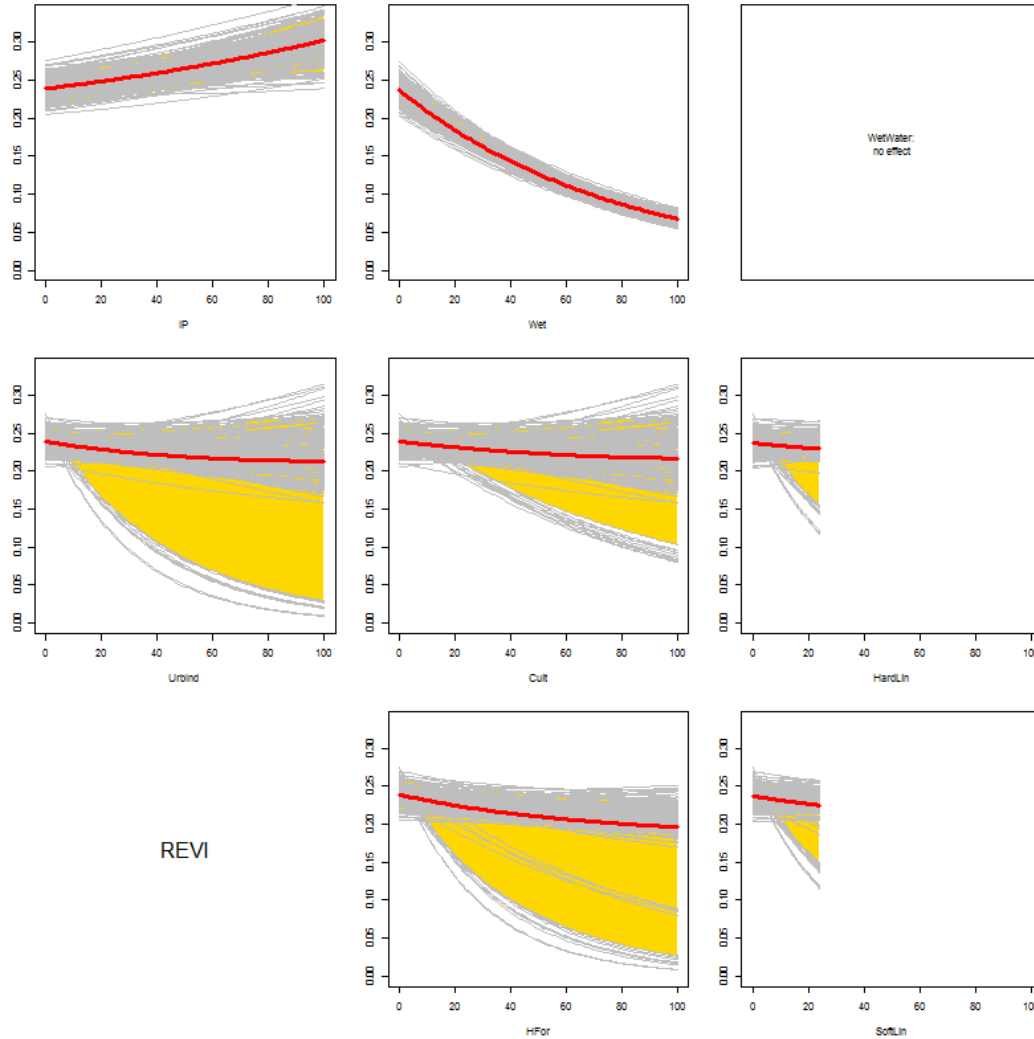


5.51.7 Relative habitat selection



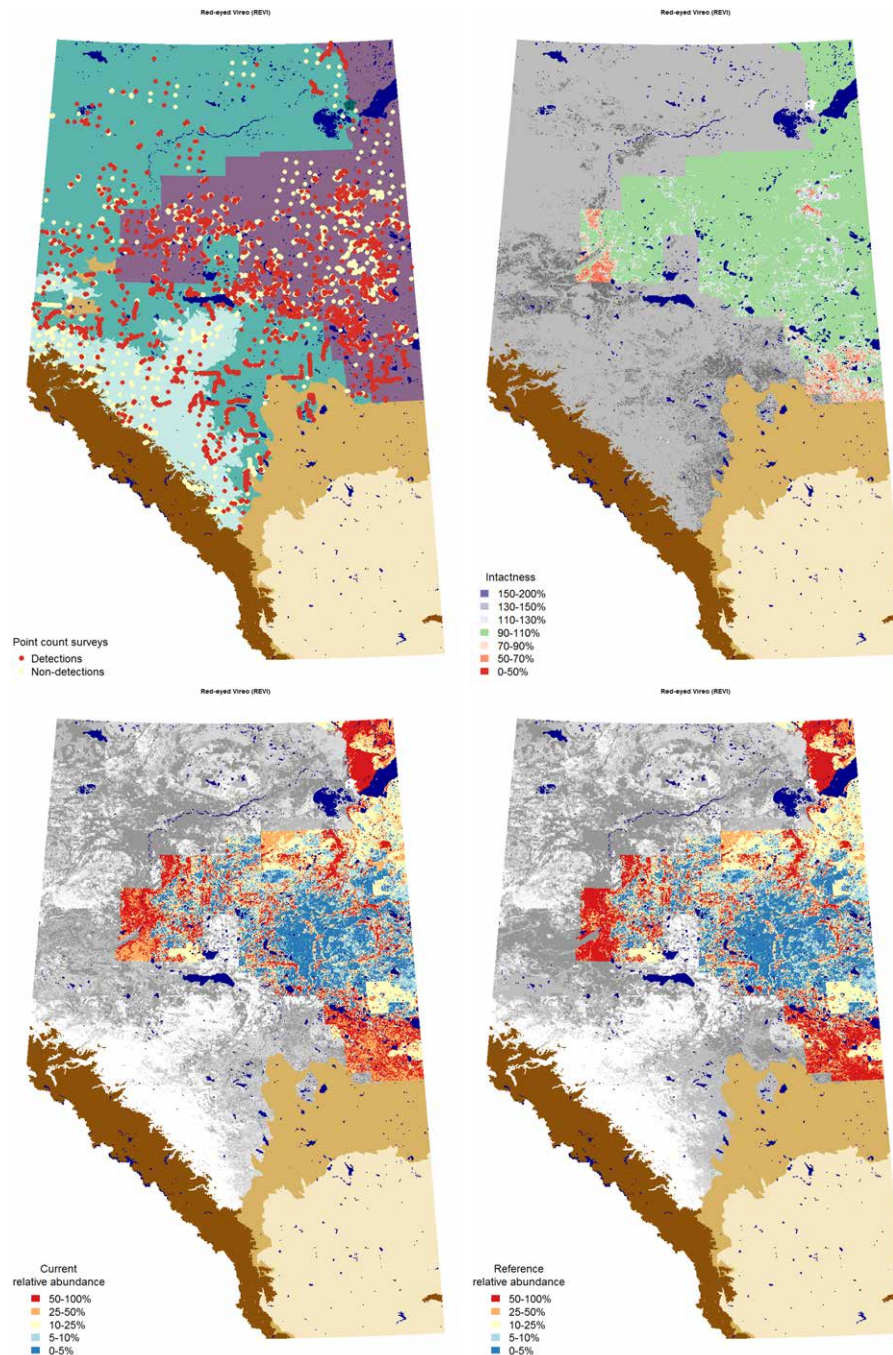
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.51.8 Quarter-section level responses



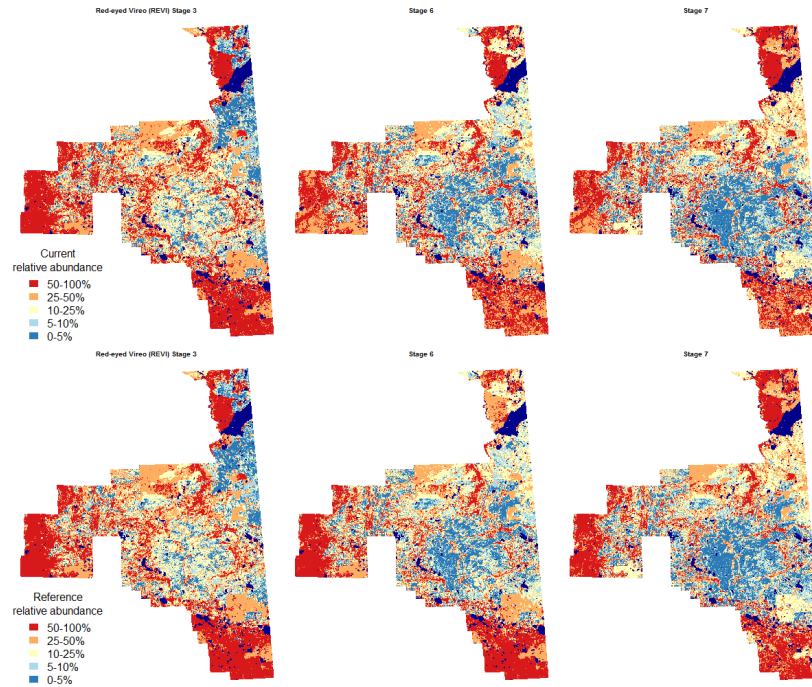
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.51.9 Maps



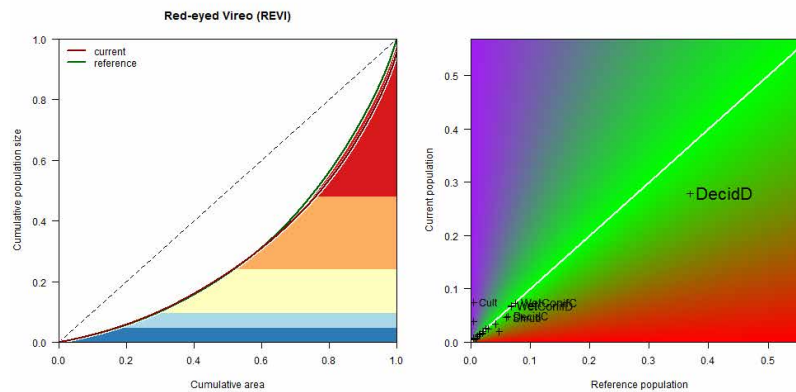
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.51.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.51.11 Population concentration



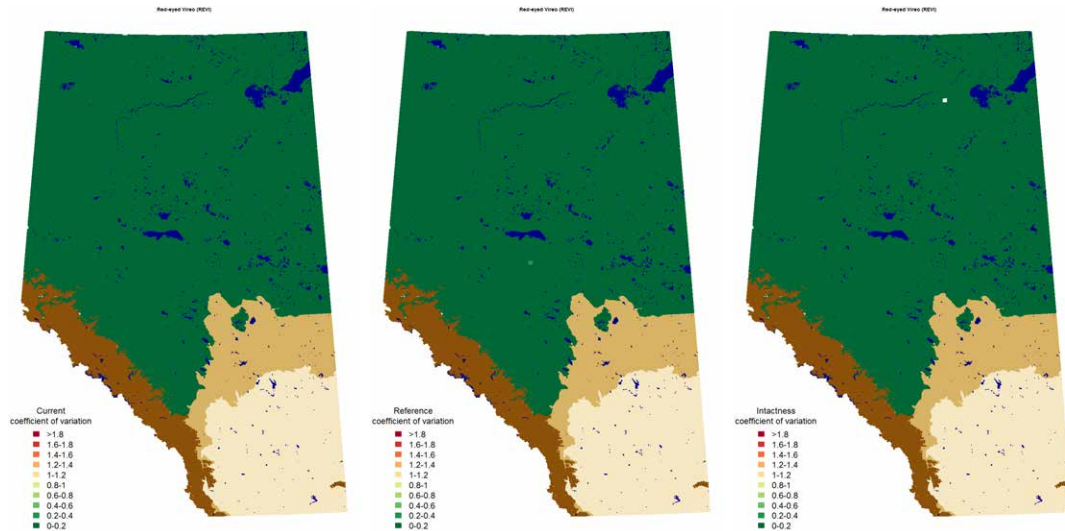
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.51.12 Potential population size

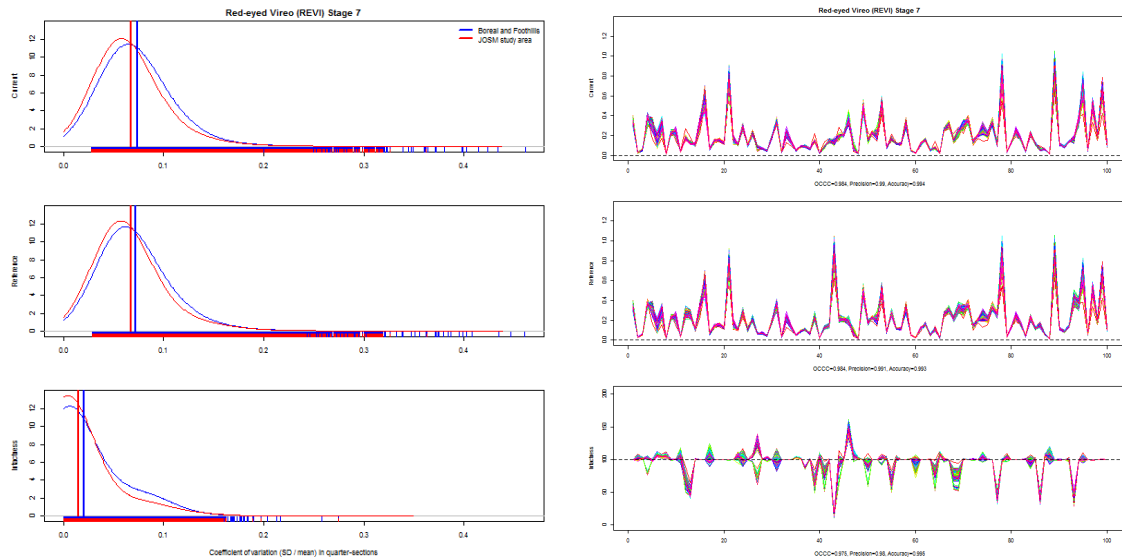
Estimated potential population size of Red-eyed Vireo in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.7696	0.7397	0.8007	1.0162	0.9637	1.0670
WetConifC	0.2022	0.1943	0.2103	0.2062	0.1955	0.2165
Wet	0.1890	0.1817	0.1966	0.1887	0.1789	0.1981
WetConifD	0.1843	0.1772	0.1918	0.1873	0.1776	0.1967
DecidC	0.1335	0.1283	0.1389	0.1718	0.1630	0.1804
Shrub	0.1278	0.1228	0.1330	0.1670	0.1584	0.1754
Grass	0.0559	0.0537	0.0582	0.1334	0.1265	0.1401
DecidB	0.0937	0.0900	0.0974	0.1145	0.1086	0.1202
MixedD	0.0692	0.0665	0.0719	0.0825	0.0782	0.0866
PineB	0.0710	0.0682	0.0738	0.0710	0.0673	0.0746
WetConifB	0.0561	0.0540	0.0584	0.0572	0.0543	0.0601
ConifC	0.0473	0.0455	0.0492	0.0542	0.0514	0.0569
ConifD	0.0450	0.0433	0.0469	0.0538	0.0510	0.0565
ConifA	0.0419	0.0403	0.0436	0.0452	0.0429	0.0475
ConifB	0.0417	0.0400	0.0433	0.0447	0.0423	0.0469
WetConifA	0.0381	0.0366	0.0396	0.0381	0.0361	0.0400
PineC	0.0316	0.0304	0.0329	0.0337	0.0320	0.0354
DecidA	0.0187	0.0179	0.0194	0.0302	0.0286	0.0317
PineA	0.0221	0.0213	0.0230	0.0223	0.0212	0.0234
PineD	0.0177	0.0170	0.0184	0.0191	0.0181	0.0201
MixedB	0.0082	0.0079	0.0085	0.0090	0.0086	0.0095
MixedC	0.0046	0.0045	0.0048	0.0053	0.0051	0.0056
MixedA	0.0039	0.0038	0.0041	0.0052	0.0049	0.0055
Cult	0.2058	0.1978	0.2141	0.0000	0.0000	0.0000
UrbInd	0.0238	0.0229	0.0248	0.0000	0.0000	0.0000
HardLin	0.0069	0.0066	0.0072	0.0000	0.0000	0.0000
SoftLin	0.0146	0.0140	0.0152	0.0000	0.0000	0.0000
HFor	0.1078	0.1036	0.1121	0.0000	0.0000	0.0000
Total	2.6321	2.5298	2.7382	2.7567	2.6141	2.8944
Loss	0.1729	0.1271	0.2208			
Gain	0.0519	0.0354	0.0733			

5.51.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.51.14 Variable selection frequencies

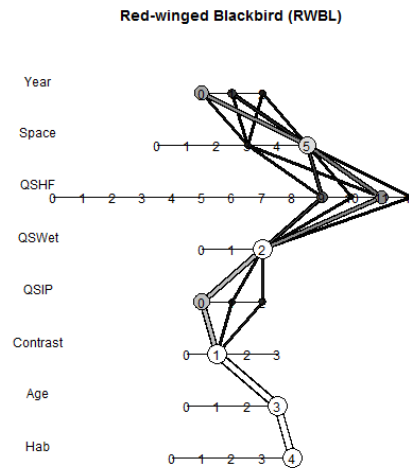
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.3	100.0	200	. + Habitat + isHForC
2.2	60.5	121	. + Age + Age2
			. + Age + Age2 + Age:isMix + Age:isPine
2.3	39.5	79	+ Age:isUplConif + Age:isWetConif +
			Age2:isMix + Age2:isPine + Age2:isUplConif
			+ Age2:isWetConif
3.0	0.5	1	NULL
3.3	99.5	199	. + ROAD + SoftLin_PC
4.0	8.0	16	NULL
4.1	92.0	184	. + Remn_QS
5.1	100.0	200	. + pWet_QS
6.4	4.5	9	. + Succ_QS + Noncult_QS + Cult_QS
6.9	92.5	185	. + Succ_QS + Alien_QS + Alien2_QS
6.10	1.0	2	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.11	2.0	4	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.3	100.0	200	. + xlat + xlong + xlat:xlong
8.0	4.0	8	NULL
8.1	94.5	189	. + xYEAR
8.2	1.5	3	. + YR5F

5.52 Red-winged Blackbird (*Agelaius phoeniceus*)

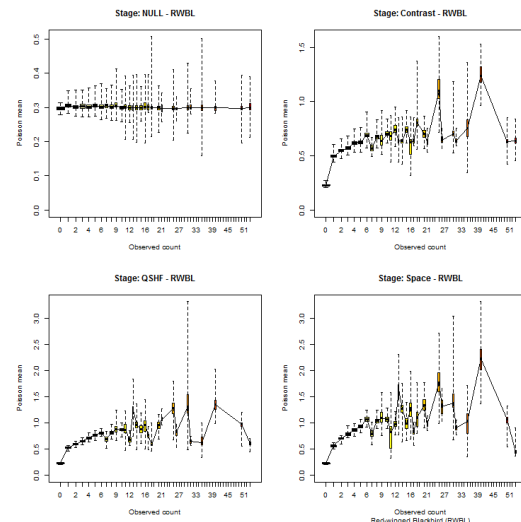
5.52.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

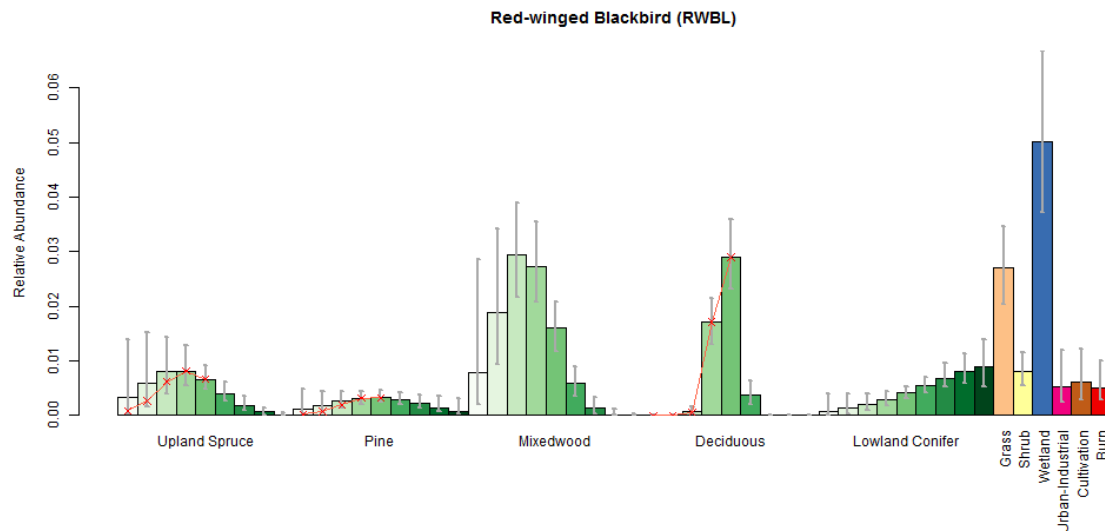


5.52.2 Cross validation

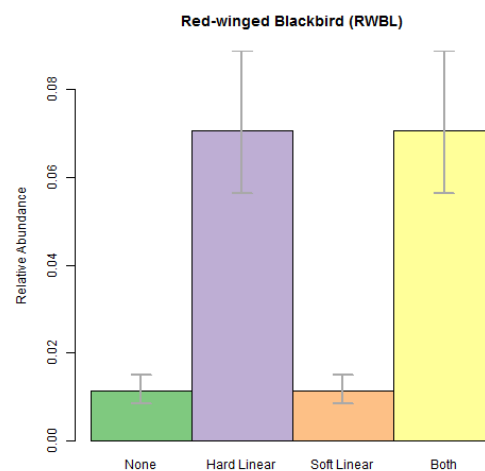
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.52.3 Point level habitat associations

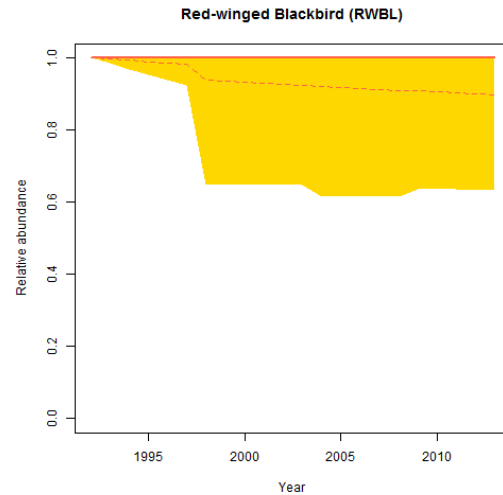


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

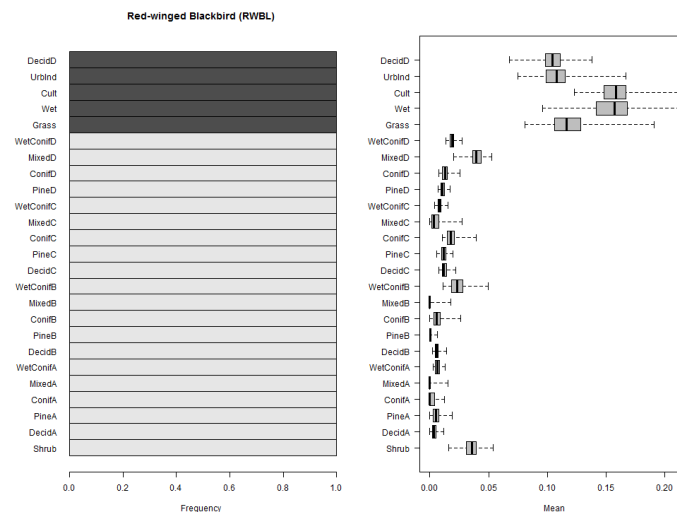


5.52.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



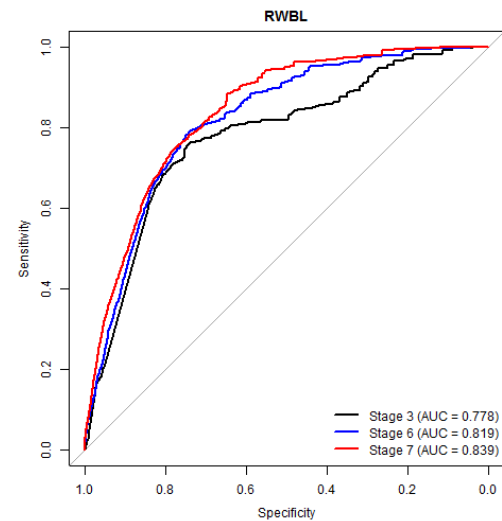
5.52.5 Habitat suitability ranking for patch delineation



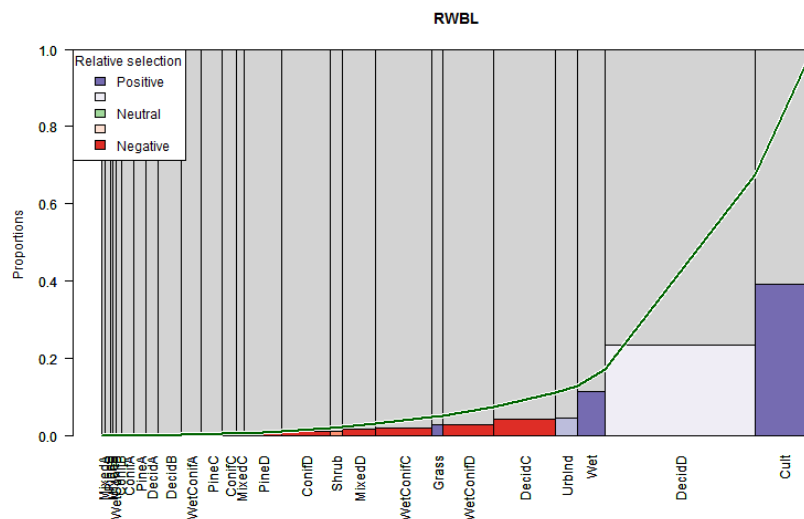
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.52.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

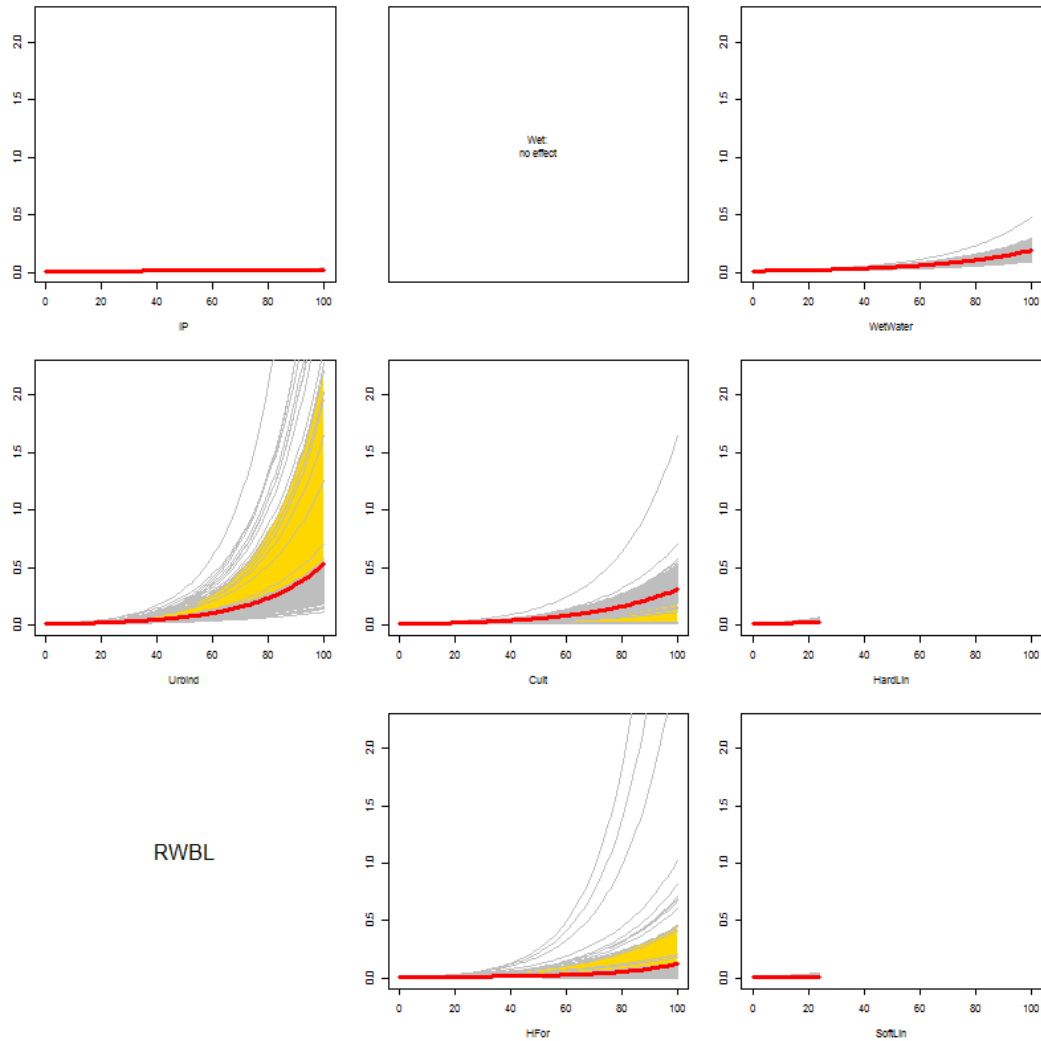


5.52.7 Relative habitat selection



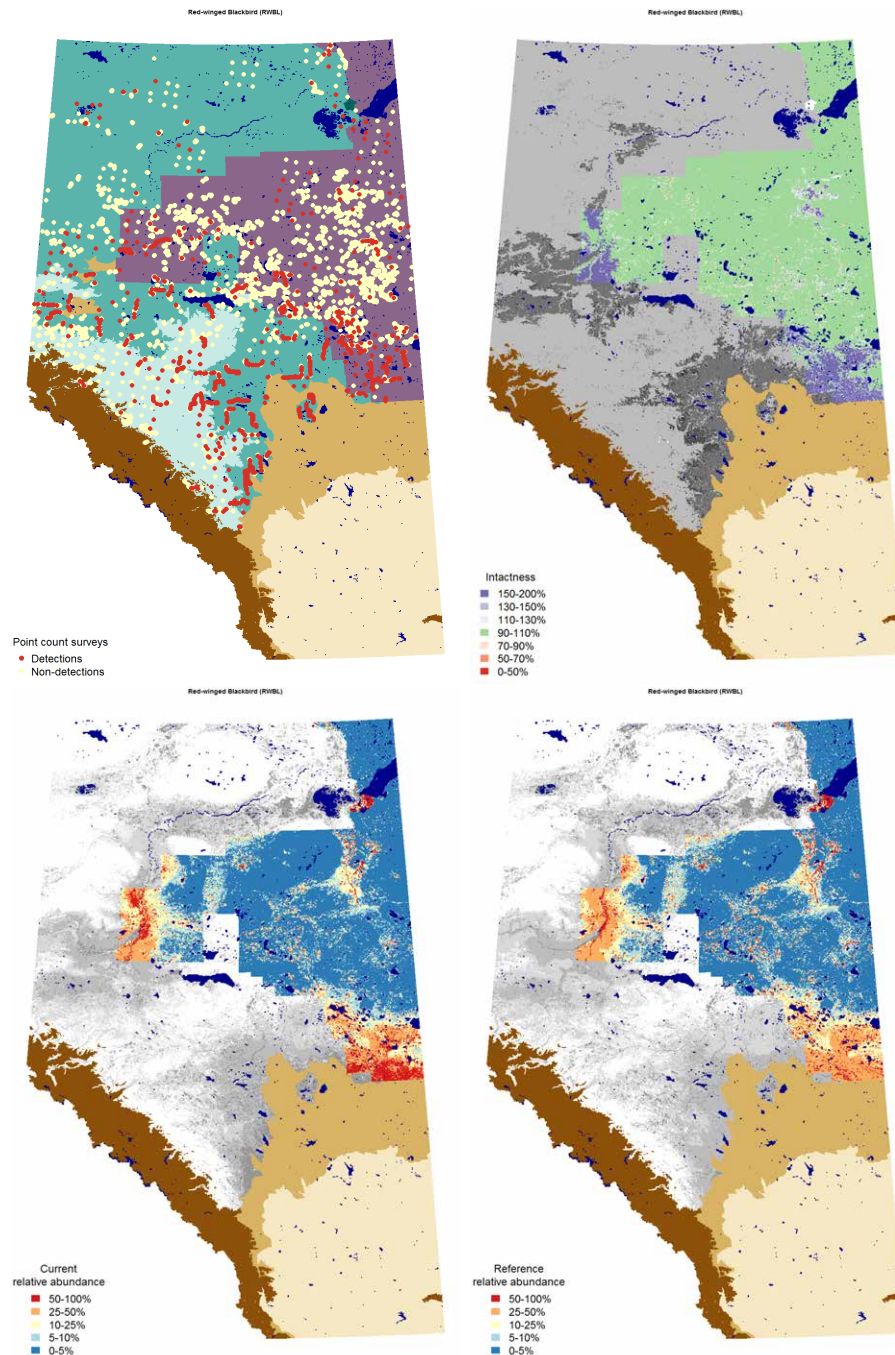
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.52.8 Quarter-section level responses



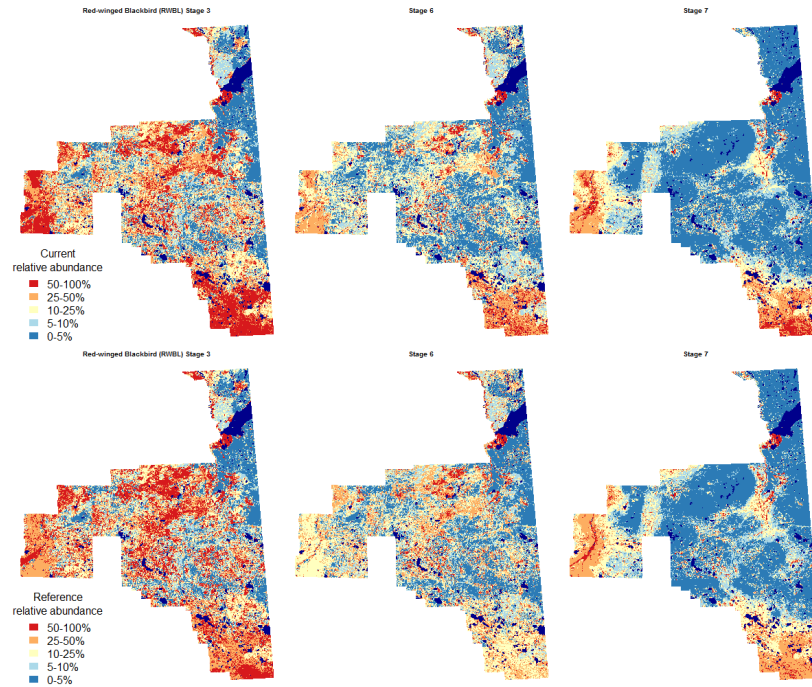
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.52.9 Maps



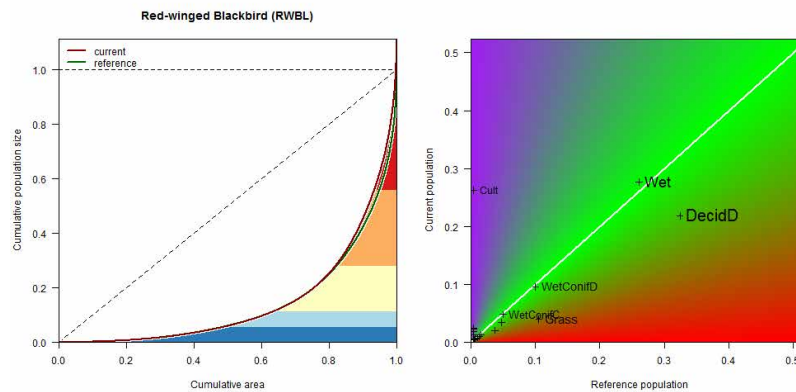
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.52.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.52.11 Population concentration



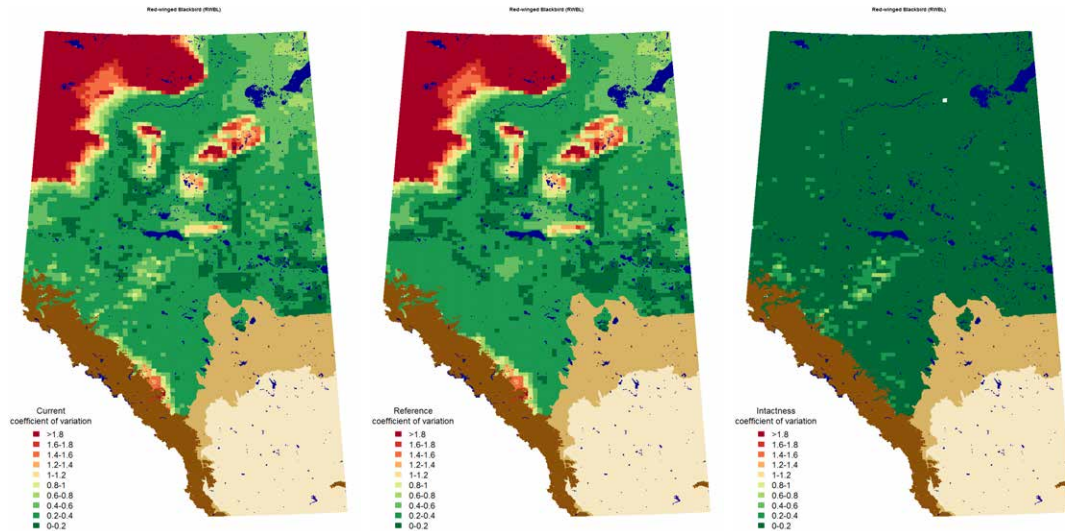
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.52.12 Potential population size

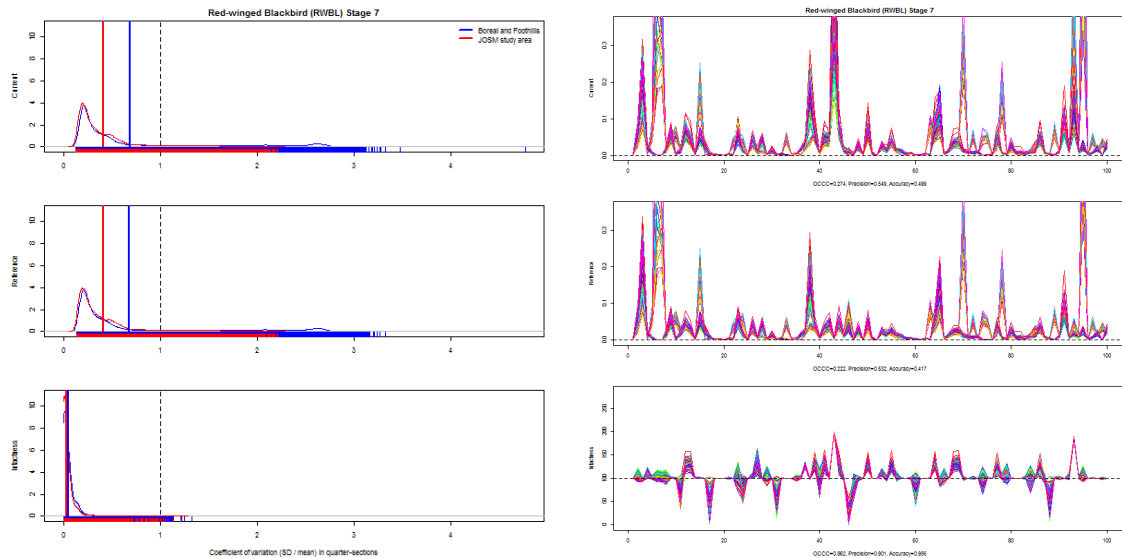
Estimated potential population size of Red-winged Blackbird in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0584	0.0420	0.0735	0.0879	0.0618	0.1101
Wet	0.0739	0.0531	0.0930	0.0707	0.0497	0.0886
Grass	0.0107	0.0077	0.0135	0.0286	0.0201	0.0359
WetConifD	0.0256	0.0184	0.0322	0.0273	0.0192	0.0341
WetConifC	0.0128	0.0092	0.0161	0.0137	0.0096	0.0171
MixedD	0.0091	0.0066	0.0115	0.0129	0.0091	0.0162
Shrub	0.0055	0.0039	0.0069	0.0101	0.0071	0.0127
ConifC	0.0034	0.0024	0.0042	0.0045	0.0032	0.0056
ConifD	0.0026	0.0019	0.0033	0.0036	0.0025	0.0045
DecidC	0.0021	0.0015	0.0026	0.0029	0.0020	0.0036
PineC	0.0015	0.0011	0.0019	0.0019	0.0013	0.0024
PineD	0.0013	0.0009	0.0016	0.0017	0.0012	0.0021
PineB	0.0010	0.0007	0.0012	0.0010	0.0007	0.0013
WetConifB	0.0009	0.0006	0.0011	0.0009	0.0006	0.0012
ConifB	0.0006	0.0004	0.0008	0.0009	0.0006	0.0011
ConifA	0.0005	0.0004	0.0006	0.0007	0.0005	0.0009
WetConifA	0.0006	0.0005	0.0008	0.0007	0.0005	0.0009
MixedC	0.0004	0.0003	0.0005	0.0006	0.0004	0.0007
PineA	0.0002	0.0002	0.0003	0.0003	0.0002	0.0003
MixedB	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002
MixedA	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
DecidB	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
DecidA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0701	0.0504	0.0883	0.0000	0.0000	0.0000
UrbInd	0.0061	0.0044	0.0077	0.0000	0.0000	0.0000
HardLin	0.0050	0.0036	0.0063	0.0000	0.0000	0.0000
SoftLin	0.0066	0.0048	0.0083	0.0000	0.0000	0.0000
HFor	0.0033	0.0024	0.0041	0.0000	0.0000	0.0000
Total	0.3024	0.2174	0.3806	0.2711	0.1906	0.3395
Loss	0.0048	0.0027	0.0087			
Gain	0.0355	0.0222	0.0532			

5.52.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.52.14 Variable selection frequencies

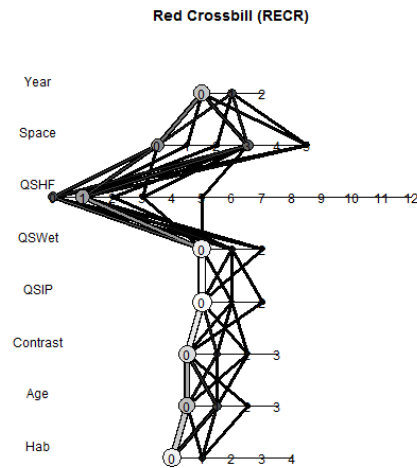
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.4	100.0	200	. + HabitatB + isHForC
2.3	100.0	200	. + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
3.1	100.0	200	. + ROAD
4.0	75.0	150	NULL
4.1	9.0	18	. + Remn_QS
4.2	16.0	32	. + Remn_QS + Remn2_QS
5.2	100.0	200	. + pWetWater_QS
6.9	38.0	76	. + Succ_QS + Alien_QS + Alien2_QS
6.10	5.5	11	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.11	55.0	110	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
6.12	1.5	3	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.3	13.0	26	. + xlat + xlong + xlat:xlong
7.5	87.0	174	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	65.5	131	NULL
8.1	23.5	47	. + xYEAR
8.2	11.0	22	. + YR5F

5.53 Red Crossbill (*Loxia curvirostra*)

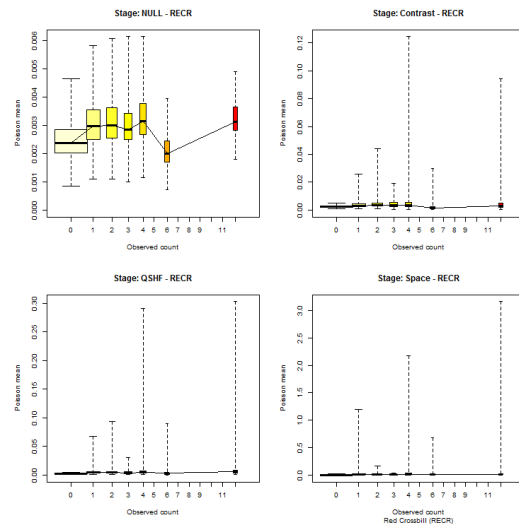
5.53.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

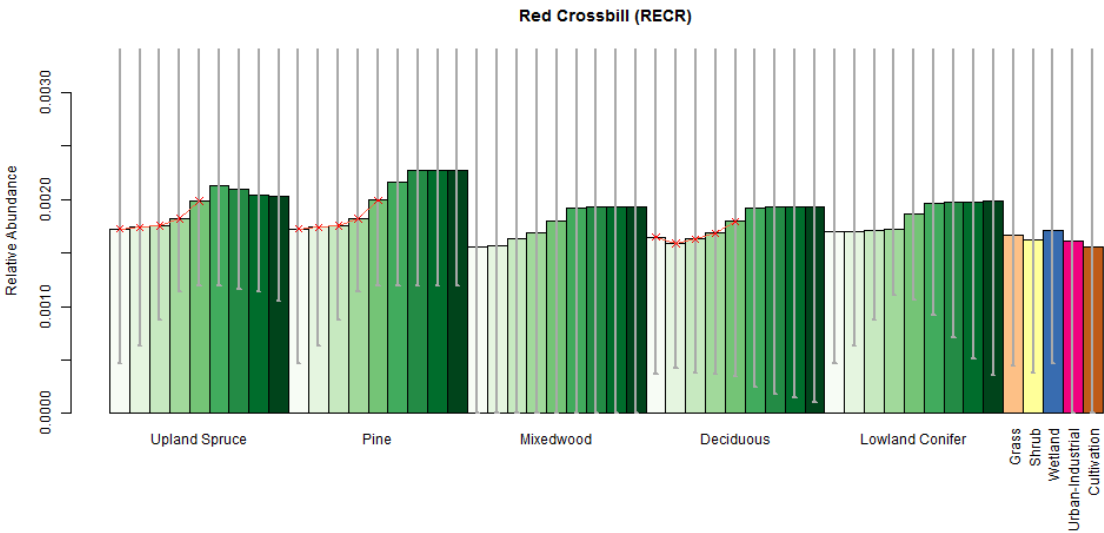


5.53.2 Cross validation

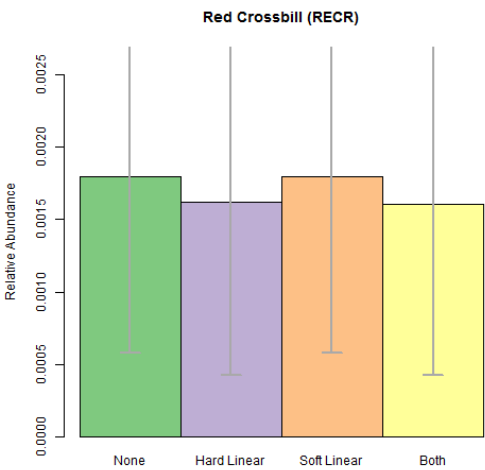
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.53.3 Point level habitat associations

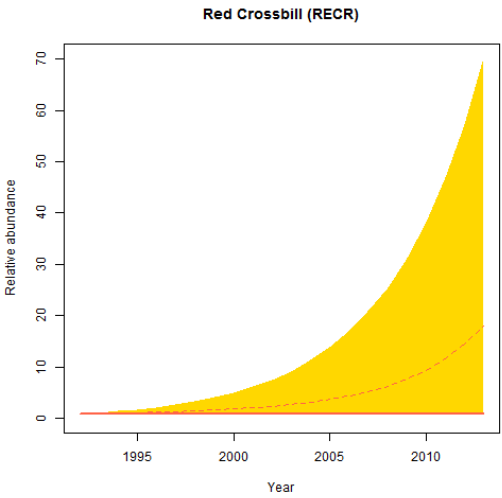


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

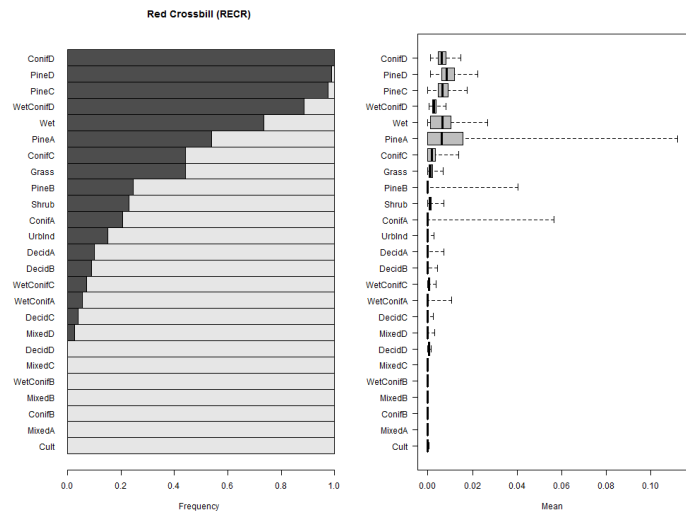


5.53.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



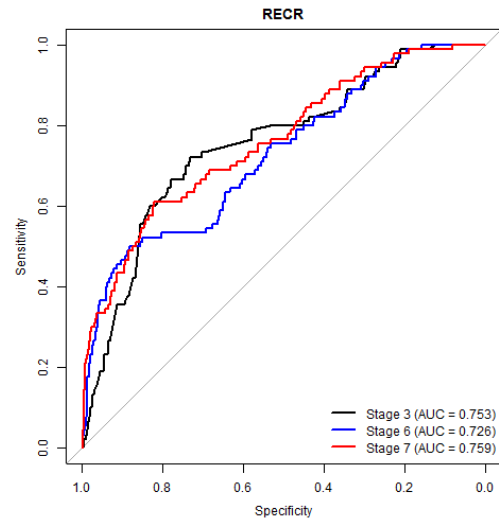
5.53.5 Habitat suitability ranking for patch delineation



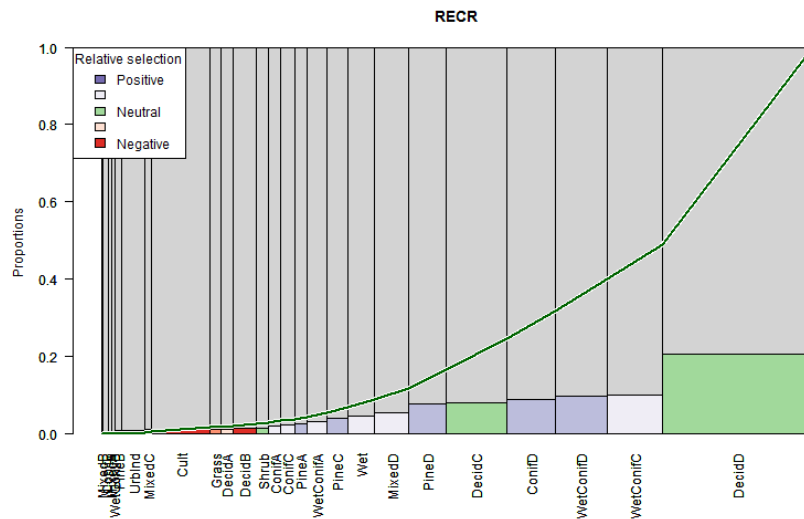
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.53.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

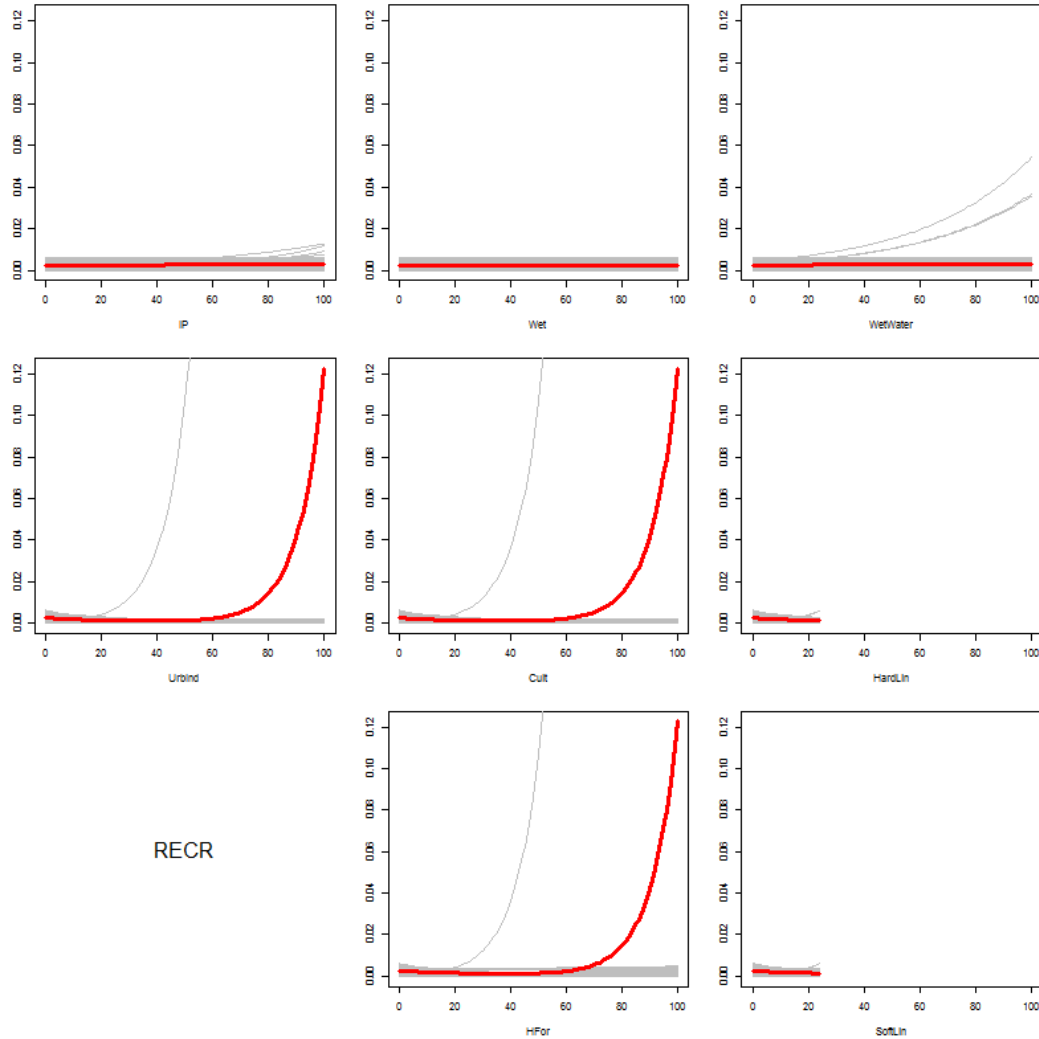


5.53.7 Relative habitat selection



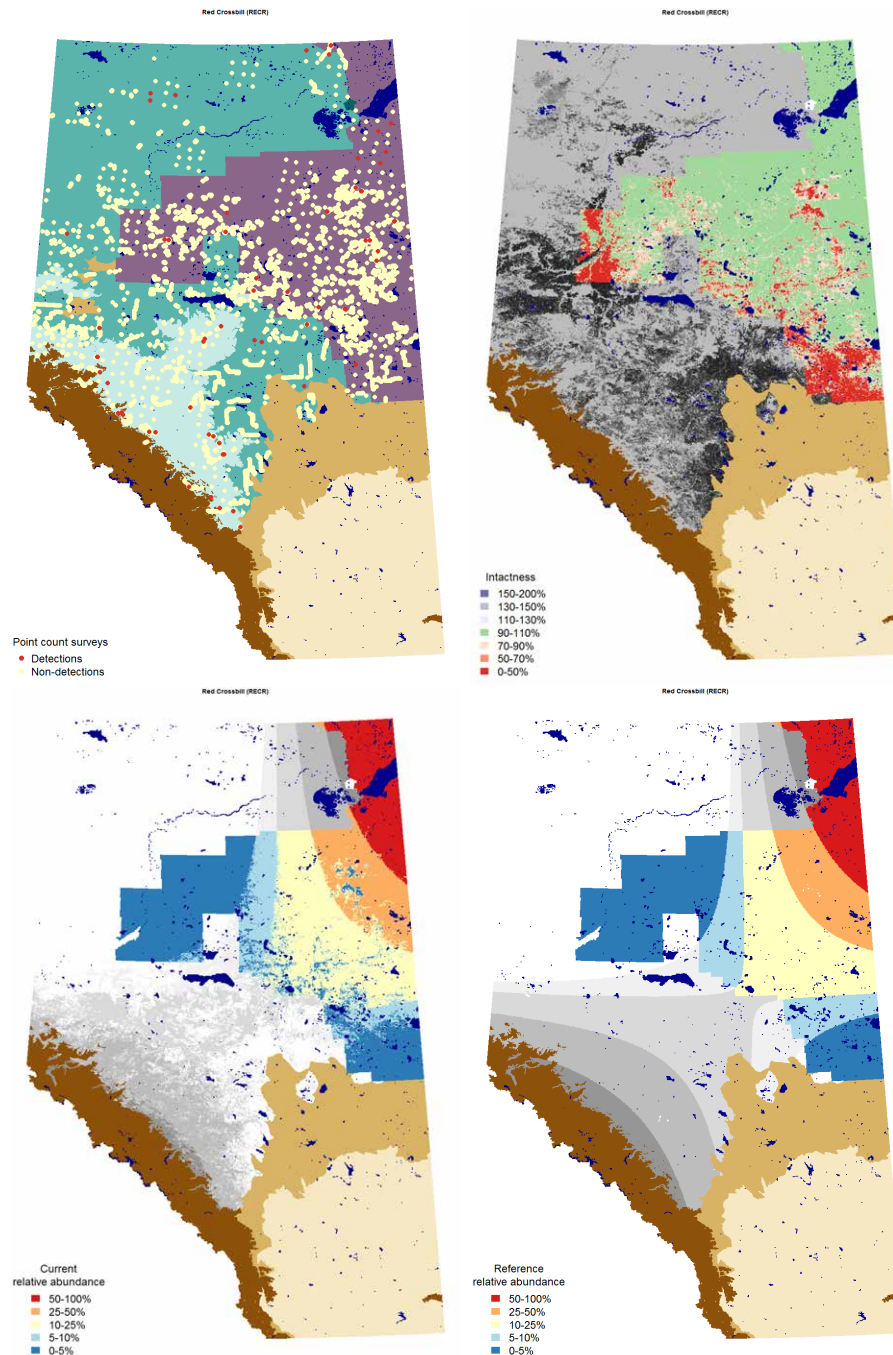
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.53.8 Quarter-section level responses



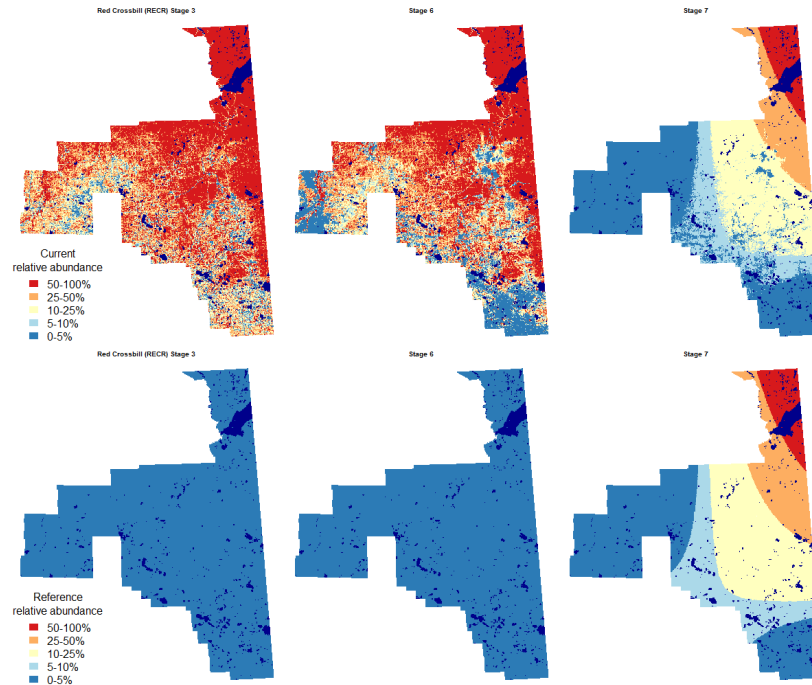
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.53.9 Maps



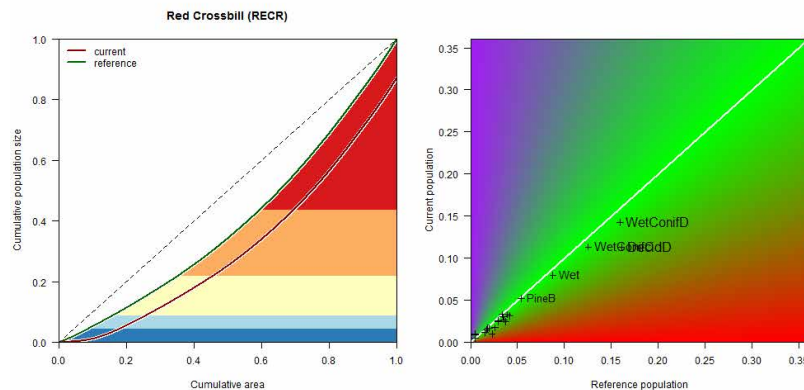
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.53.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.53.11 Population concentration



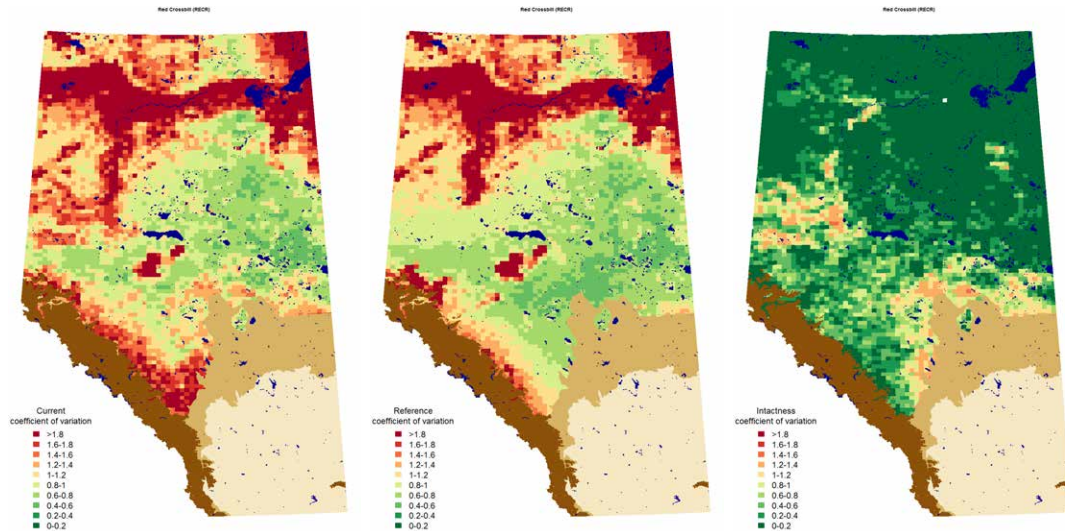
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.53.12 Potential population size

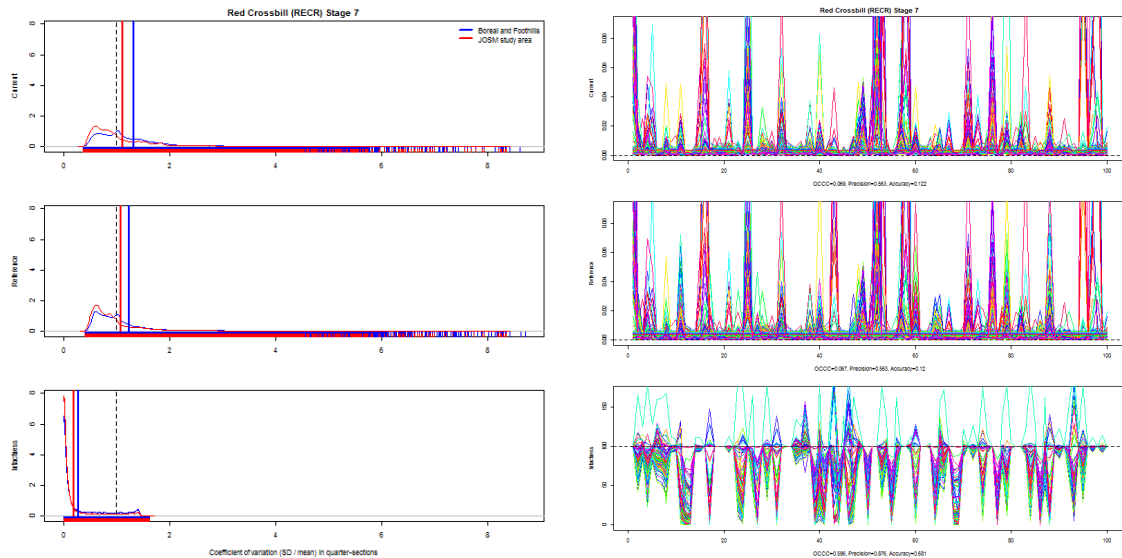
Estimated potential population size of Red Crossbill in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0072	0.0027	0.0677	0.0102	0.0034	0.0829
WetConifD	0.0090	0.0034	0.0850	0.0102	0.0034	0.0822
WetConifC	0.0072	0.0027	0.0678	0.0080	0.0027	0.0647
Wet	0.0050	0.0019	0.0476	0.0056	0.0019	0.0452
PineB	0.0033	0.0013	0.0313	0.0034	0.0011	0.0278
ConifD	0.0020	0.0008	0.0187	0.0027	0.0009	0.0215
PineC	0.0021	0.0008	0.0197	0.0025	0.0008	0.0202
Shrub	0.0016	0.0006	0.0148	0.0024	0.0008	0.0192
MixedD	0.0017	0.0007	0.0162	0.0023	0.0008	0.0183
PineD	0.0019	0.0007	0.0180	0.0022	0.0007	0.0179
WetConifB	0.0021	0.0008	0.0198	0.0022	0.0007	0.0175
ConifC	0.0015	0.0006	0.0146	0.0019	0.0006	0.0152
WetConifA	0.0016	0.0006	0.0153	0.0019	0.0006	0.0151
DecidC	0.0011	0.0004	0.0104	0.0017	0.0006	0.0135
Grass	0.0006	0.0002	0.0059	0.0015	0.0005	0.0118
ConifA	0.0010	0.0004	0.0099	0.0013	0.0004	0.0103
PineA	0.0011	0.0004	0.0101	0.0012	0.0004	0.0094
ConifB	0.0010	0.0004	0.0090	0.0011	0.0004	0.0088
DecidB	0.0008	0.0003	0.0071	0.0010	0.0003	0.0080
DecidA	0.0002	0.0001	0.0019	0.0003	0.0001	0.0027
MixedB	0.0001	0.0000	0.0012	0.0002	0.0001	0.0012
MixedA	0.0001	0.0000	0.0008	0.0001	0.0000	0.0011
MixedC	0.0001	0.0000	0.0008	0.0001	0.0000	0.0008
Cult	0.0003	0.0001	0.0030	0.0000	0.0000	0.0000
UrbInd	0.0002	0.0001	0.0022	0.0000	0.0000	0.0000
HardLin	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000
SoftLin	0.0006	0.0002	0.0055	0.0000	0.0000	0.0000
HFor	0.0006	0.0002	0.0057	0.0000	0.0000	0.0000
Total	0.0539	0.0206	0.5103	0.0637	0.0211	0.5153
Loss	0.0061	0.0000	0.0207			
Gain	0.0000	0.0000	0.0005			

5.53.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.53.14 Variable selection frequencies

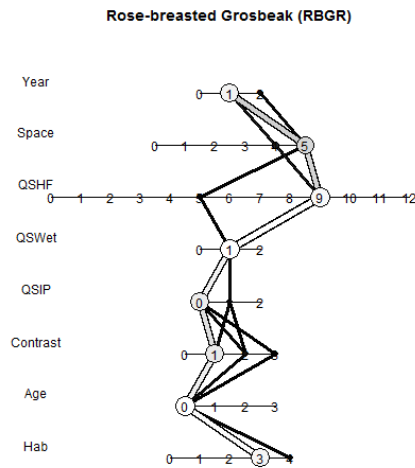
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	89.5	179	NULL
1.1	10.5	21	. + Habitat
2.0	71.5	143	NULL
2.1	28.0	56	. + Age
2.2	0.5	1	. + Age + Age2
3.0	81.5	163	NULL
3.1	13.0	26	. + ROAD
3.2	5.5	11	. + SoftLin_PC
4.0	95.0	190	NULL
4.1	4.5	9	. + Remn_QS
4.2	0.5	1	. + Remn_QS + Remn2_QS
5.0	89.0	178	NULL
5.1	9.0	18	. + pWet_QS
5.2	2.0	4	. + pWetWater_QS
6.0	35.0	70	NULL
6.1	60.0	120	. + THF_QS
6.2	0.5	1	. + Lin_QS + Nonlin_QS
6.3	4.0	8	. + Succ_QS + Alien_QS
6.5	0.5	1	. + THF_QS + THF2_QS
7.0	54.0	108	NULL
7.1	2.0	4	. + xlat
7.2	0.5	1	. + xlat + xlong
7.3	38.0	76	. + xlat + xlong + xlat:xdong
7.5	5.5	11	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	73.0	146	NULL
8.1	27.0	54	. + xYEAR

5.54 Rose-breasted Grosbeak (*Pheucticus ludovicianus*)

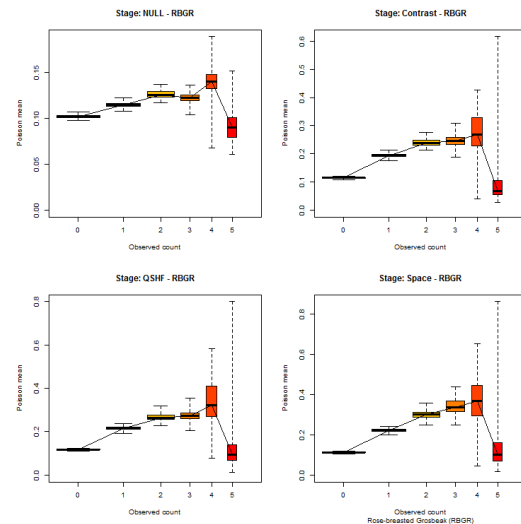
5.54.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

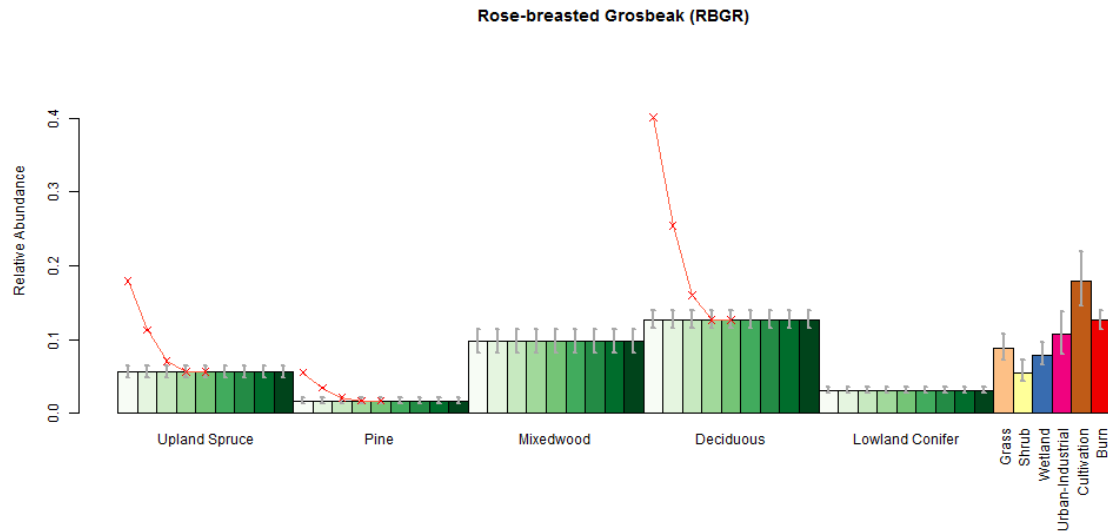


5.54.2 Cross validation

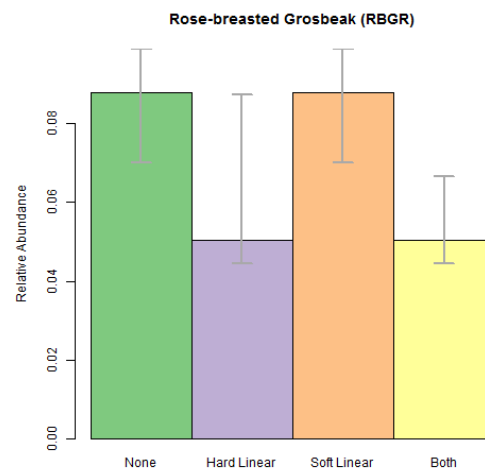
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.54.3 Point level habitat associations

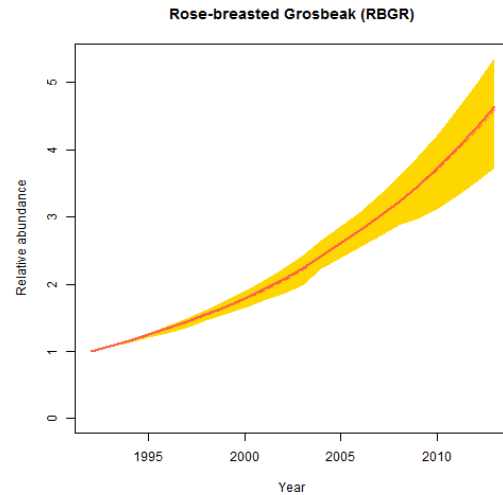


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

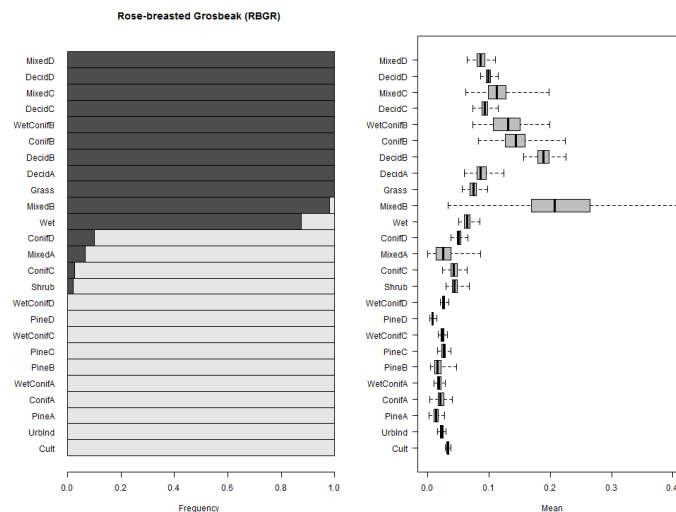


5.54.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



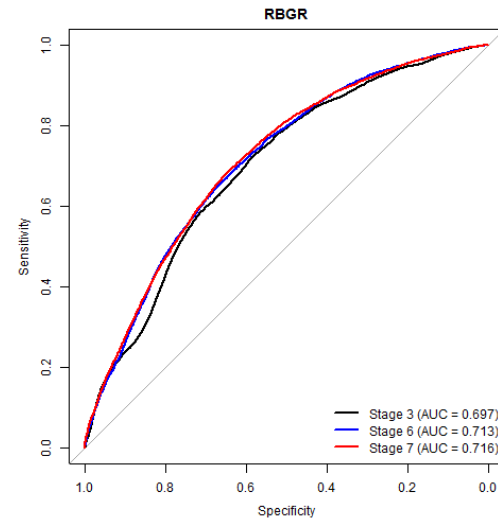
5.54.5 Habitat suitability ranking for patch delineation



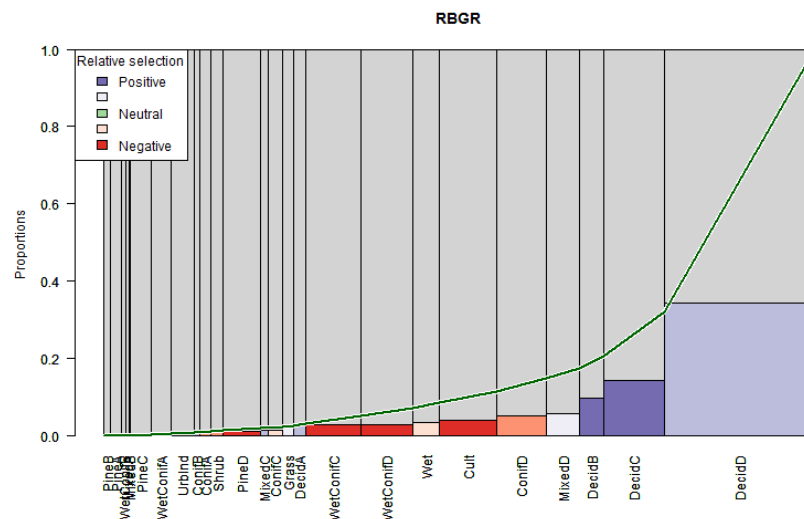
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.54.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

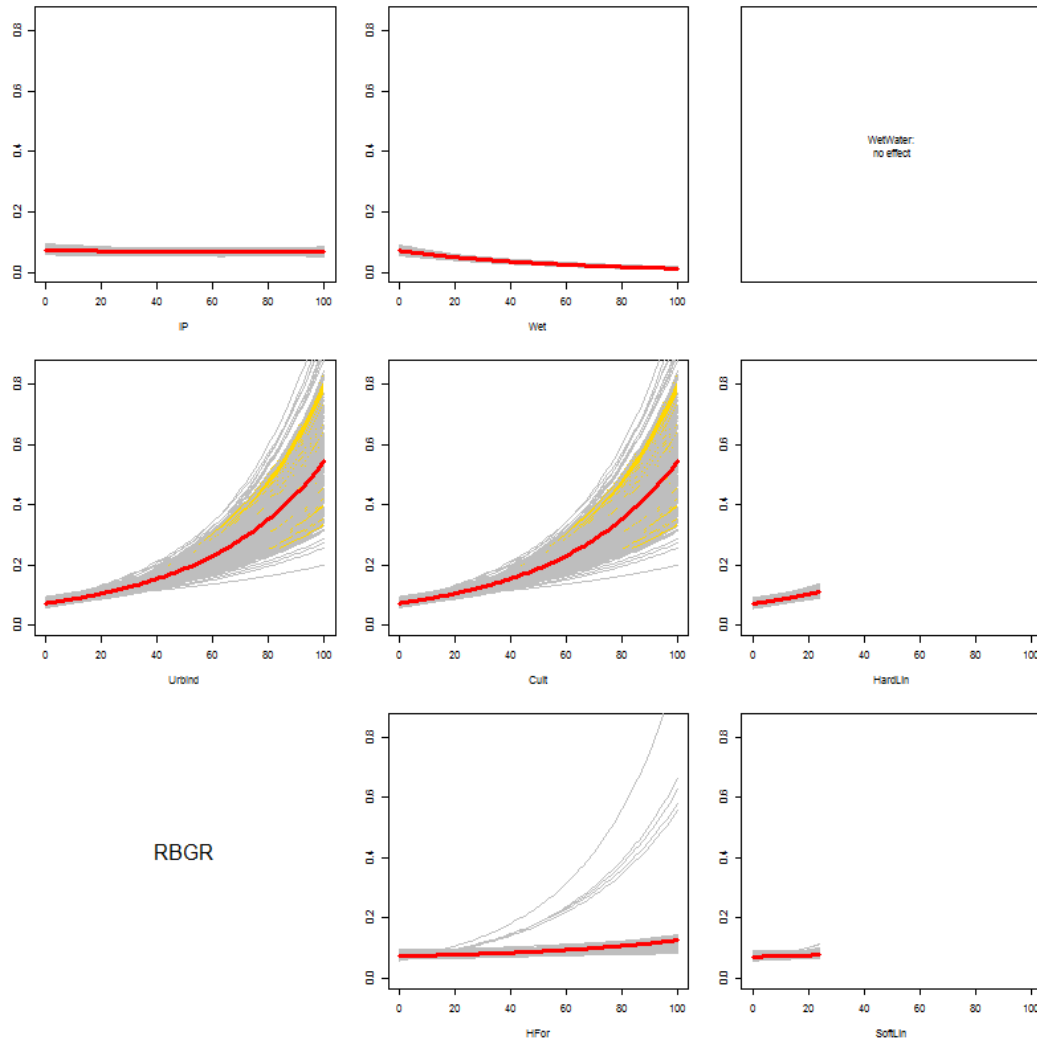


5.54.7 Relative habitat selection



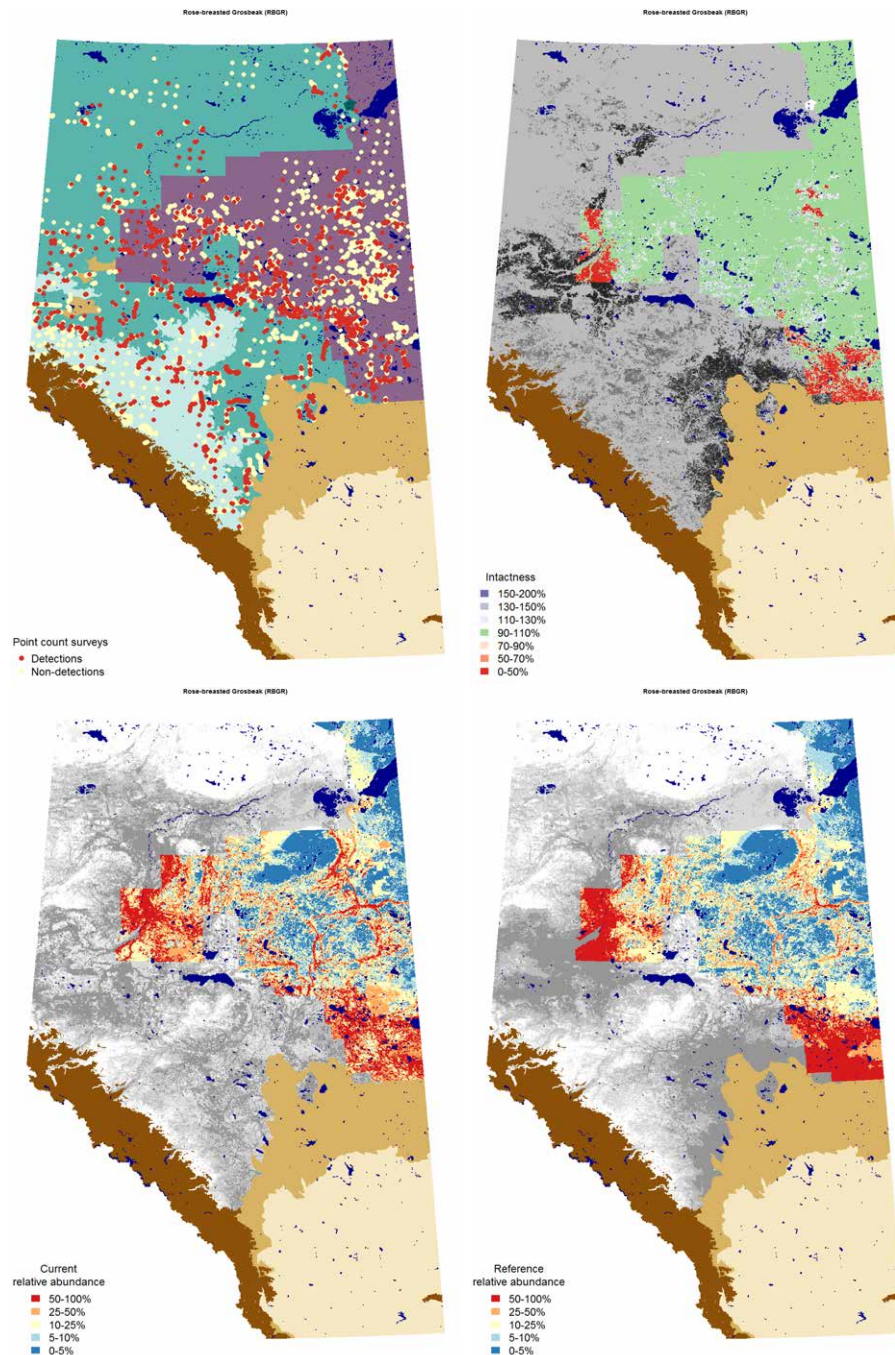
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.54.8 Quarter-section level responses



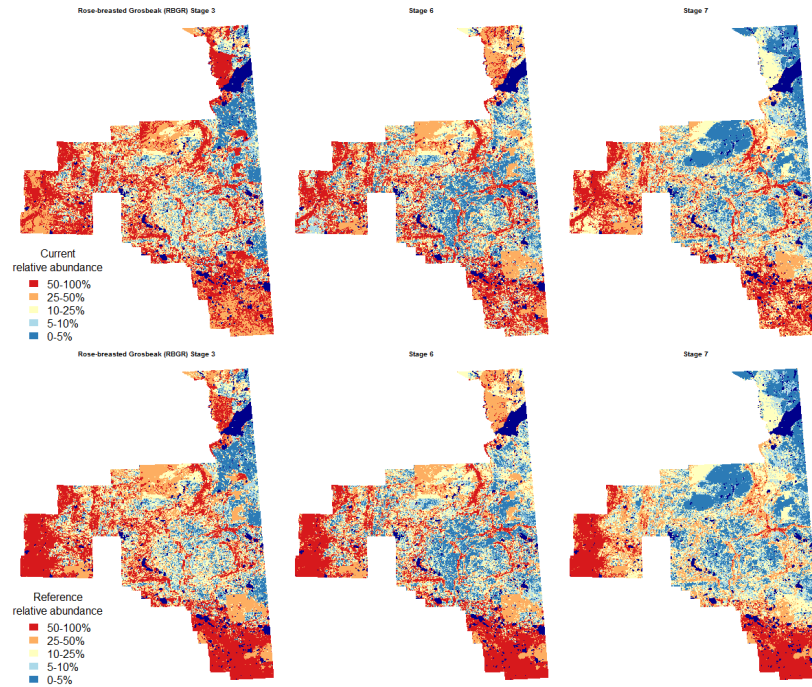
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.54.9 Maps



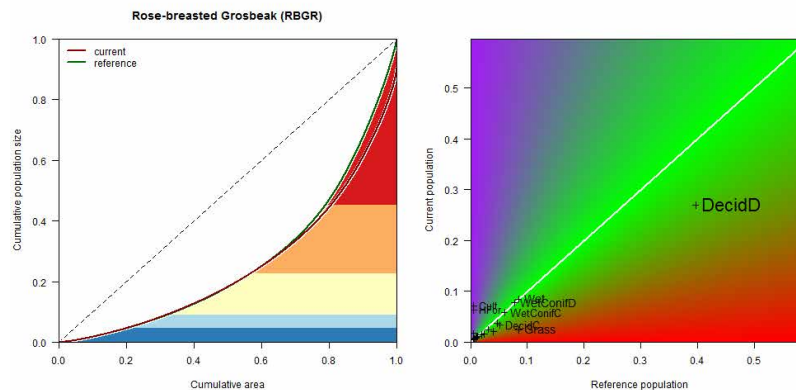
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.54.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.54.11 Population concentration



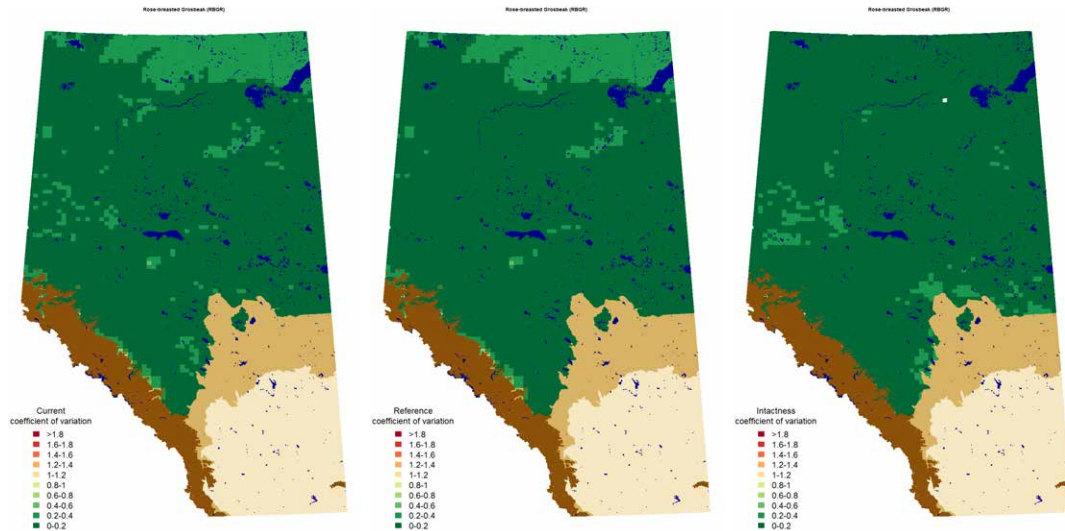
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.54.12 Potential population size

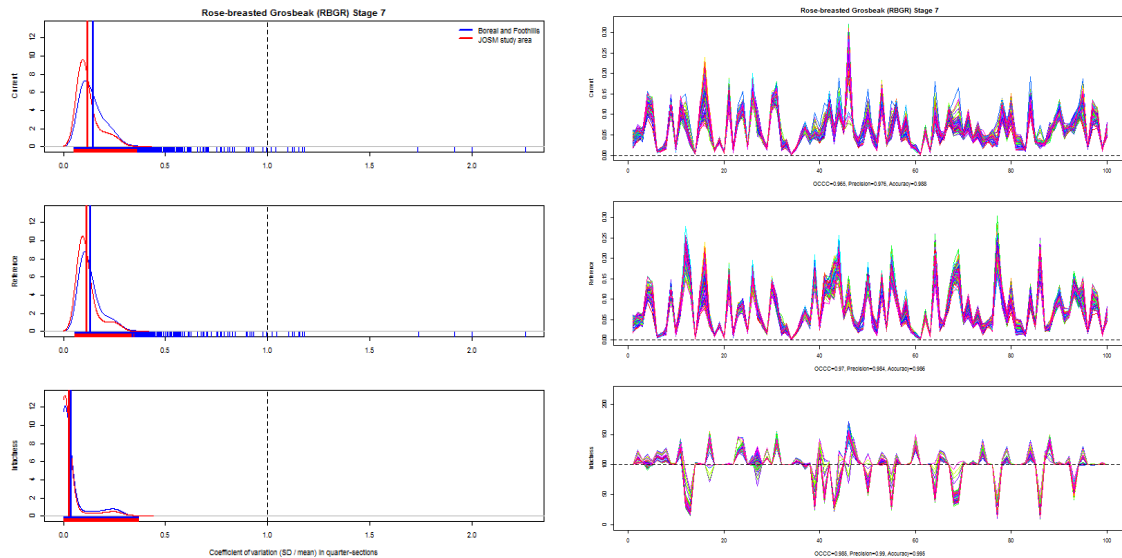
Estimated potential population size of Rose-breasted Grosbeak in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.2753	0.2519	0.3022	0.4029	0.3681	0.4439
Grass	0.0252	0.0230	0.0276	0.0859	0.0784	0.0946
Wet	0.0872	0.0798	0.0957	0.0857	0.0783	0.0944
WetConifD	0.0790	0.0723	0.0867	0.0793	0.0724	0.0873
WetConifC	0.0595	0.0545	0.0653	0.0605	0.0553	0.0667
DecidC	0.0347	0.0317	0.0381	0.0525	0.0480	0.0579
MixedD	0.0384	0.0352	0.0422	0.0484	0.0442	0.0533
Shrub	0.0221	0.0202	0.0242	0.0410	0.0375	0.0452
ConifD	0.0258	0.0236	0.0283	0.0317	0.0289	0.0349
DecidB	0.0169	0.0155	0.0185	0.0242	0.0221	0.0266
ConifC	0.0155	0.0142	0.0170	0.0192	0.0175	0.0211
WetConifB	0.0122	0.0112	0.0134	0.0125	0.0114	0.0137
PineB	0.0119	0.0109	0.0131	0.0119	0.0109	0.0131
WetConifA	0.0106	0.0097	0.0117	0.0105	0.0095	0.0115
ConifA	0.0089	0.0081	0.0097	0.0099	0.0091	0.0109
ConifB	0.0086	0.0079	0.0094	0.0097	0.0089	0.0107
DecidA	0.0038	0.0035	0.0042	0.0073	0.0067	0.0080
PineC	0.0063	0.0057	0.0069	0.0072	0.0066	0.0079
PineD	0.0052	0.0047	0.0057	0.0059	0.0054	0.0065
PineA	0.0034	0.0031	0.0038	0.0035	0.0032	0.0038
MixedB	0.0021	0.0019	0.0023	0.0024	0.0022	0.0027
MixedA	0.0016	0.0014	0.0017	0.0023	0.0021	0.0025
MixedC	0.0015	0.0014	0.0016	0.0020	0.0018	0.0022
Cult	0.0740	0.0677	0.0812	0.0000	0.0000	0.0000
UrbInd	0.0066	0.0061	0.0073	0.0000	0.0000	0.0000
HardLin	0.0010	0.0009	0.0011	0.0000	0.0000	0.0000
SoftLin	0.0178	0.0163	0.0196	0.0000	0.0000	0.0000
HFor	0.0641	0.0586	0.0703	0.0000	0.0000	0.0000
Total	0.9191	0.8411	1.0090	1.0161	0.9282	1.1195
Loss	0.1592	0.1258	0.1962			
Gain	0.0600	0.0486	0.0764			

5.54.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.54.14 Variable selection frequencies

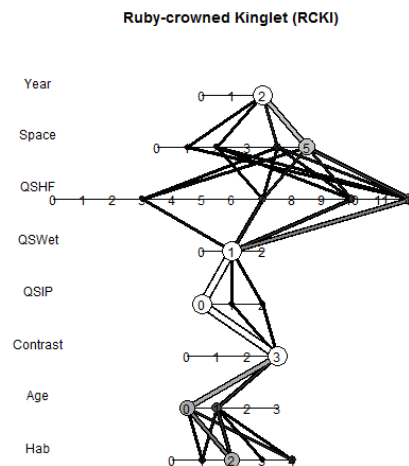
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.3	96.5	193	. + Habitat + isHForC
1.4	3.5	7	. + HabitatB + isHForC
2.0	100.0	200	NULL
3.1	91.5	183	. + ROAD
3.2	7.5	15	. + SoftLin_PC
3.3	1.0	2	. + ROAD + SoftLin_PC
4.0	93.0	186	NULL
4.1	7.0	14	. + Remn_QS
5.1	100.0	200	. + pWet_QS
6.5	2.5	5	. + THF_QS + THF2_QS
6.9	97.5	195	. + Succ_QS + Alien_QS + Alien2_QS
7.4	15.5	31	. + xMAP + xPET + xMAT + xCMD
7.5	84.5	169	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	95.0	190	. + xYEAR
8.2	5.0	10	. + YR5F

5.55 Ruby-crowned Kinglet (*Regulus calendula*)

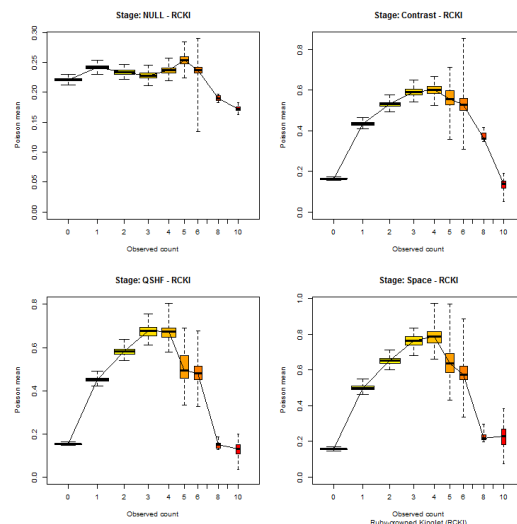
5.55.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

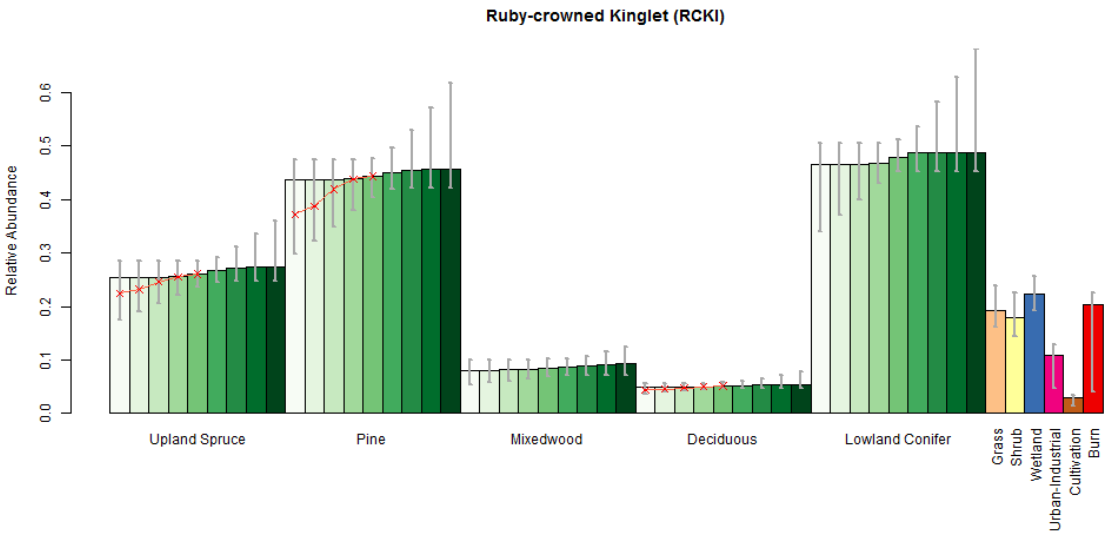


5.55.2 Cross validation

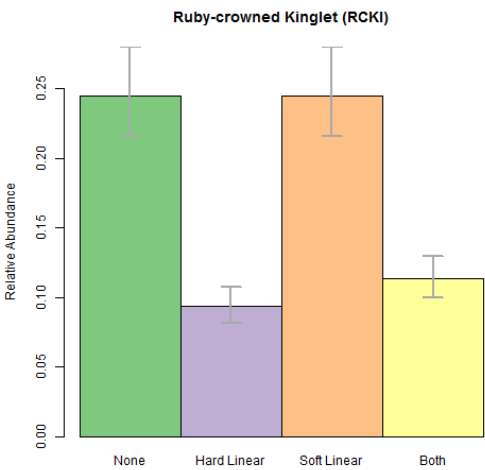
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.55.3 Point level habitat associations

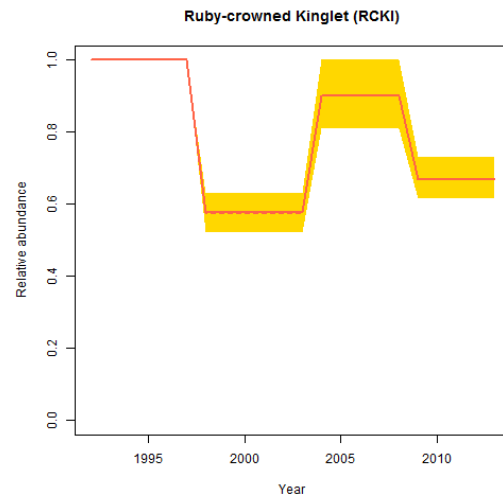


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

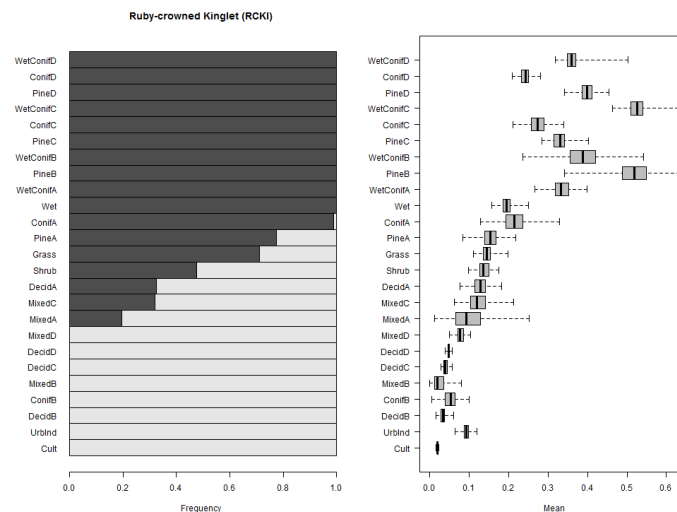


5.55.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



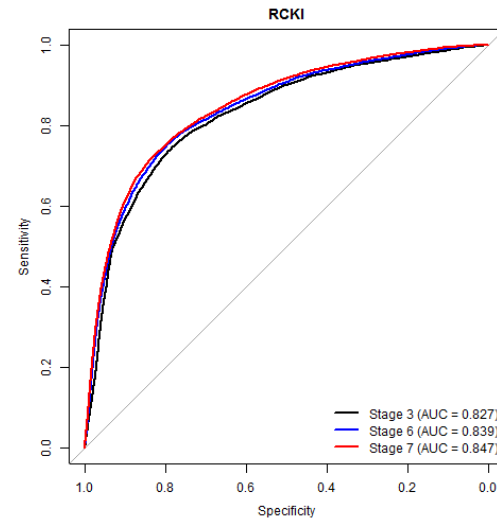
5.55.5 Habitat suitability ranking for patch delineation



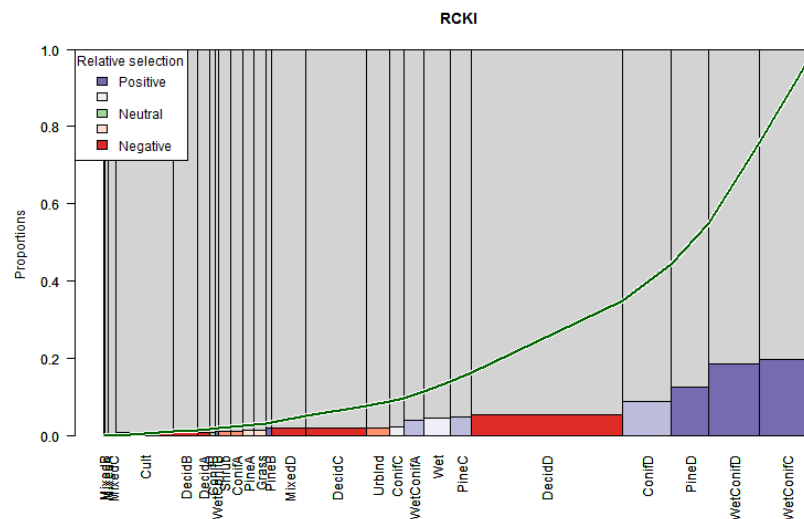
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.55.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

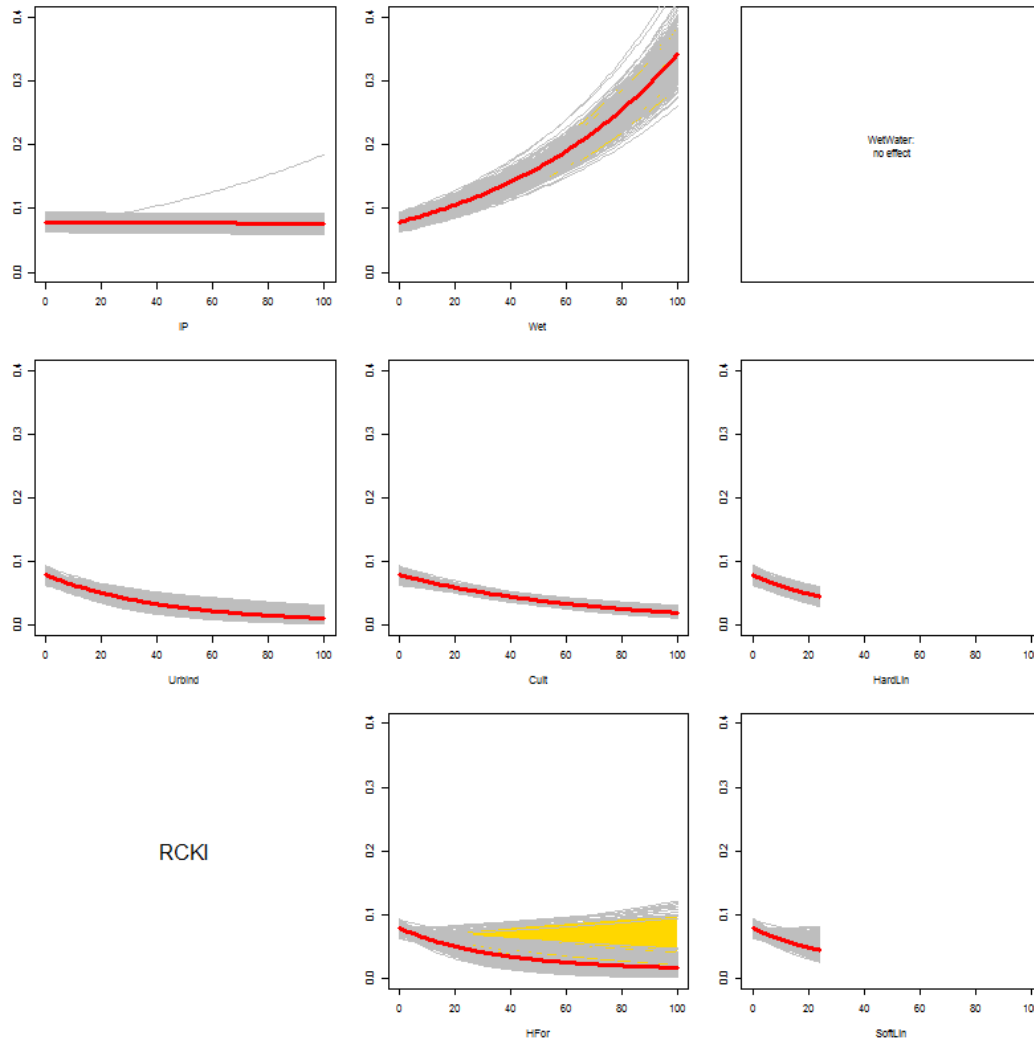


5.55.7 Relative habitat selection



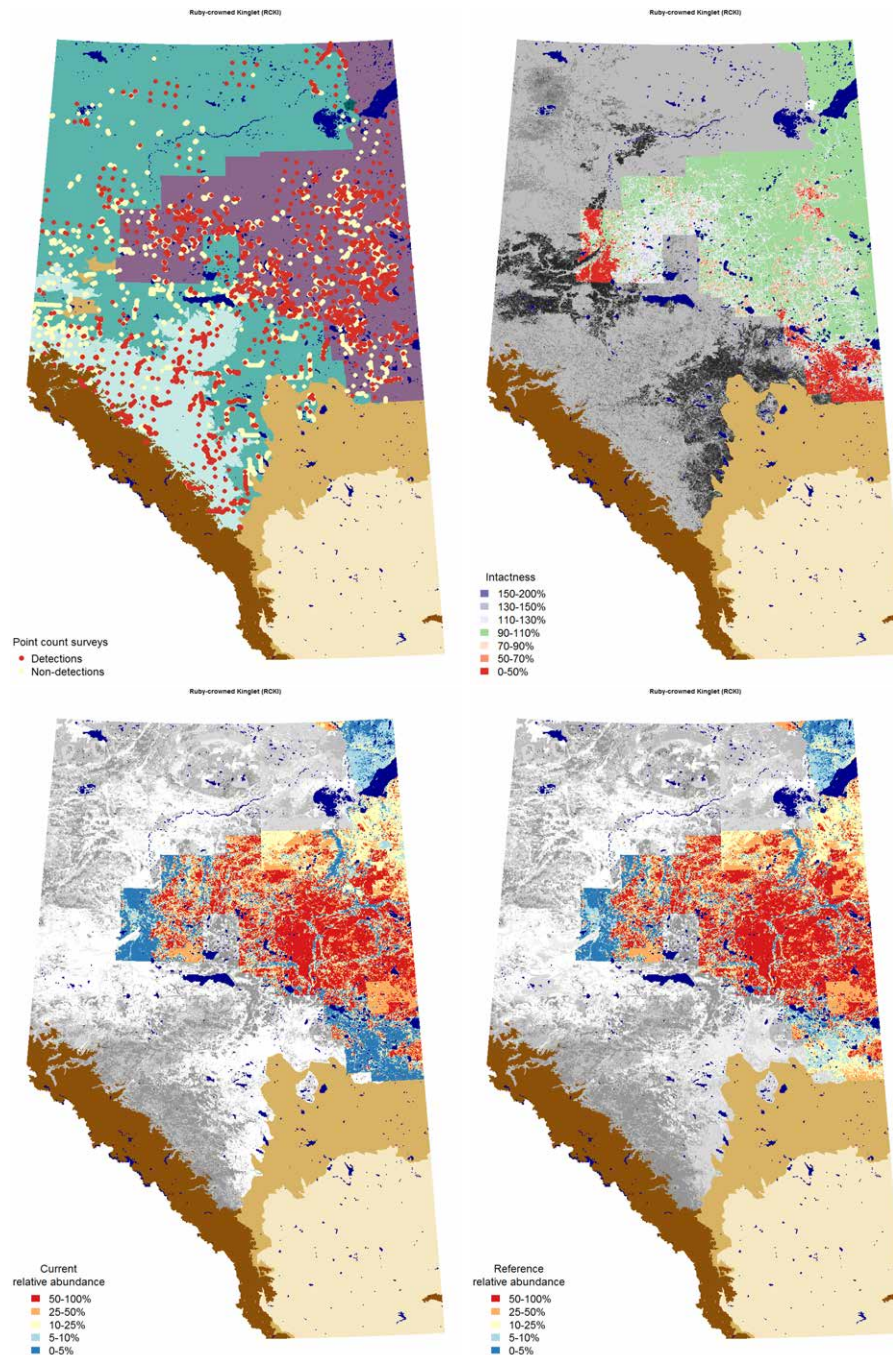
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.55.8 Quarter-section level responses



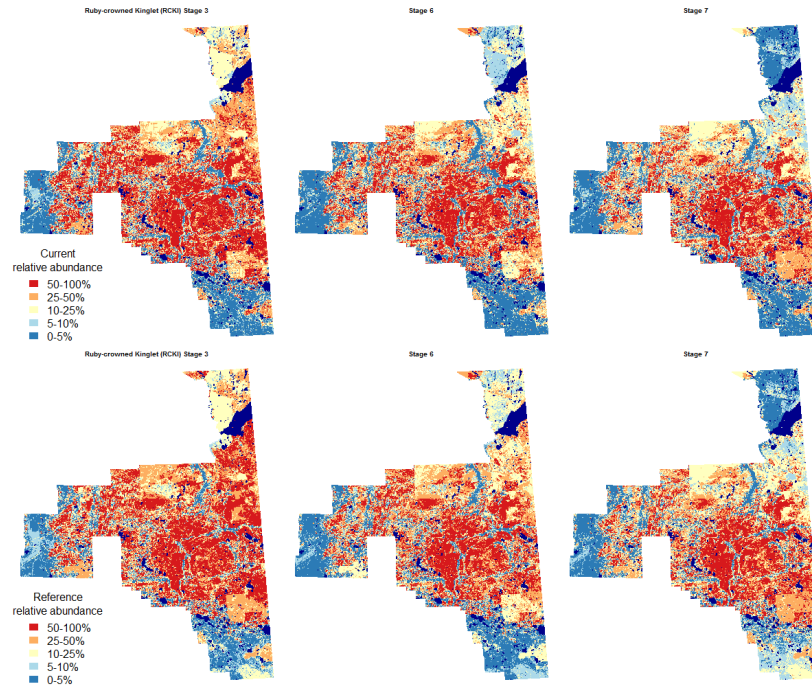
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.55.9 Maps



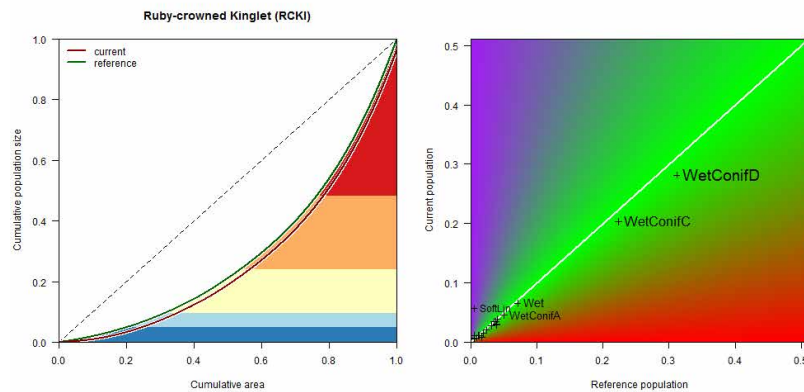
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.55.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.55.11 Population concentration



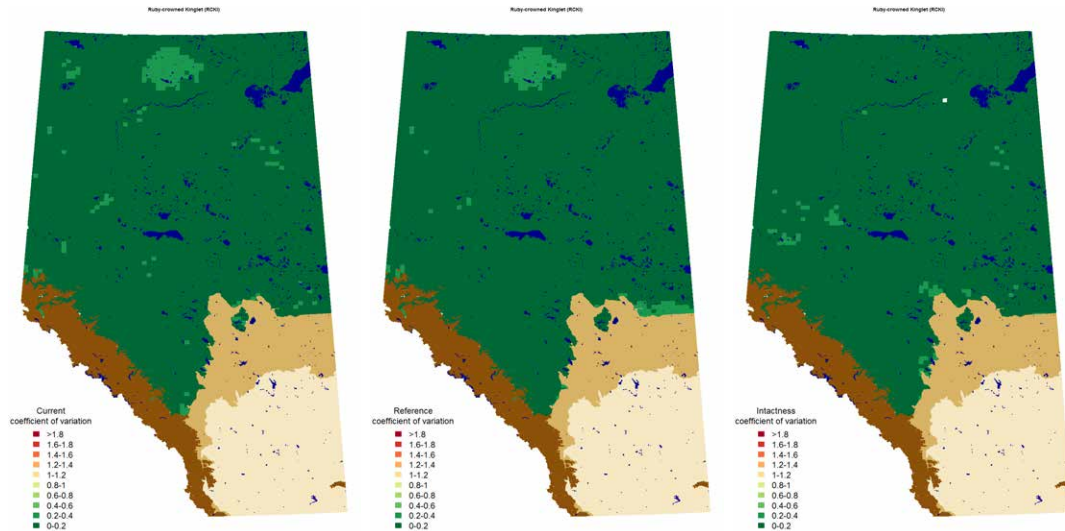
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.55.12 Potential population size

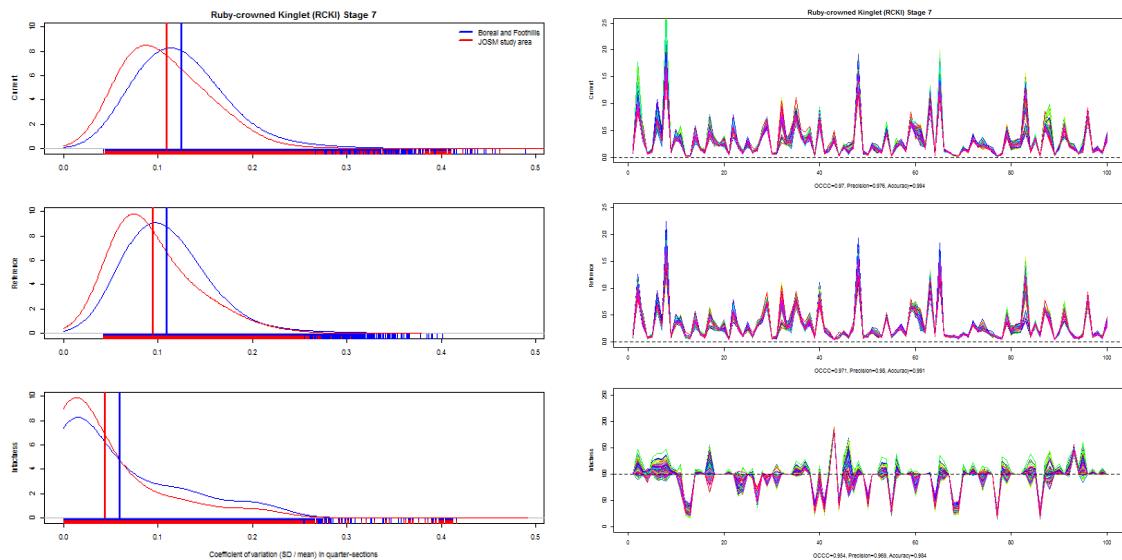
Estimated potential population size of Ruby-crowned Kinglet in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	1.4103	1.2970	1.5212	1.5555	1.4338	1.6681
WetConifC	1.0190	0.9372	1.0992	1.1143	1.0271	1.1949
Wet	0.3286	0.3022	0.3544	0.3546	0.3268	0.3802
WetConifA	0.2288	0.2104	0.2468	0.2506	0.2310	0.2688
WetConifB	0.1939	0.1784	0.2092	0.2044	0.1884	0.2192
ConifD	0.1560	0.1434	0.1682	0.1968	0.1814	0.2111
DecidD	0.1454	0.1338	0.1569	0.1943	0.1791	0.2084
PineC	0.1739	0.1599	0.1876	0.1915	0.1765	0.2053
PineB	0.1738	0.1598	0.1874	0.1774	0.1635	0.1902
PineD	0.1403	0.1291	0.1514	0.1583	0.1460	0.1698
ConifC	0.1019	0.0937	0.1099	0.1210	0.1115	0.1297
Shrub	0.0756	0.0696	0.0816	0.0991	0.0913	0.1063
Grass	0.0407	0.0375	0.0439	0.0860	0.0793	0.0922
MixedD	0.0545	0.0501	0.0588	0.0669	0.0616	0.0717
ConifA	0.0533	0.0490	0.0575	0.0651	0.0600	0.0698
PineA	0.0563	0.0518	0.0608	0.0603	0.0556	0.0646
ConifB	0.0381	0.0350	0.0411	0.0444	0.0409	0.0476
DecidC	0.0177	0.0163	0.0191	0.0237	0.0219	0.0254
DecidB	0.0115	0.0106	0.0124	0.0149	0.0137	0.0160
DecidA	0.0040	0.0037	0.0044	0.0060	0.0055	0.0065
MixedA	0.0026	0.0024	0.0028	0.0039	0.0036	0.0042
MixedB	0.0028	0.0026	0.0031	0.0033	0.0031	0.0036
MixedC	0.0021	0.0020	0.0023	0.0026	0.0024	0.0028
Cult	0.0229	0.0211	0.0248	0.0000	0.0000	0.0000
UrbInd	0.0320	0.0294	0.0345	0.0000	0.0000	0.0000
HardLin	0.0013	0.0012	0.0014	0.0000	0.0000	0.0000
SoftLin	0.2833	0.2606	0.3056	0.0000	0.0000	0.0000
HFor	0.0540	0.0497	0.0582	0.0000	0.0000	0.0000
Total	4.8250	4.4375	5.2045	4.9949	4.6041	5.3565
Loss	0.2271	0.1674	0.3236			
Gain	0.0320	0.0036	0.2376			

5.55.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.55.14 Variable selection frequencies

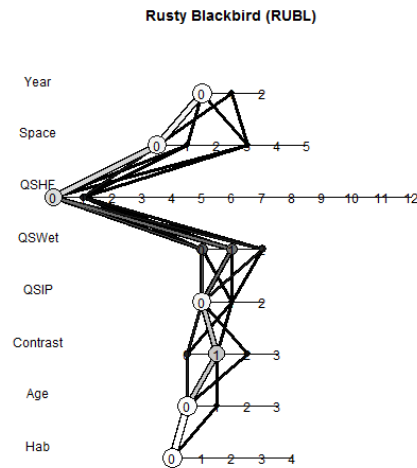
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	9.5	19	. + Habitat
1.2	71.5	143	. + HabitatB
1.3	1.0	2	. + Habitat + isHForC
1.4	18.0	36	. + HabitatB + isHForC
2.0	67.5	135	NULL
2.1	32.5	65	. + Age
3.3	100.0	200	. + ROAD + SoftLin_PC
4.0	98.5	197	NULL
4.1	1.0	2	. + Remn_QS
4.2	0.5	1	. + Remn_QS + Remn2_QS
5.1	100.0	200	. + pWet_QS
6.3	6.0	12	. + Succ_QS + Alien_QS
6.7	21.5	43	. + Succ_QS + Alien_QS + Succ2_QS
6.10	21.5	43	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.12	51.0	102	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.1	0.5	1	. + xlat
7.2	5.5	11	. + xlat + xlong
7.4	17.0	34	. + xMAP + xPET + xMAT + xCMD
7.5	77.0	154	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.2	100.0	200	. + YR5F

5.56 Rusty Blackbird (*Euphagus carolinus*)

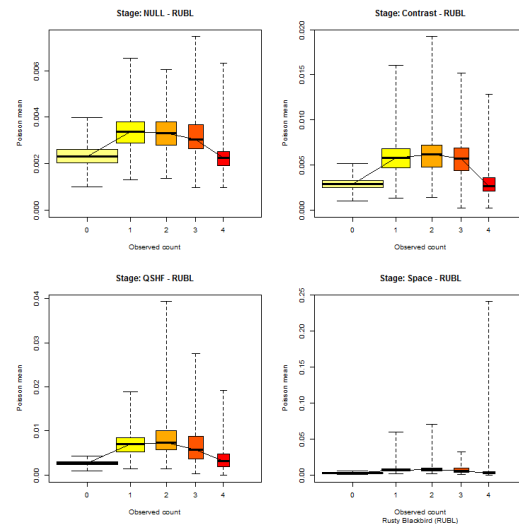
5.56.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

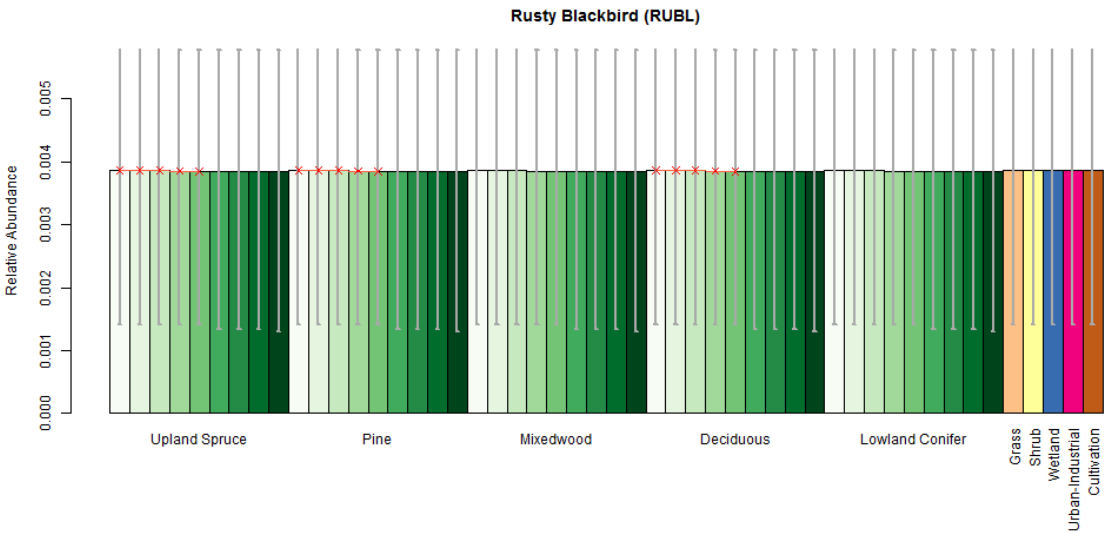


5.56.2 Cross validation

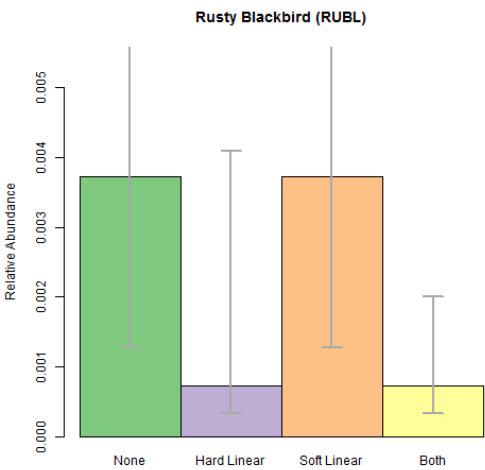
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.56.3 Point level habitat associations

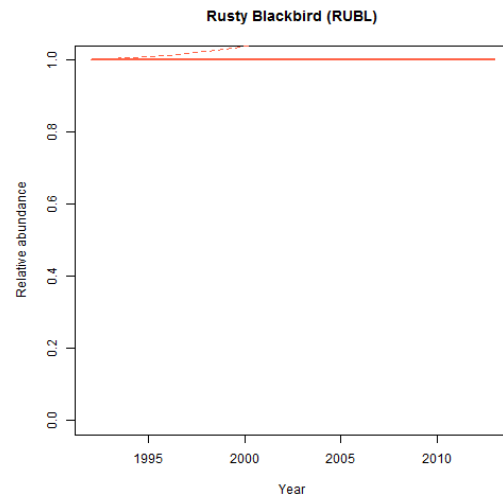


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

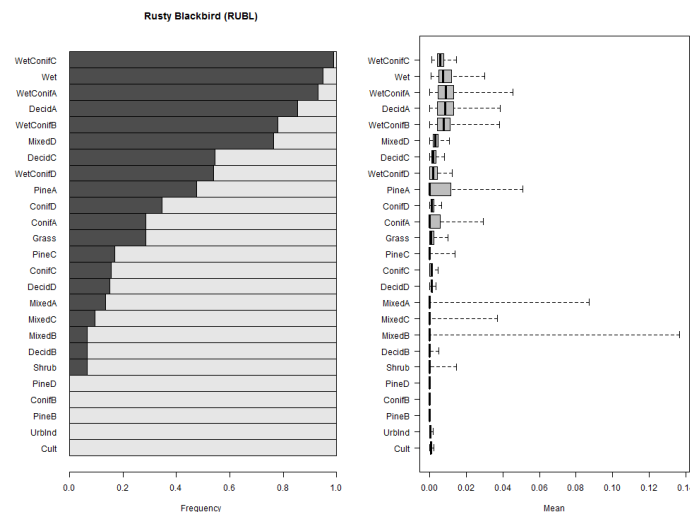


5.56.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



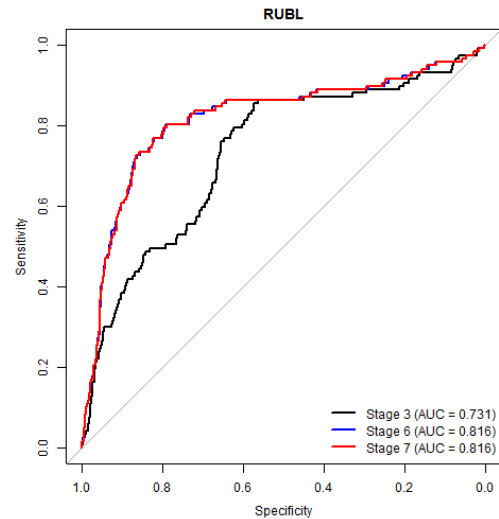
5.56.5 Habitat suitability ranking for patch delineation



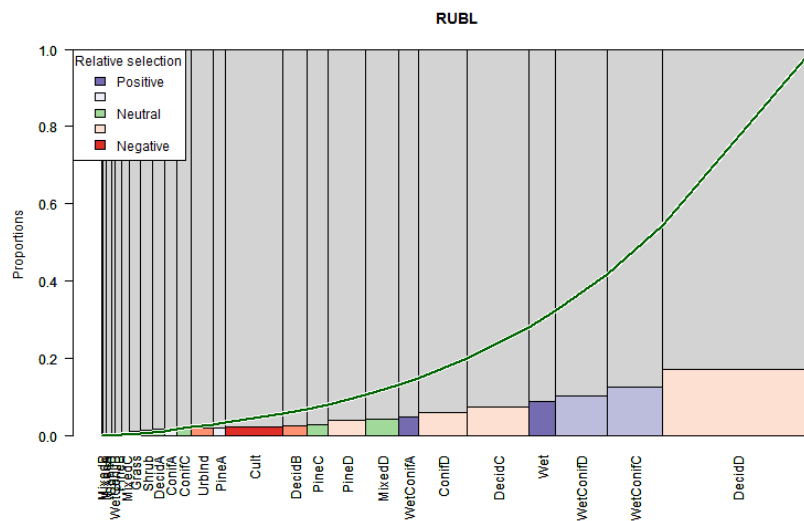
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.56.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

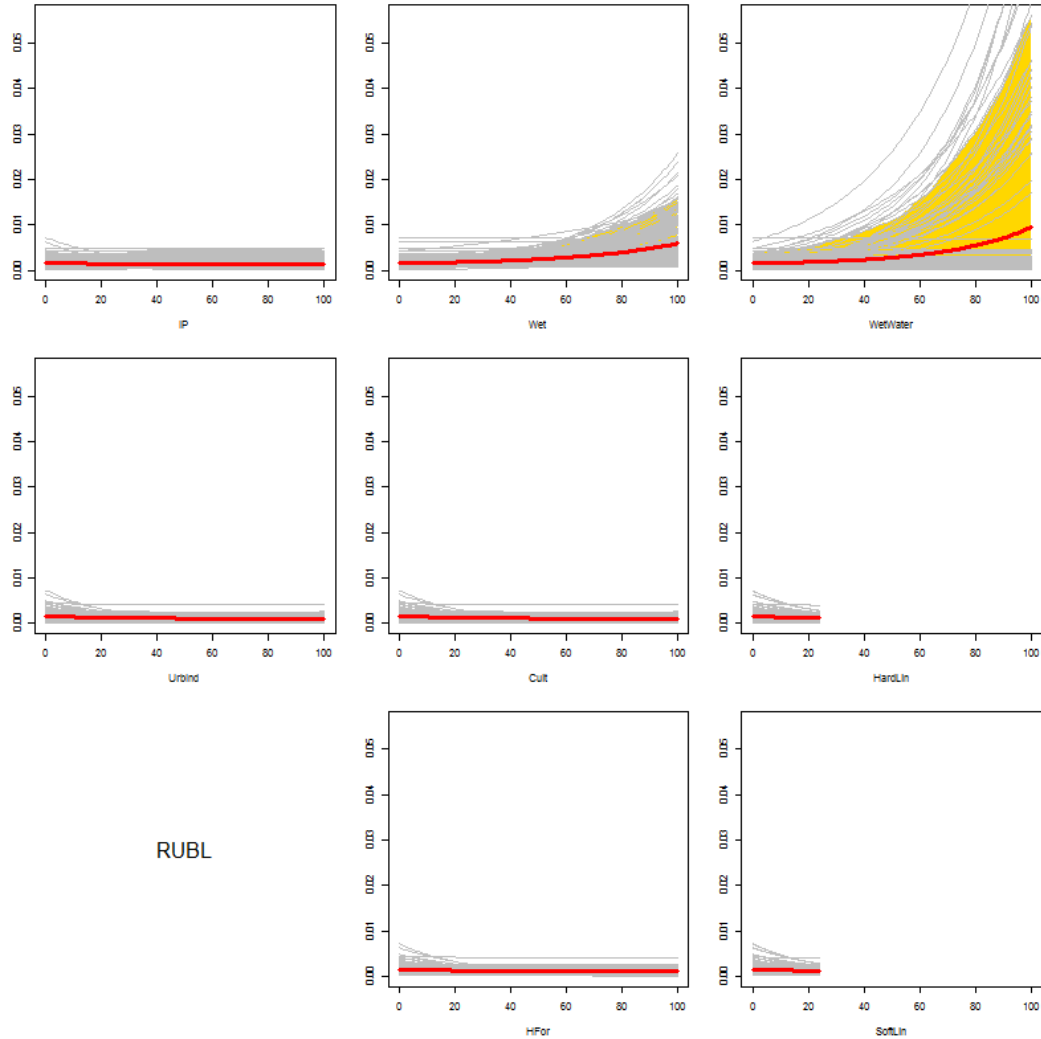


5.56.7 Relative habitat selection



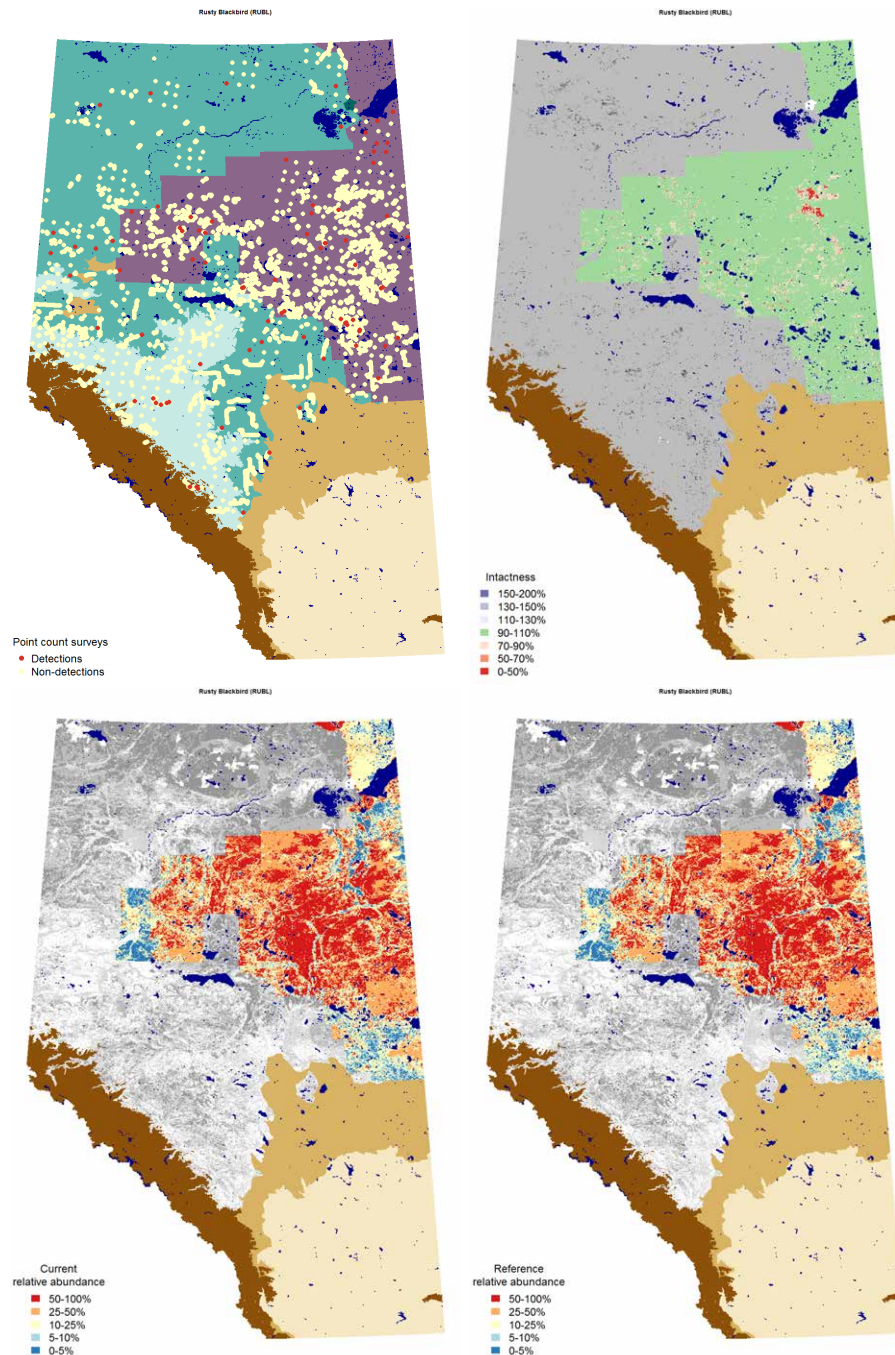
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.56.8 Quarter-section level responses



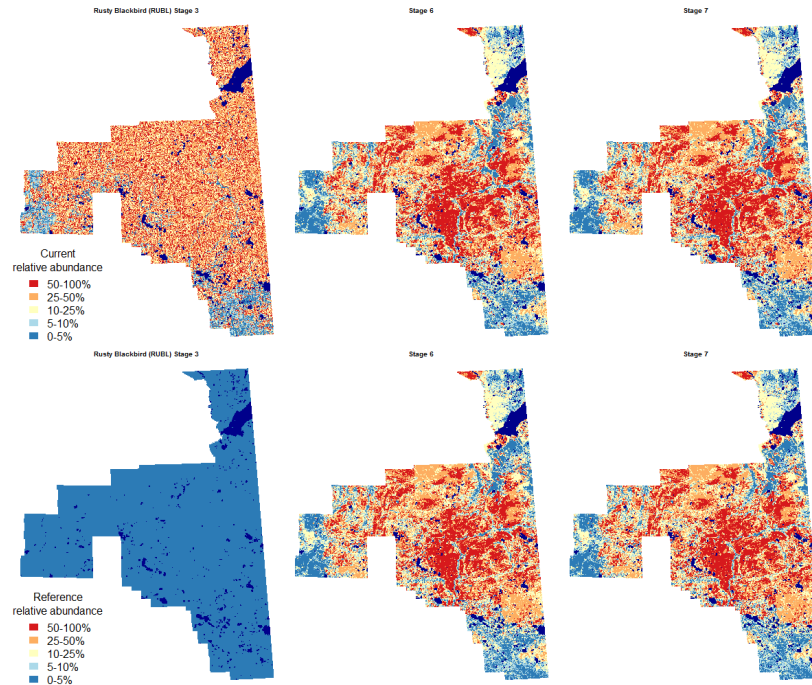
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.56.9 Maps



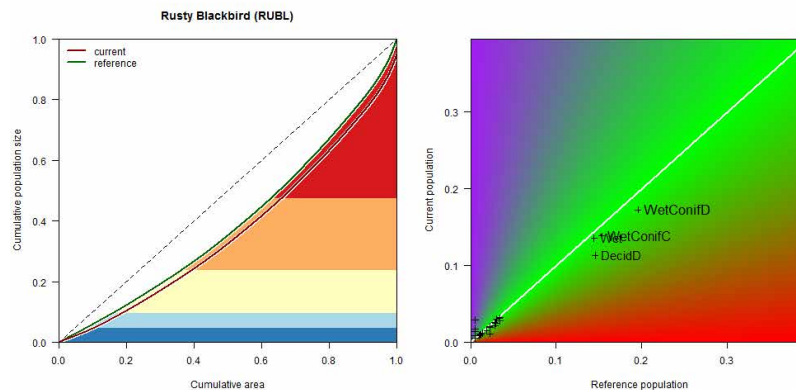
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.56.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.56.11 Population concentration



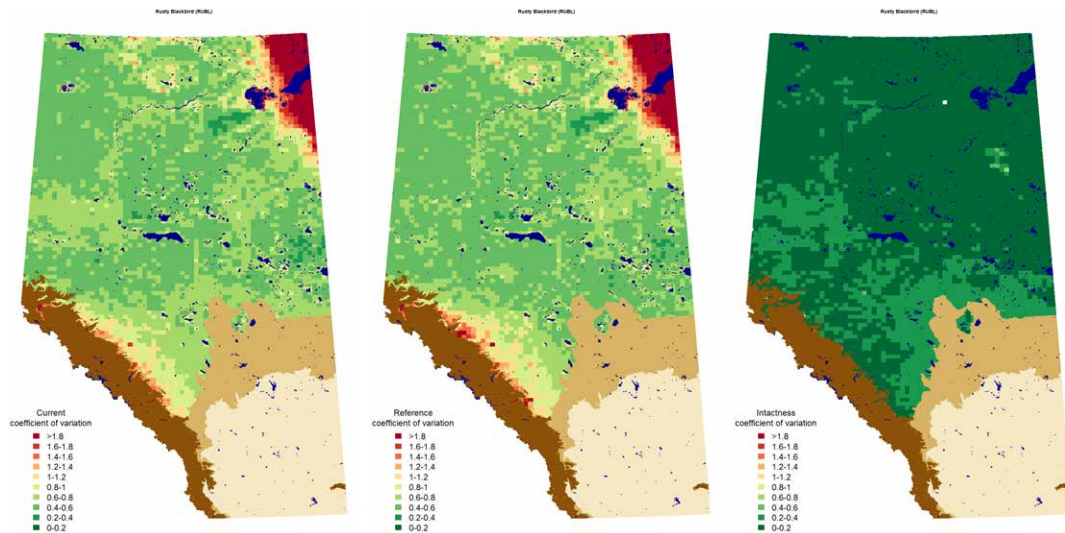
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.56.12 Potential population size

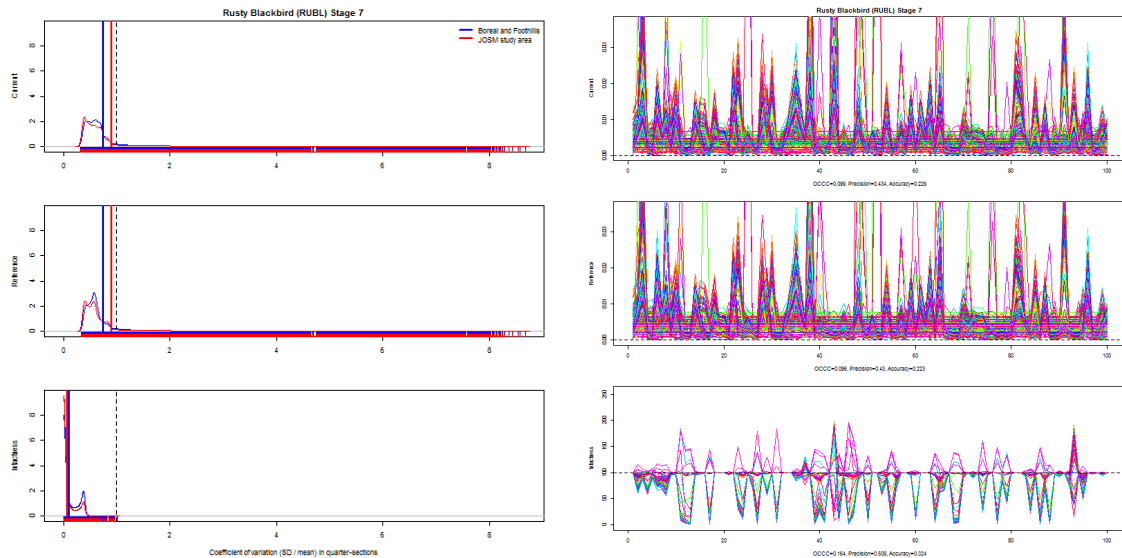
Estimated potential population size of Rusty Blackbird in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.0146	0.0064	0.0240	0.0169	0.0067	0.0276
WetConifC	0.0117	0.0052	0.0192	0.0132	0.0053	0.0216
DecidD	0.0095	0.0042	0.0157	0.0125	0.0050	0.0205
Wet	0.0115	0.0051	0.0189	0.0125	0.0050	0.0204
WetConifA	0.0027	0.0012	0.0044	0.0030	0.0012	0.0049
ConifD	0.0024	0.0011	0.0039	0.0030	0.0012	0.0048
WetConifB	0.0027	0.0012	0.0044	0.0029	0.0012	0.0048
PineB	0.0026	0.0011	0.0042	0.0026	0.0011	0.0043
MixedD	0.0021	0.0009	0.0034	0.0025	0.0010	0.0041
Shrub	0.0019	0.0008	0.0031	0.0024	0.0010	0.0040
PineC	0.0022	0.0010	0.0036	0.0024	0.0010	0.0039
Grass	0.0009	0.0004	0.0016	0.0020	0.0008	0.0032
ConifC	0.0016	0.0007	0.0027	0.0020	0.0008	0.0032
PineD	0.0017	0.0008	0.0028	0.0019	0.0008	0.0031
DecidC	0.0013	0.0006	0.0021	0.0017	0.0007	0.0027
ConifA	0.0010	0.0004	0.0016	0.0012	0.0005	0.0019
DecidB	0.0008	0.0004	0.0014	0.0011	0.0004	0.0017
PineA	0.0009	0.0004	0.0014	0.0009	0.0004	0.0015
ConifB	0.0007	0.0003	0.0012	0.0009	0.0003	0.0014
DecidA	0.0003	0.0001	0.0004	0.0004	0.0002	0.0006
MixedB	0.0001	0.0001	0.0002	0.0002	0.0001	0.0003
MixedA	0.0001	0.0000	0.0002	0.0002	0.0001	0.0002
MixedC	0.0001	0.0000	0.0002	0.0001	0.0000	0.0002
Cult	0.0025	0.0011	0.0040	0.0000	0.0000	0.0000
UrbInd	0.0007	0.0003	0.0012	0.0000	0.0000	0.0000
HardLin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SoftLin	0.0012	0.0005	0.0020	0.0000	0.0000	0.0000
HFor	0.0014	0.0006	0.0024	0.0000	0.0000	0.0000
Total	0.0793	0.0350	0.1304	0.0863	0.0344	0.1410
Loss	0.0029	0.0001	0.0180			
Gain	0.0001	0.0000	0.0007			

5.56.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.56.14 Variable selection frequencies

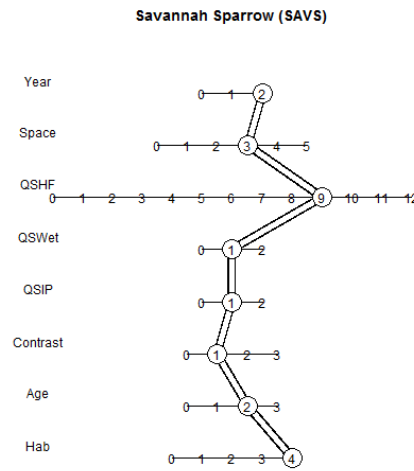
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	200	NULL
2.0	99.0	198	NULL
2.1	1.0	2	. + Age
3.0	15.5	31	NULL
3.1	78.5	157	. + ROAD
3.2	6.0	12	. + SoftLin_PC
4.0	96.0	192	NULL
4.1	4.0	8	. + Remn_QS
5.0	38.0	76	NULL
5.1	45.0	90	. + pWet_QS
5.2	17.0	34	. + pWetWater_QS
6.0	86.5	173	NULL
6.1	13.5	27	. + THF_QS
7.0	96.0	192	NULL
7.1	2.5	5	. + xlat
7.3	1.5	3	. + xlat + xlong + xlat:xlong
8.0	98.5	197	NULL
8.1	1.5	3	. + xYEAR

5.57 Savannah Sparrow (*Passerculus sandwichensis*)

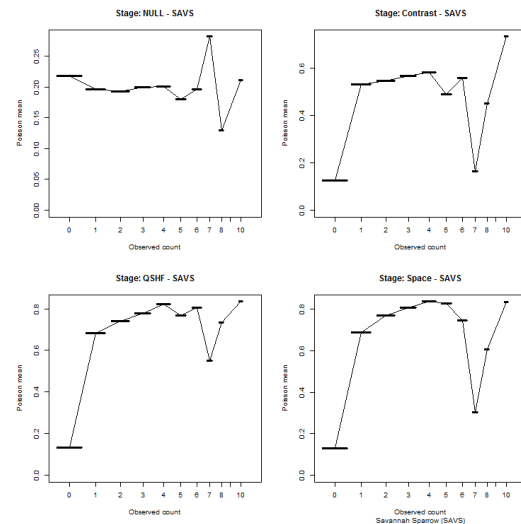
5.57.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

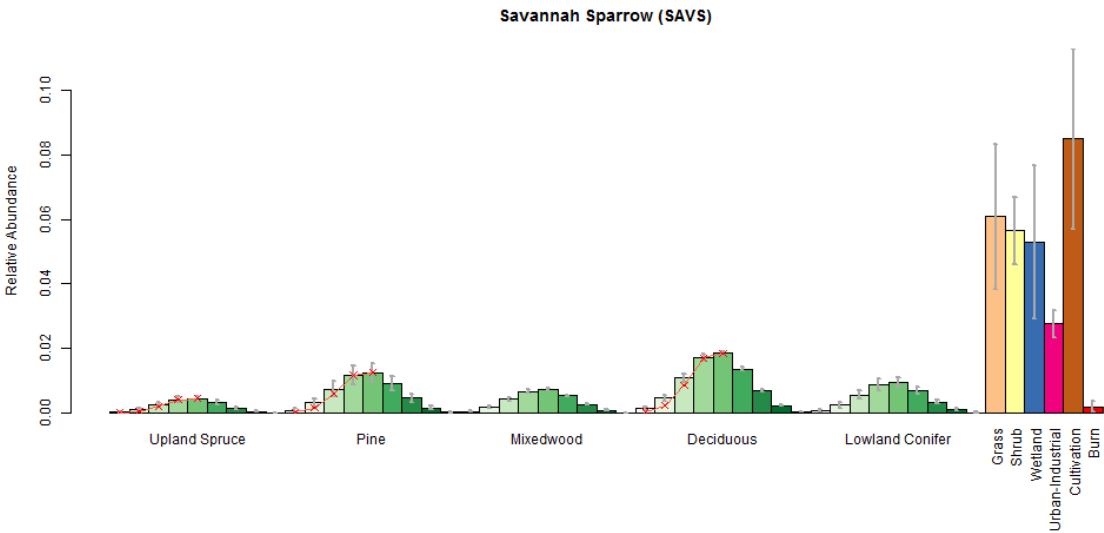


5.57.2 Cross validation

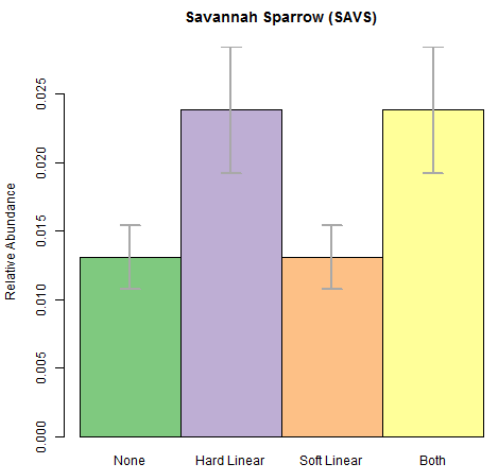
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.57.3 Point level habitat associations

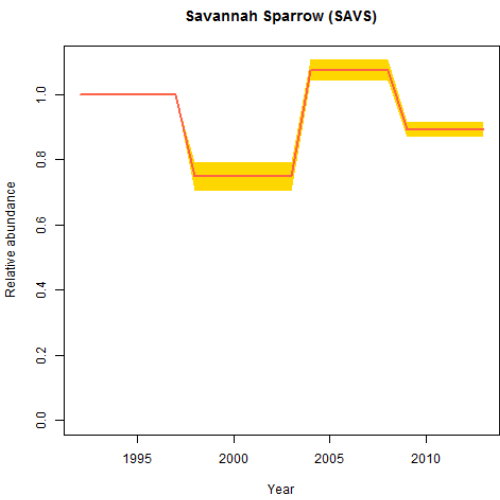


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

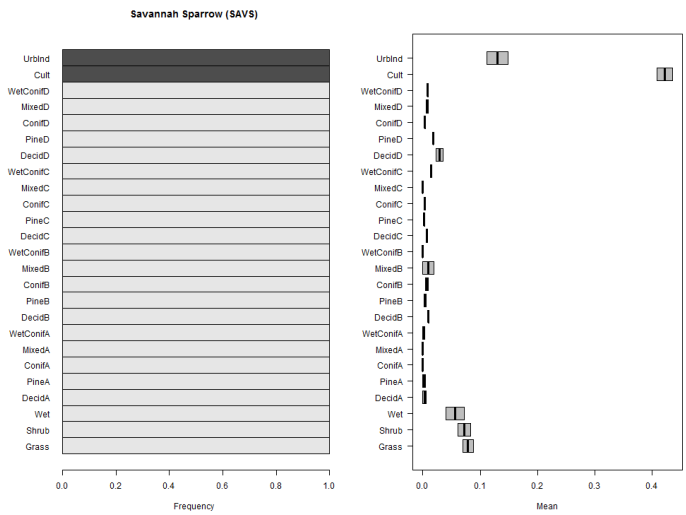


5.57.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



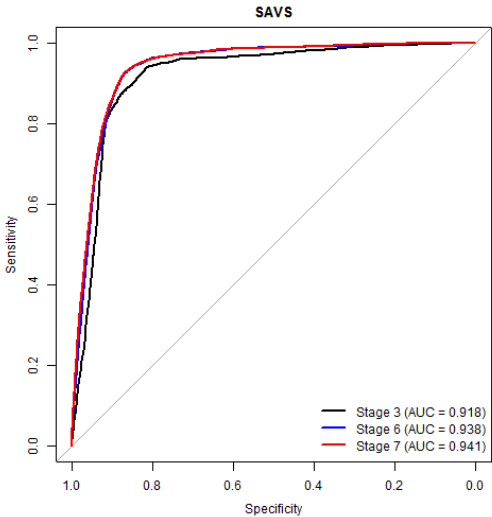
5.57.5 Habitat suitability ranking for patch delineation



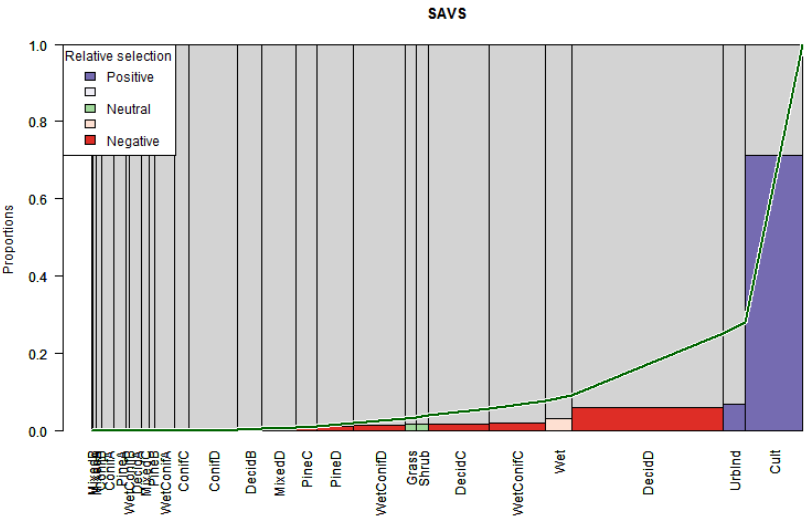
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.57.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

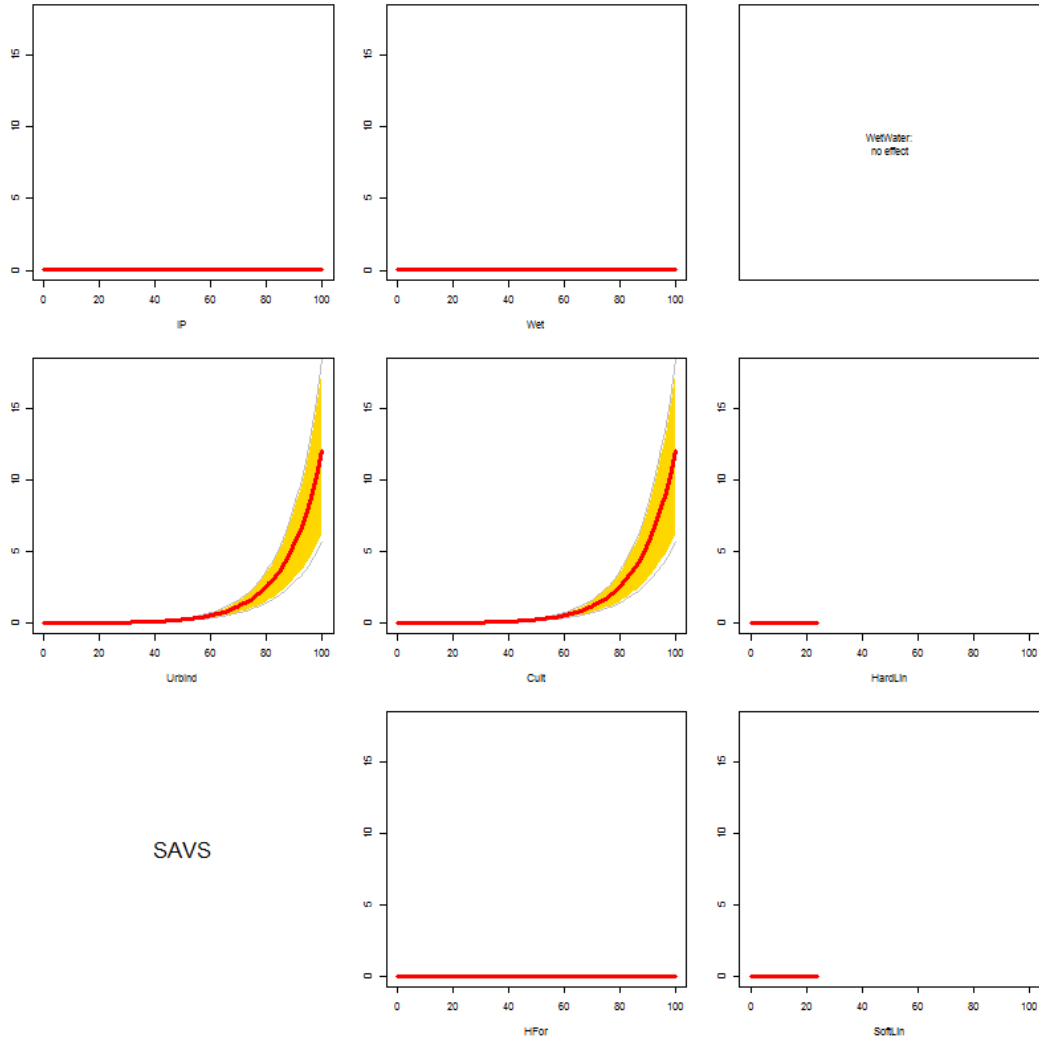


5.57.7 Relative habitat selection



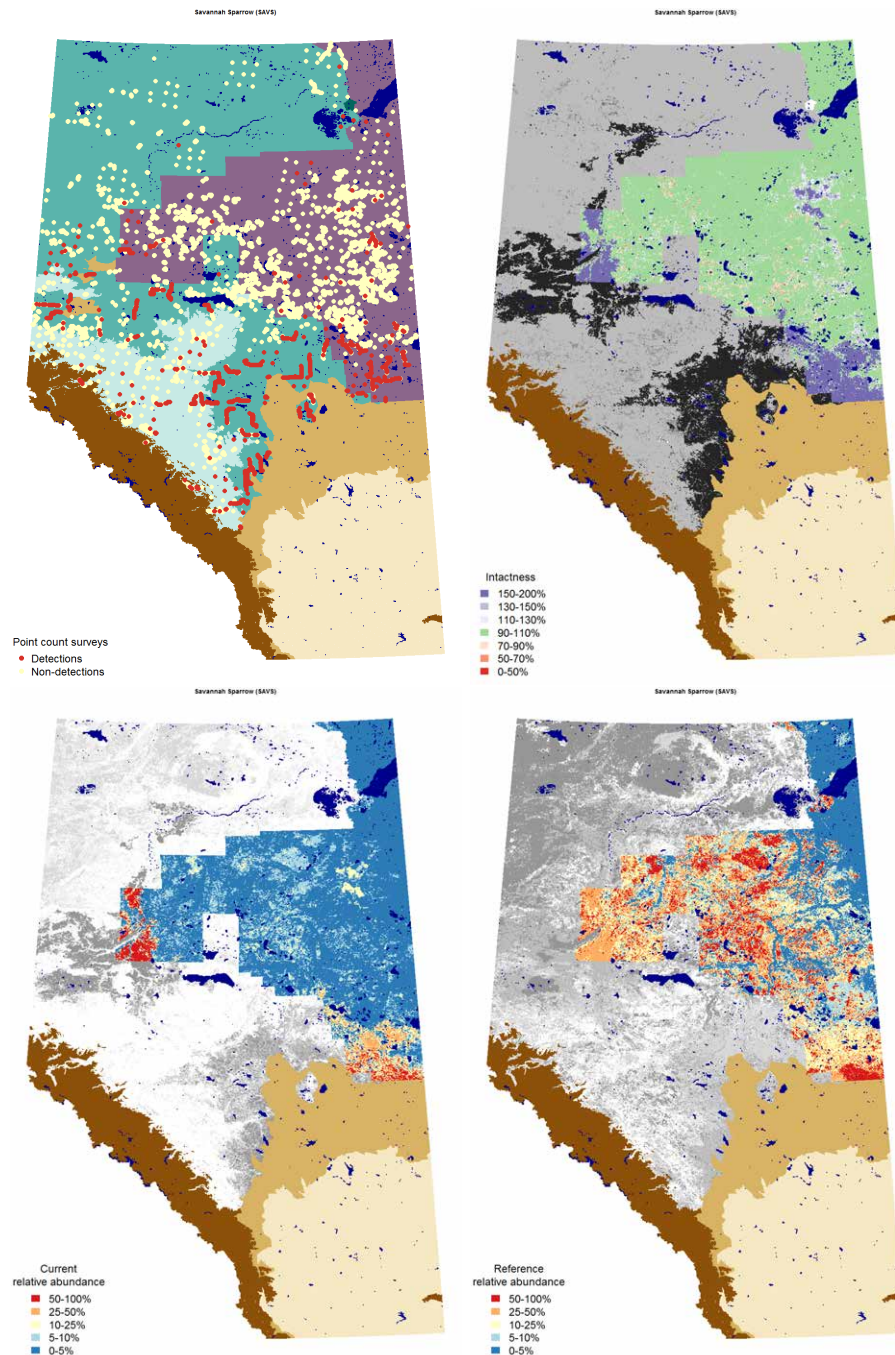
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.57.8 Quarter-section level responses



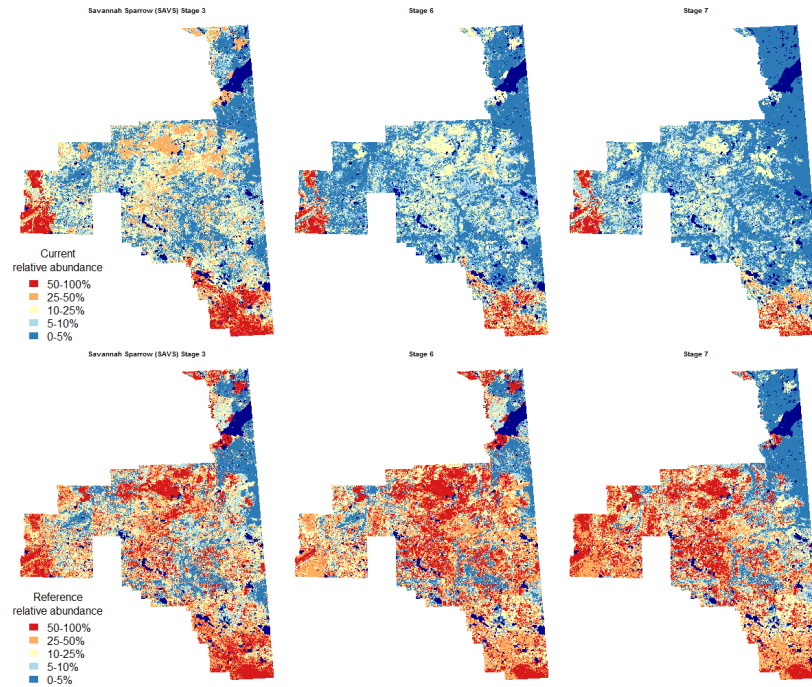
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.57.9 Maps



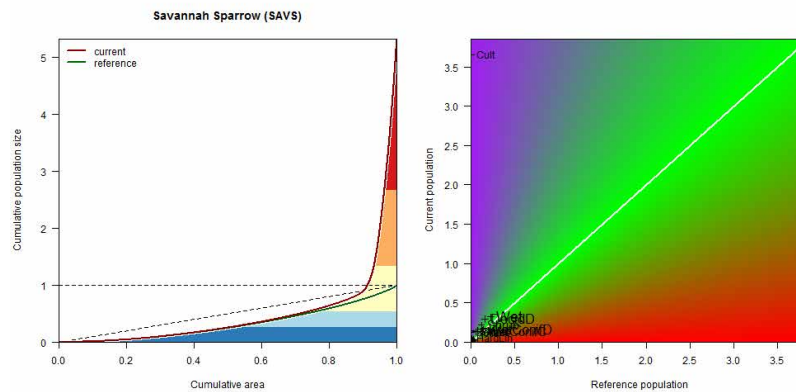
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.57.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.57.11 Population concentration



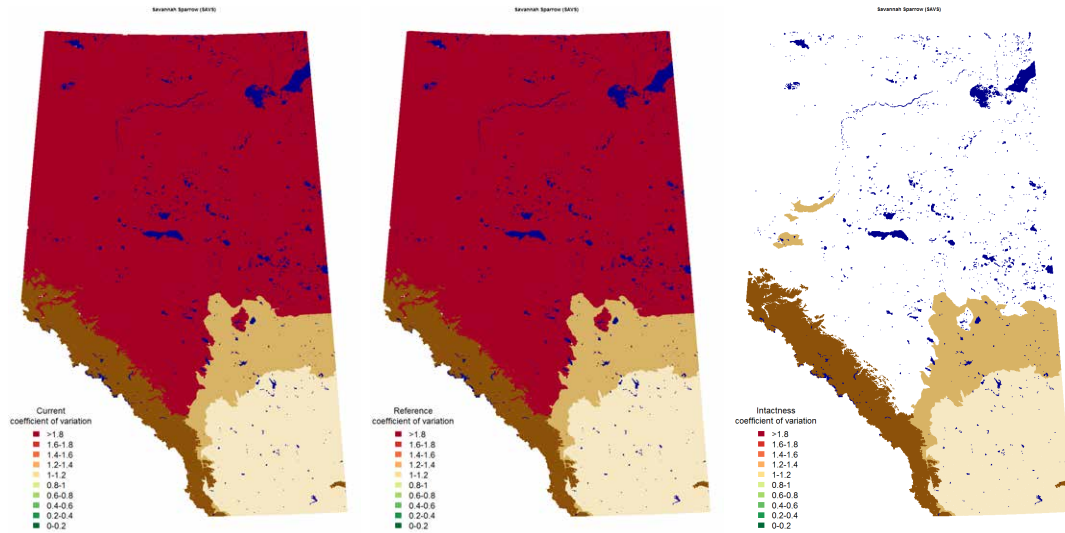
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.57.12 Potential population size

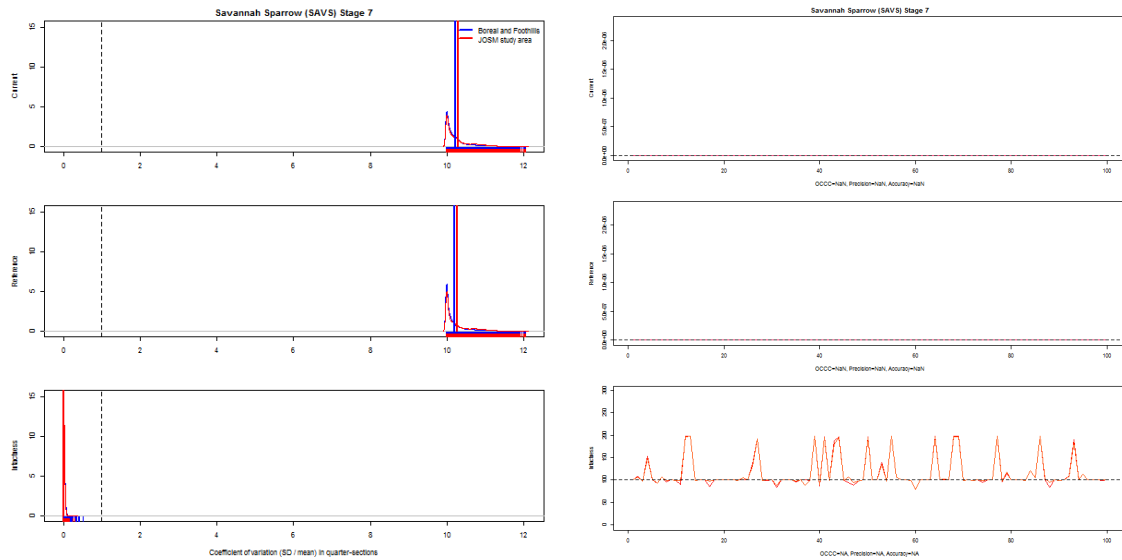
Estimated potential population size of Savannah Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.0440	0.0368	0.0513	0.0323	0.0279	0.0368
DecidD	0.0406	0.0339	0.0473	0.0234	0.0201	0.0266
WetConifD	0.0225	0.0188	0.0262	0.0206	0.0177	0.0234
Shrub	0.0298	0.0249	0.0347	0.0172	0.0148	0.0196
WetConifC	0.0190	0.0159	0.0221	0.0171	0.0148	0.0195
Grass	0.0182	0.0152	0.0212	0.0087	0.0075	0.0099
PineC	0.0050	0.0041	0.0058	0.0045	0.0039	0.0051
PineD	0.0034	0.0028	0.0040	0.0030	0.0026	0.0034
MixedD	0.0038	0.0032	0.0044	0.0026	0.0023	0.0030
DecidC	0.0055	0.0046	0.0064	0.0023	0.0020	0.0026
PineB	0.0017	0.0014	0.0020	0.0017	0.0015	0.0020
WetConifB	0.0016	0.0013	0.0018	0.0017	0.0015	0.0019
ConifD	0.0016	0.0013	0.0018	0.0013	0.0012	0.0015
ConifC	0.0014	0.0011	0.0016	0.0012	0.0010	0.0013
WetConifA	0.0011	0.0009	0.0013	0.0011	0.0010	0.0013
DecidB	0.0009	0.0007	0.0010	0.0010	0.0008	0.0011
PineA	0.0003	0.0003	0.0004	0.0003	0.0003	0.0004
DecidA	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
ConifB	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002
ConifA	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
MixedC	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001
MixedB	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Cult	0.5015	0.4187	0.5843	0.0000	0.0000	0.0000
UrbInd	0.0198	0.0165	0.0230	0.0000	0.0000	0.0000
HardLin	0.0074	0.0062	0.0086	0.0000	0.0000	0.0000
SoftLin	0.0181	0.0151	0.0210	0.0000	0.0000	0.0000
HFor	0.0027	0.0022	0.0031	0.0000	0.0000	0.0000
Total	0.7501	0.6263	0.8739	0.1408	0.1214	0.1601
Loss	0.0018	0.0014	0.0022			
Gain	0.6111	0.5062	0.7160			

5.57.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.57.14 Variable selection frequencies

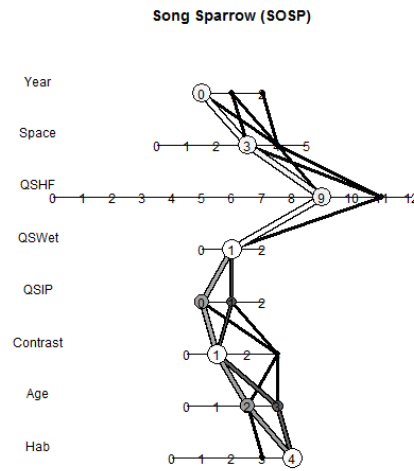
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.4	100.0	2	. + HabitatB + isHForC
2.2	100.0	2	. + Age + Age2
3.1	100.0	2	. + ROAD
4.1	100.0	2	. + Remn_QS
5.1	100.0	2	. + pWet_QS
6.9	100.0	2	. + Succ_QS + Alien_QS + Alien2_QS
7.3	100.0	2	. + xlat + xlong + xlat:xlong
8.2	100.0	2	. + YR5F

5.58 Song Sparrow (*Melospiza melodia*)

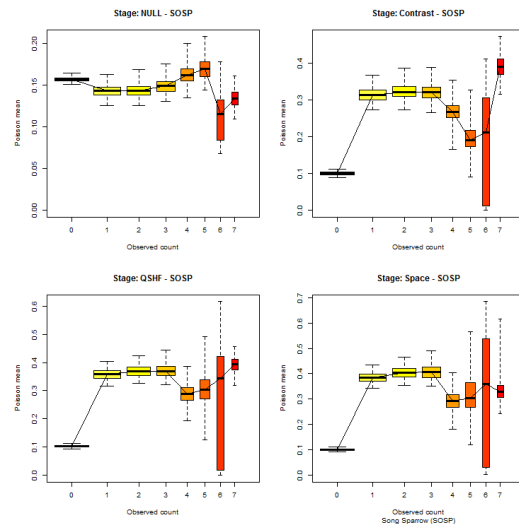
5.58.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

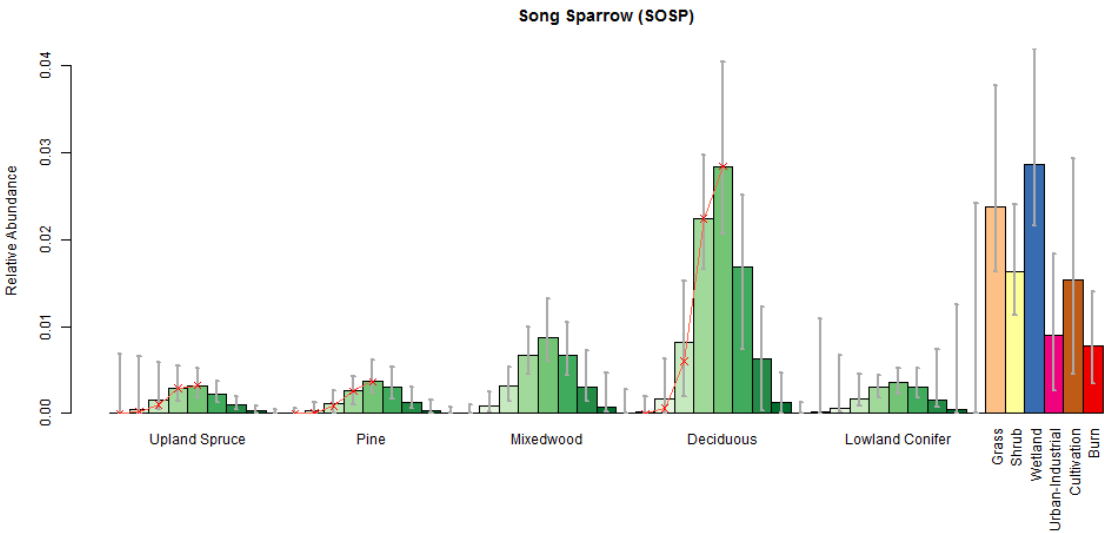


5.58.2 Cross validation

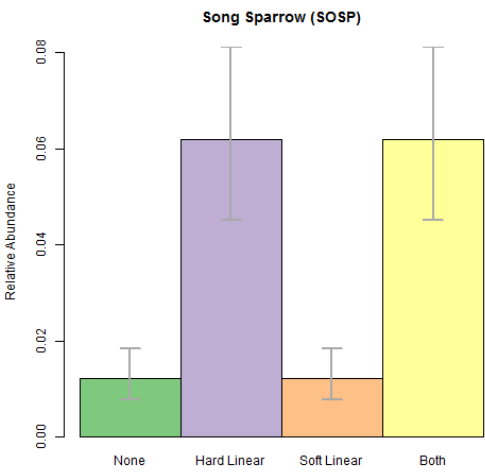
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.58.3 Point level habitat associations

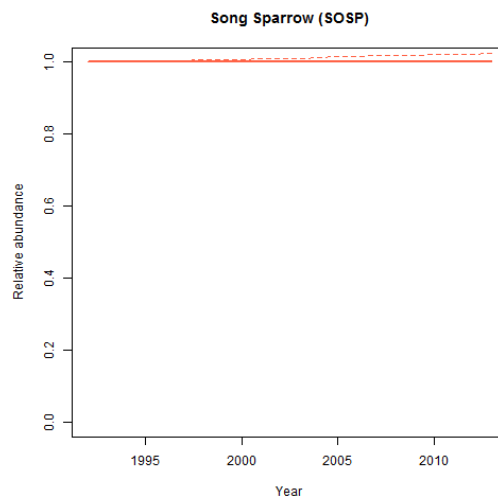


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

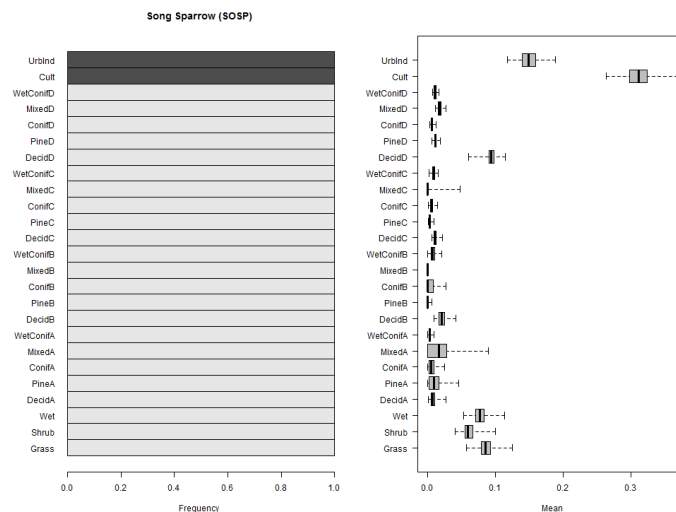


5.58.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



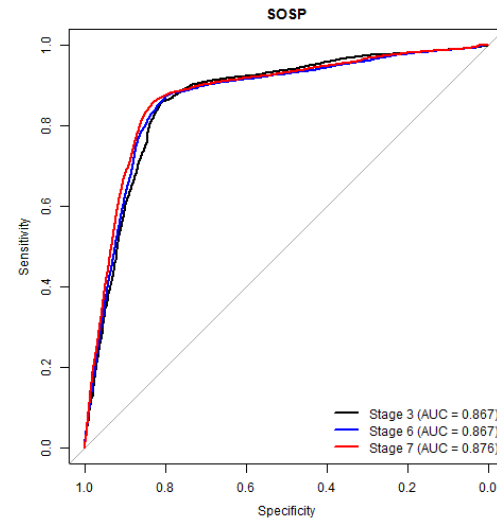
5.58.5 Habitat suitability ranking for patch delineation



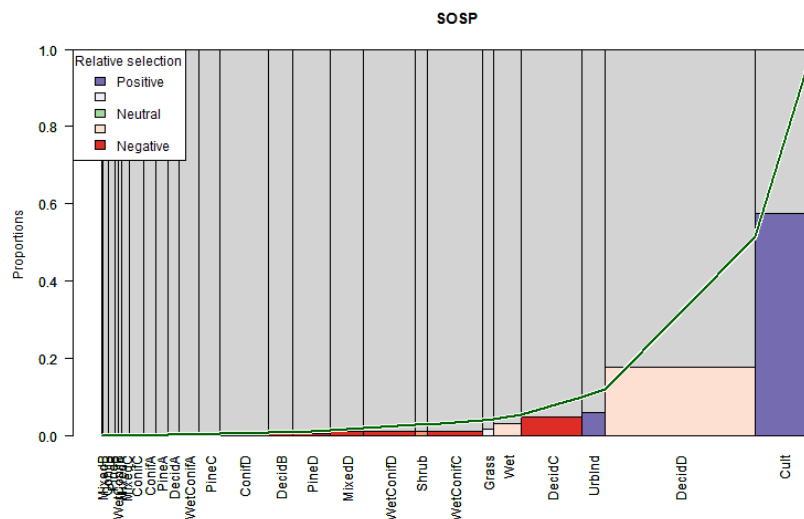
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.58.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

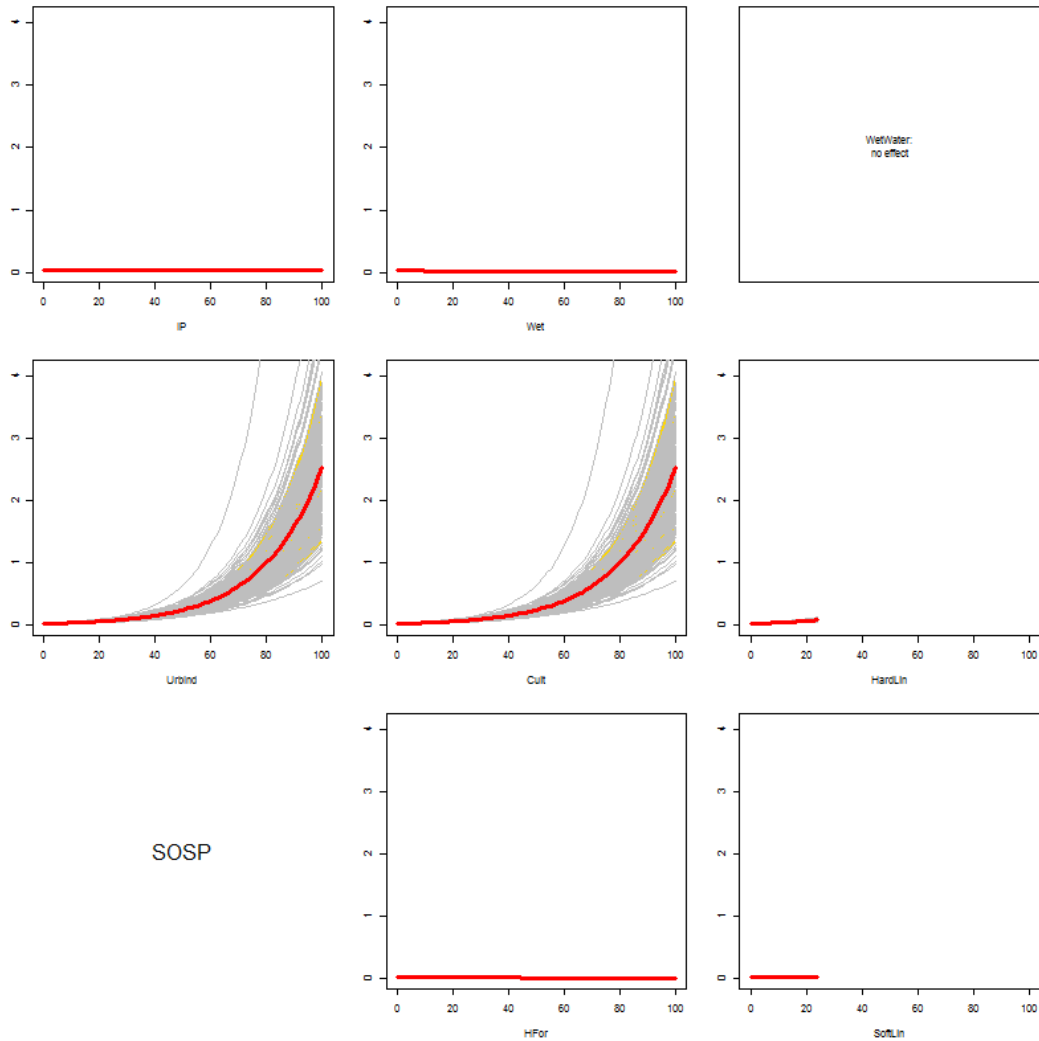


5.58.7 Relative habitat selection



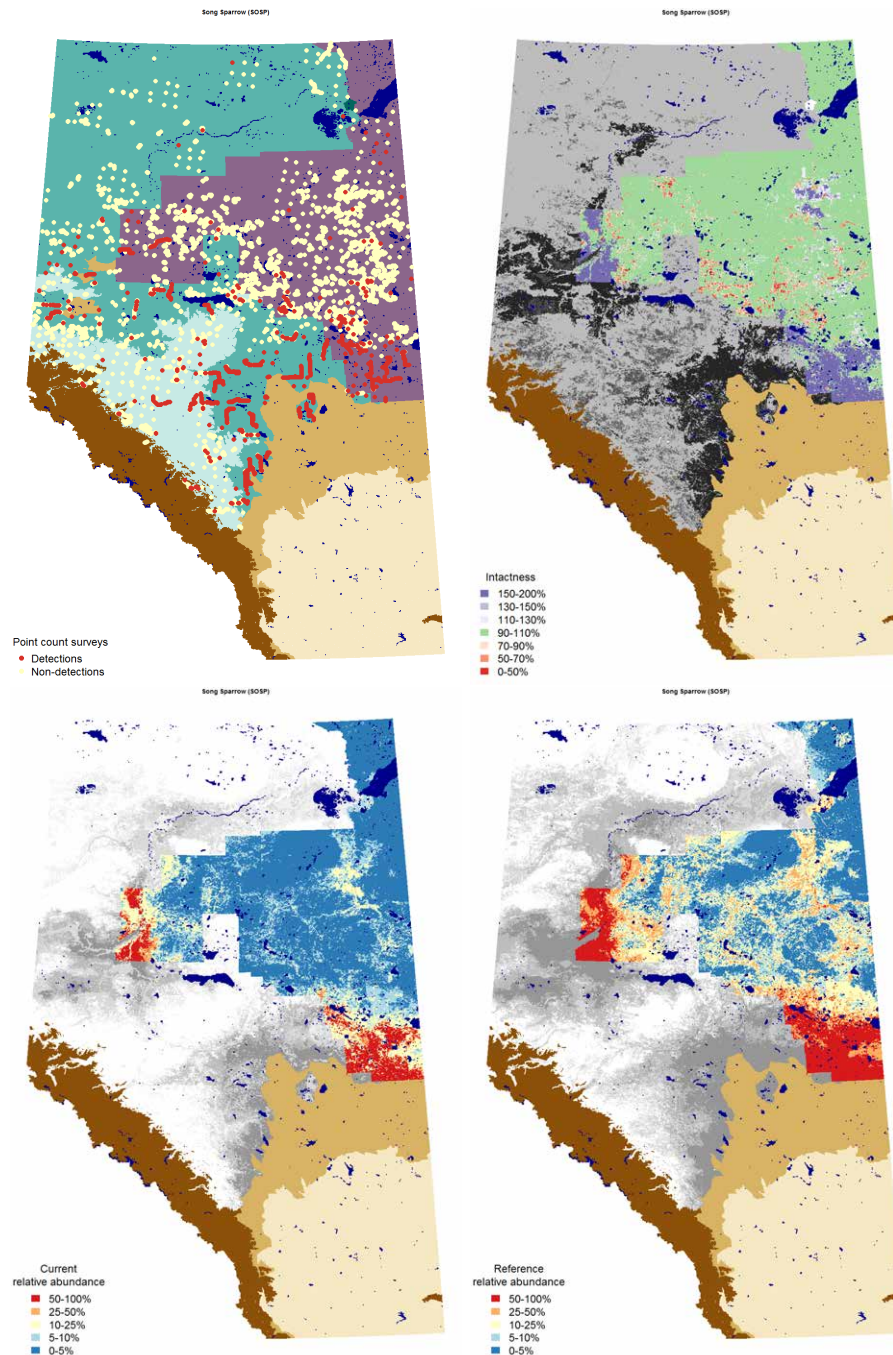
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.58.8 Quarter-section level responses



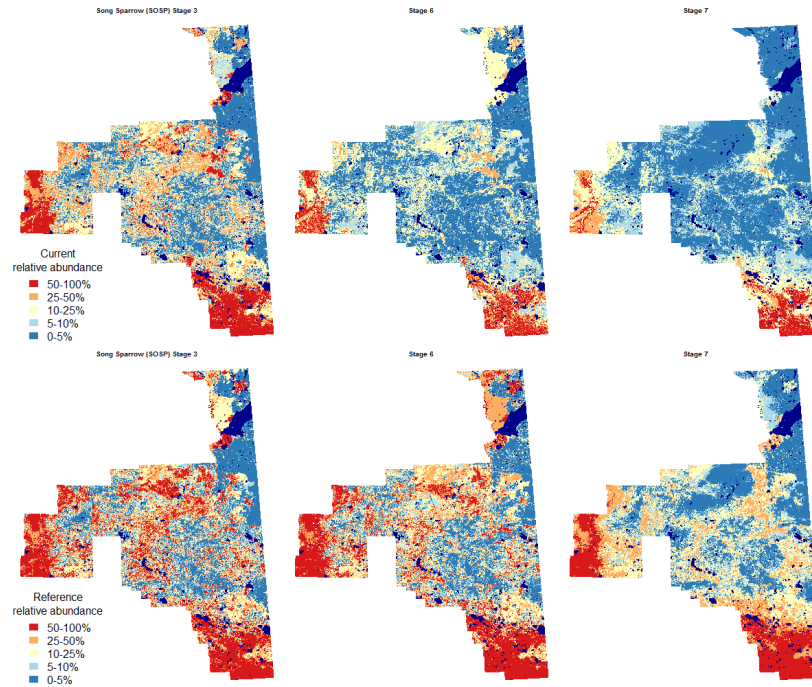
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.58.9 Maps



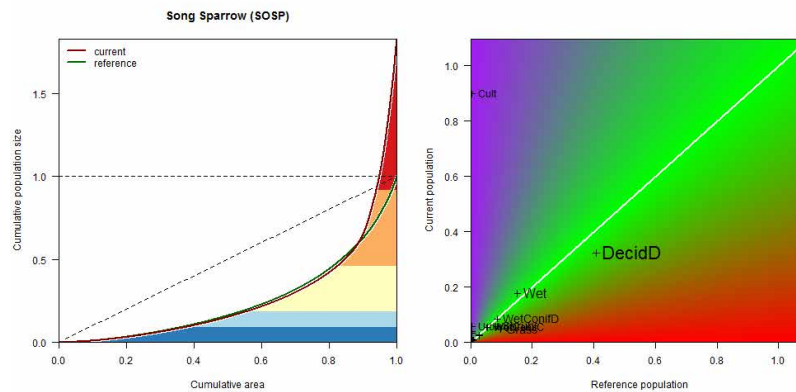
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.58.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.58.11 Population concentration



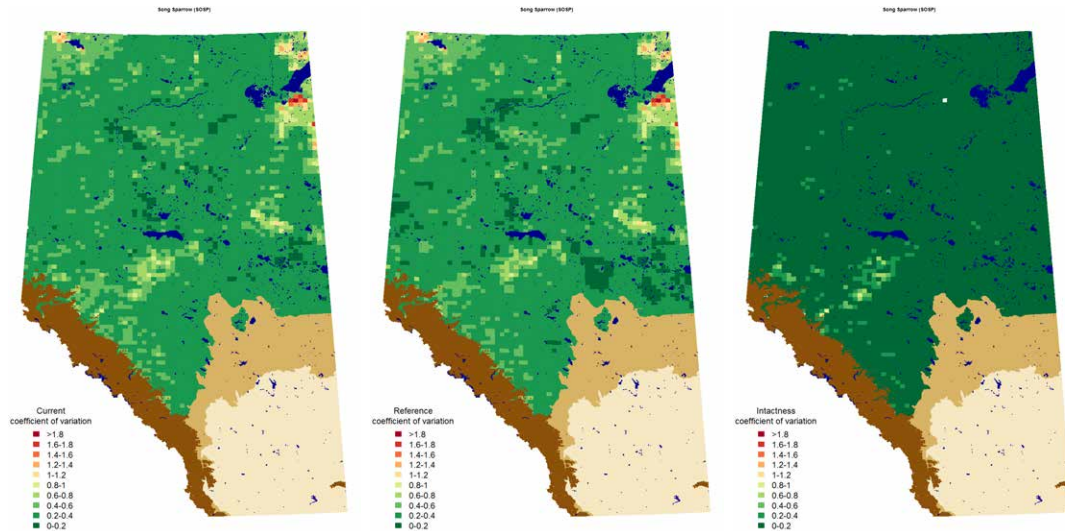
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.58.12 Potential population size

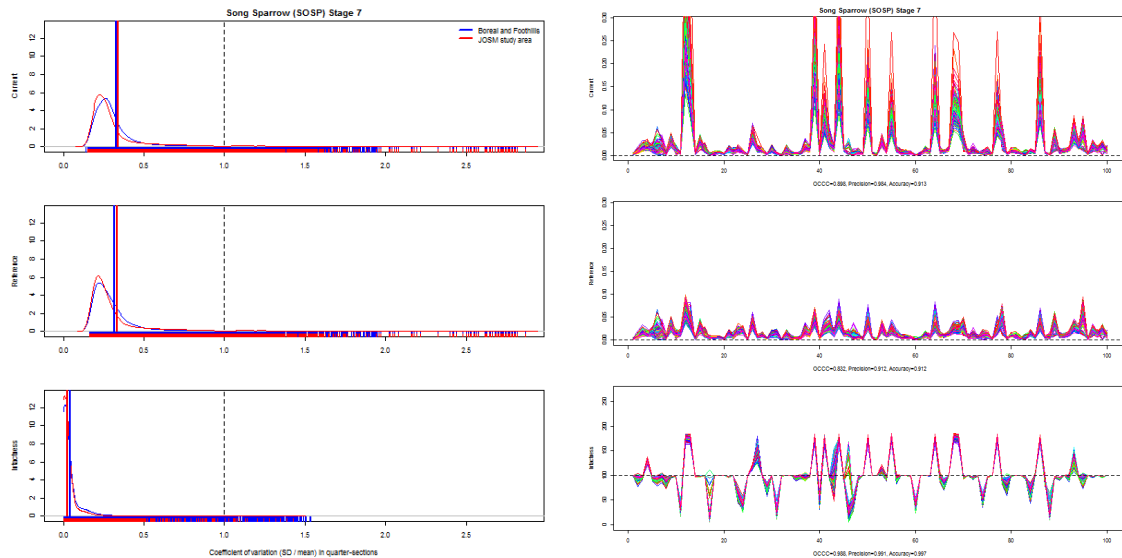
Estimated potential population size of Song Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0574	0.0425	0.0806	0.0750	0.0582	0.1027
Wet	0.0313	0.0232	0.0440	0.0279	0.0216	0.0382
Grass	0.0084	0.0062	0.0118	0.0181	0.0140	0.0247
WetConifD	0.0151	0.0112	0.0212	0.0159	0.0124	0.0219
Shrub	0.0103	0.0076	0.0145	0.0158	0.0123	0.0217
WetConifC	0.0097	0.0072	0.0136	0.0101	0.0078	0.0138
MixedD	0.0042	0.0031	0.0060	0.0053	0.0041	0.0072
DecidC	0.0046	0.0034	0.0064	0.0052	0.0040	0.0071
ConifD	0.0014	0.0011	0.0020	0.0019	0.0015	0.0026
PineD	0.0014	0.0010	0.0020	0.0017	0.0013	0.0023
PineC	0.0013	0.0010	0.0018	0.0015	0.0012	0.0021
ConifC	0.0011	0.0008	0.0016	0.0014	0.0011	0.0019
WetConifB	0.0011	0.0008	0.0015	0.0012	0.0009	0.0016
DecidB	0.0008	0.0006	0.0011	0.0011	0.0009	0.0015
WetConifA	0.0005	0.0004	0.0008	0.0006	0.0005	0.0008
PineB	0.0005	0.0004	0.0007	0.0005	0.0004	0.0007
ConifB	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002
MixedC	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
DecidA	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
ConifA	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
MixedB	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
PineA	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.1595	0.1180	0.2238	0.0000	0.0000	0.0000
UrbInd	0.0102	0.0075	0.0143	0.0000	0.0000	0.0000
HardLin	0.0059	0.0043	0.0082	0.0000	0.0000	0.0000
SoftLin	0.0070	0.0052	0.0098	0.0000	0.0000	0.0000
HFor	0.0023	0.0017	0.0032	0.0000	0.0000	0.0000
Total	0.3344	0.2475	0.4693	0.1837	0.1426	0.2518
Loss	0.0085	0.0053	0.0135			
Gain	0.1594	0.1077	0.2419			

5.58.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.58.14 Variable selection frequencies

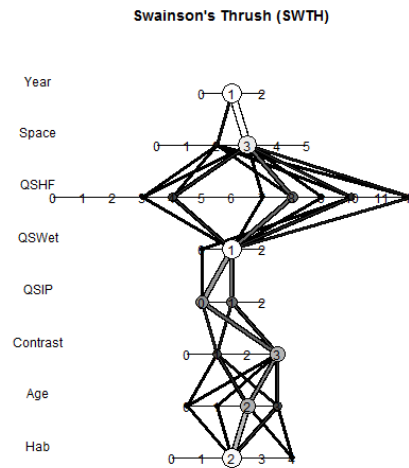
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.3	2.0	4	. + Habitat + isHForC
1.4	98.0	196	. + HabitatB + isHForC
2.2	61.5	123	. + Age + Age2 . + Age + Age2 + Age:isMix + Age:isPine
2.3	38.5	77	+ Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
3.1	99.0	198	. + ROAD
3.3	1.0	2	. + ROAD + SoftLin_PC
4.0	63.5	127	NULL
4.1	36.5	73	. + Remn_QS
5.1	100.0	200	. + pWet_QS
6.9	94.0	188	. + Succ_QS + Alien_QS + Alien2_QS
6.11	6.0	12	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.3	95.5	191	. + xlat + xlong + xlat:xlong
7.4	4.5	9	. + xMAP + xPET + xMAT + xCMD
8.0	95.5	191	NULL
8.1	4.0	8	. + xYEAR
8.2	0.5	1	. + YR5F

5.59 Swainson's Thrush (*Catharus ustulatus*)

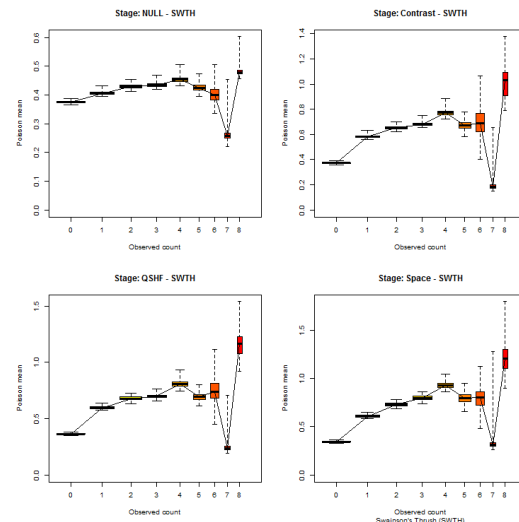
5.59.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

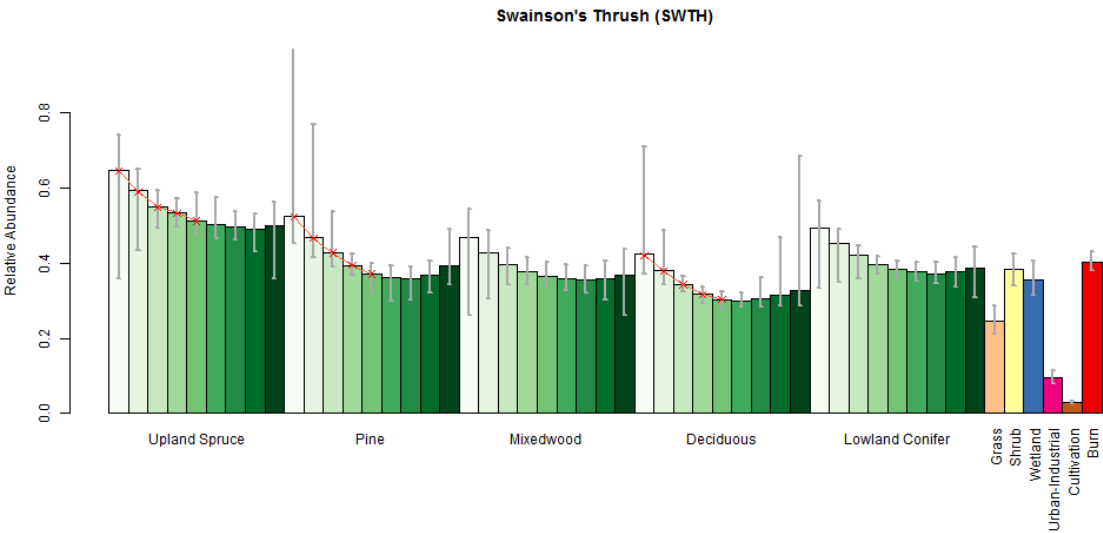


5.59.2 Cross validation

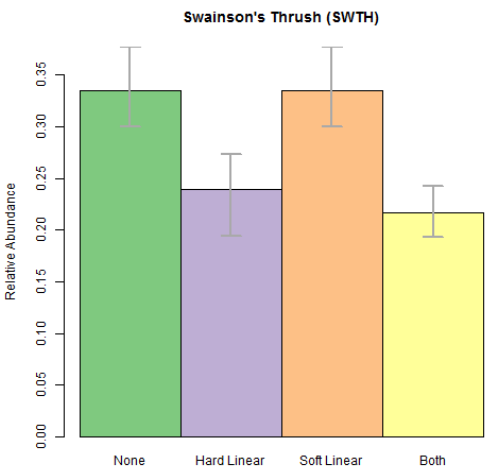
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.59.3 Point level habitat associations

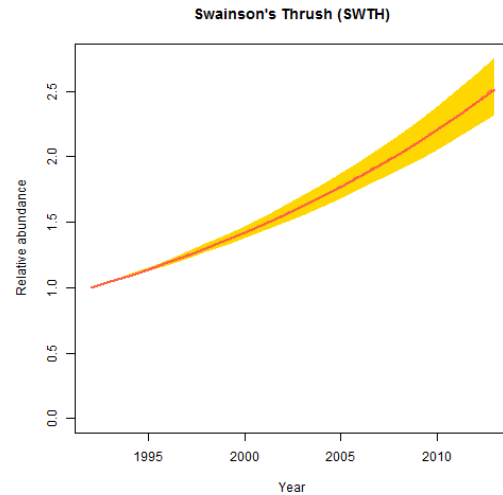


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

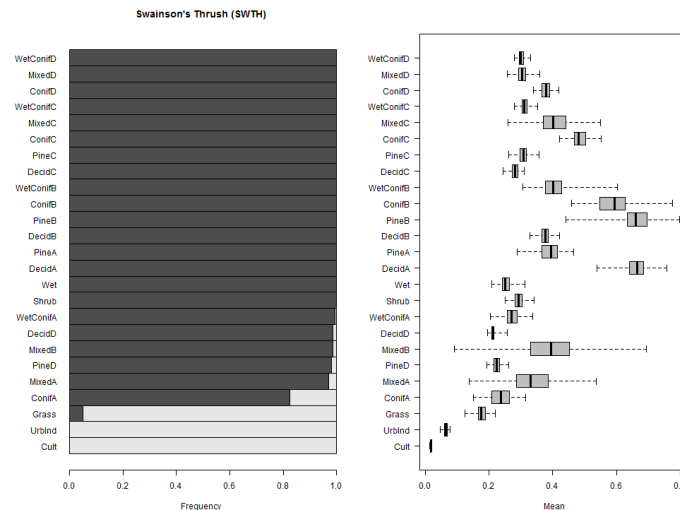


5.59.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



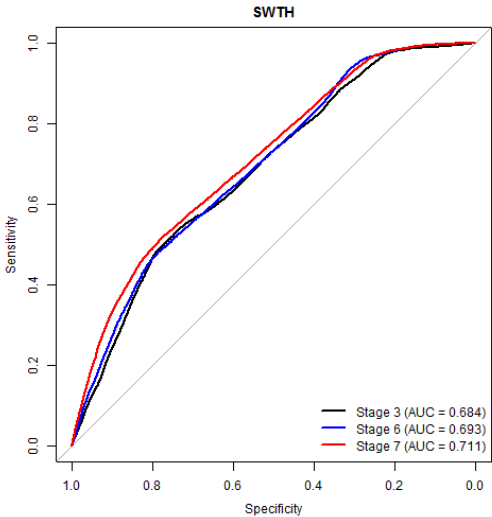
5.59.5 Habitat suitability ranking for patch delineation



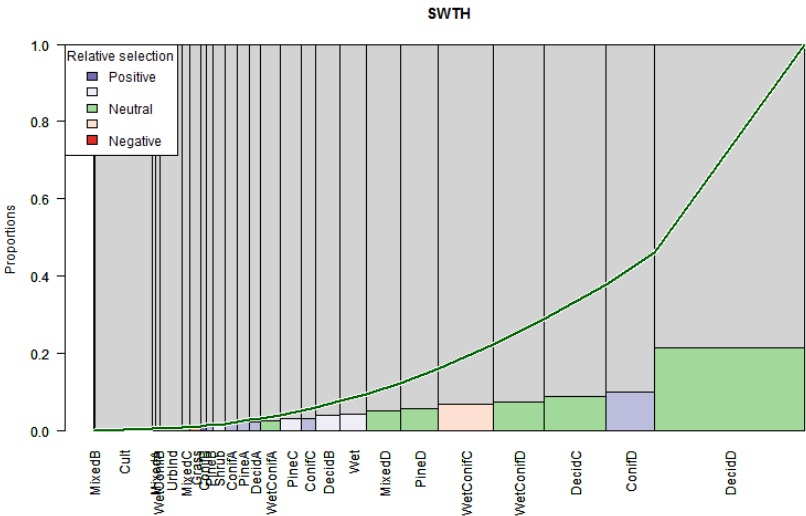
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.59.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

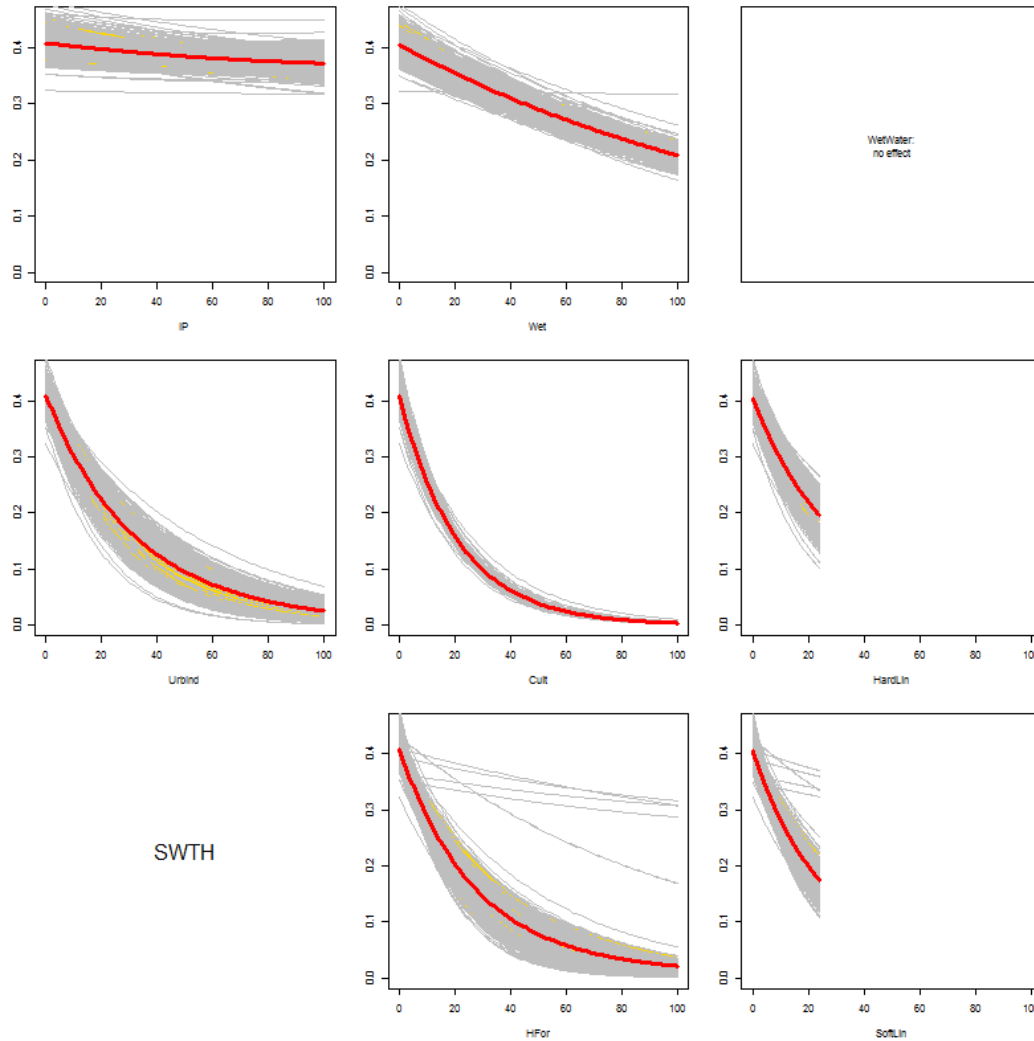


5.59.7 Relative habitat selection



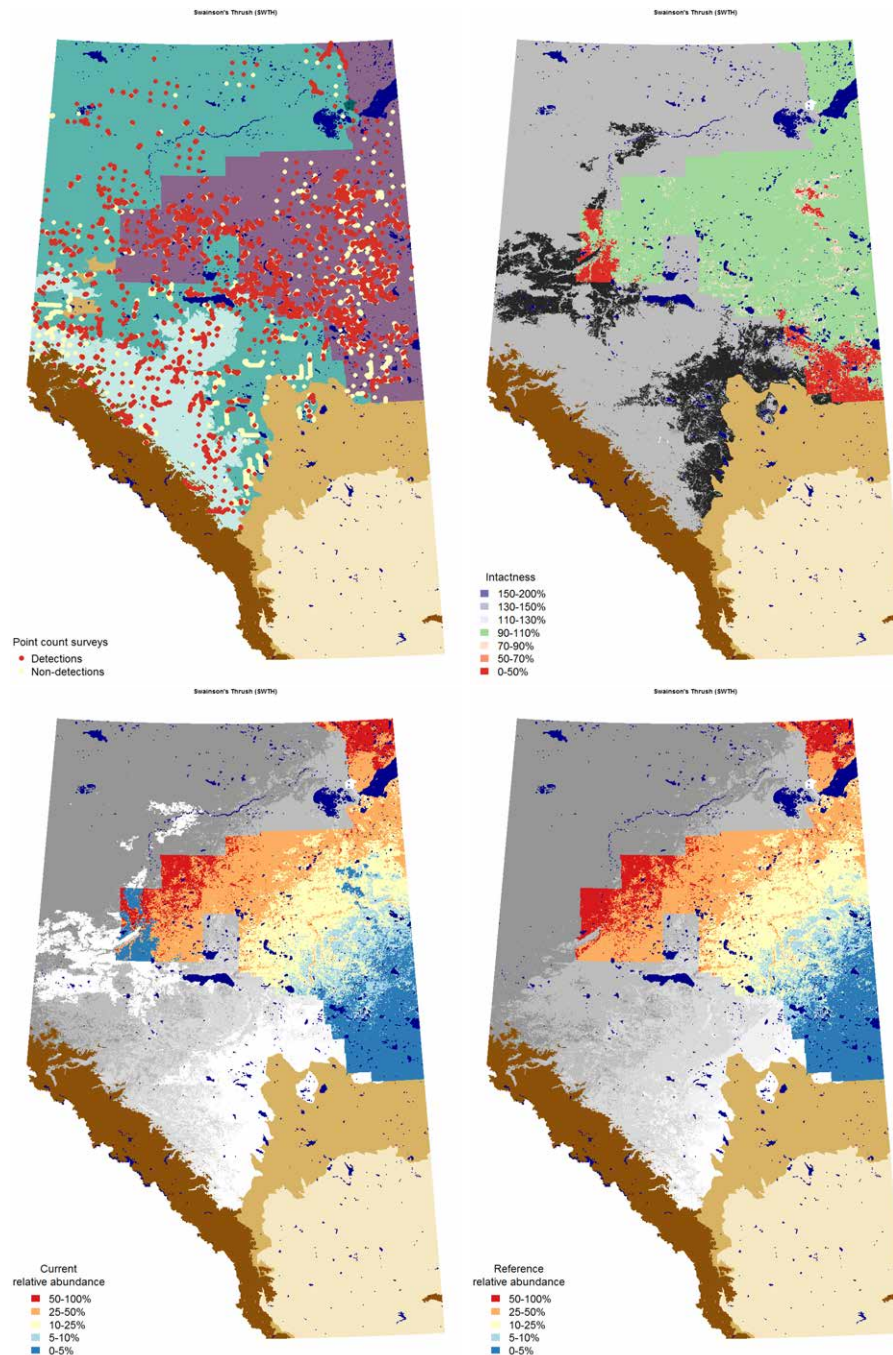
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.59.8 Quarter-section level responses



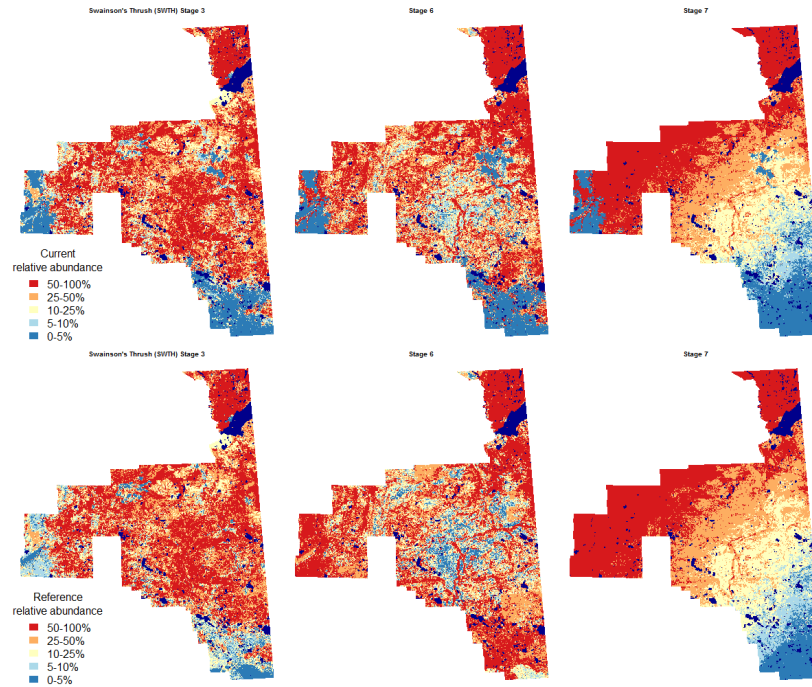
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.59.9 Maps



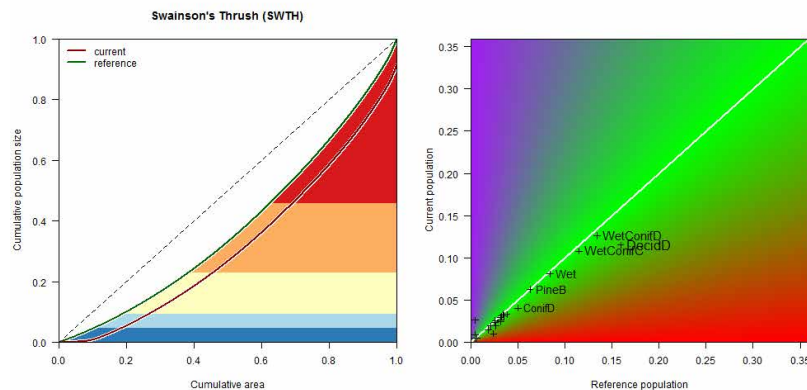
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.59.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.59.11 Population concentration



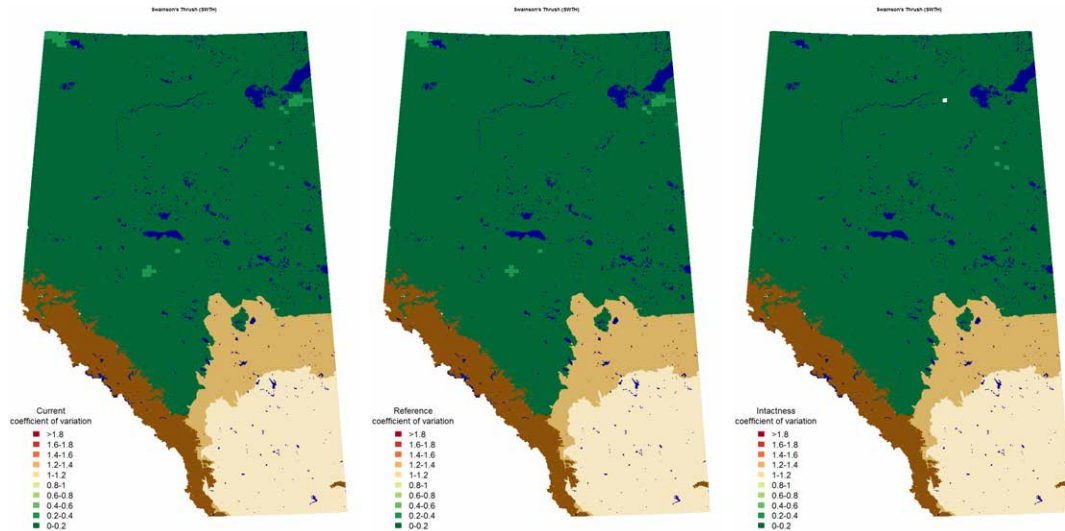
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.59.12 Potential population size

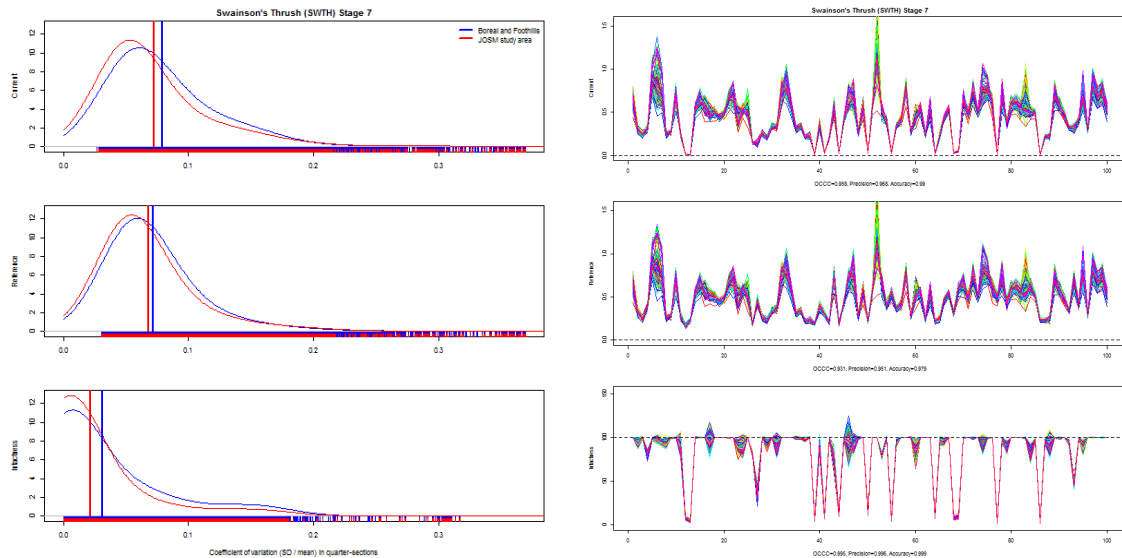
Estimated potential population size of Swainson's Thrush in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.7527	0.7112	0.8058	1.0397	0.9702	1.1139
WetConifD	0.8236	0.7782	0.8817	0.8746	0.8161	0.9370
WetConifC	0.7060	0.6671	0.7559	0.7520	0.7018	0.8057
Wet	0.5287	0.4995	0.5660	0.5522	0.5153	0.5916
PineB	0.4082	0.3857	0.4370	0.4110	0.3835	0.4403
ConifD	0.2655	0.2509	0.2842	0.3269	0.3050	0.3502
ConifC	0.2157	0.2038	0.2309	0.2515	0.2347	0.2694
ConifA	0.2067	0.1953	0.2213	0.2282	0.2129	0.2445
WetConifB	0.2167	0.2047	0.2320	0.2239	0.2090	0.2399
WetConifA	0.2023	0.1911	0.2166	0.2114	0.1972	0.2264
MixedD	0.1719	0.1624	0.1840	0.2098	0.1958	0.2248
PineC	0.1933	0.1827	0.2070	0.2097	0.1957	0.2247
Shrub	0.1573	0.1486	0.1684	0.2090	0.1950	0.2239
DecidC	0.1298	0.1227	0.1390	0.1745	0.1628	0.1869
PineA	0.1667	0.1575	0.1785	0.1707	0.1593	0.1829
ConifB	0.1545	0.1460	0.1654	0.1692	0.1579	0.1813
Grass	0.0669	0.0632	0.0716	0.1588	0.1482	0.1702
PineD	0.1253	0.1184	0.1341	0.1388	0.1295	0.1487
DecidB	0.0964	0.0911	0.1032	0.1217	0.1135	0.1304
DecidA	0.0270	0.0255	0.0289	0.0414	0.0386	0.0444
MixedB	0.0191	0.0180	0.0204	0.0212	0.0198	0.0227
MixedA	0.0122	0.0115	0.0131	0.0166	0.0155	0.0178
MixedC	0.0107	0.0102	0.0115	0.0128	0.0119	0.0137
Cult	0.0286	0.0270	0.0306	0.0000	0.0000	0.0000
UrbInd	0.0249	0.0236	0.0267	0.0000	0.0000	0.0000
HardLin	0.0026	0.0024	0.0027	0.0000	0.0000	0.0000
SoftLin	0.0610	0.0576	0.0653	0.0000	0.0000	0.0000
HFor	0.1705	0.1611	0.1825	0.0000	0.0000	0.0000
Total	5.9446	5.6169	6.3645	6.5255	6.0892	6.9913
Loss	0.5674	0.4838	0.6716			
Gain	0.0036	0.0007	0.0196			

5.59.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.59.14 Variable selection frequencies

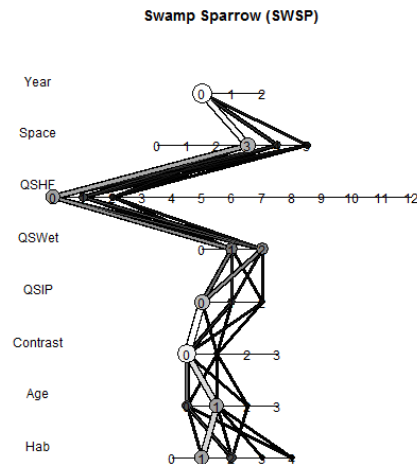
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	97.5	195	. + HabitatB
1.4	2.5	5	. + HabitatB + isHForC
2.0	1.0	2	NULL
2.1	0.5	1	. + Age
2.2	69.0	138	. + Age + Age2 . + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
2.3	29.5	59	
3.1	29.0	58	. + ROAD
3.3	71.0	142	. + ROAD + SoftLin_PC
4.0	56.5	113	NULL
4.1	43.5	87	. + Remn_QS
5.0	0.5	1	NULL
5.1	99.5	199	. + pWet_QS
6.3	1.0	2	. + Succ_QS + Alien_QS
6.4	26.0	52	. + Succ_QS + Noncult_QS + Cult_QS
6.7	1.0	2	. + Succ_QS + Alien_QS + Succ2_QS
6.8	39.5	79	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	1.0	2	. + Succ_QS + Alien_QS + Alien2_QS
6.10	19.0	38	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.12	12.5	25	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.2	7.5	15	. + xlat + xlong
7.3	92.5	185	. + xlat + xlong + xlat:xlong
8.1	100.0	200	. + xYEAR

5.60 Swamp Sparrow (*Melospiza georgiana*)

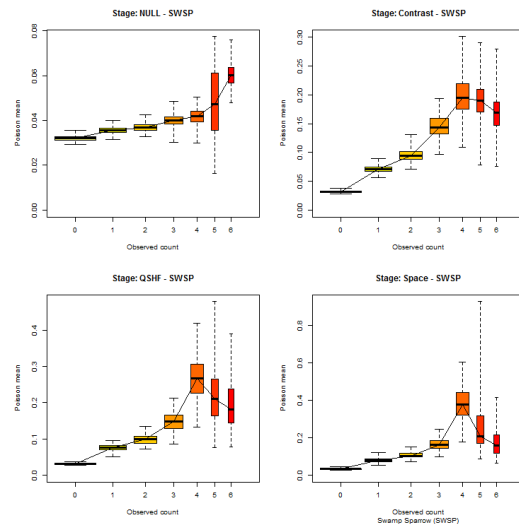
5.60.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

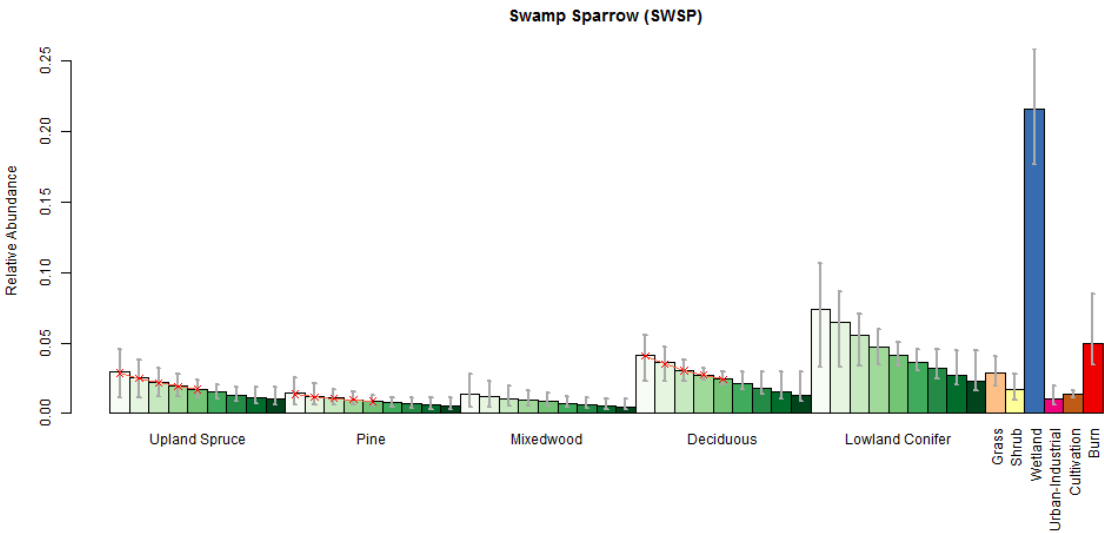


5.60.2 Cross validation

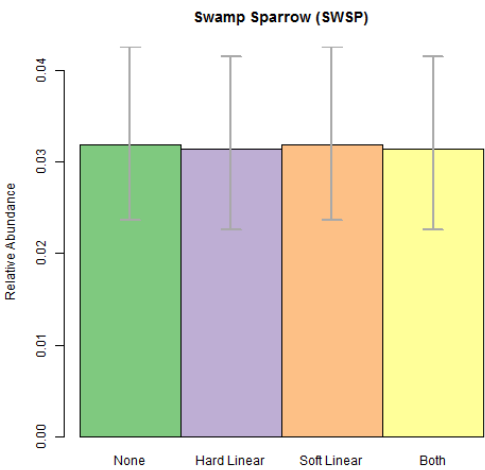
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.60.3 Point level habitat associations

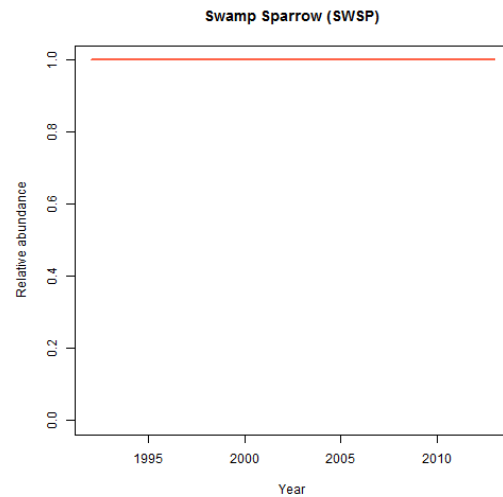


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

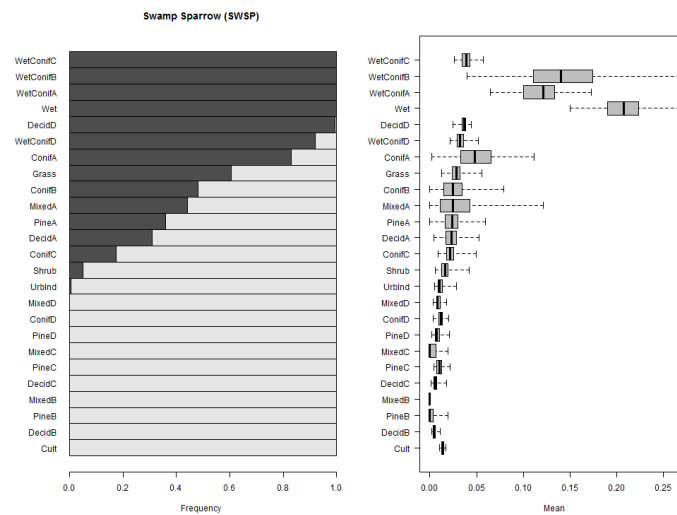


5.60.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



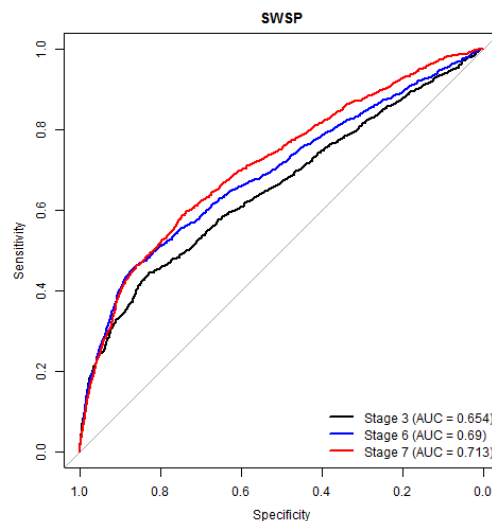
5.60.5 Habitat suitability ranking for patch delineation



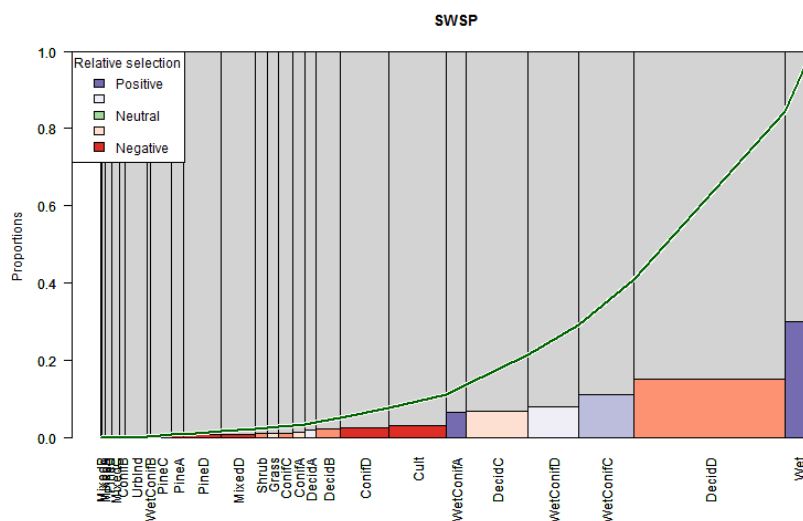
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.60.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

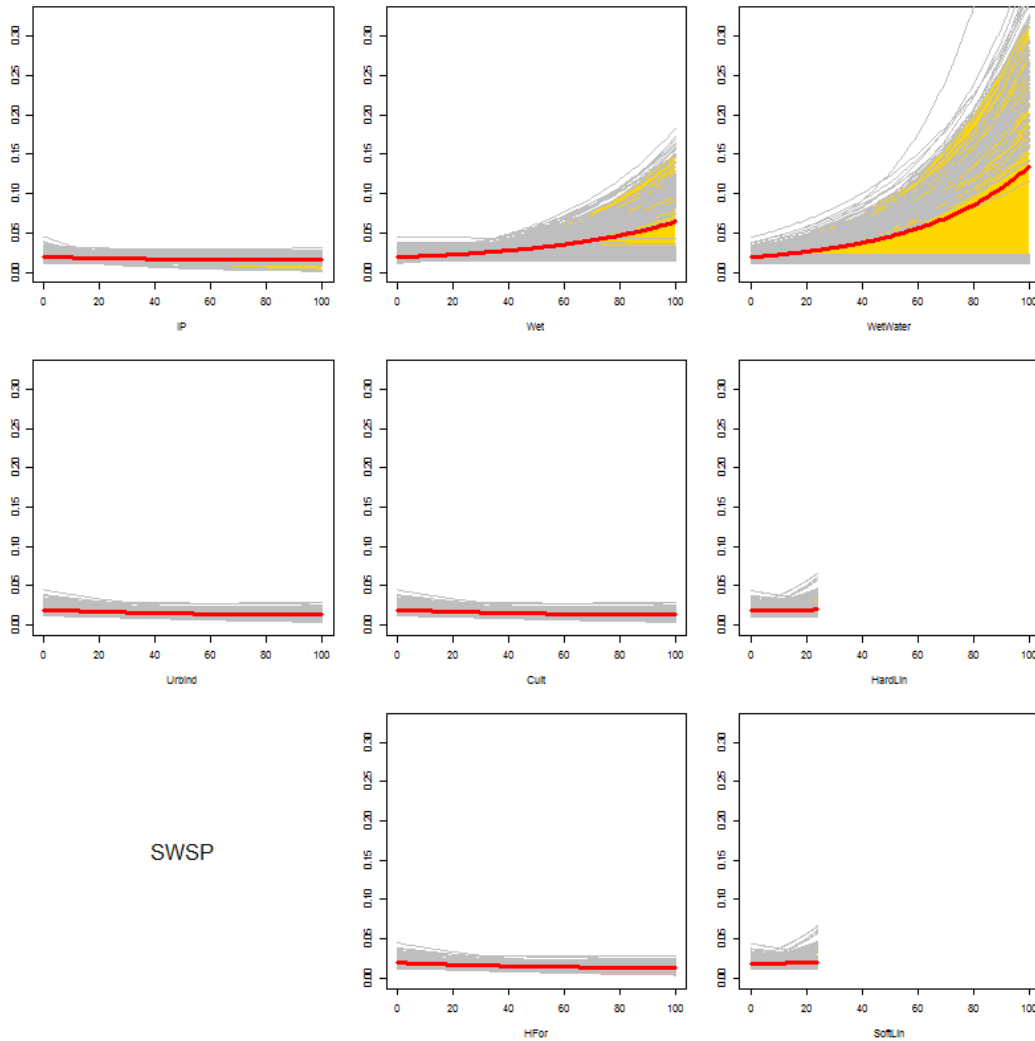


5.60.7 Relative habitat selection



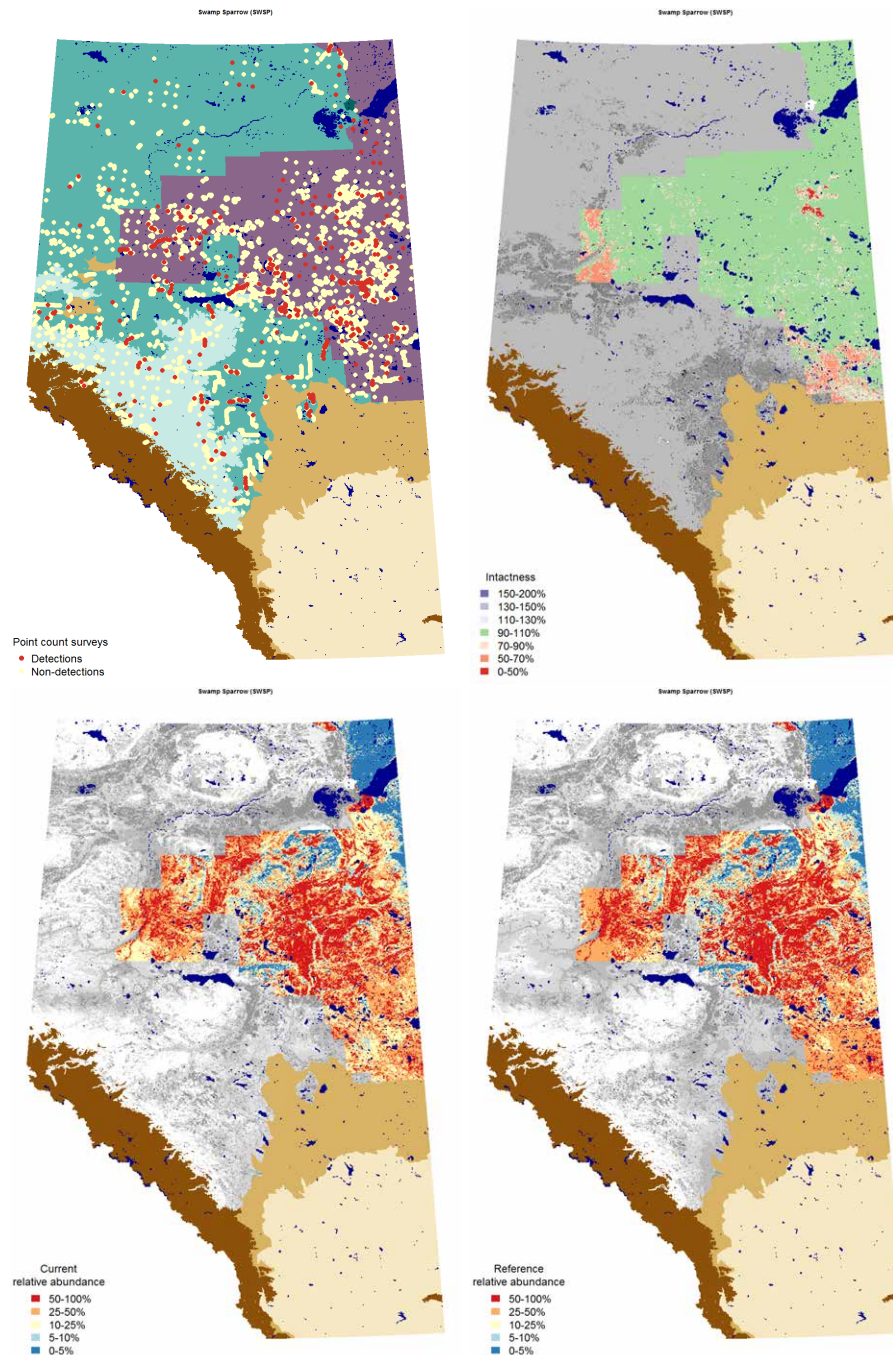
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.60.8 Quarter-section level responses



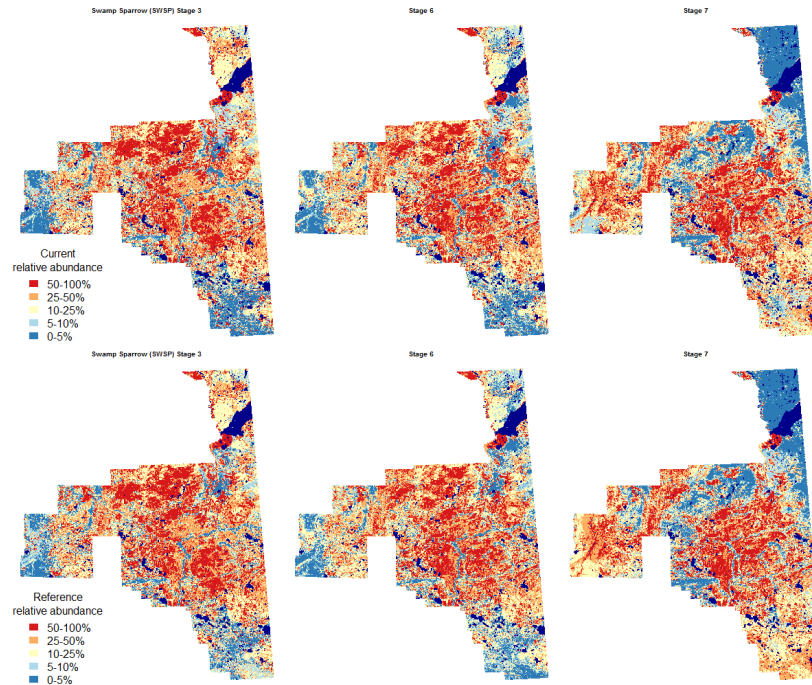
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.60.9 Maps



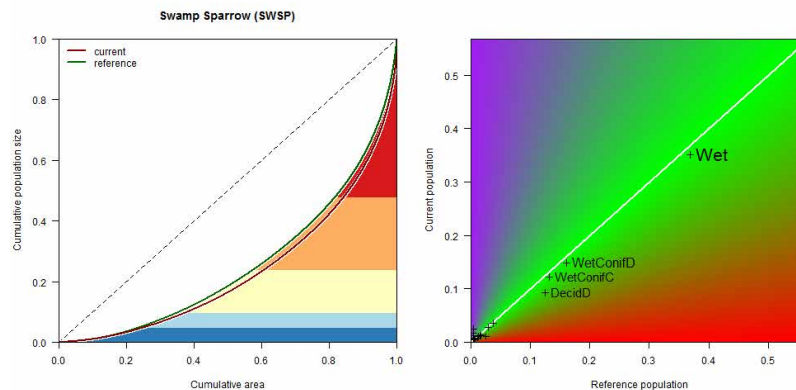
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.60.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.60.11 Population concentration



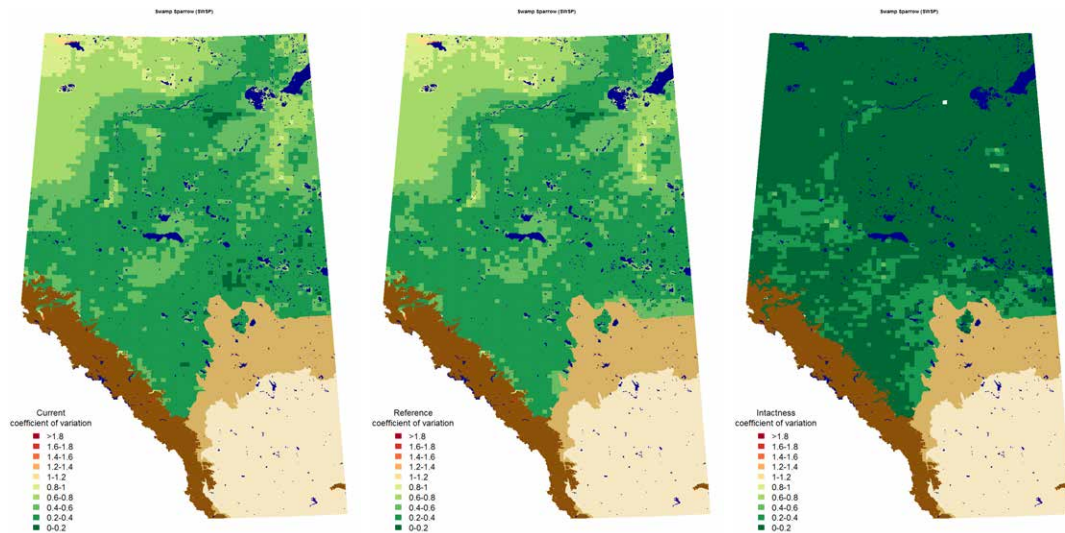
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.60.12 Potential population size

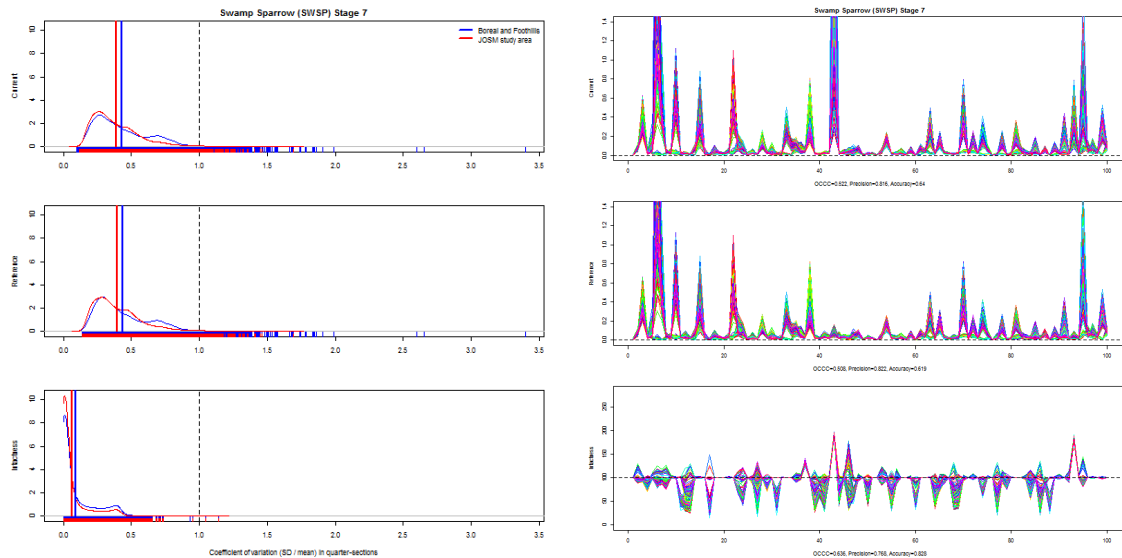
Estimated potential population size of Swamp Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.3083	0.2438	0.3840	0.3214	0.2473	0.4134
WetConifD	0.1307	0.1034	0.1628	0.1409	0.1085	0.1813
WetConifC	0.1078	0.0853	0.1342	0.1150	0.0885	0.1479
DecidD	0.0815	0.0645	0.1015	0.1094	0.0842	0.1407
WetConifA	0.0315	0.0250	0.0393	0.0332	0.0255	0.0426
WetConifB	0.0245	0.0194	0.0305	0.0257	0.0198	0.0330
Grass	0.0103	0.0081	0.0128	0.0227	0.0175	0.0292
ConifD	0.0124	0.0098	0.0154	0.0154	0.0119	0.0199
Shrub	0.0107	0.0085	0.0134	0.0150	0.0116	0.0194
DecidC	0.0103	0.0081	0.0128	0.0141	0.0109	0.0182
ConifC	0.0093	0.0074	0.0116	0.0111	0.0085	0.0142
DecidB	0.0073	0.0058	0.0091	0.0099	0.0076	0.0127
PineC	0.0062	0.0049	0.0078	0.0069	0.0053	0.0089
MixedD	0.0048	0.0038	0.0059	0.0059	0.0045	0.0075
PineB	0.0054	0.0043	0.0067	0.0055	0.0042	0.0070
ConifA	0.0042	0.0033	0.0052	0.0053	0.0041	0.0068
PineD	0.0040	0.0032	0.0050	0.0046	0.0035	0.0059
DecidA	0.0026	0.0021	0.0033	0.0039	0.0030	0.0051
ConifB	0.0028	0.0022	0.0035	0.0035	0.0027	0.0045
PineA	0.0019	0.0015	0.0024	0.0020	0.0016	0.0026
MixedA	0.0003	0.0002	0.0003	0.0004	0.0003	0.0005
MixedB	0.0002	0.0002	0.0003	0.0003	0.0002	0.0004
MixedC	0.0002	0.0002	0.0003	0.0003	0.0002	0.0003
Cult	0.0220	0.0174	0.0274	0.0000	0.0000	0.0000
UrbInd	0.0030	0.0024	0.0037	0.0000	0.0000	0.0000
HardLin	0.0010	0.0008	0.0012	0.0000	0.0000	0.0000
SoftLin	0.0145	0.0115	0.0181	0.0000	0.0000	0.0000
HFor	0.0107	0.0084	0.0133	0.0000	0.0000	0.0000
Total	0.8285	0.6552	1.0317	0.8722	0.6713	1.1221
Loss	0.0469	0.0200	0.1295			
Gain	0.0083	0.0047	0.0264			

5.60.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.60.14 Variable selection frequencies

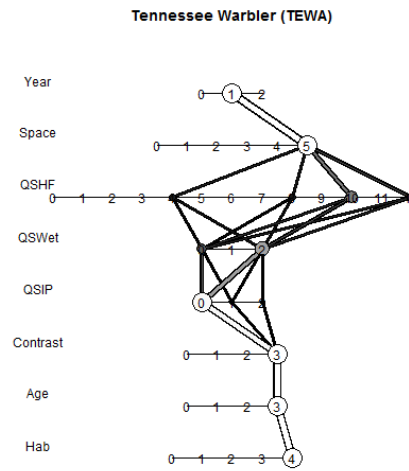
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	64.5	129	. + Habitat
1.2	31.0	62	. + HabitatB
1.3	2.0	4	. + Habitat + isHForC
1.4	2.5	5	. + HabitatB + isHForC
2.0	33.0	66	NULL
2.1	64.0	128	. + Age
2.2	3.0	6	. + Age + Age2
3.0	95.0	190	NULL
3.1	5.0	10	. + ROAD
4.0	74.0	148	NULL
4.1	19.5	39	. + Remn_QS
4.2	6.5	13	. + Remn_QS + Remn2_QS
5.1	47.5	95	. + pWet_QS
5.2	52.5	105	. + pWetWater_QS
6.0	63.5	127	NULL
6.1	26.0	52	. + THF_QS
6.2	10.5	21	. + Lin_QS + Nonlin_QS
7.3	69.5	139	. + xlat + xlong + xlat:xlong
7.4	21.5	43	. + xMAP + xPET + xMAT + xCMD
7.5	9.0	18	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	100.0	200	NULL

5.61 Tennessee Warbler (*Oreothlypis peregrina*)

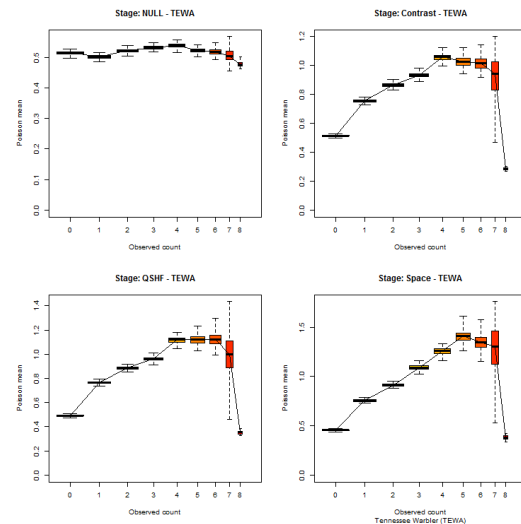
5.61.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

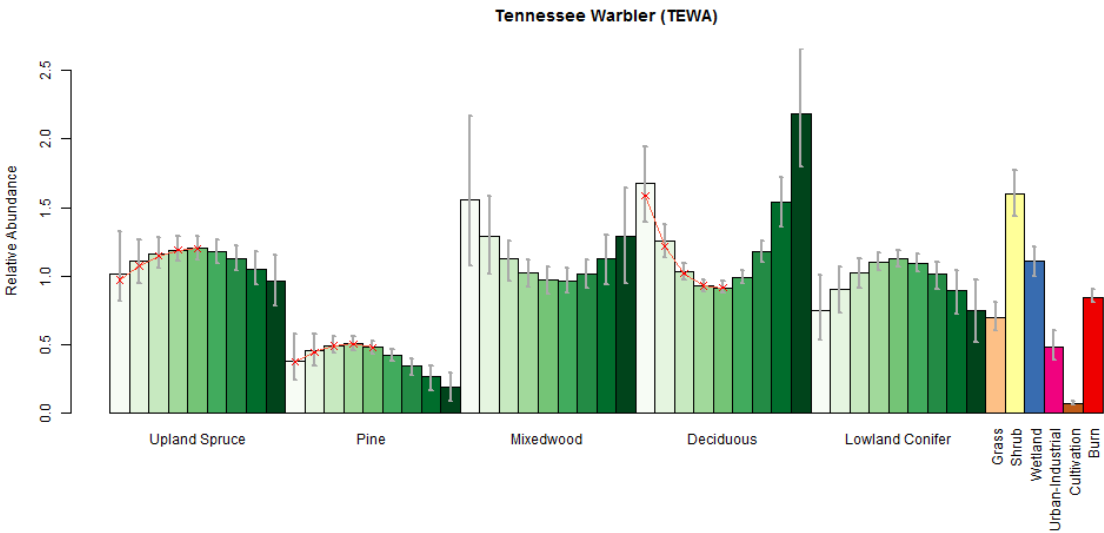


5.61.2 Cross validation

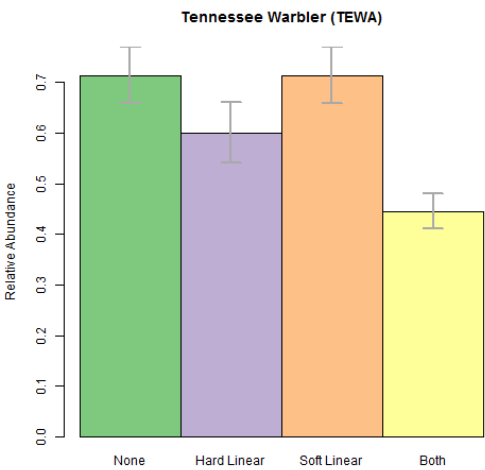
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.61.3 Point level habitat associations

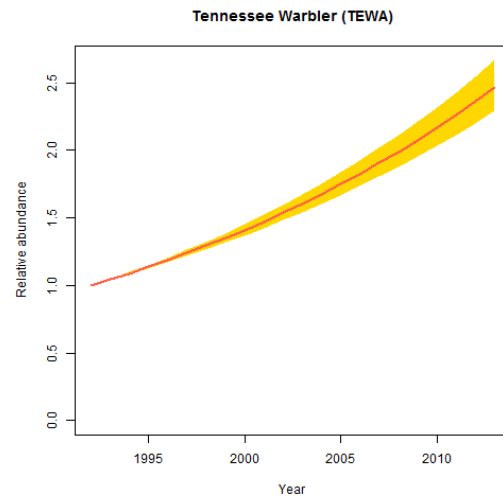


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

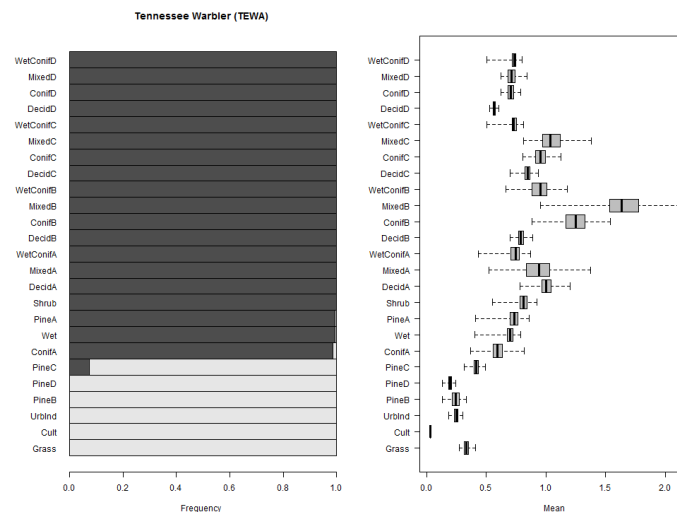


5.61.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



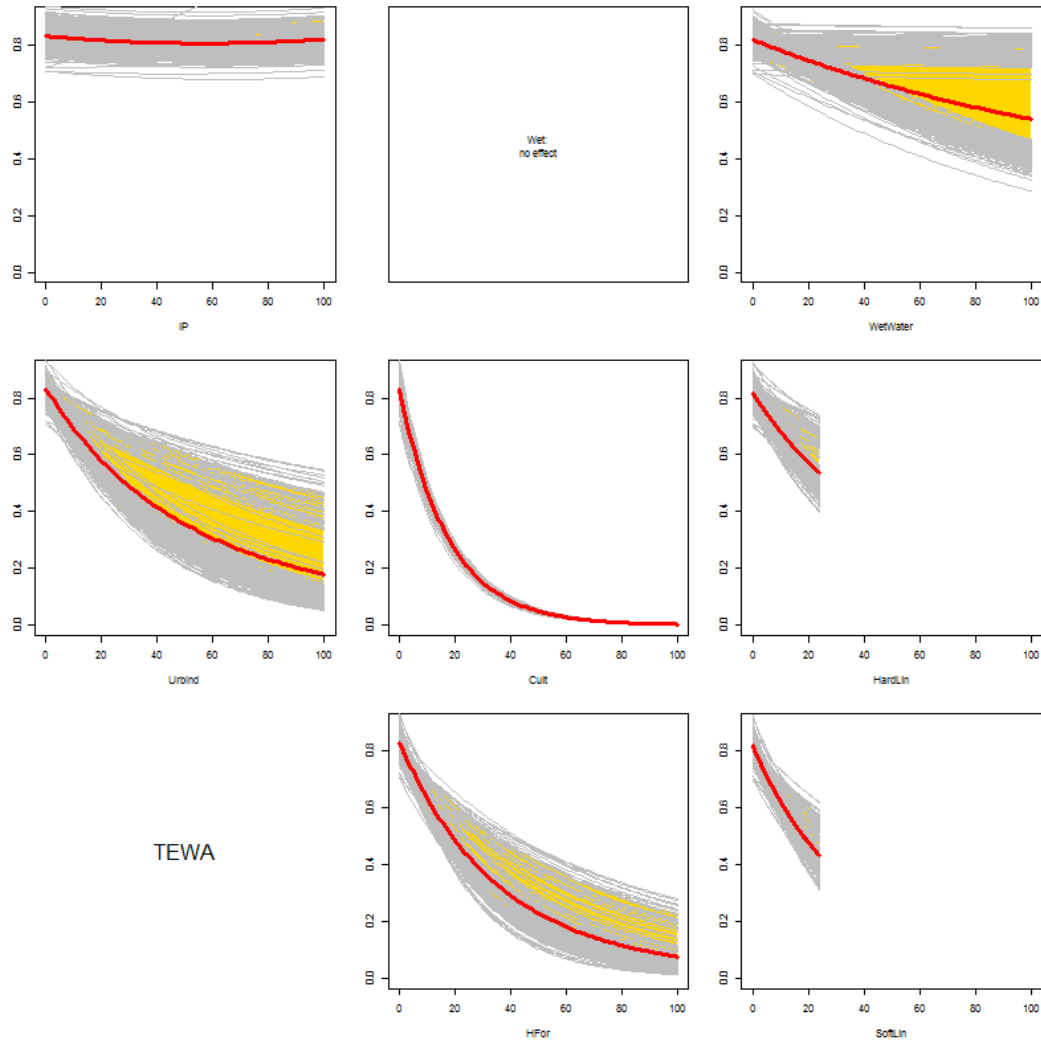
5.61.5 Habitat suitability ranking for patch delineation



Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

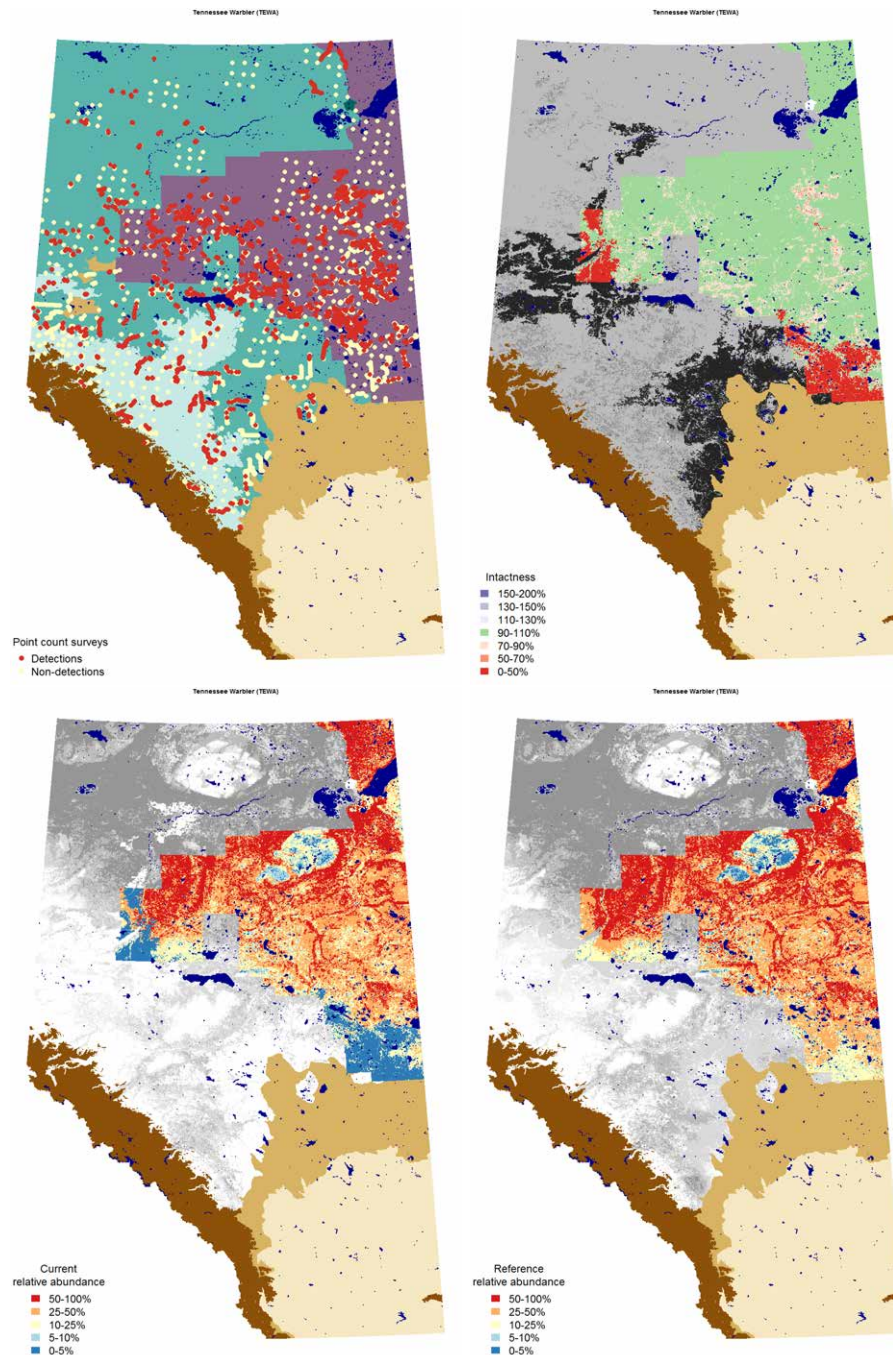
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.61.8 Quarter-section level responses



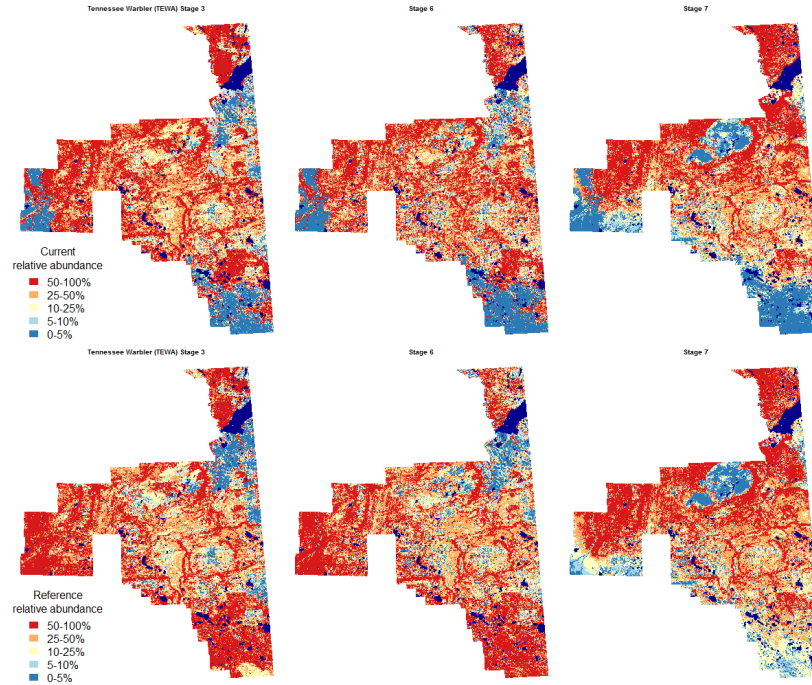
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.61.9 Maps



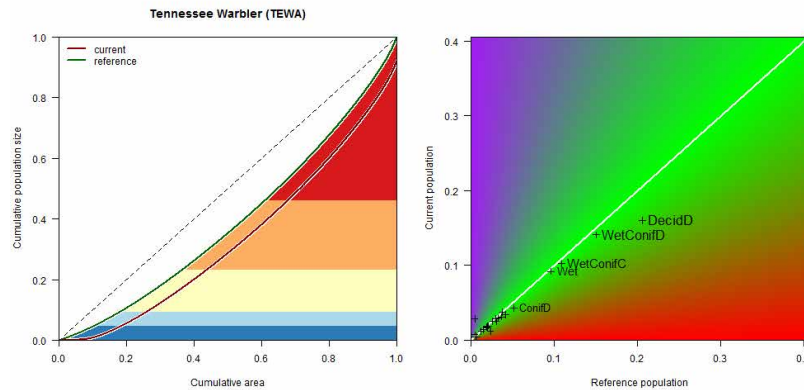
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.61.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.61.11 Population concentration



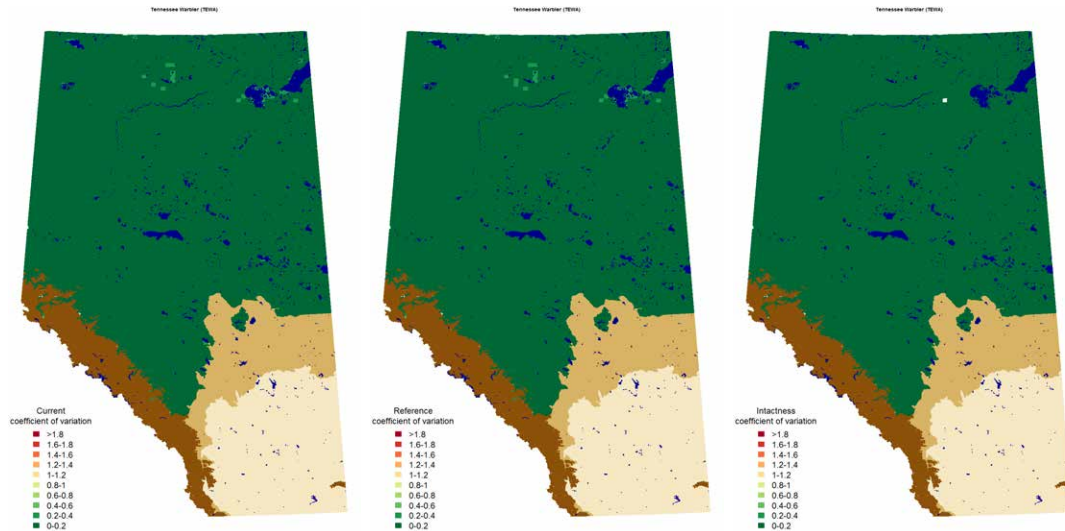
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.61.12 Potential population size

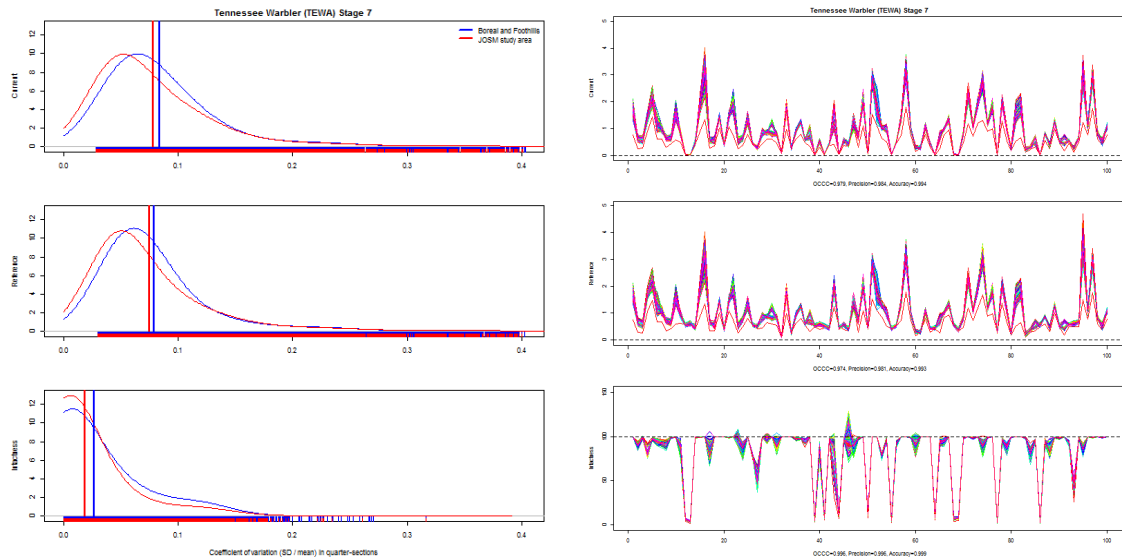
Estimated potential population size of Tennessee Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	2.6911	2.5911	2.8390	3.4540	3.3037	3.6351
WetConifD	2.3678	2.2799	2.4980	2.5253	2.4154	2.6577
WetConifC	1.7210	1.6571	1.8156	1.8299	1.7502	1.9258
Wet	1.5484	1.4909	1.6335	1.6215	1.5509	1.7065
ConifD	0.7301	0.7030	0.7702	0.8708	0.8329	0.9165
Shrub	0.5750	0.5536	0.6066	0.7050	0.6743	0.7420
PineB	0.6309	0.6075	0.6656	0.6360	0.6084	0.6694
MixedD	0.5296	0.5100	0.5587	0.6258	0.5986	0.6586
ConifC	0.4950	0.4766	0.5222	0.5615	0.5370	0.5909
DecidC	0.4194	0.4038	0.4424	0.5156	0.4931	0.5426
WetConifB	0.4880	0.4699	0.5149	0.5032	0.4813	0.5296
WetConifA	0.4244	0.4086	0.4477	0.4470	0.4276	0.4705
Grass	0.1968	0.1895	0.2077	0.3981	0.3808	0.4190
ConifA	0.3247	0.3127	0.3426	0.3597	0.3440	0.3785
DecidB	0.2779	0.2675	0.2931	0.3386	0.3239	0.3564
ConifB	0.3119	0.3003	0.3290	0.3385	0.3238	0.3563
PineC	0.3028	0.2916	0.3195	0.3237	0.3096	0.3407
PineD	0.2371	0.2283	0.2502	0.2563	0.2451	0.2697
PineA	0.2096	0.2018	0.2211	0.2145	0.2052	0.2258
DecidA	0.0806	0.0776	0.0851	0.1204	0.1152	0.1267
MixedB	0.0530	0.0510	0.0559	0.0588	0.0562	0.0619
MixedA	0.0378	0.0364	0.0399	0.0513	0.0491	0.0540
MixedC	0.0294	0.0283	0.0310	0.0335	0.0321	0.0353
Cult	0.0681	0.0655	0.0718	0.0000	0.0000	0.0000
UrbInd	0.1246	0.1200	0.1315	0.0000	0.0000	0.0000
HardLin	0.0054	0.0052	0.0057	0.0000	0.0000	0.0000
SoftLin	0.0705	0.0679	0.0744	0.0000	0.0000	0.0000
HFor	0.4812	0.4634	0.5077	0.0000	0.0000	0.0000
Total	15.4319	14.8590	16.2804	16.7890	16.0585	17.6695
Loss	1.3197	1.1630	1.5364			
Gain	0.0113	0.0034	0.0277			

5.61.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.61.14 Variable selection frequencies

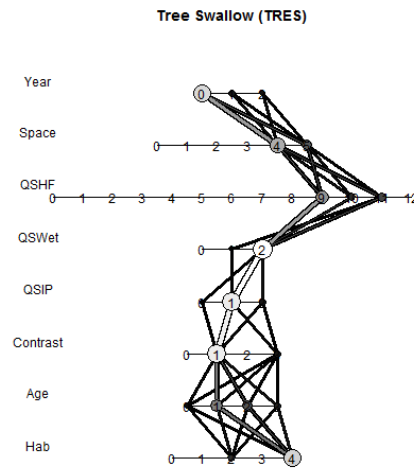
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.4	100.0	200	. + HabitatB + isHForC
2.3	100.0	200	. + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
3.3	100.0	200	. + ROAD + SoftLin_PC
4.0	97.5	195	NULL
4.1	2.0	4	. + Remn_QS
4.2	0.5	1	. + Remn_QS + Remn2_QS
5.0	36.0	72	NULL
5.2	64.0	128	. + pWetWater_QS
6.4	13.0	26	. + Succ_QS + Noncult_QS + Cult_QS
6.8	10.5	21	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.10	47.5	95	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.12	29.0	58	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.5	100.0	200	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	100.0	200	. + xYEAR

5.62 Tree Swallow (*Tachycineta bicolor*)

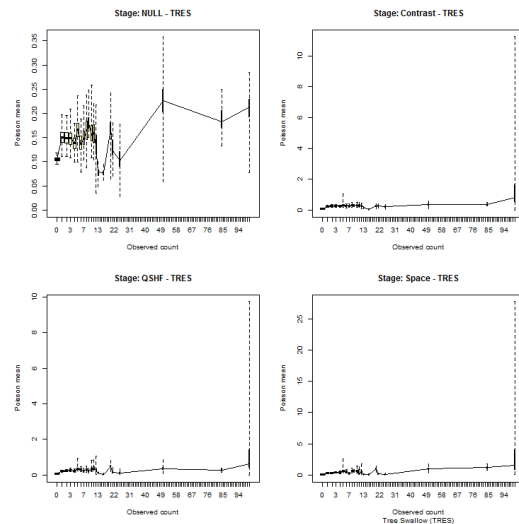
5.62.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

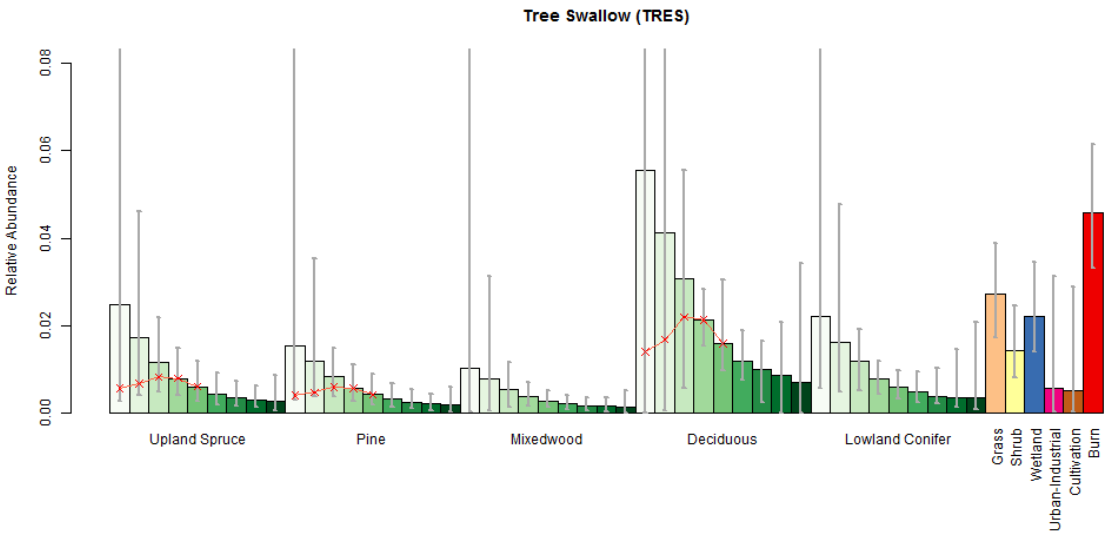


5.62.2 Cross validation

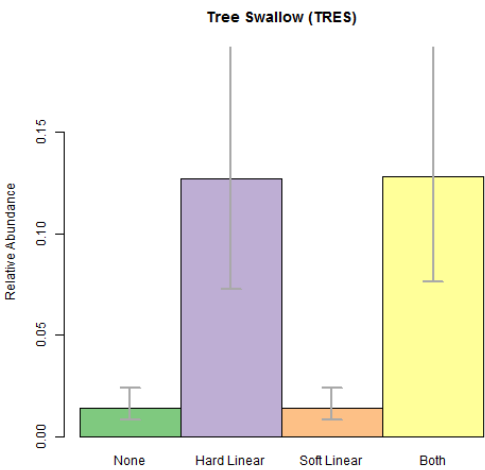
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.62.3 Point level habitat associations

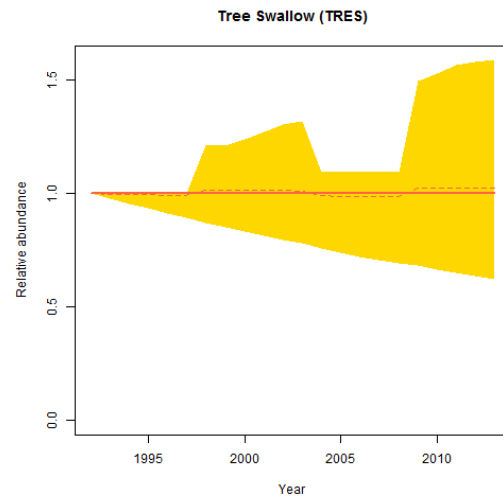


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

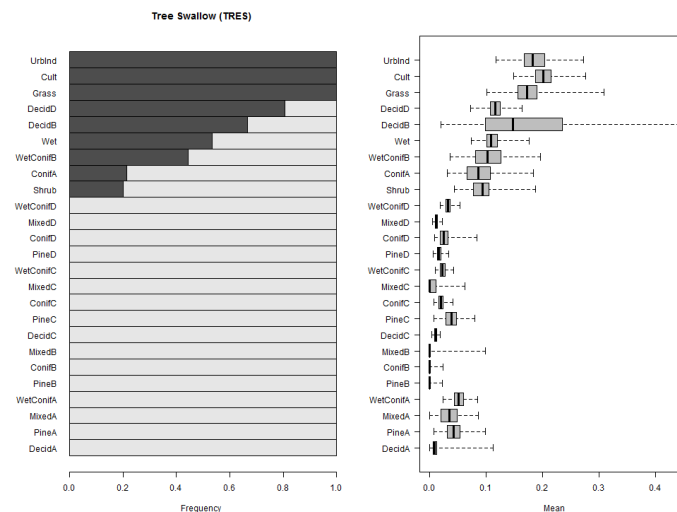


5.62.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



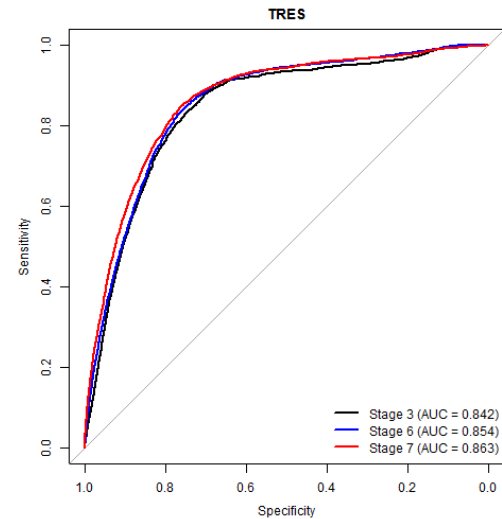
5.62.5 Habitat suitability ranking for patch delineation



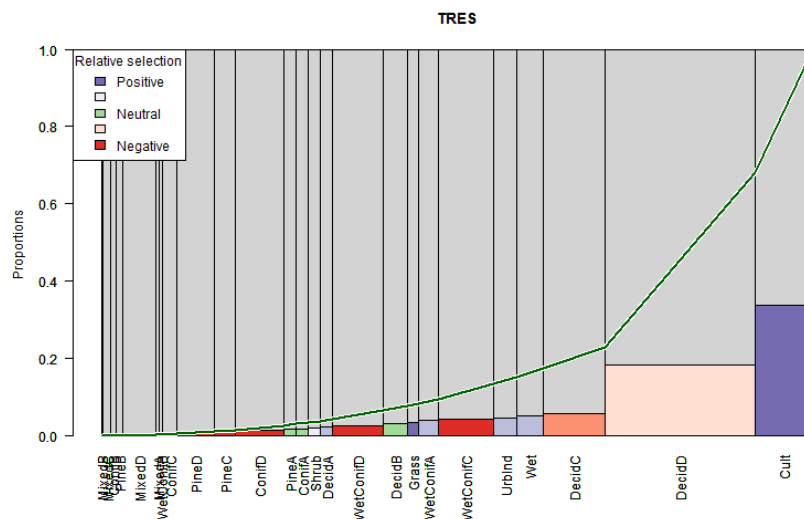
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.62.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

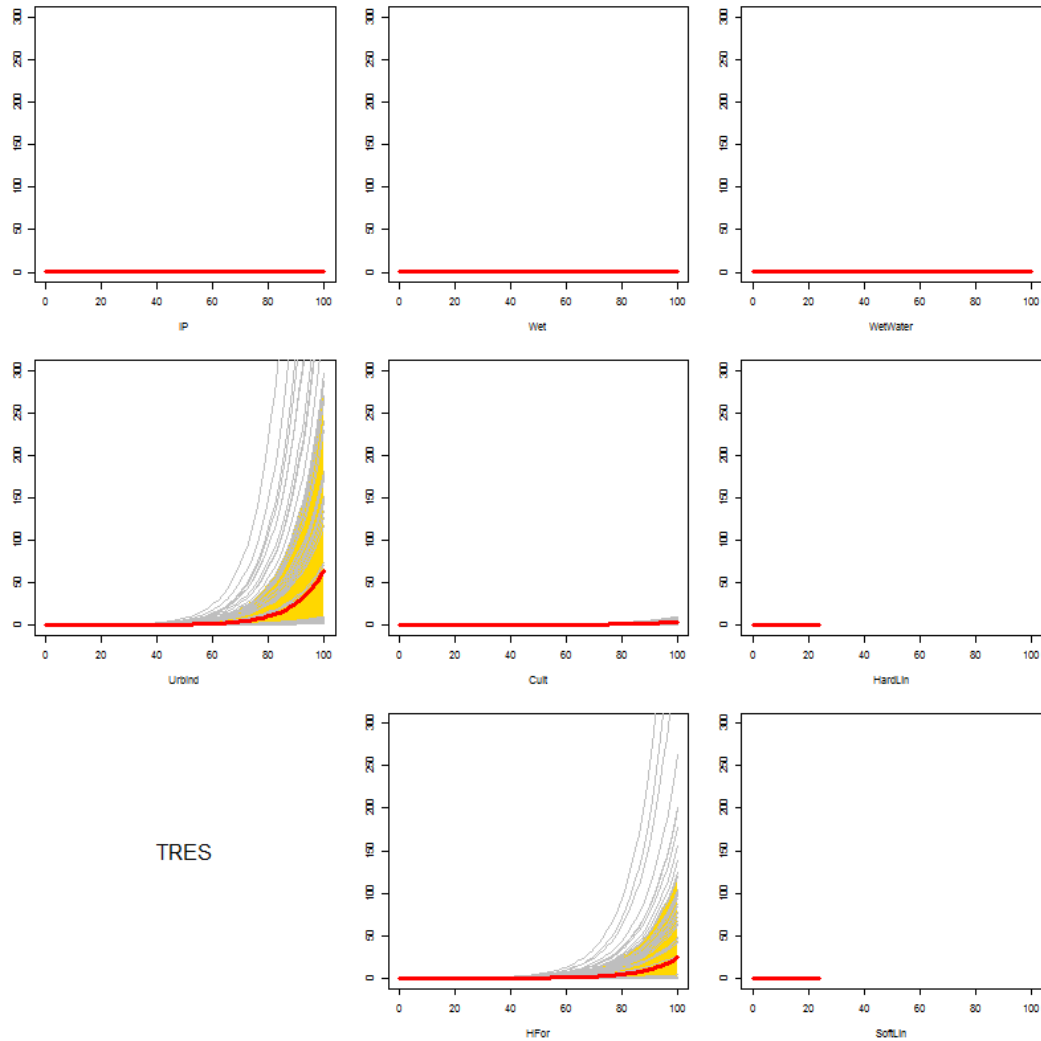


5.62.7 Relative habitat selection



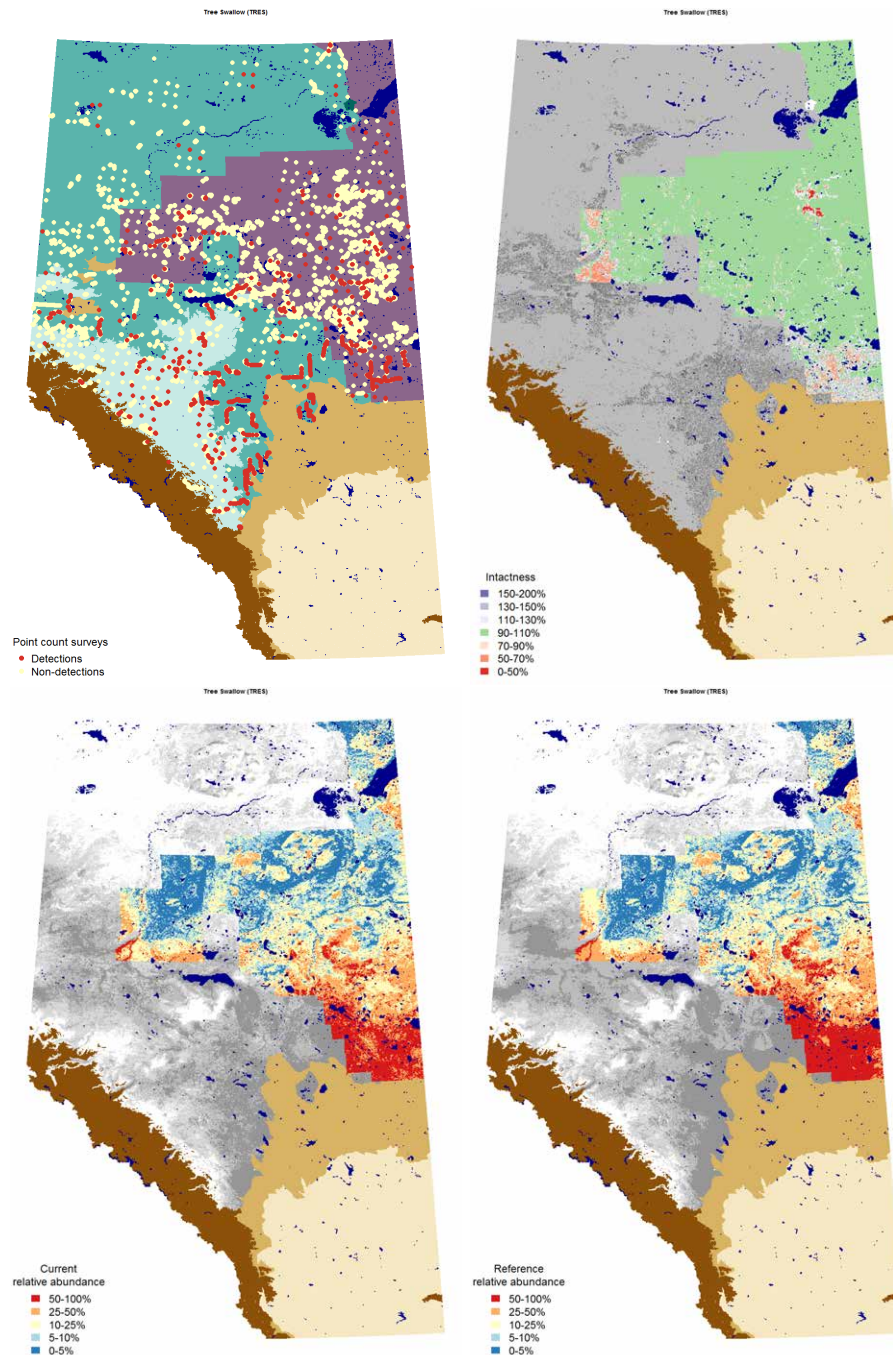
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.62.8 Quarter-section level responses



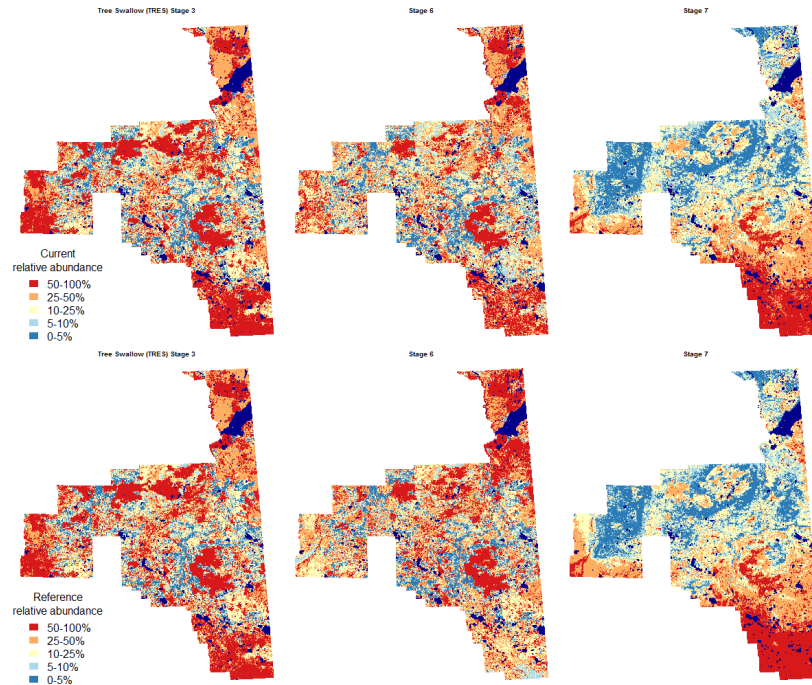
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.62.9 Maps



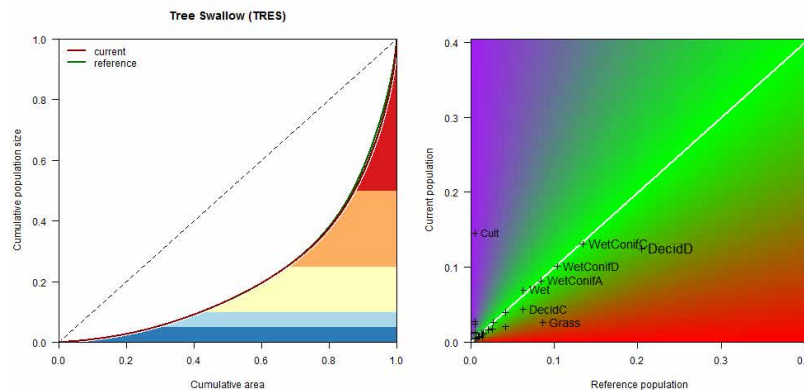
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.62.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.62.11 Population concentration



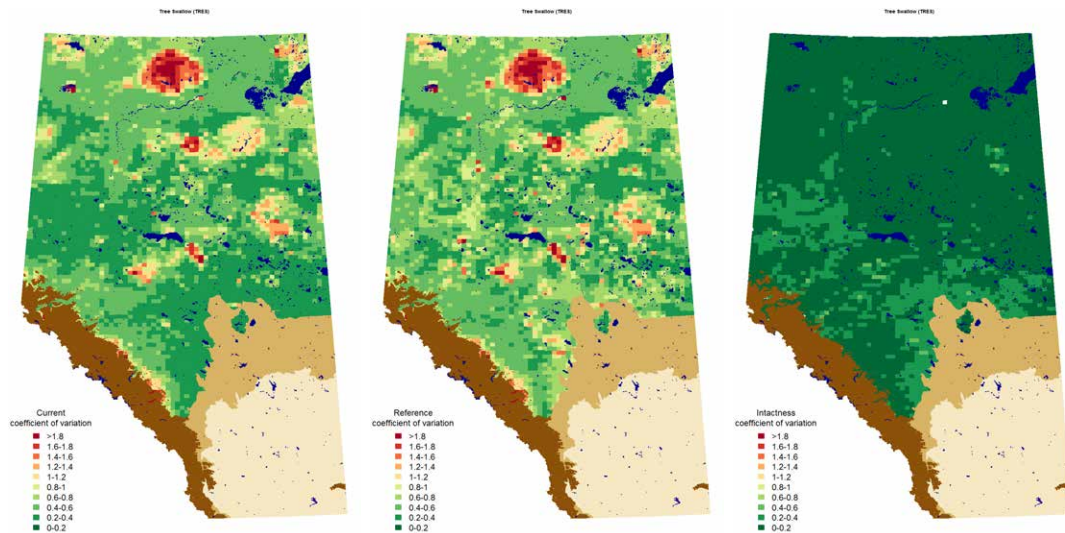
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.62.12 Potential population size

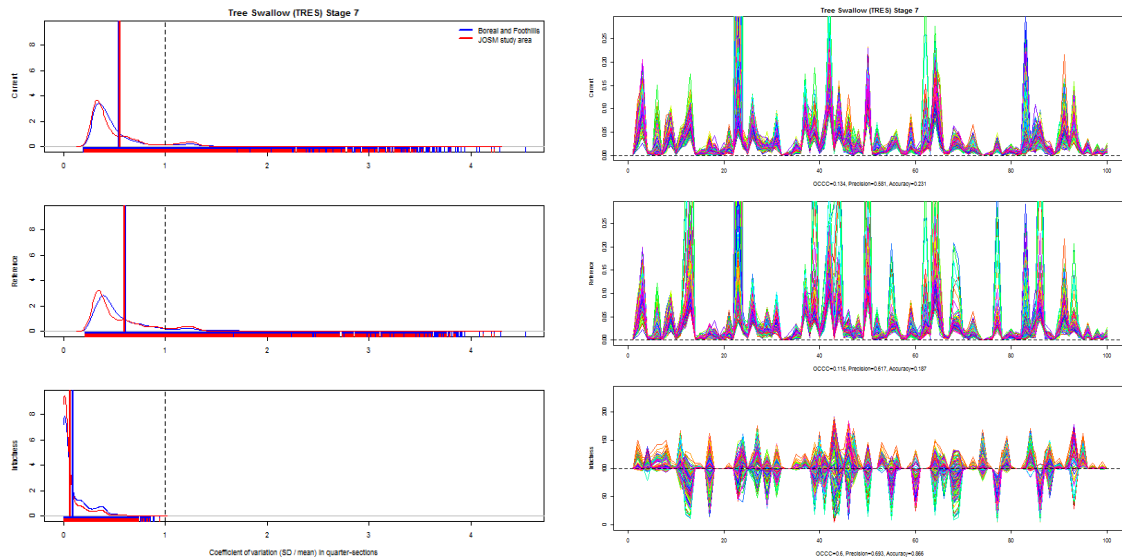
Estimated potential population size of Tree Swallow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0455	0.0312	0.0946	0.0752	0.0514	0.1738
WetConifC	0.0477	0.0327	0.0994	0.0493	0.0337	0.1139
WetConifD	0.0369	0.0253	0.0768	0.0381	0.0260	0.0881
Grass	0.0095	0.0065	0.0198	0.0318	0.0217	0.0734
WetConifA	0.0299	0.0205	0.0622	0.0310	0.0212	0.0718
DecidC	0.0159	0.0109	0.0332	0.0231	0.0158	0.0534
Wet	0.0254	0.0174	0.0529	0.0231	0.0158	0.0534
Shrub	0.0075	0.0051	0.0156	0.0153	0.0104	0.0353
WetConifB	0.0145	0.0100	0.0302	0.0153	0.0104	0.0353
PineB	0.0098	0.0067	0.0204	0.0101	0.0069	0.0233
DecidB	0.0065	0.0045	0.0135	0.0096	0.0066	0.0222
ConifA	0.0060	0.0041	0.0125	0.0078	0.0053	0.0180
PineC	0.0045	0.0031	0.0094	0.0057	0.0039	0.0132
ConifC	0.0038	0.0026	0.0079	0.0053	0.0037	0.0124
DecidA	0.0024	0.0016	0.0050	0.0051	0.0035	0.0118
ConifD	0.0036	0.0025	0.0076	0.0050	0.0034	0.0117
PineA	0.0044	0.0030	0.0091	0.0047	0.0032	0.0109
MixedD	0.0028	0.0019	0.0058	0.0040	0.0027	0.0092
ConifB	0.0026	0.0018	0.0054	0.0034	0.0023	0.0079
PineD	0.0022	0.0015	0.0045	0.0027	0.0018	0.0062
MixedA	0.0005	0.0004	0.0011	0.0008	0.0006	0.0019
MixedB	0.0002	0.0002	0.0005	0.0004	0.0002	0.0008
MixedC	0.0002	0.0002	0.0005	0.0003	0.0002	0.0008
Cult	0.0530	0.0364	0.1104	0.0000	0.0000	0.0000
UrbInd	0.0045	0.0031	0.0094	0.0000	0.0000	0.0000
HardLin	0.0047	0.0032	0.0097	0.0000	0.0000	0.0000
SoftLin	0.0100	0.0068	0.0208	0.0000	0.0000	0.0000
HFor	0.0087	0.0060	0.0182	0.0000	0.0000	0.0000
Total	0.3633	0.2491	0.7564	0.3670	0.2510	0.8488
Loss	0.0216	0.0069	0.1056			
Gain	0.0212	0.0085	0.0756			

5.62.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.62.14 Variable selection frequencies

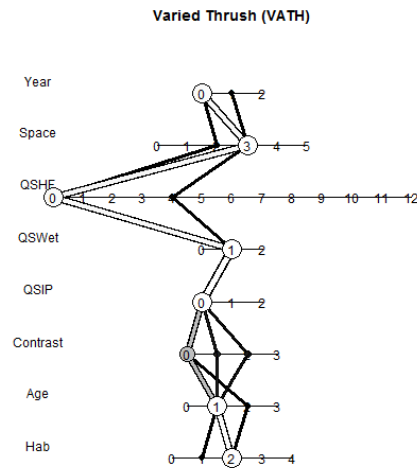
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	18.5	37	. + HabitatB
1.4	81.5	163	. + HabitatB + isHForC
2.0	4.5	9	NULL
2.1	49.0	98	. + Age
2.2	33.0	66	. + Age + Age2 . + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
2.3	13.5	27	
3.1	91.5	183	. + ROAD
3.3	8.5	17	. + ROAD + SoftLin_PC
4.0	0.5	1	NULL
4.1	91.0	182	. + Remn_QS
4.2	8.5	17	. + Remn_QS + Remn2_QS
5.1	1.5	3	. + pWet_QS
5.2	98.5	197	. + pWetWater_QS
6.9	56.0	112	. + Succ_QS + Alien_QS + Alien2_QS
6.10	17.5	35	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.11	26.5	53	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.4	66.5	133	. + xMAP + xPET + xMAT + xCMD
7.5	33.5	67	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	84.0	168	NULL
8.1	9.0	18	. + xYEAR
8.2	7.0	14	. + YR5F

5.63 Varied Thrush (*Ixoreus naevius*)

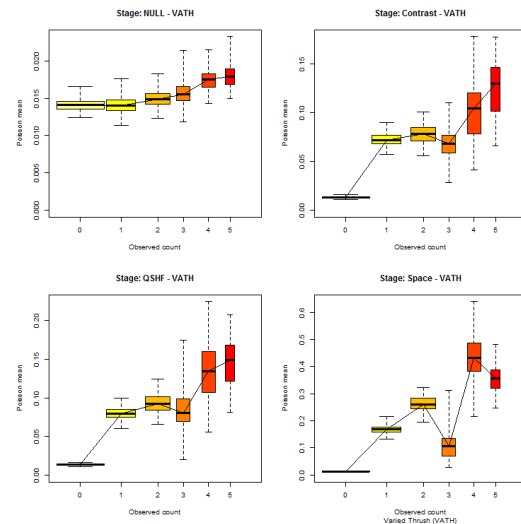
5.63.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

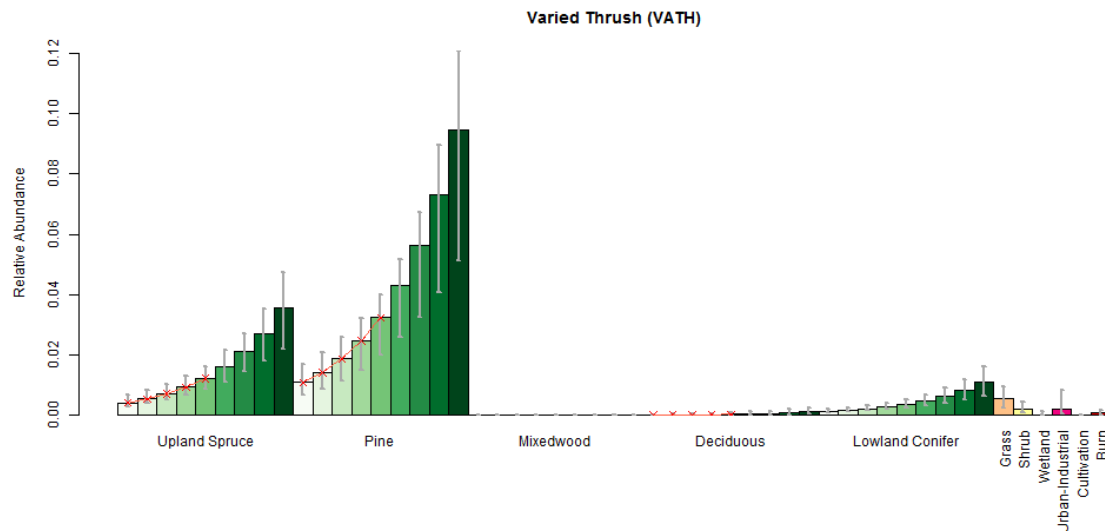


5.63.2 Cross validation

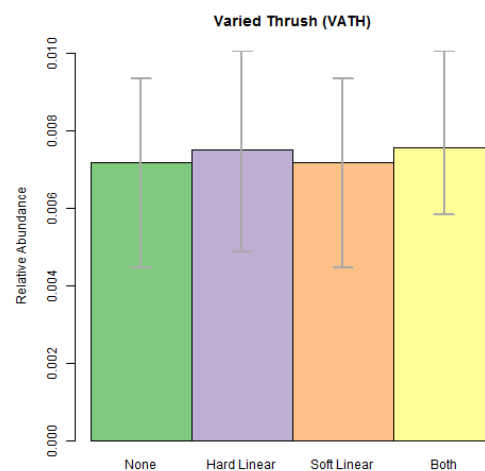
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.63.3 Point level habitat associations

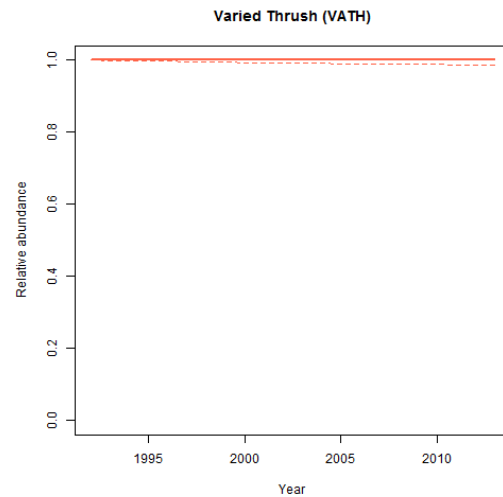


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

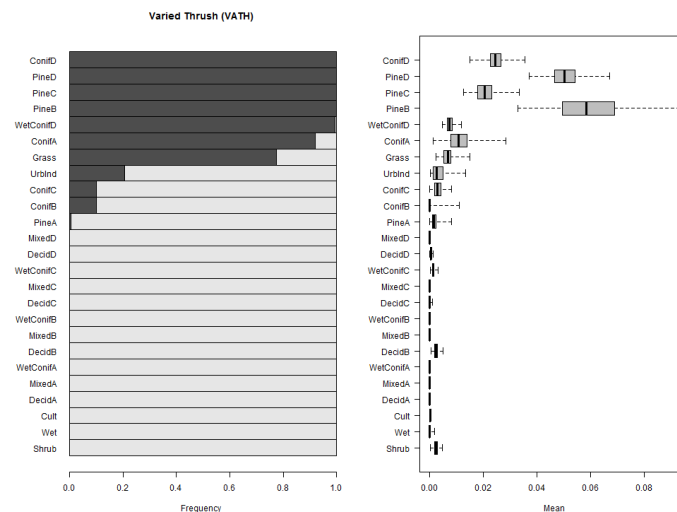


5.63.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



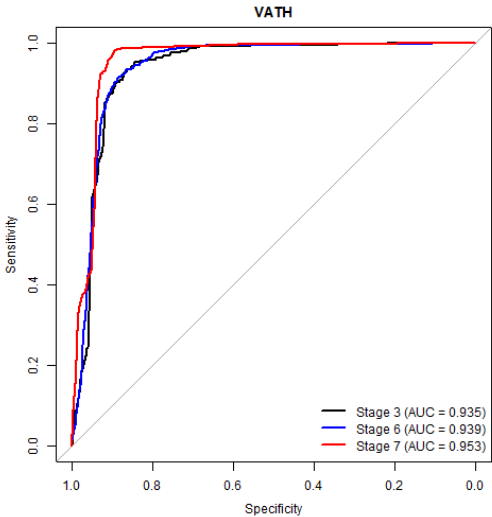
5.63.5 Habitat suitability ranking for patch delineation



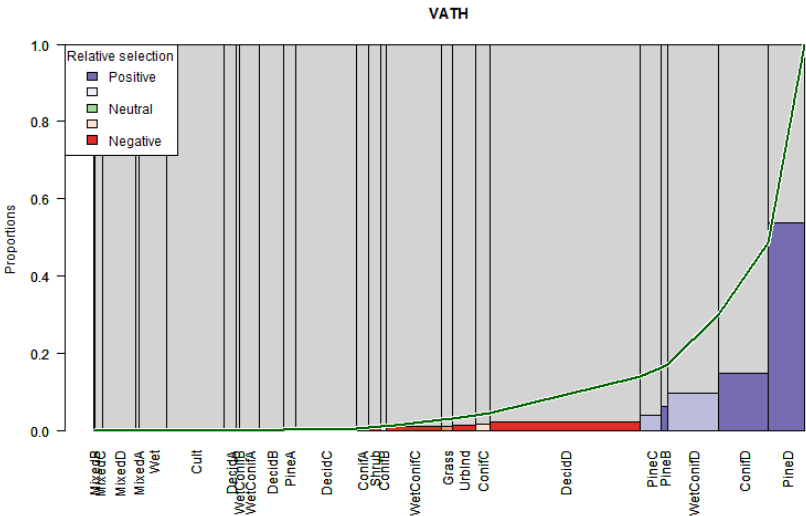
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.63.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

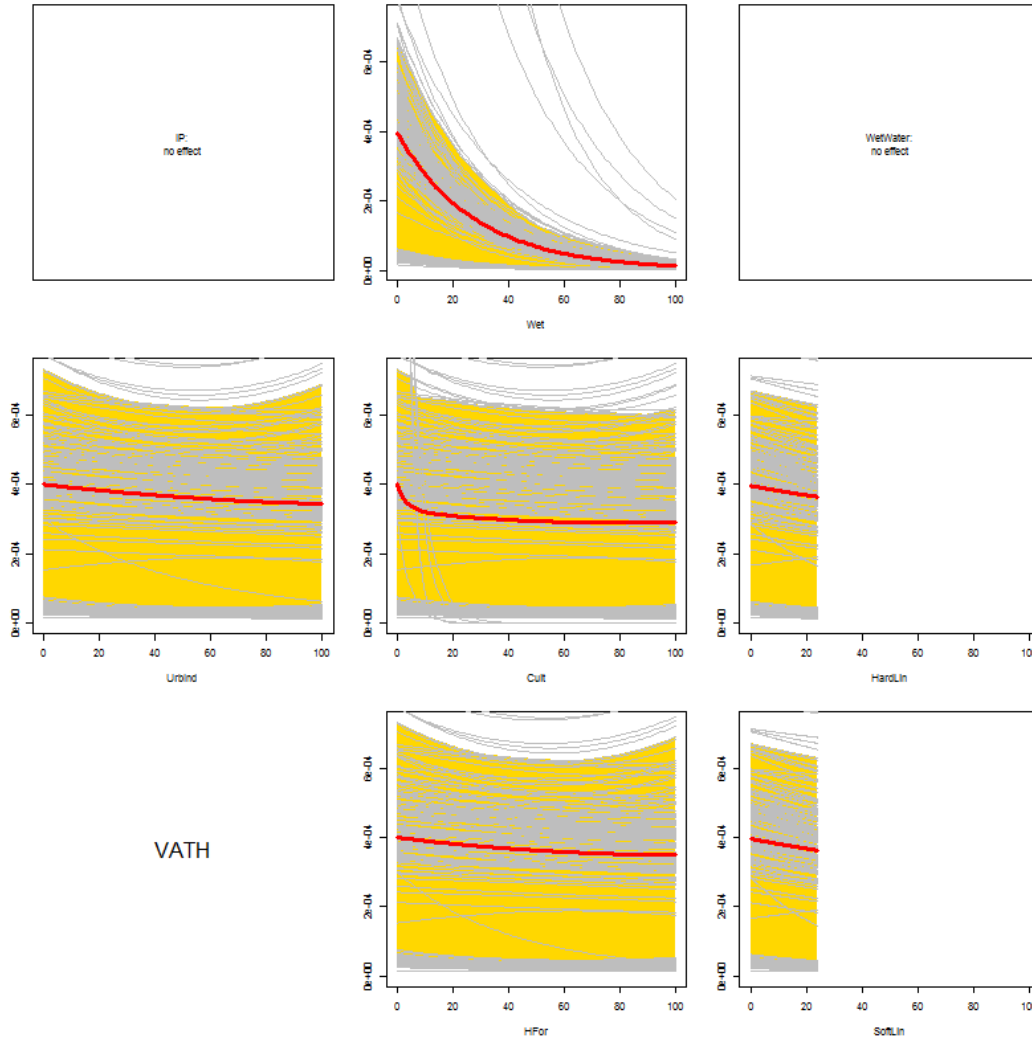


5.63.7 Relative habitat selection



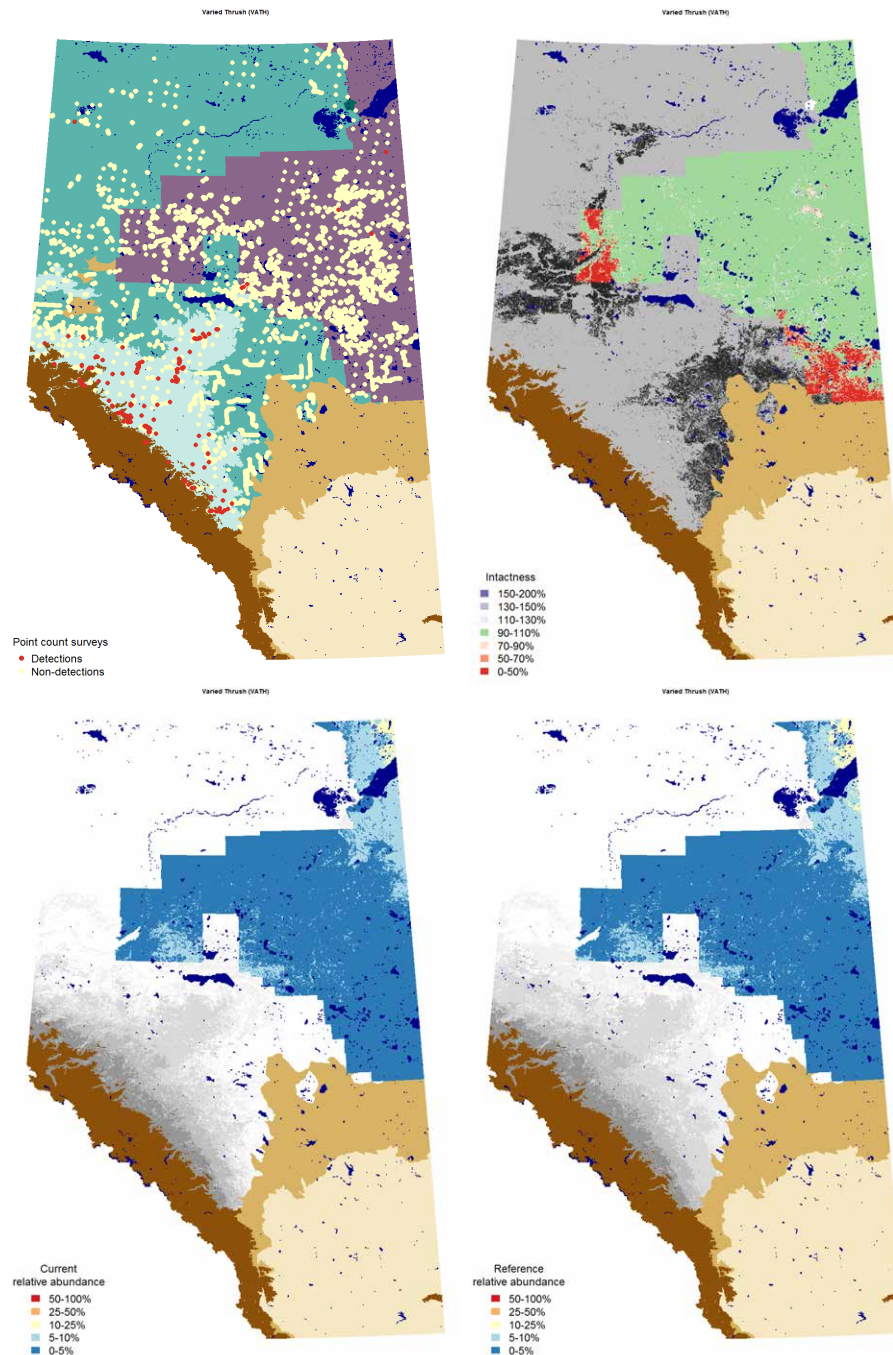
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.63.8 Quarter-section level responses



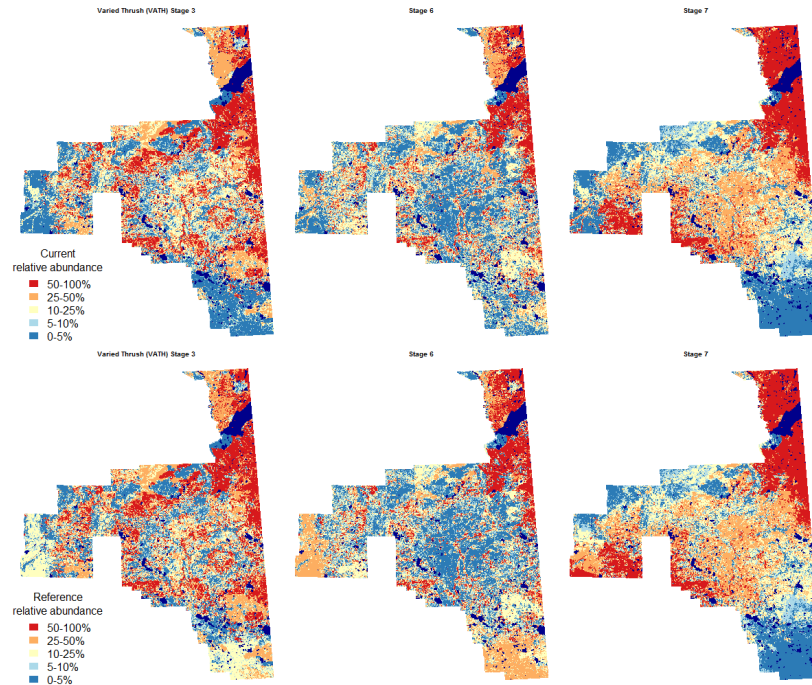
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.63.9 Maps



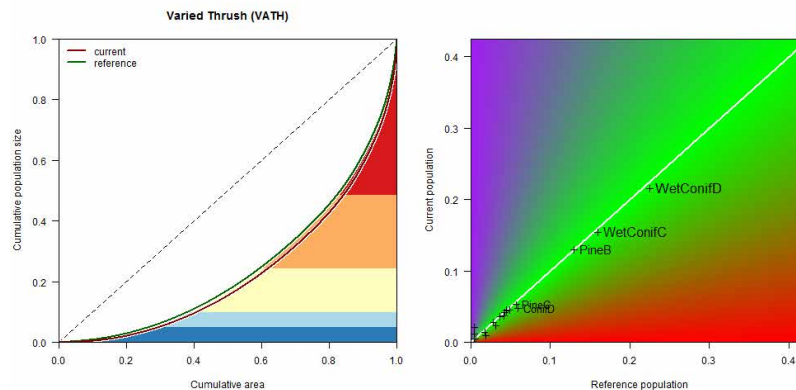
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.63.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.63.11 Population concentration



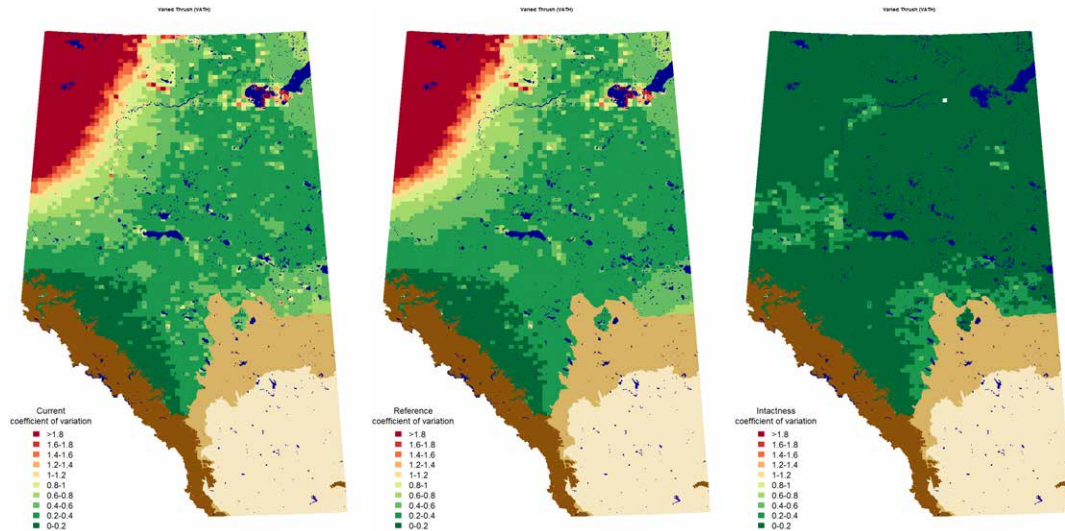
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.63.12 Potential population size

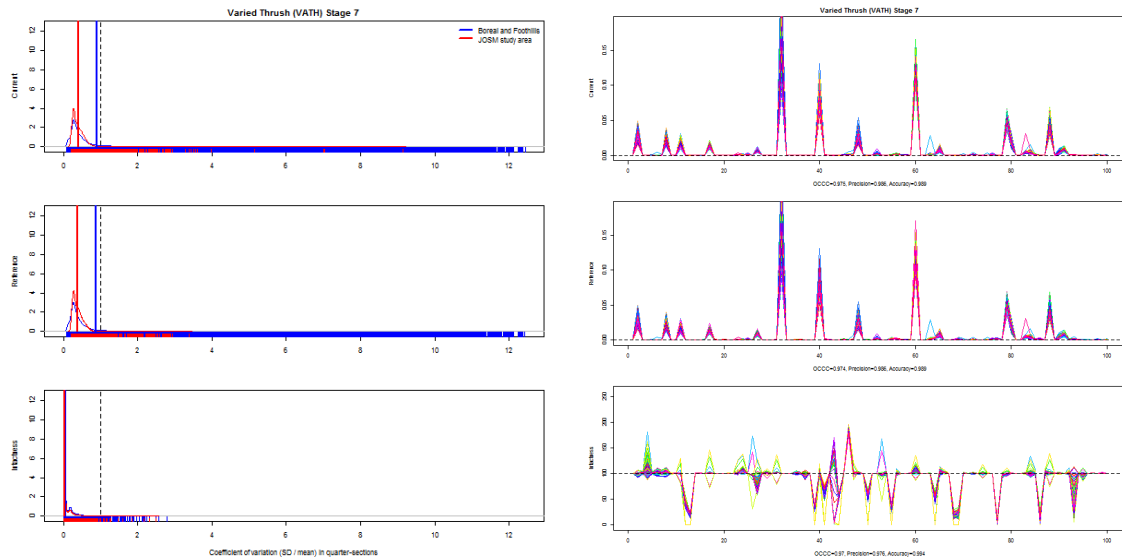
Estimated potential population size of Varied Thrush in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.0015	0.0011	0.0023	0.0016	0.0012	0.0024
WetConifC	0.0011	0.0008	0.0017	0.0011	0.0008	0.0017
PineB	0.0009	0.0007	0.0014	0.0009	0.0007	0.0014
ConifD	0.0003	0.0002	0.0005	0.0004	0.0003	0.0006
PineC	0.0004	0.0003	0.0006	0.0004	0.0003	0.0006
PineD	0.0003	0.0002	0.0005	0.0004	0.0003	0.0005
PineA	0.0003	0.0002	0.0005	0.0003	0.0002	0.0005
WetConifB	0.0003	0.0002	0.0005	0.0003	0.0002	0.0005
ConifA	0.0003	0.0002	0.0004	0.0003	0.0002	0.0005
ConifC	0.0003	0.0002	0.0004	0.0003	0.0002	0.0004
ConifB	0.0003	0.0002	0.0004	0.0003	0.0002	0.0004
DecidD	0.0002	0.0001	0.0002	0.0002	0.0002	0.0003
WetConifA	0.0002	0.0001	0.0003	0.0002	0.0002	0.0003
Grass	0.0001	0.0000	0.0001	0.0001	0.0001	0.0002
Shrub	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002
DecidC	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
DecidB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DecidA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wet	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
UrbInd	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HardLin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SoftLin	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
HFor	0.0001	0.0001	0.0002	0.0000	0.0000	0.0000
Total	0.0069	0.0050	0.0104	0.0071	0.0052	0.0105
Loss	0.0002	0.0001	0.0005			
Gain	0.0000	0.0000	0.0001			

5.63.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.63.14 Variable selection frequencies

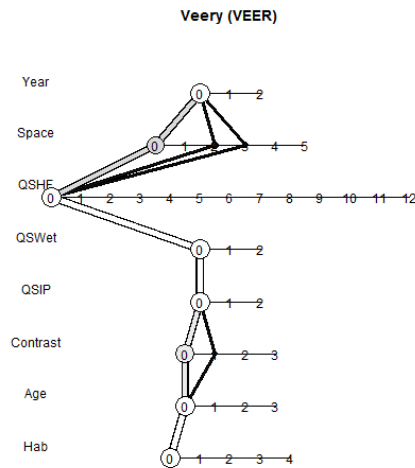
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	1.0	2	. + Habitat
1.2	99.0	198	. + HabitatB
2.1	99.5	199	. + Age
2.2	0.5	1	. + Age + Age2
3.0	74.5	149	NULL
3.1	15.0	30	. + ROAD
3.2	10.5	21	. + SoftLin_PC
4.0	100.0	200	NULL
5.1	100.0	200	. + pWet_QS
6.0	97.5	195	NULL
6.4	2.5	5	. + Succ_QS + Noncult_QS + Cult_QS
7.2	0.5	1	. + xlat + xlong
7.3	99.5	199	. + xlat + xlong + xlat:xlong
8.0	98.0	196	NULL
8.1	2.0	4	. + xYEAR

5.64 Veery (*Catharus fuscescens*)

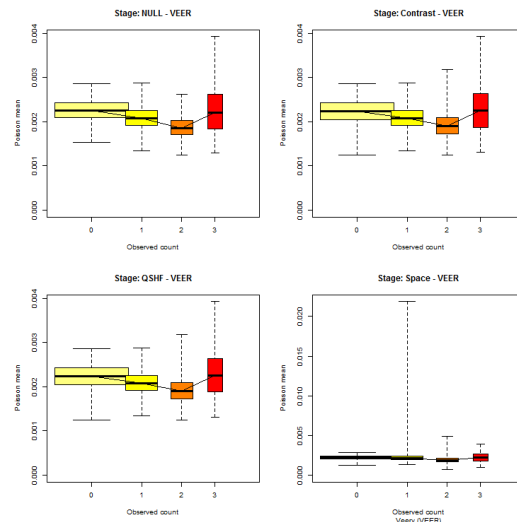
5.64.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

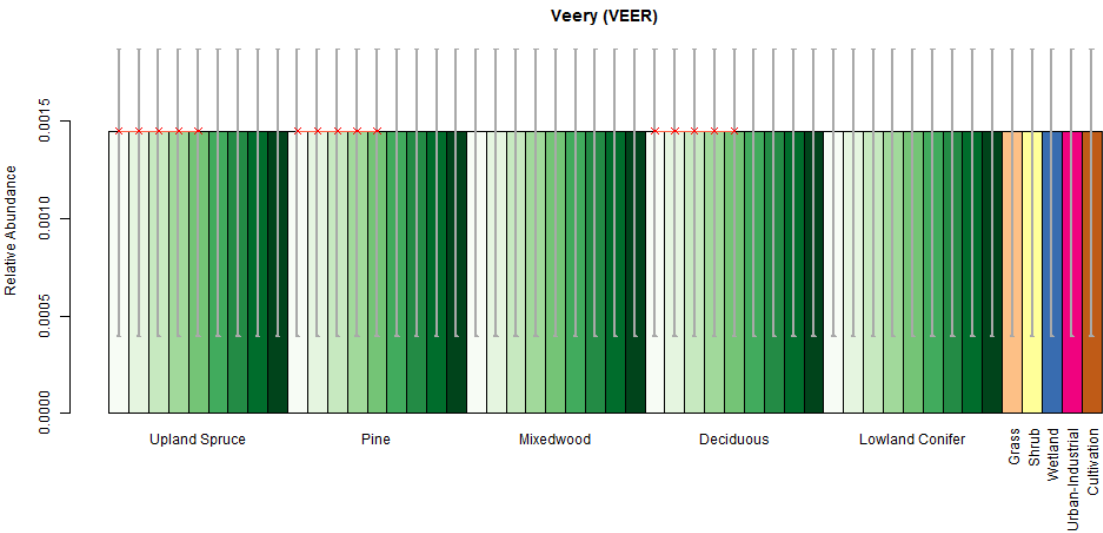


5.64.2 Cross validation

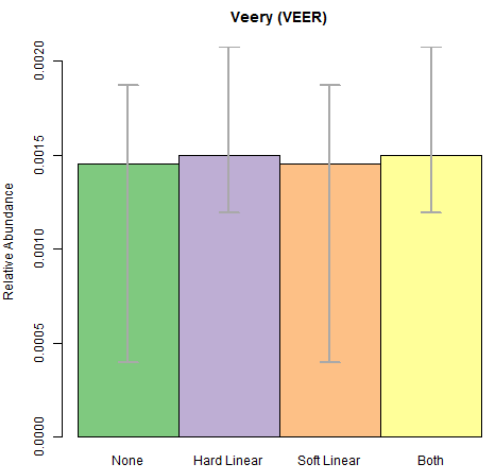
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.64.3 Point level habitat associations

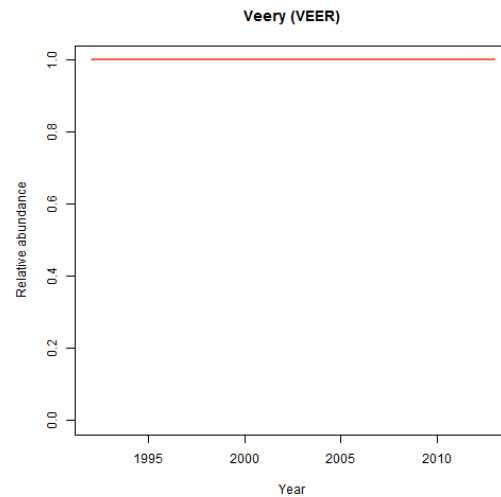


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

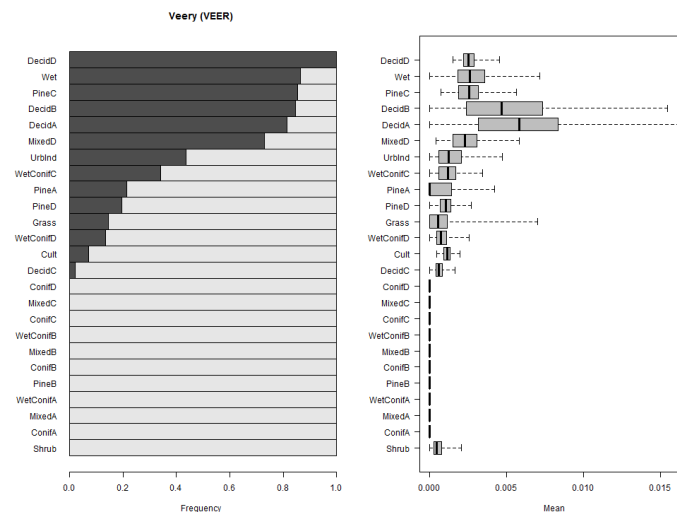


5.64.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



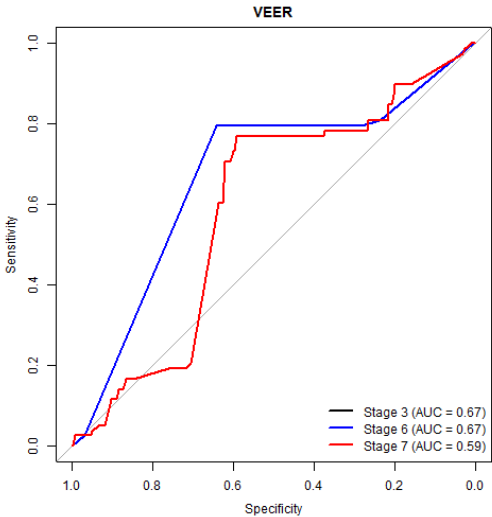
5.64.5 Habitat suitability ranking for patch delineation



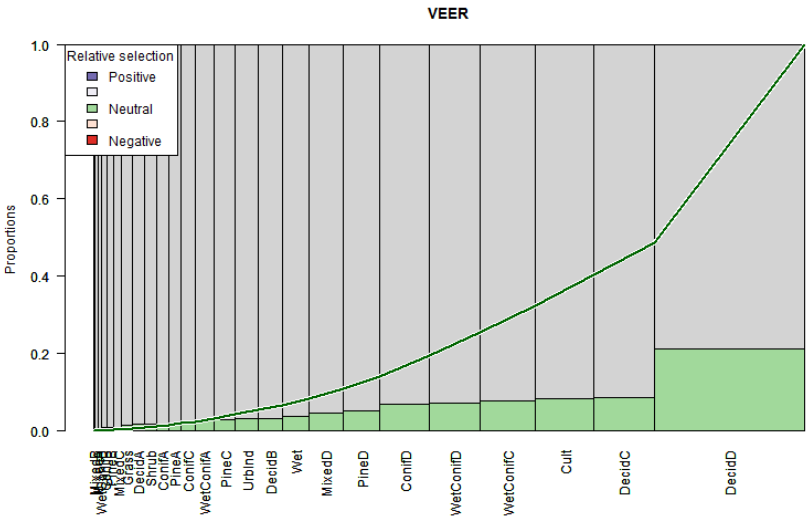
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.64.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).



5.64.7 Relative habitat selection



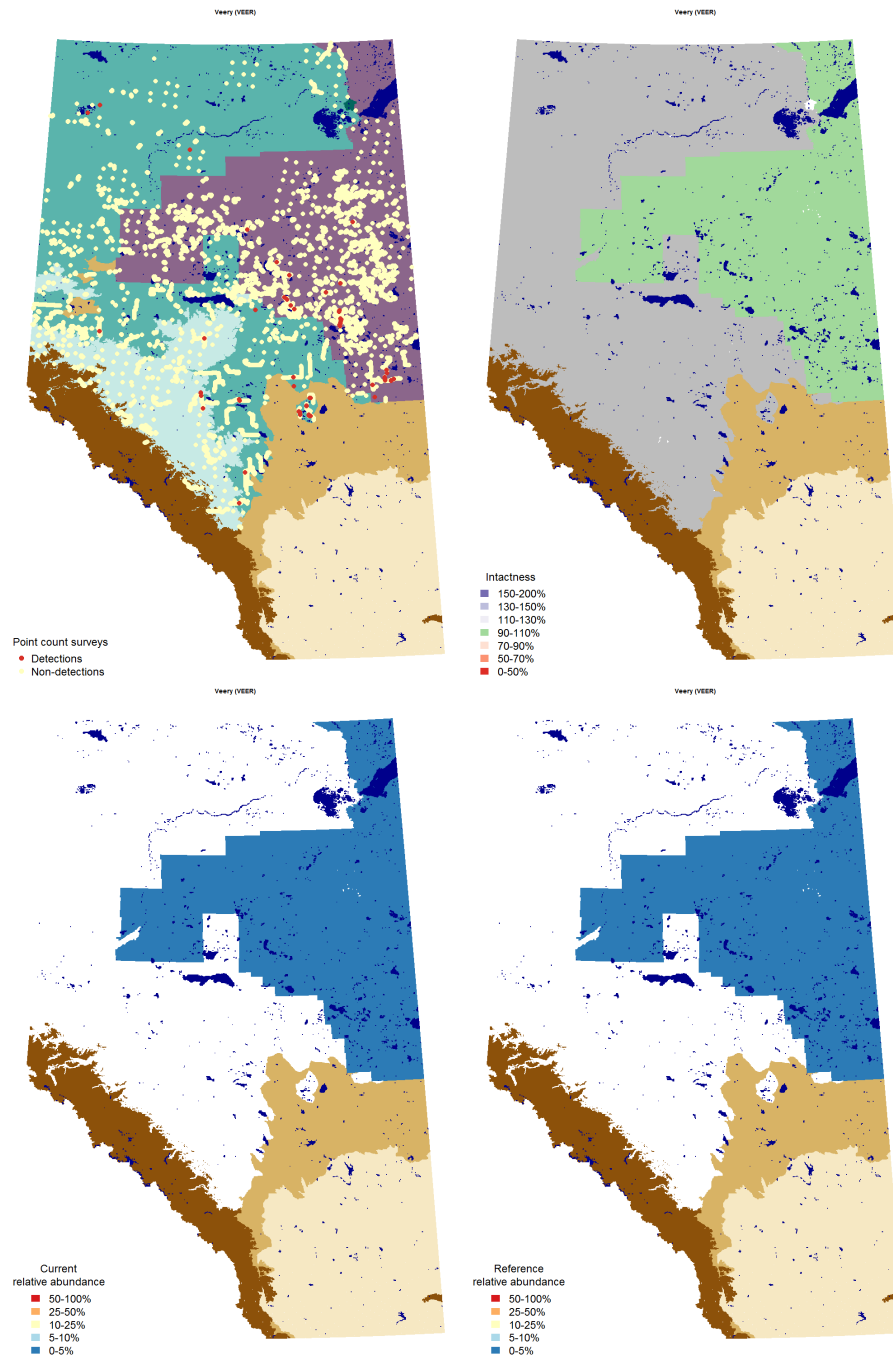
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.64.8 Quarter-section level responses



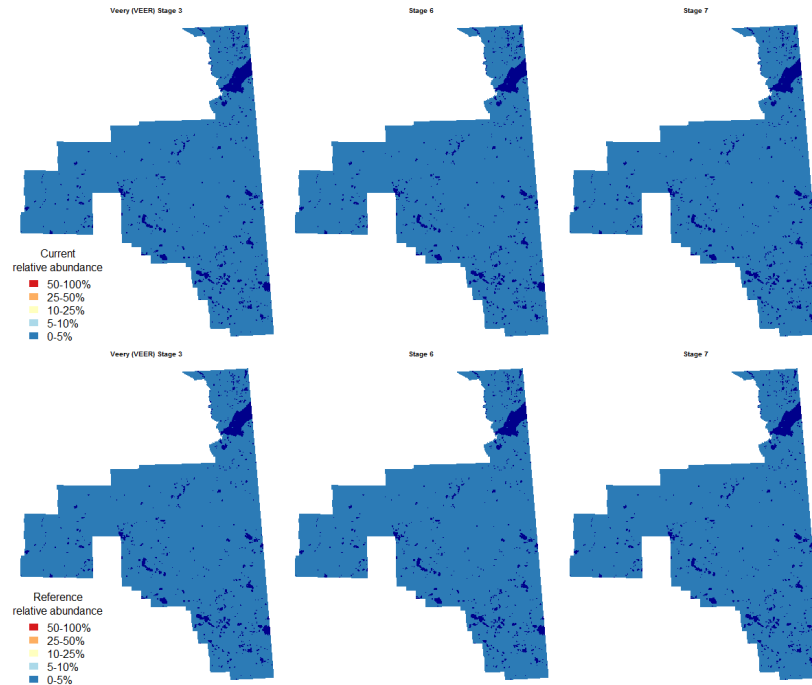
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.64.9 Maps



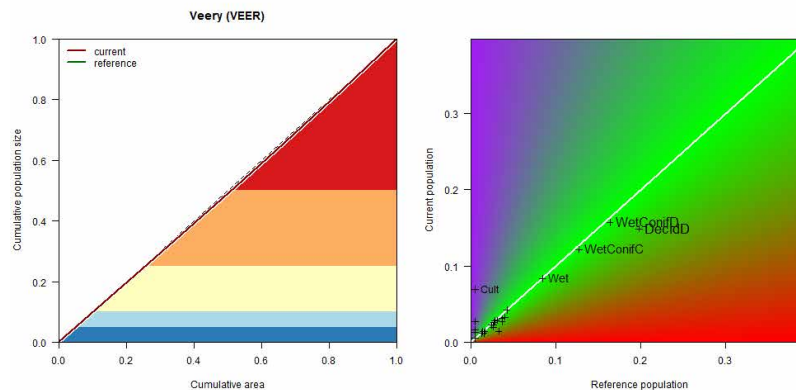
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.64.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.64.11 Population concentration



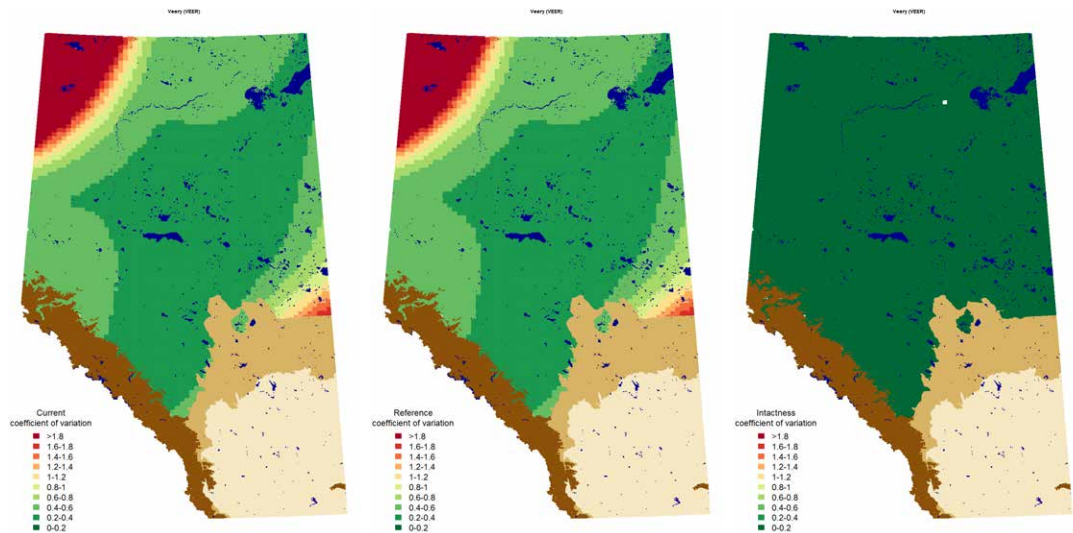
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.64.12 Potential population size

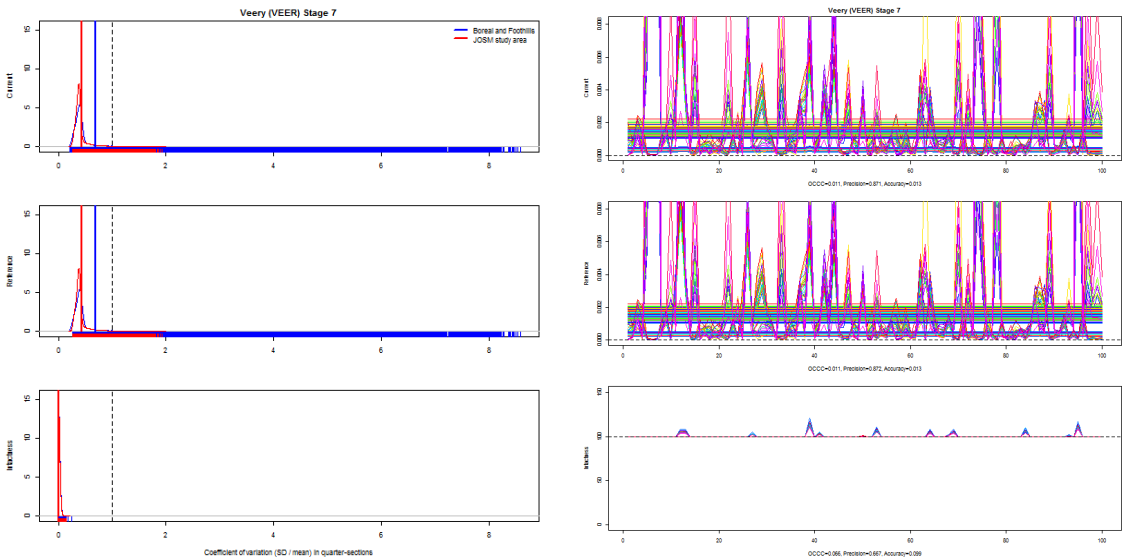
Estimated potential population size of Veery in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0035	0.0010	0.0046	0.0046	0.0013	0.0061
WetConifD	0.0037	0.0010	0.0049	0.0038	0.0010	0.0051
WetConifC	0.0029	0.0008	0.0038	0.0030	0.0008	0.0039
Wet	0.0020	0.0005	0.0026	0.0020	0.0005	0.0026
PineB	0.0010	0.0003	0.0013	0.0010	0.0003	0.0013
ConifD	0.0008	0.0002	0.0010	0.0009	0.0003	0.0013
MixedD	0.0007	0.0002	0.0010	0.0009	0.0002	0.0011
Shrub	0.0006	0.0002	0.0008	0.0009	0.0002	0.0011
Grass	0.0003	0.0001	0.0005	0.0008	0.0002	0.0010
PineC	0.0007	0.0002	0.0009	0.0007	0.0002	0.0010
WetConifB	0.0007	0.0002	0.0009	0.0007	0.0002	0.0009
WetConifA	0.0006	0.0002	0.0008	0.0006	0.0002	0.0008
DecidC	0.0005	0.0001	0.0006	0.0006	0.0002	0.0008
ConifC	0.0005	0.0001	0.0007	0.0006	0.0002	0.0008
PineD	0.0005	0.0001	0.0007	0.0006	0.0002	0.0008
ConifA	0.0003	0.0001	0.0005	0.0004	0.0001	0.0005
DecidB	0.0003	0.0001	0.0004	0.0004	0.0001	0.0005
PineA	0.0003	0.0001	0.0004	0.0003	0.0001	0.0004
ConifB	0.0003	0.0001	0.0004	0.0003	0.0001	0.0004
DecidA	0.0001	0.0000	0.0001	0.0001	0.0000	0.0002
MixedB	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
MixedA	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Cult	0.0016	0.0004	0.0022	0.0000	0.0000	0.0000
UrbInd	0.0003	0.0001	0.0004	0.0000	0.0000	0.0000
HardLin	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0004	0.0001	0.0005	0.0000	0.0000	0.0000
HFor	0.0006	0.0002	0.0009	0.0000	0.0000	0.0000
Total	0.0234	0.0064	0.0309	0.0234	0.0064	0.0309
Loss	0.0000	0.0000	0.0000			
Gain	0.0000	0.0000	0.0000			

5.64.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations. Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.64.14 Variable selection frequencies

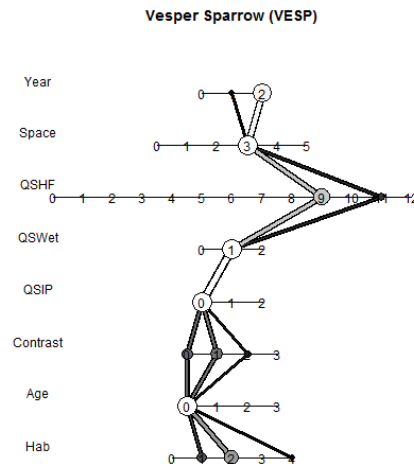
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	200	NULL
2.0	100.0	200	NULL
3.0	92.0	184	NULL
3.1	8.0	16	. + ROAD
4.0	100.0	200	NULL
5.0	100.0	200	NULL
6.0	100.0	200	NULL
7.0	85.5	171	NULL
7.2	9.0	18	. + xlat + xlong
7.3	5.5	11	. + xlat + xlong + xlat:xlong
8.0	100.0	200	NULL

5.65 Vesper Sparrow (*Pooecetes gramineus*)

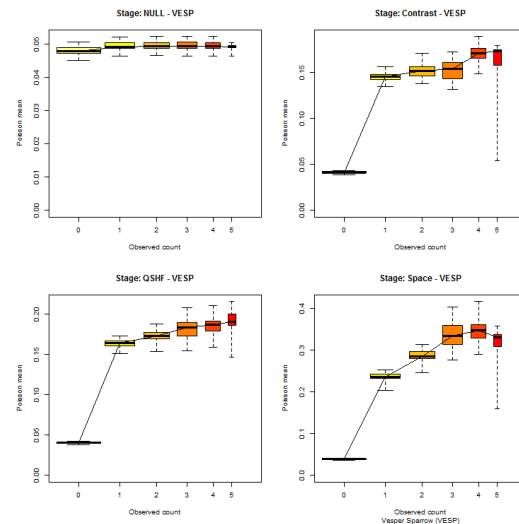
5.65.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

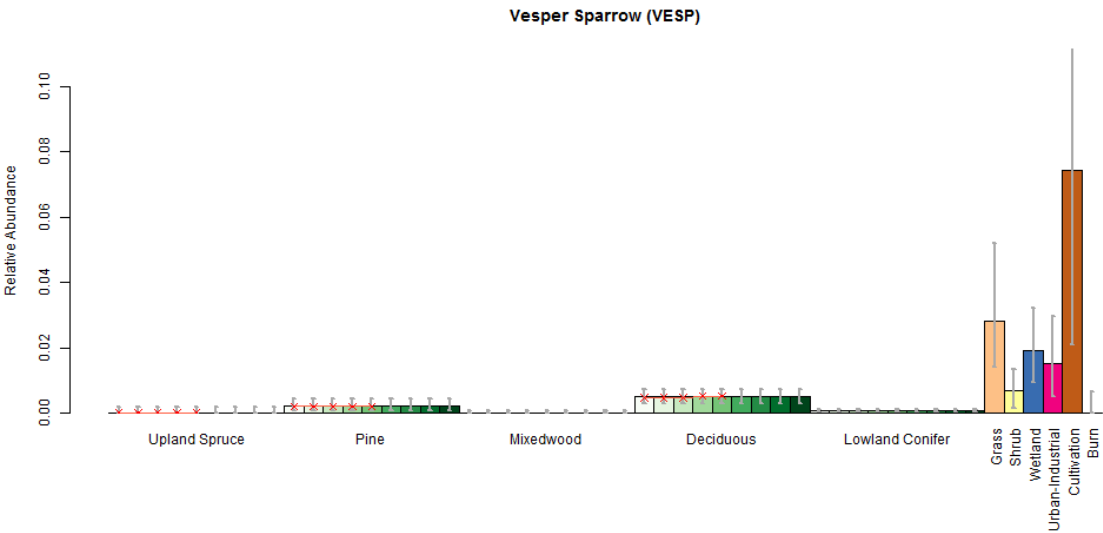


5.65.2 Cross validation

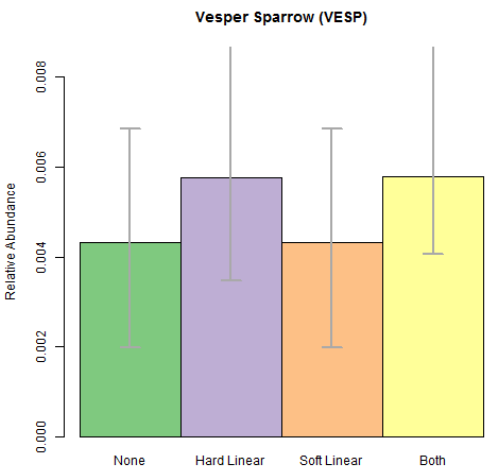
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.65.3 Point level habitat associations

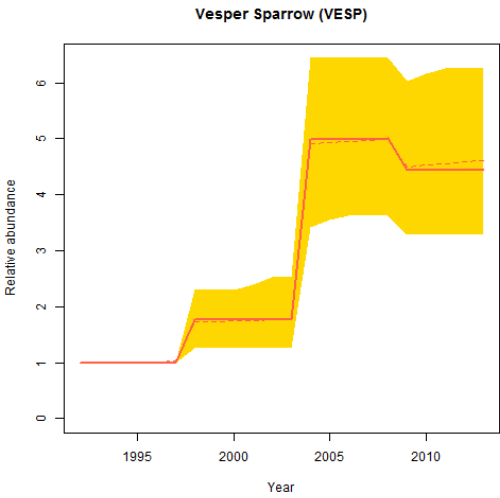


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

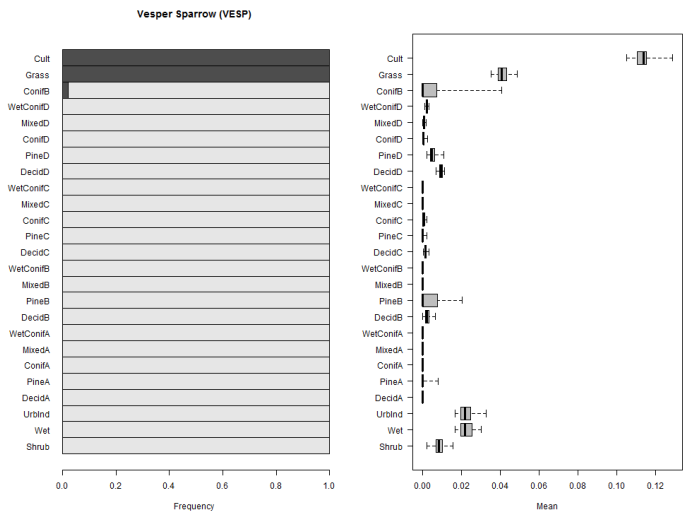


5.65.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



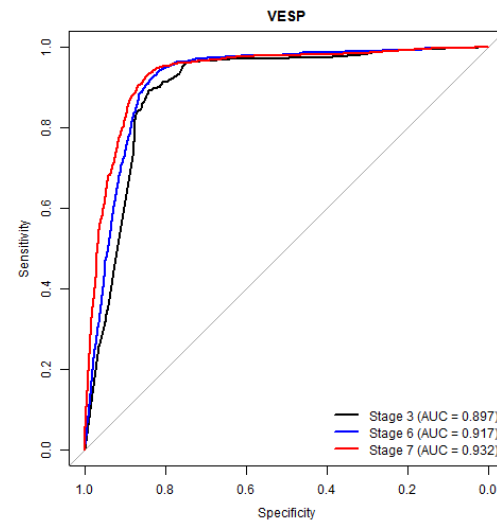
5.65.5 Habitat suitability ranking for patch delineation



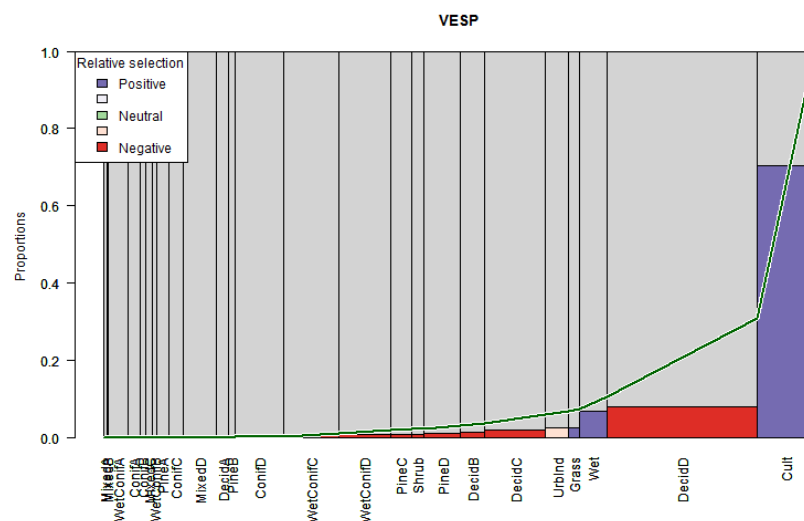
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.65.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

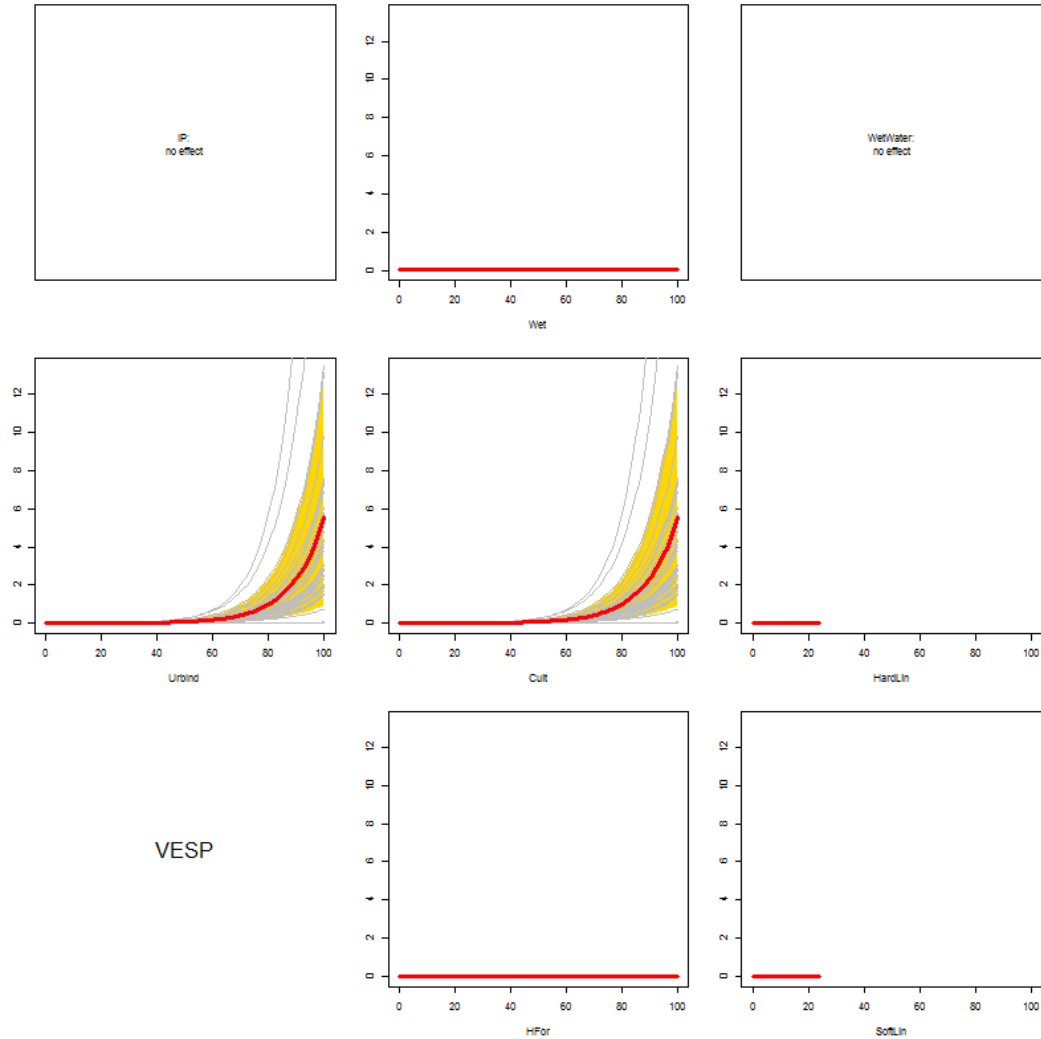


5.65.7 Relative habitat selection



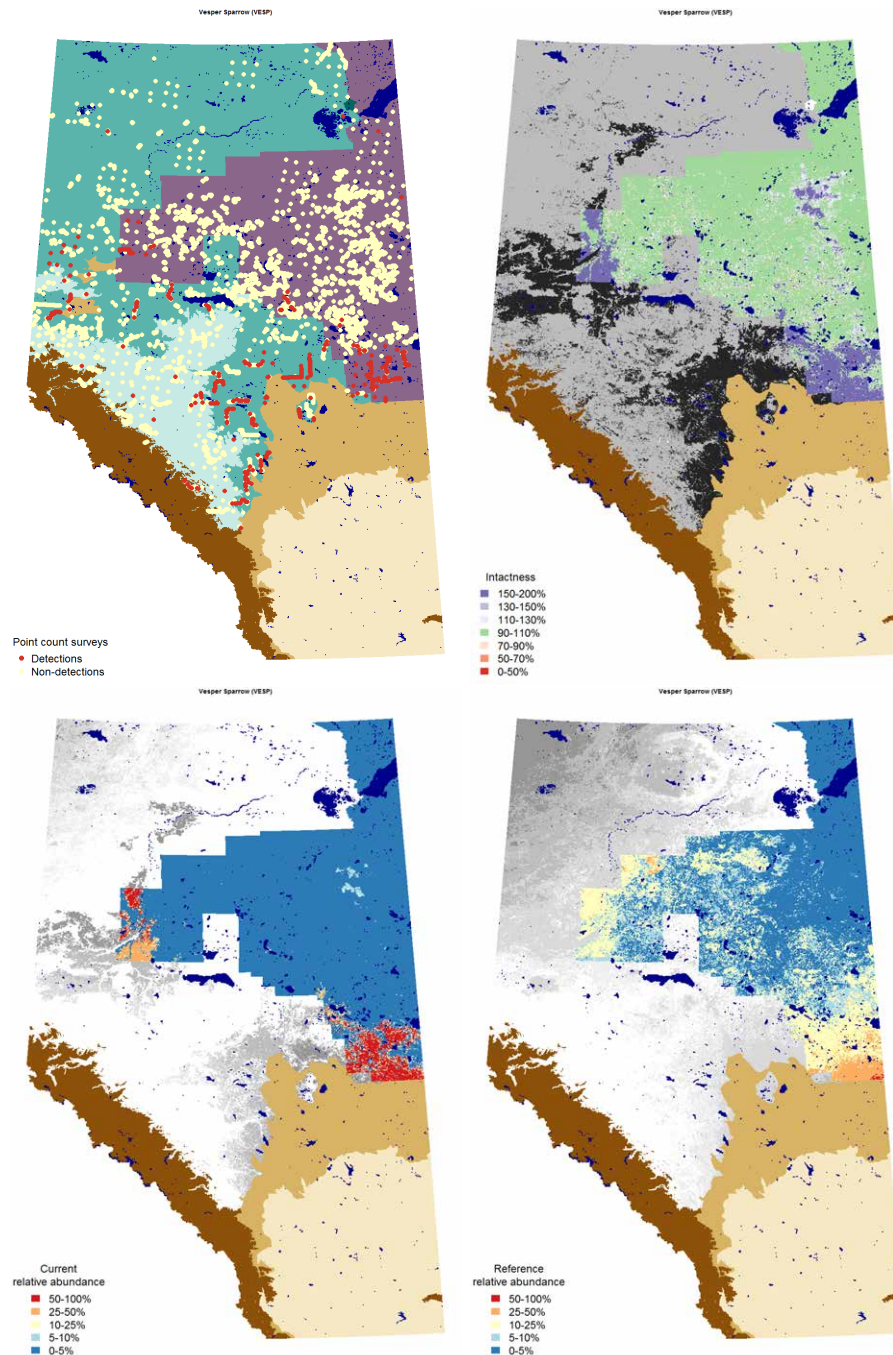
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.65.8 Quarter-section level responses



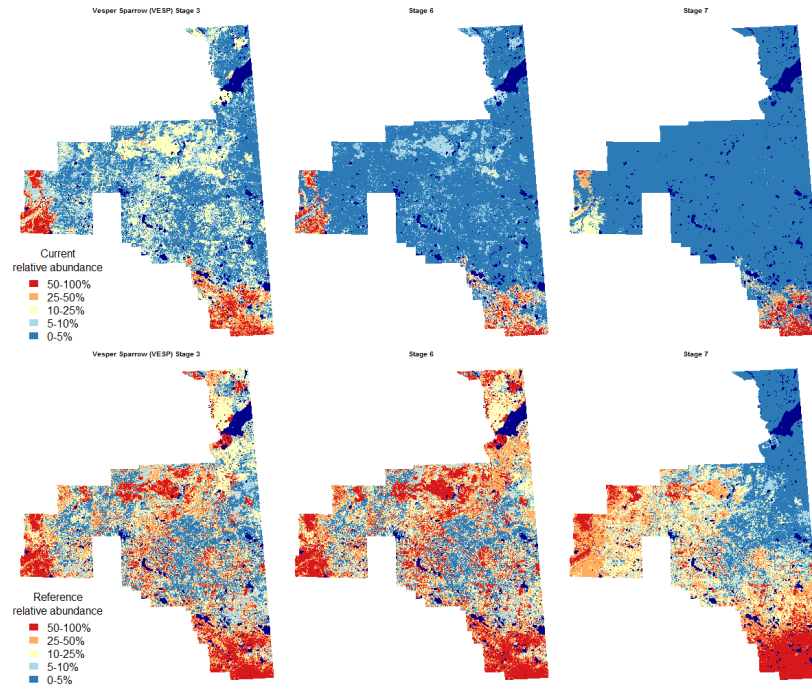
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.65.9 Maps



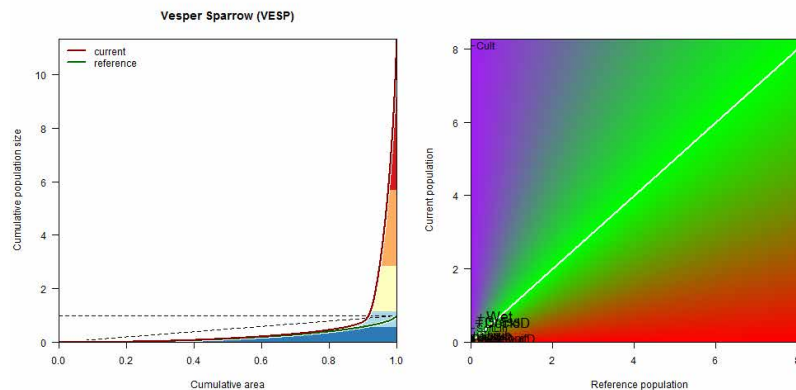
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.65.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.65.11 Population concentration



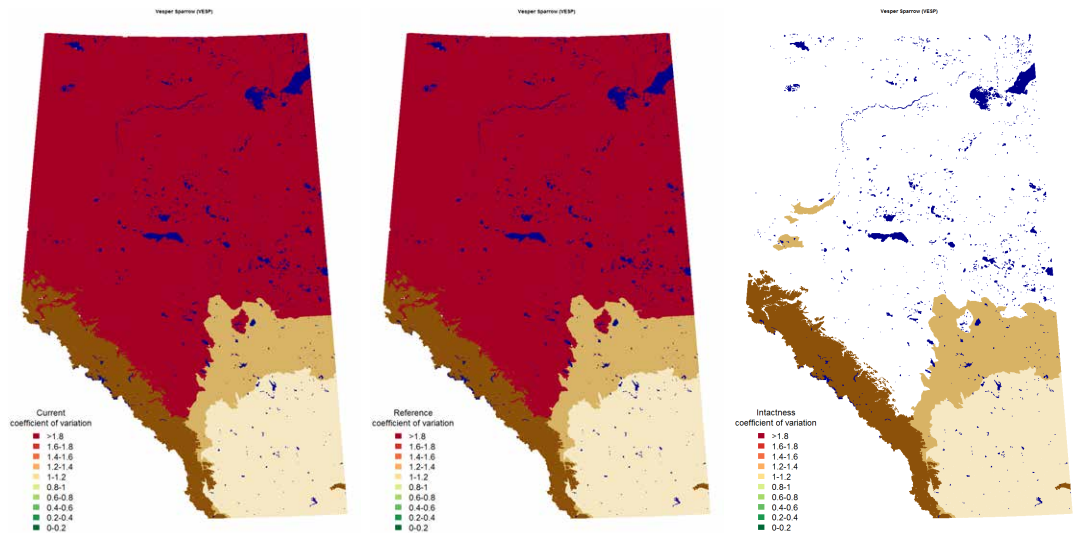
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.65.12 Potential population size

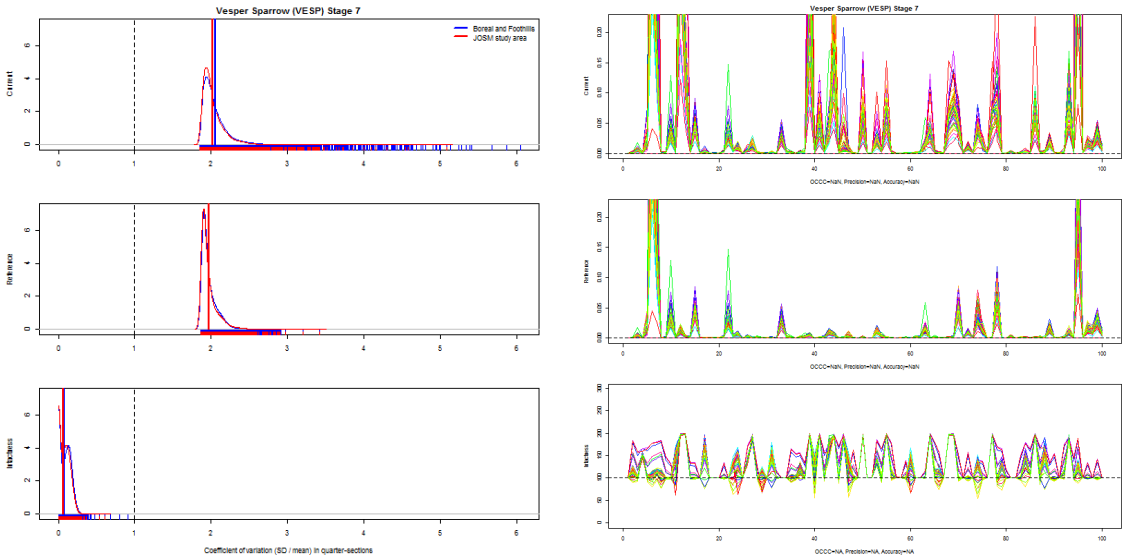
Estimated potential population size of Vesper Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.0213	0.0091	0.0412	0.0077	0.0047	0.0105
Grass	0.0180	0.0077	0.0348	0.0066	0.0040	0.0089
DecidD	0.0163	0.0069	0.0314	0.0065	0.0040	0.0088
Shrub	0.0061	0.0026	0.0118	0.0026	0.0016	0.0036
WetConifD	0.0029	0.0012	0.0057	0.0020	0.0012	0.0027
WetConifC	0.0020	0.0009	0.0039	0.0013	0.0008	0.0018
PineC	0.0016	0.0007	0.0031	0.0011	0.0007	0.0015
PineD	0.0013	0.0005	0.0025	0.0008	0.0005	0.0011
DecidC	0.0029	0.0012	0.0055	0.0007	0.0005	0.0010
PineB	0.0005	0.0002	0.0010	0.0005	0.0003	0.0007
DecidB	0.0004	0.0002	0.0008	0.0004	0.0002	0.0005
WetConifB	0.0002	0.0001	0.0005	0.0002	0.0001	0.0003
WetConifA	0.0003	0.0001	0.0005	0.0002	0.0001	0.0003
ConifD	0.0003	0.0001	0.0006	0.0002	0.0001	0.0003
PineA	0.0002	0.0001	0.0003	0.0002	0.0001	0.0002
ConifC	0.0002	0.0001	0.0003	0.0001	0.0001	0.0002
DecidA	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
MixedD	0.0002	0.0001	0.0003	0.0001	0.0001	0.0001
ConifA	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
ConifB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.2525	0.1074	0.4878	0.0000	0.0000	0.0000
UrbInd	0.0050	0.0021	0.0097	0.0000	0.0000	0.0000
HardLin	0.0047	0.0020	0.0090	0.0000	0.0000	0.0000
SoftLin	0.0119	0.0051	0.0230	0.0000	0.0000	0.0000
HFor	0.0015	0.0006	0.0029	0.0000	0.0000	0.0000
Total	0.3503	0.1490	0.6767	0.0315	0.0192	0.0427
Loss	0.0000	0.0000	0.0008			
Gain	0.3191	0.1293	0.6505			

5.65.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations. Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.65.14 Variable selection frequencies

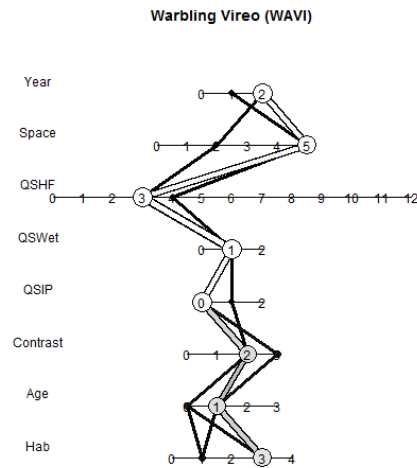
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	34.0	16	. + Habitat
1.2	61.7	29	. + HabitatB
1.4	4.3	2	. + HabitatB + isHForC
2.0	100.0	47	NULL
3.0	40.4	19	NULL
3.1	46.8	22	. + ROAD
3.2	12.8	6	. + SoftLin_PC
4.0	100.0	47	NULL
5.1	100.0	47	. + pWet_QS
6.9	78.7	37	. + Succ_QS + Alien_QS + Alien2_QS
6.11	21.3	10	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.3	100.0	47	. + xlat + xlong + xlat:xlong
8.1	4.3	2	. + xYEAR
8.2	95.7	45	. + YR5F

5.66 Warbling Vireo (*Vireo gilvus*)

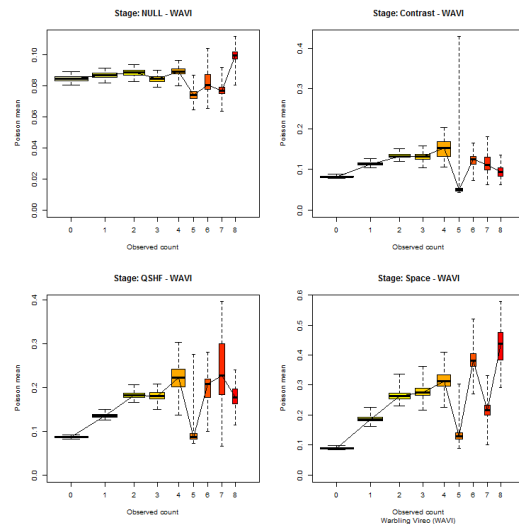
5.66.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

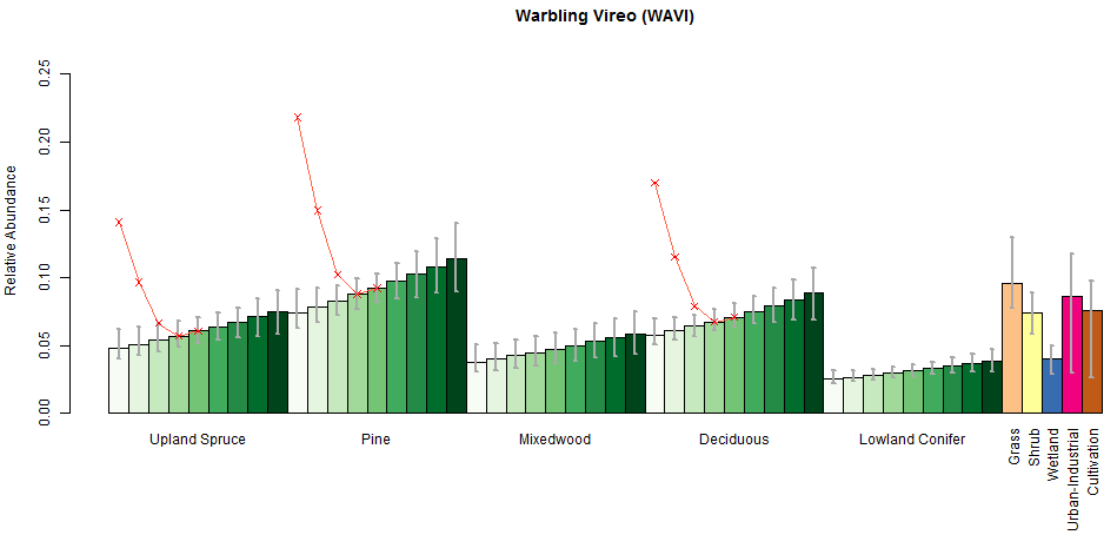


5.66.2 Cross validation

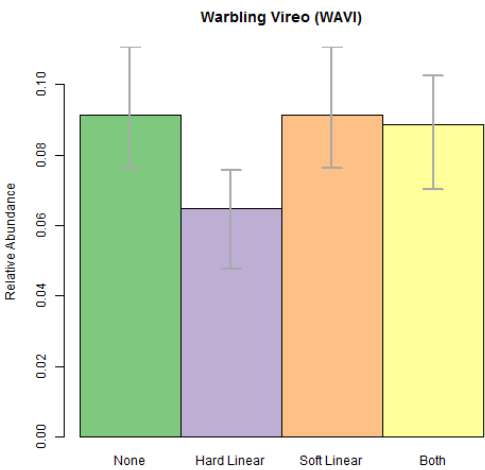
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.66.3 Point level habitat associations

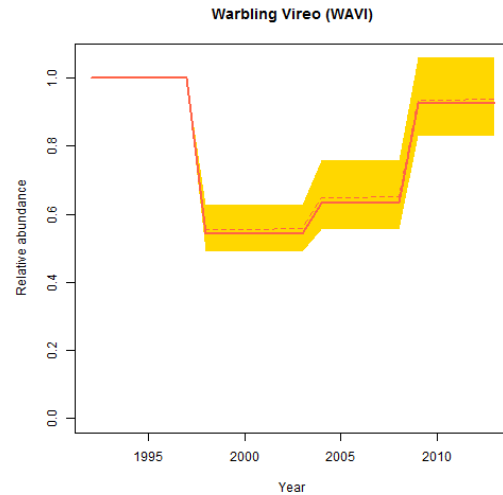


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

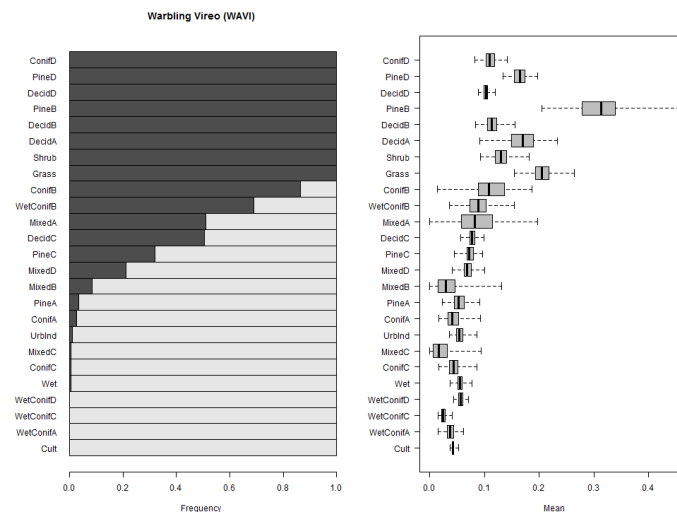


5.66.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



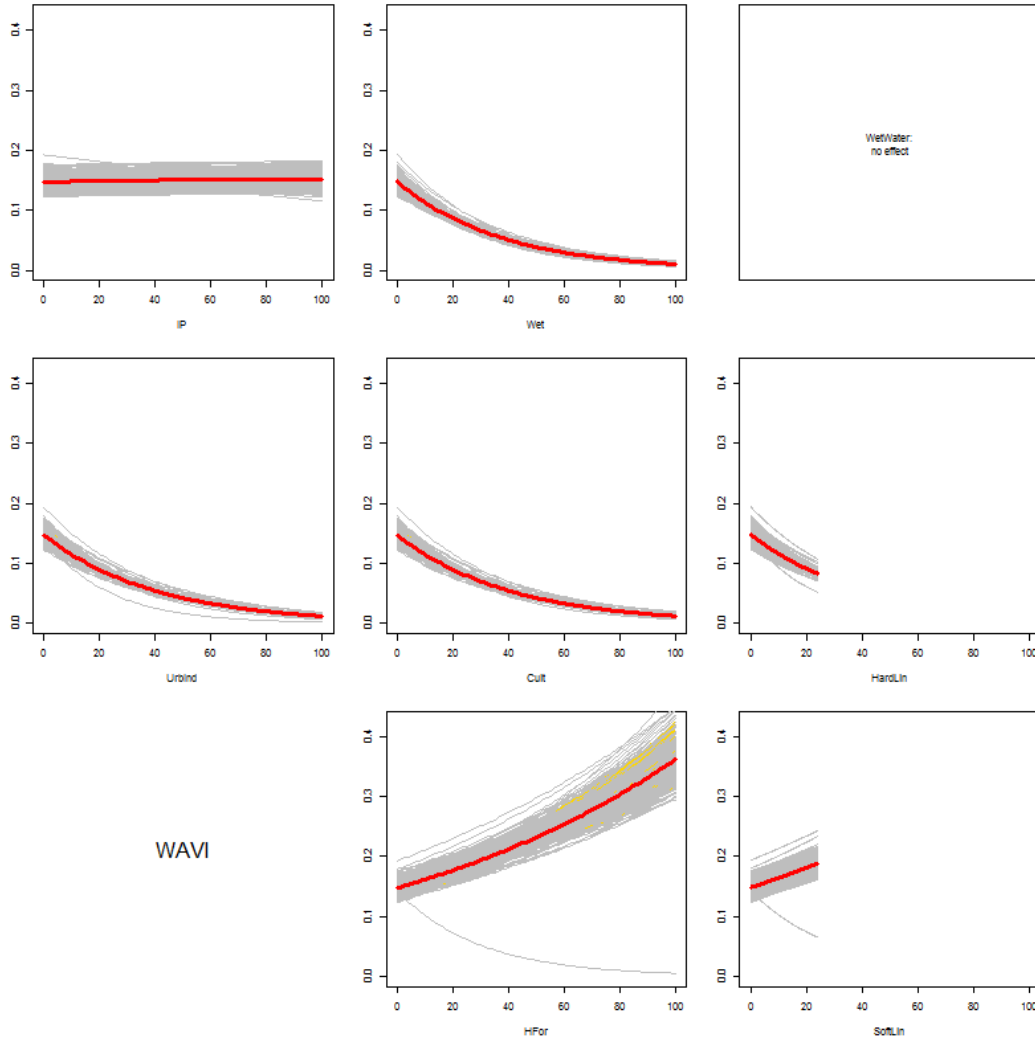
5.66.5 Habitat suitability ranking for patch delineation



Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

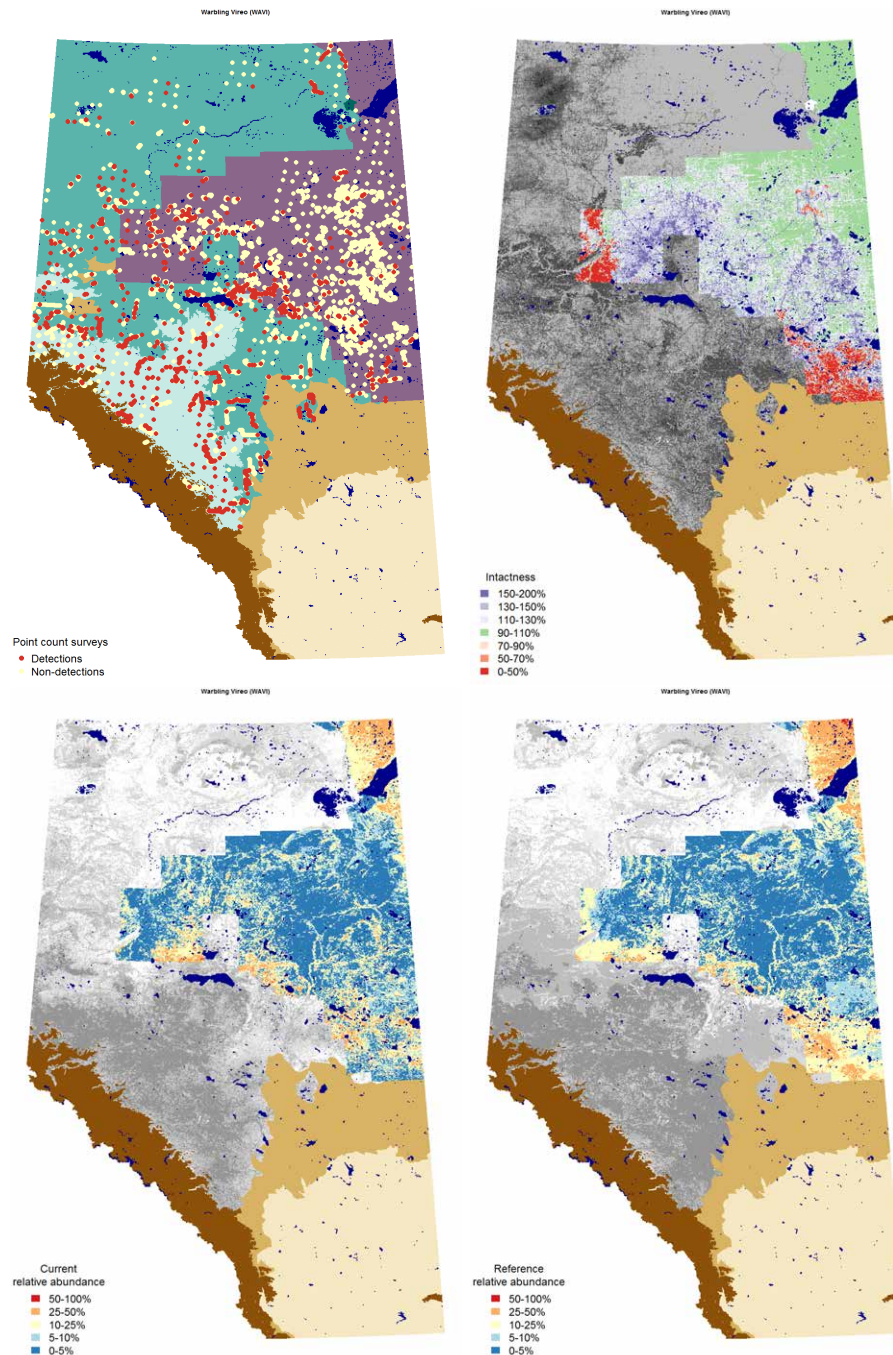
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.66.8 Quarter-section level responses



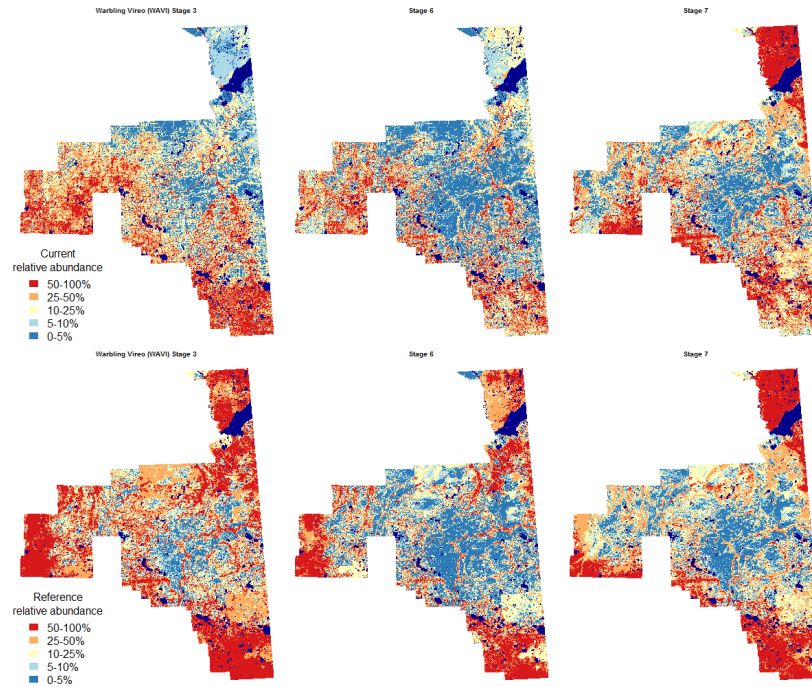
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.66.9 Maps



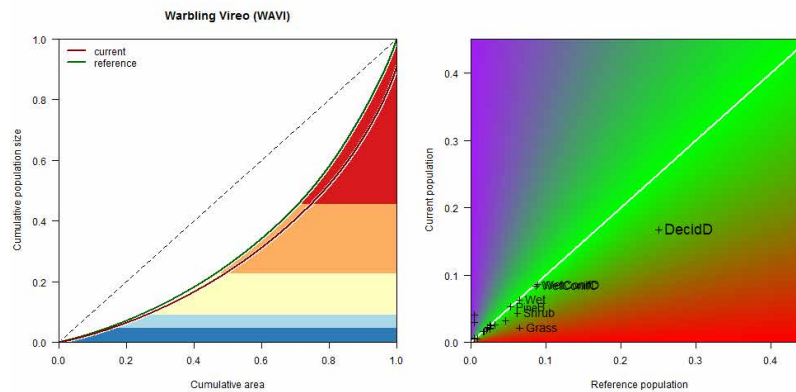
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on "Space" stage of the variable selection procedure (no year effect).

5.66.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.66.11 Population concentration



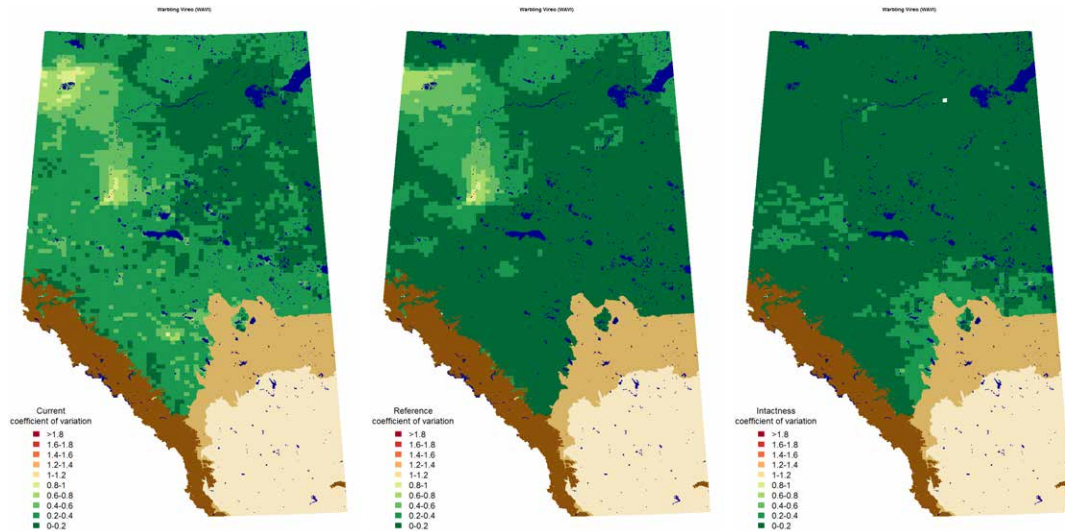
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.66.12 Potential population size

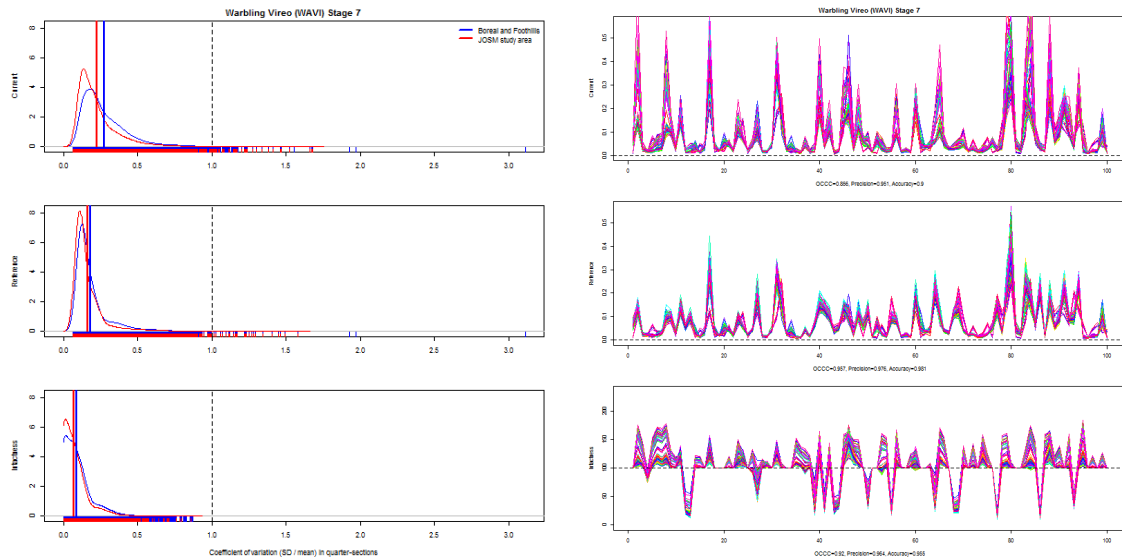
Estimated potential population size of Warbling Vireo in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0925	0.0822	0.1311	0.1373	0.1222	0.1530
WetConifD	0.0474	0.0421	0.0671	0.0489	0.0436	0.0545
WetConifC	0.0463	0.0411	0.0656	0.0477	0.0425	0.0532
Grass	0.0119	0.0106	0.0169	0.0359	0.0319	0.0400
Wet	0.0348	0.0309	0.0493	0.0357	0.0318	0.0398
Shrub	0.0240	0.0213	0.0340	0.0342	0.0304	0.0381
PineB	0.0291	0.0258	0.0412	0.0289	0.0258	0.0323
DecidC	0.0179	0.0159	0.0253	0.0254	0.0226	0.0283
MixedD	0.0143	0.0127	0.0203	0.0177	0.0157	0.0197
PineC	0.0134	0.0119	0.0190	0.0146	0.0130	0.0163
WetConifB	0.0142	0.0126	0.0201	0.0143	0.0127	0.0160
ConifD	0.0113	0.0100	0.0160	0.0143	0.0127	0.0159
DecidB	0.0110	0.0097	0.0155	0.0140	0.0124	0.0155
WetConifA	0.0124	0.0111	0.0176	0.0126	0.0112	0.0140
PineA	0.0124	0.0110	0.0175	0.0125	0.0111	0.0139
ConifA	0.0116	0.0103	0.0165	0.0125	0.0111	0.0139
ConifC	0.0100	0.0088	0.0141	0.0119	0.0106	0.0132
PineD	0.0087	0.0077	0.0123	0.0097	0.0087	0.0108
ConifB	0.0086	0.0077	0.0122	0.0092	0.0082	0.0102
DecidA	0.0028	0.0025	0.0040	0.0048	0.0043	0.0054
MixedB	0.0017	0.0015	0.0024	0.0018	0.0016	0.0021
MixedA	0.0012	0.0011	0.0017	0.0016	0.0014	0.0018
MixedC	0.0009	0.0008	0.0013	0.0011	0.0010	0.0013
Cult	0.0166	0.0147	0.0235	0.0000	0.0000	0.0000
UrbInd	0.0036	0.0032	0.0051	0.0000	0.0000	0.0000
HardLin	0.0006	0.0005	0.0008	0.0000	0.0000	0.0000
SoftLin	0.0162	0.0143	0.0229	0.0000	0.0000	0.0000
HFor	0.0227	0.0201	0.0321	0.0000	0.0000	0.0000
Total	0.4978	0.4423	0.7055	0.5468	0.4866	0.6092
Loss	0.0679	0.0533	0.0856			
Gain	0.0182	0.0113	0.1516			

5.66.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.66.14 Variable selection frequencies

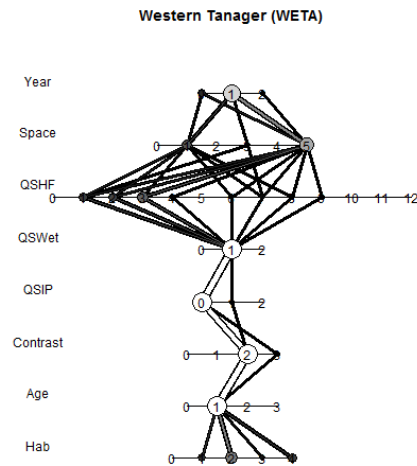
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	10.0	20	. + Habitat
1.3	90.0	180	. + Habitat + isHForC
2.0	12.0	24	NULL
2.1	88.0	176	. + Age
3.2	86.5	173	. + SoftLin_PC
3.3	13.5	27	. + ROAD + SoftLin_PC
4.0	97.5	195	NULL
4.1	2.5	5	. + Remn_QS
5.1	100.0	200	. + pWet_QS
6.3	99.5	199	. + Succ_QS + Alien_QS
6.4	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS
7.2	3.0	6	. + xlat + xlong
7.5	97.0	194	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	1.0	2	. + xYEAR
8.2	99.0	198	. + YR5F

5.67 Western Tanager (*Piranga ludoviciana*)

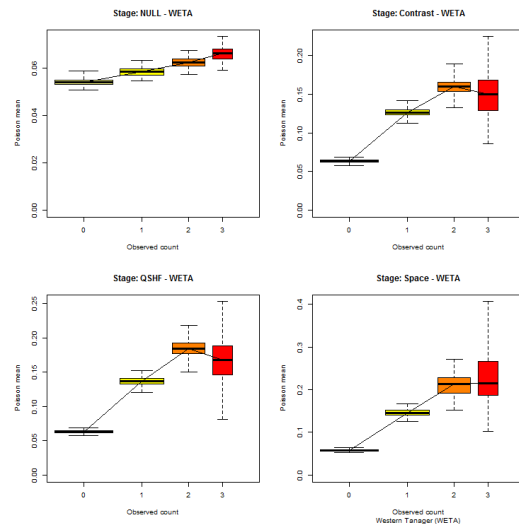
5.67.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

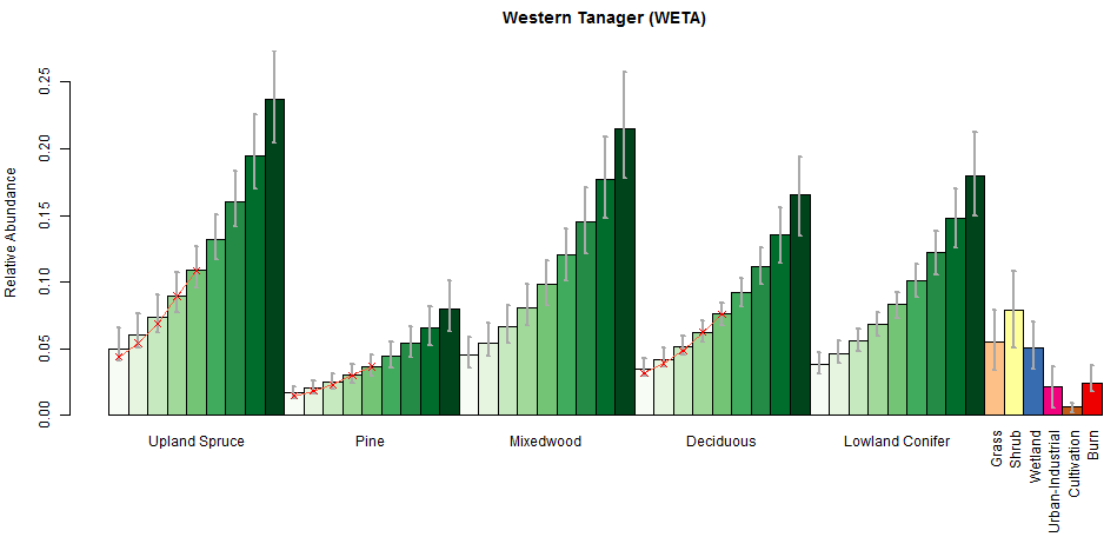


5.67.2 Cross validation

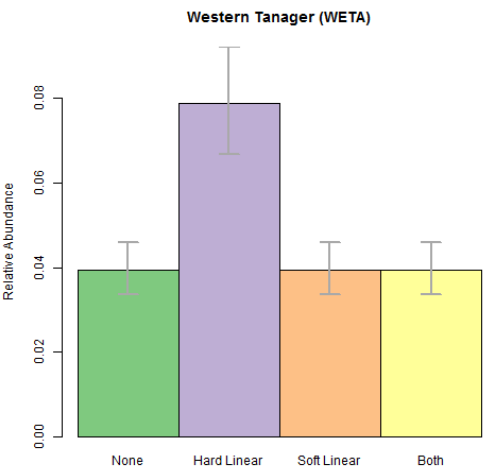
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.67.3 Point level habitat associations

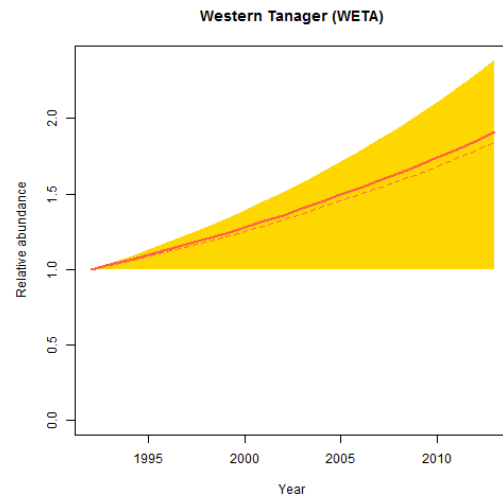


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

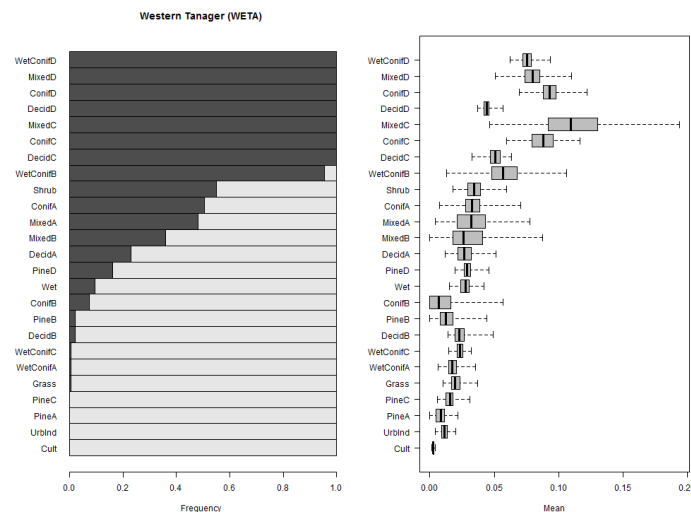


5.67.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



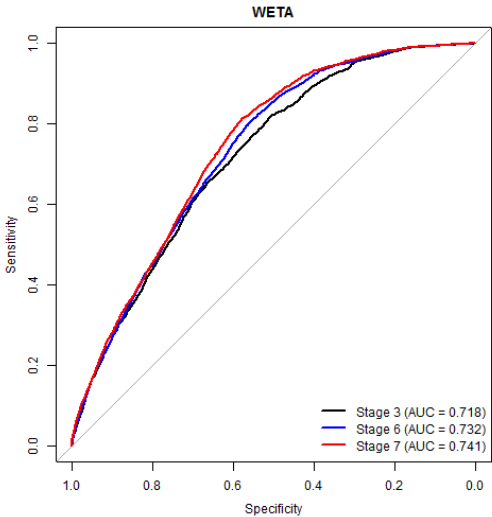
5.67.5 Habitat suitability ranking for patch delineation



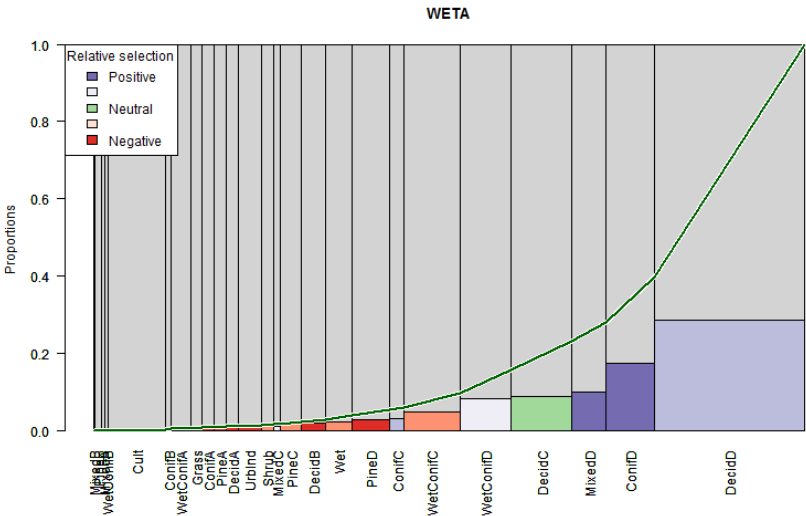
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.67.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

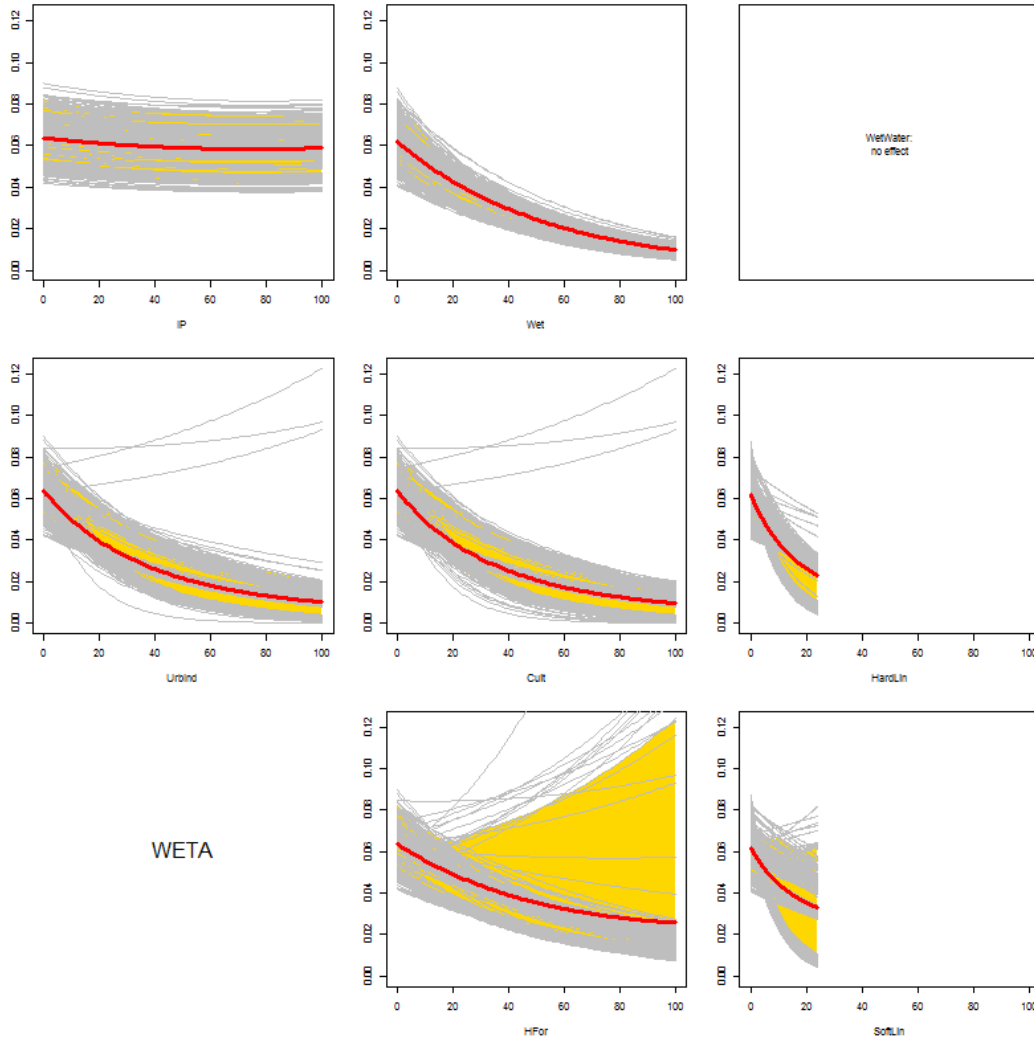


5.67.7 Relative habitat selection



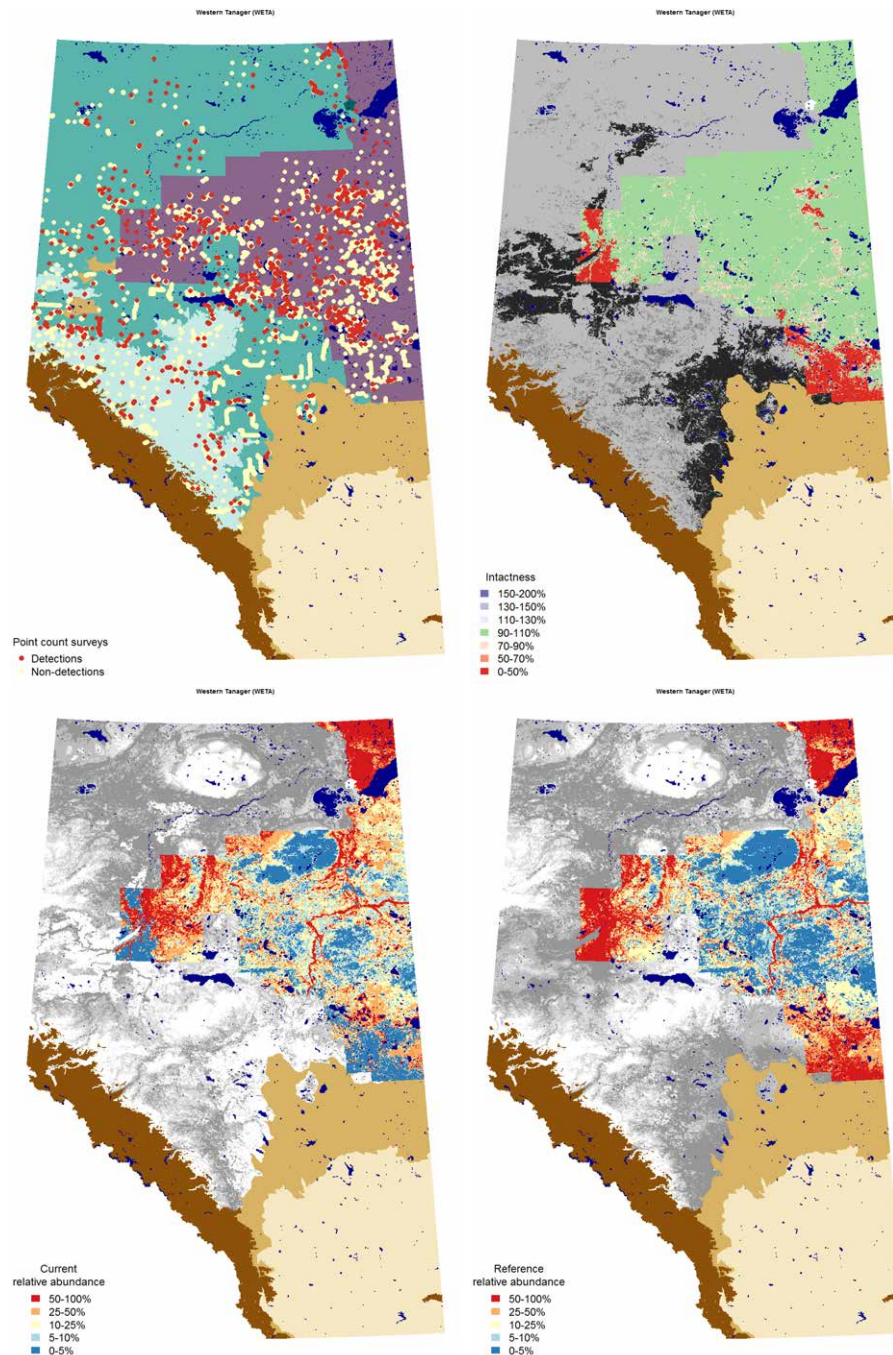
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.67.8 Quarter-section level responses



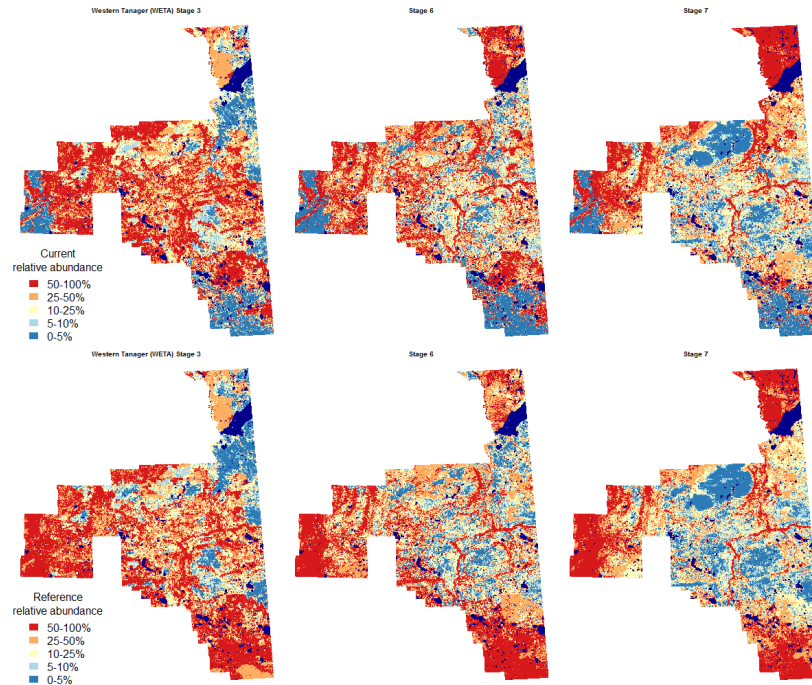
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.67.9 Maps



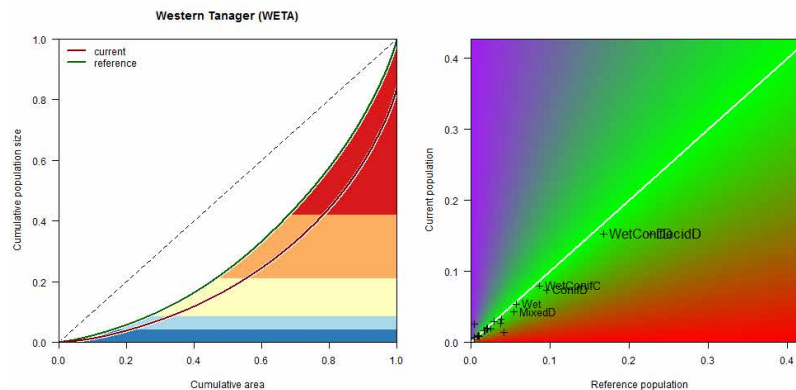
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.67.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.67.11 Population concentration



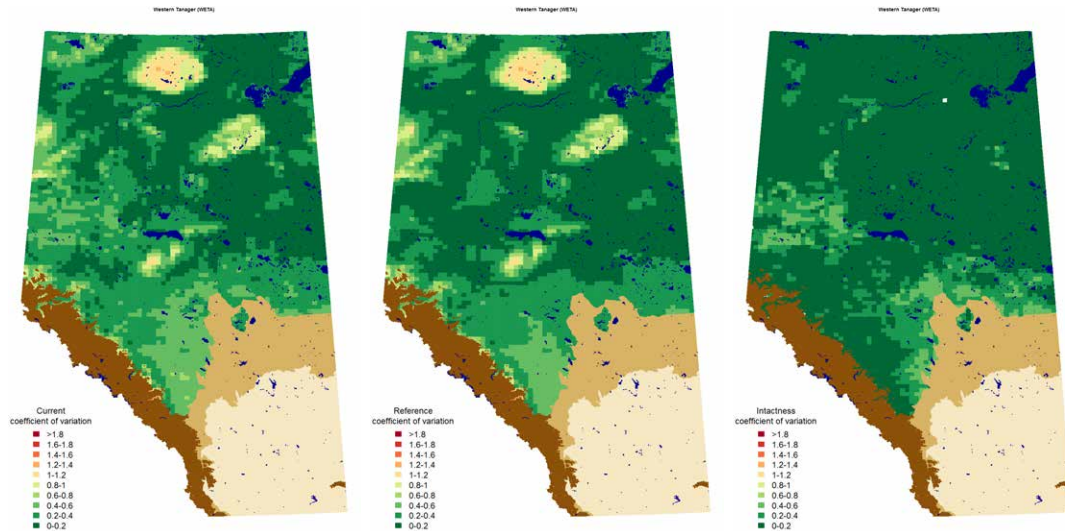
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.67.12 Potential population size

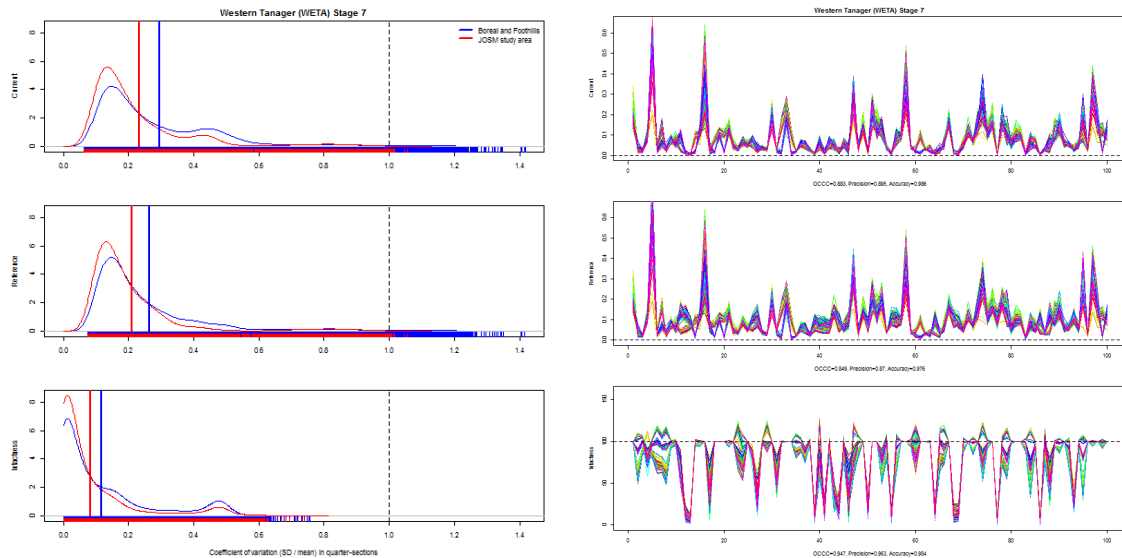
Estimated potential population size of Western Tanager in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.1980	0.1828	0.2200	0.2933	0.2615	0.3303
WetConifD	0.1980	0.1827	0.2199	0.2167	0.1932	0.2440
ConifD	0.0954	0.0881	0.1060	0.1237	0.1103	0.1393
WetConifC	0.1033	0.0954	0.1148	0.1119	0.0997	0.1260
Wet	0.0700	0.0646	0.0778	0.0745	0.0664	0.0839
MixedD	0.0552	0.0510	0.0614	0.0704	0.0628	0.0793
Grass	0.0178	0.0164	0.0197	0.0545	0.0486	0.0614
ConifC	0.0420	0.0387	0.0466	0.0498	0.0444	0.0561
Shrub	0.0350	0.0323	0.0389	0.0487	0.0434	0.0549
PineB	0.0382	0.0353	0.0424	0.0385	0.0343	0.0434
DecidC	0.0249	0.0230	0.0277	0.0333	0.0297	0.0375
ConifB	0.0263	0.0243	0.0292	0.0281	0.0250	0.0316
PineD	0.0243	0.0224	0.0270	0.0274	0.0244	0.0309
ConifA	0.0244	0.0225	0.0271	0.0261	0.0233	0.0294
PineC	0.0212	0.0196	0.0236	0.0235	0.0210	0.0265
WetConifB	0.0208	0.0192	0.0231	0.0215	0.0192	0.0242
DecidB	0.0105	0.0097	0.0117	0.0141	0.0125	0.0158
WetConifA	0.0123	0.0113	0.0136	0.0128	0.0114	0.0144
PineA	0.0107	0.0098	0.0118	0.0108	0.0097	0.0122
DecidA	0.0020	0.0018	0.0022	0.0033	0.0030	0.0037
MixedB	0.0029	0.0027	0.0032	0.0032	0.0029	0.0036
MixedC	0.0021	0.0019	0.0023	0.0025	0.0022	0.0028
MixedA	0.0012	0.0011	0.0014	0.0017	0.0015	0.0019
Cult	0.0089	0.0082	0.0099	0.0000	0.0000	0.0000
UrbInd	0.0066	0.0061	0.0074	0.0000	0.0000	0.0000
HardLin	0.0010	0.0009	0.0011	0.0000	0.0000	0.0000
SoftLin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HFor	0.0338	0.0312	0.0375	0.0000	0.0000	0.0000
Total	1.0869	1.0033	1.2077	1.2904	1.1504	1.4530
Loss	0.2015	0.1222	0.2971			
Gain	0.0011	0.0003	0.0299			

5.67.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.67.14 Variable selection frequencies

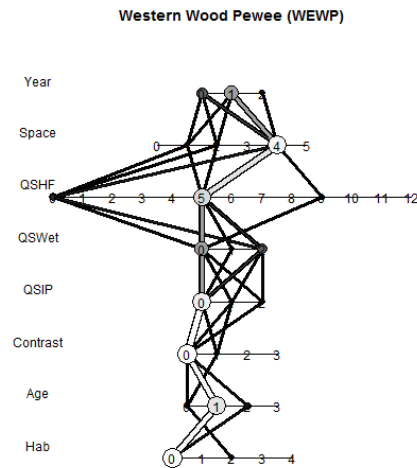
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	19.5	39	. + Habitat
1.2	48.0	96	. + HabitatB
1.3	8.0	16	. + Habitat + isHForC
1.4	24.5	49	. + HabitatB + isHForC
2.1	100.0	200	. + Age
3.2	99.5	199	. + SoftLin_PC
3.3	0.5	1	. + ROAD + SoftLin_PC
4.0	99.5	199	NULL
4.1	0.5	1	. + Remn_QS
5.1	100.0	200	. + pWet_QS
6.1	24.5	49	. + THF_QS
6.2	26.5	53	. + Lin_QS + Nonlin_QS
6.3	39.0	78	. + Succ_QS + Alien_QS
6.4	1.5	3	. + Succ_QS + Noncult_QS + Cult_QS
6.6	1.5	3	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.7	5.5	11	. + Succ_QS + Alien_QS + Succ2_QS
6.8	1.0	2	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	0.5	1	. + Succ_QS + Alien_QS + Alien2_QS
7.1	33.0	66	. + xlat
7.3	1.0	2	. + xlat + xlong + xlat:xlong
7.5	66.0	132	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	16.0	32	NULL
8.1	83.5	167	. + xYEAR
8.2	0.5	1	. + YR5F

5.68 Western Wood Pewee (*Contopus sordidulus*)

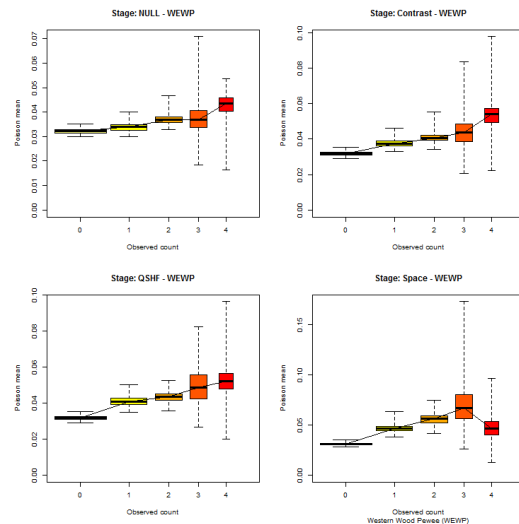
5.68.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

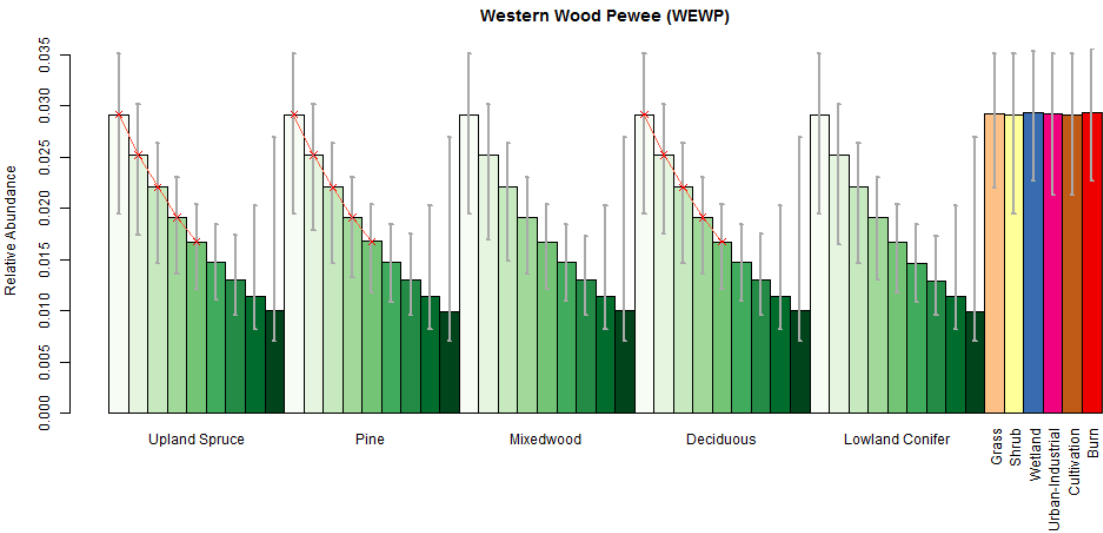


5.68.2 Cross validation

Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.68.3 Point level habitat associations

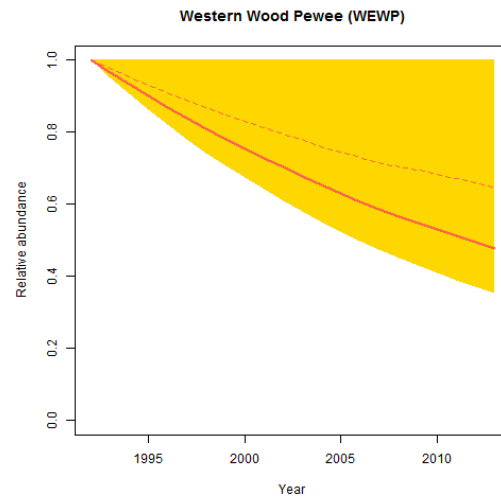


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

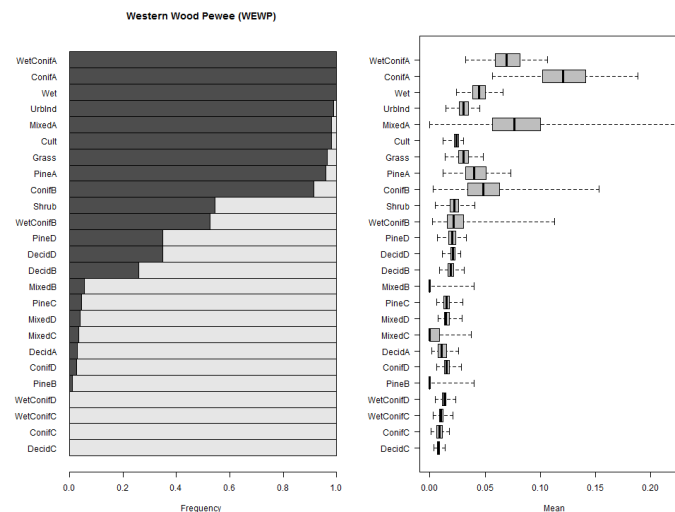


5.68.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



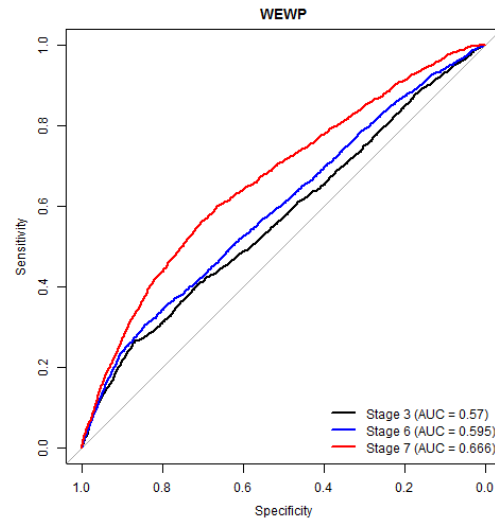
5.68.5 Habitat suitability ranking for patch delineation



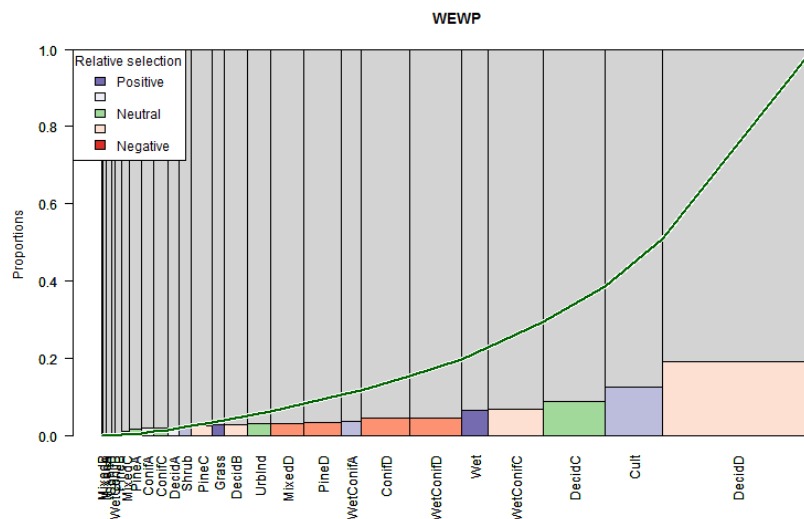
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.68.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

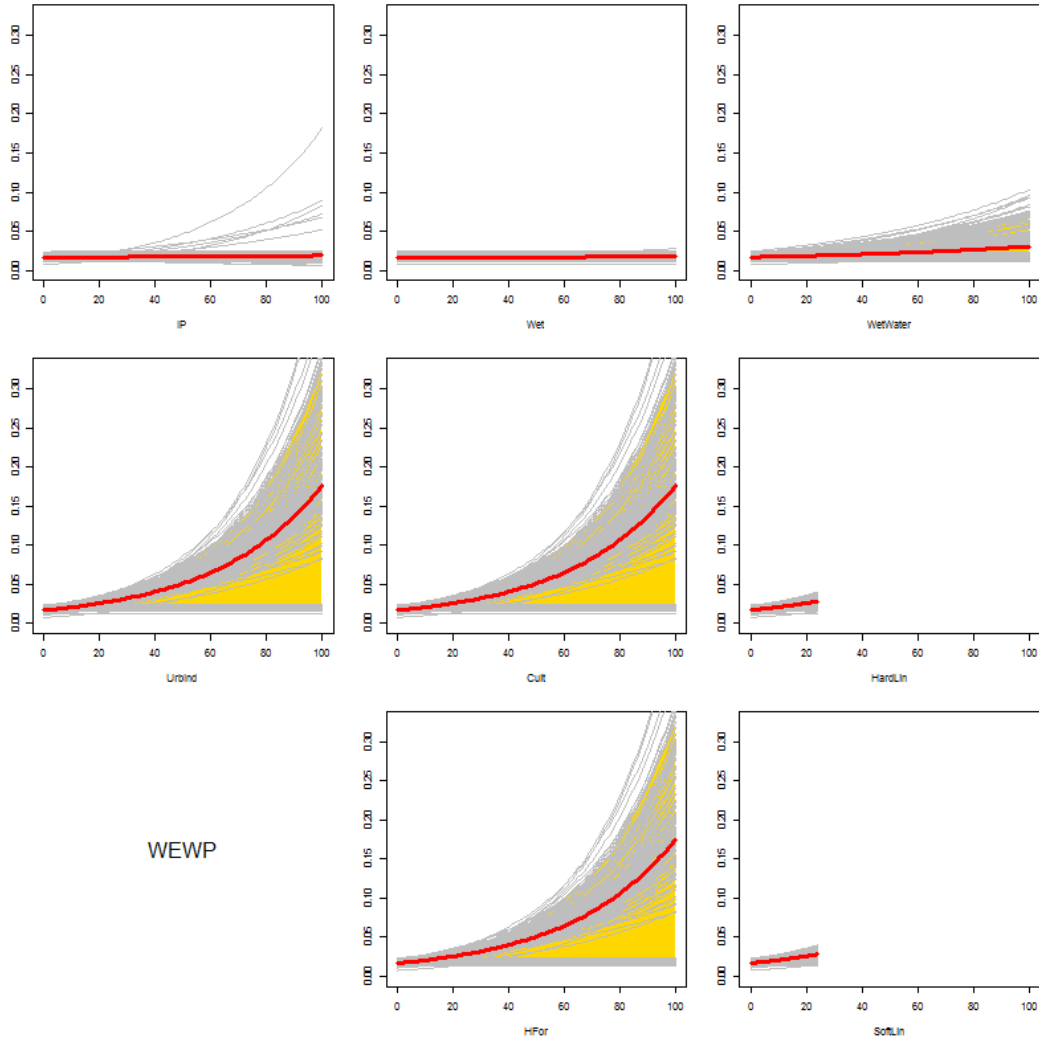


5.68.7 Relative habitat selection



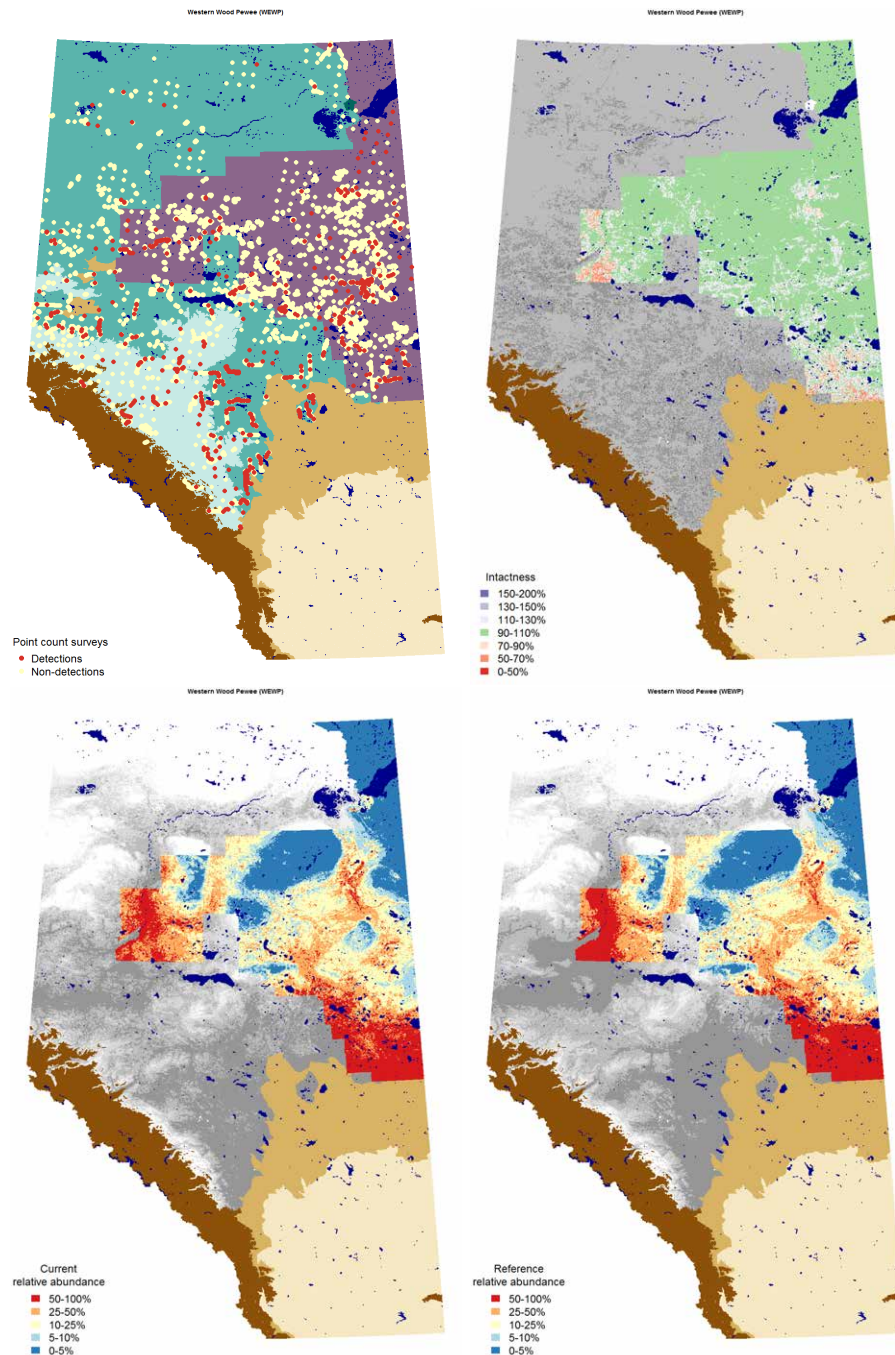
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.68.8 Quarter-section level responses



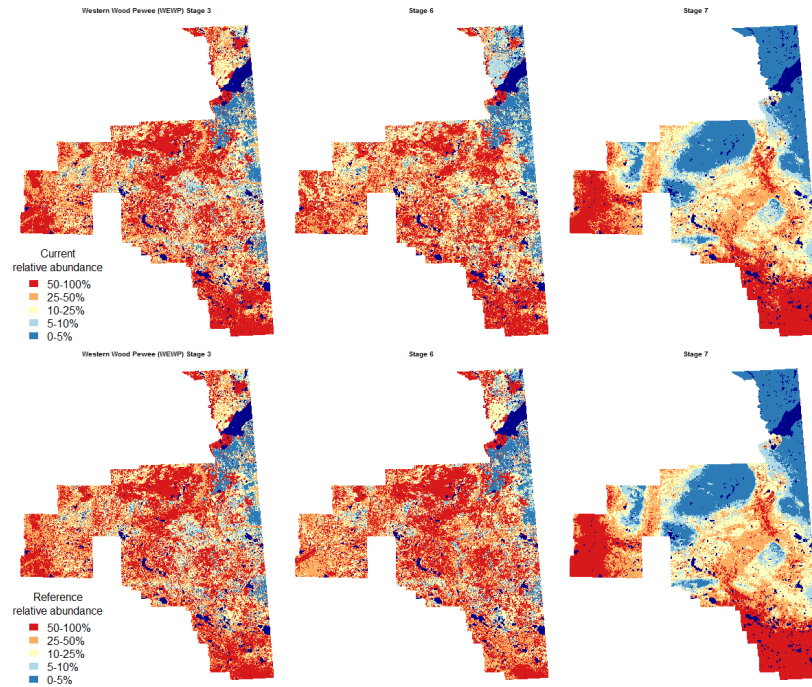
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.68.9 Maps



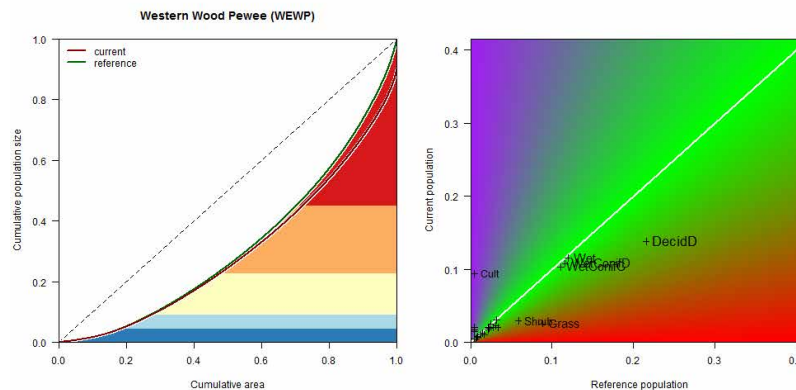
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.68.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.68.11 Population concentration



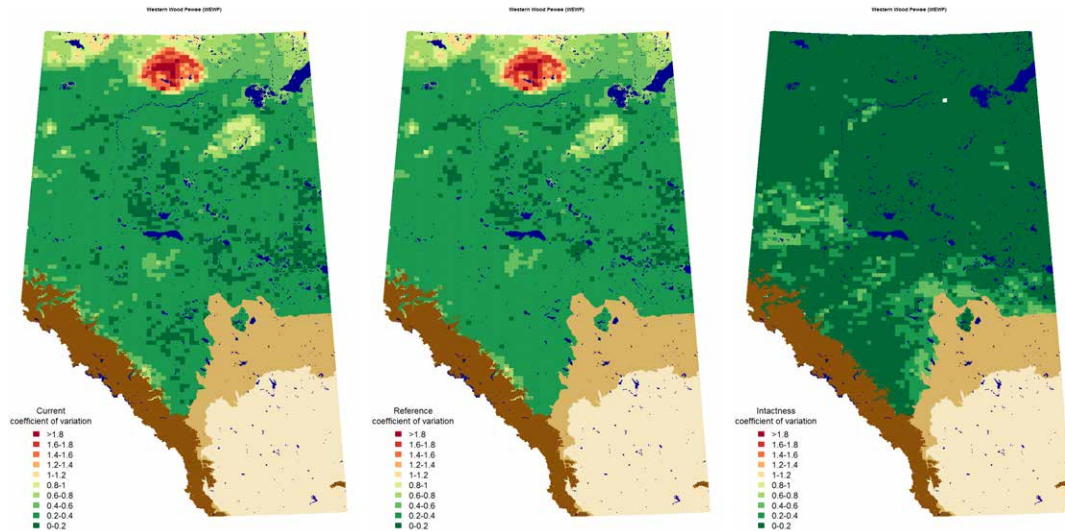
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.68.12 Potential population size

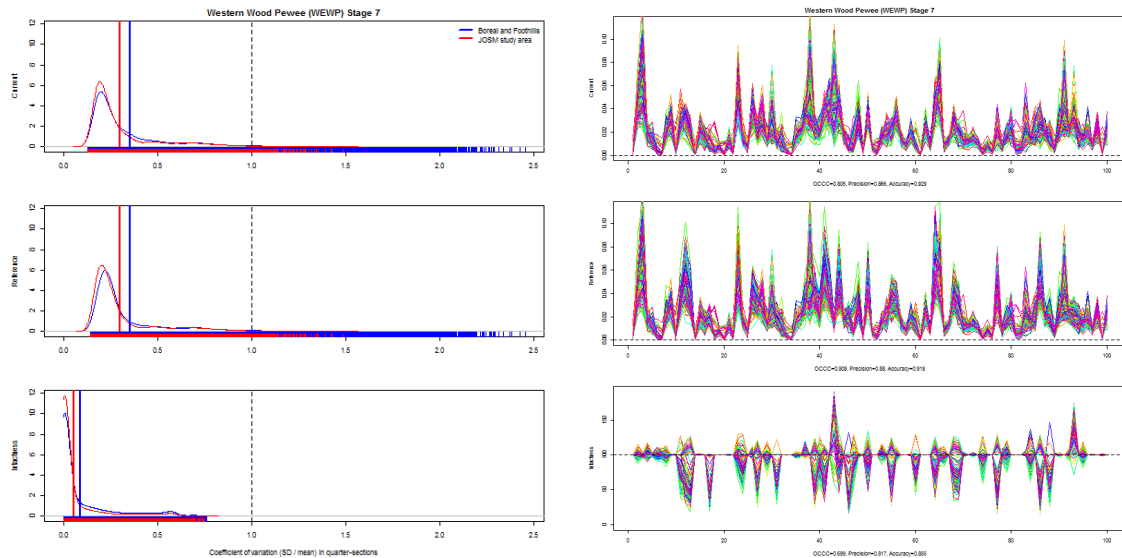
Estimated potential population size of Western Wood Pewee in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0435	0.0331	0.0538	0.0668	0.0495	0.0831
Wet	0.0364	0.0277	0.0450	0.0371	0.0275	0.0462
WetConifD	0.0340	0.0258	0.0420	0.0360	0.0267	0.0448
WetConifC	0.0326	0.0247	0.0402	0.0344	0.0255	0.0428
Grass	0.0080	0.0061	0.0099	0.0274	0.0203	0.0341
Shrub	0.0092	0.0070	0.0113	0.0182	0.0135	0.0226
DecidC	0.0064	0.0049	0.0079	0.0104	0.0077	0.0129
WetConifA	0.0095	0.0072	0.0118	0.0099	0.0074	0.0123
MixedD	0.0072	0.0055	0.0089	0.0096	0.0071	0.0120
ConifD	0.0065	0.0049	0.0080	0.0086	0.0064	0.0108
PineB	0.0078	0.0059	0.0096	0.0078	0.0058	0.0097
PineC	0.0060	0.0046	0.0075	0.0070	0.0052	0.0087
ConifC	0.0053	0.0040	0.0065	0.0068	0.0051	0.0085
WetConifB	0.0064	0.0049	0.0079	0.0067	0.0049	0.0083
DecidB	0.0034	0.0025	0.0041	0.0051	0.0038	0.0064
PineD	0.0040	0.0030	0.0049	0.0046	0.0034	0.0058
ConifA	0.0032	0.0024	0.0039	0.0041	0.0030	0.0050
PineA	0.0026	0.0020	0.0032	0.0027	0.0020	0.0034
ConifB	0.0020	0.0015	0.0025	0.0025	0.0018	0.0031
DecidA	0.0011	0.0009	0.0014	0.0021	0.0016	0.0027
MixedA	0.0005	0.0004	0.0006	0.0008	0.0006	0.0010
MixedB	0.0004	0.0003	0.0004	0.0005	0.0004	0.0006
MixedC	0.0003	0.0002	0.0004	0.0004	0.0003	0.0006
Cult	0.0296	0.0225	0.0366	0.0000	0.0000	0.0000
UrbInd	0.0047	0.0036	0.0058	0.0000	0.0000	0.0000
HardLin	0.0006	0.0005	0.0007	0.0000	0.0000	0.0000
SoftLin	0.0055	0.0042	0.0068	0.0000	0.0000	0.0000
HFor	0.0063	0.0048	0.0078	0.0000	0.0000	0.0000
Total	0.2830	0.2151	0.3495	0.3095	0.2295	0.3853
Loss	0.0317	0.0026	0.0609			
Gain	0.0020	0.0002	0.0088			

5.68.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.68.14 Variable selection frequencies

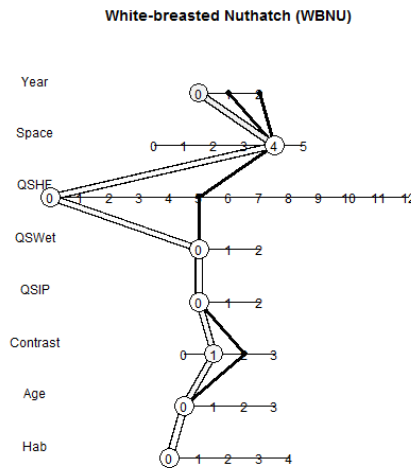
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	97.5	195	NULL
1.2	2.5	5	. + HabitatB
2.0	2.5	5	NULL
2.1	88.5	177	. + Age
2.2	9.0	18	. + Age + Age2
3.0	98.5	197	NULL
3.1	1.5	3	. + ROAD
4.0	92.0	184	NULL
4.1	5.0	10	. + Remn_QS
4.2	3.0	6	. + Remn_QS + Remn2_QS
5.0	61.5	123	NULL
5.1	1.5	3	. + pWet_QS
5.2	37.0	74	. + pWetWater_QS
6.0	16.0	32	NULL
6.5	83.5	167	. + THF_QS + THF2_QS
6.9	0.5	1	. + Succ_QS + Alien_QS + Alien2_QS
7.1	4.0	8	. + xlat
7.2	1.5	3	. + xlat + xlong
7.4	94.5	189	. + xMAP + xPET + xMAT + xCMD
8.0	38.0	76	NULL
8.1	61.0	122	. + xYEAR
8.2	1.0	2	. + YR5F

5.69 White-breasted Nuthatch (*Sitta carolinensis*)

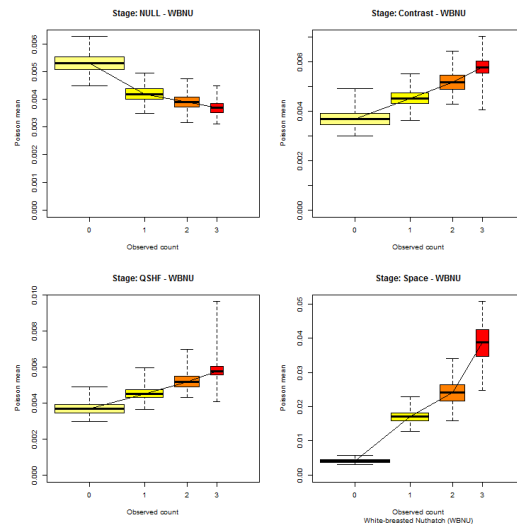
5.69.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

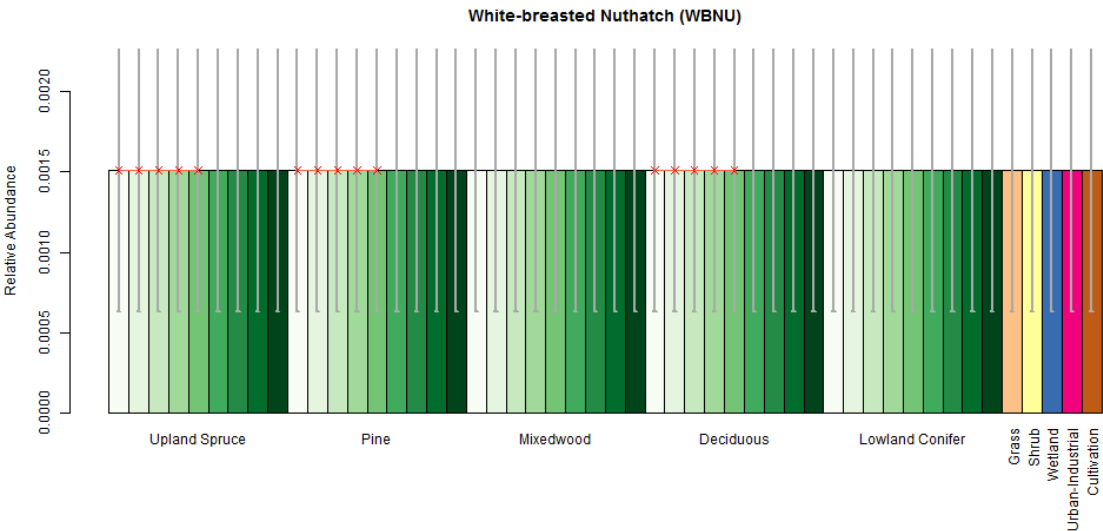


5.69.2 Cross validation

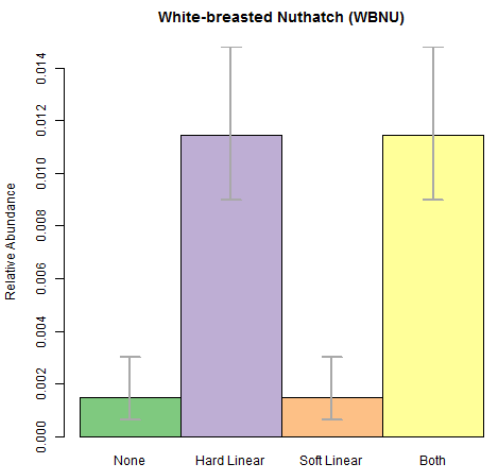
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.69.3 Point level habitat associations

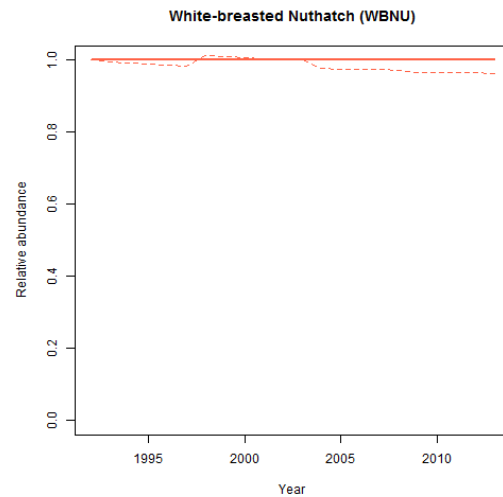


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

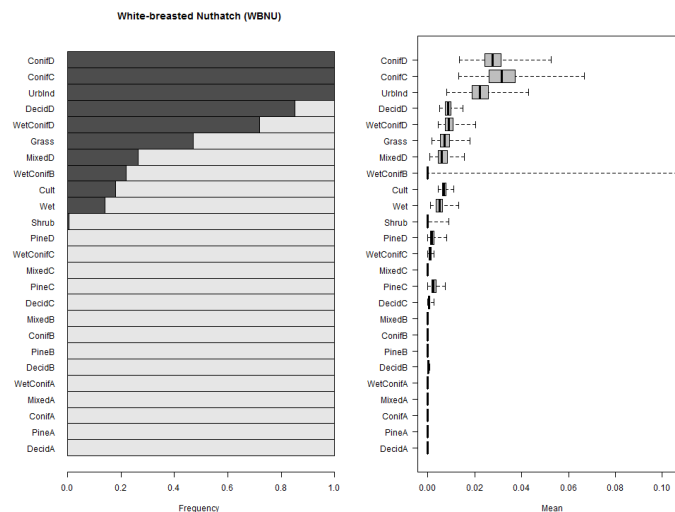


5.69.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



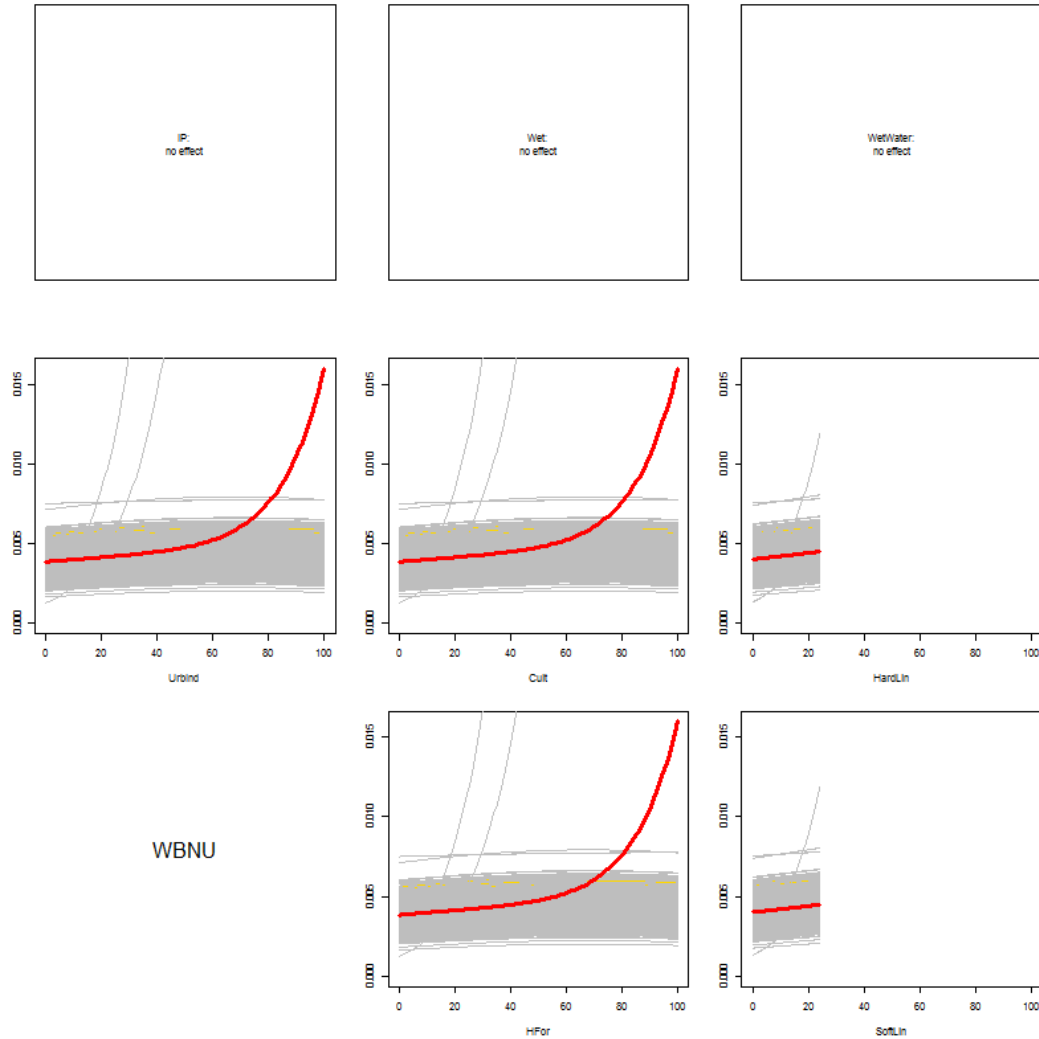
5.69.5 Habitat suitability ranking for patch delineation



Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

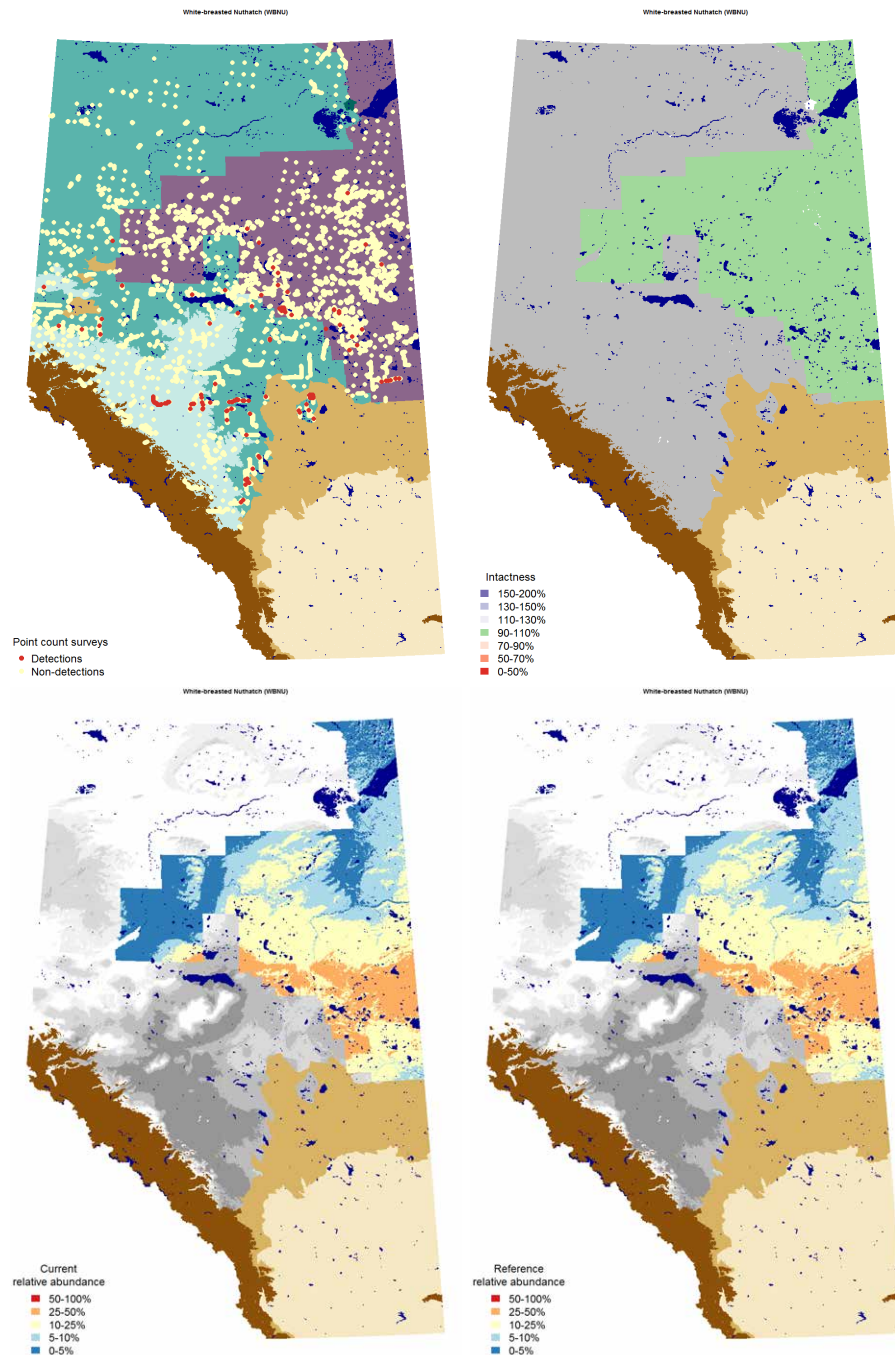
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.69.8 Quarter-section level responses



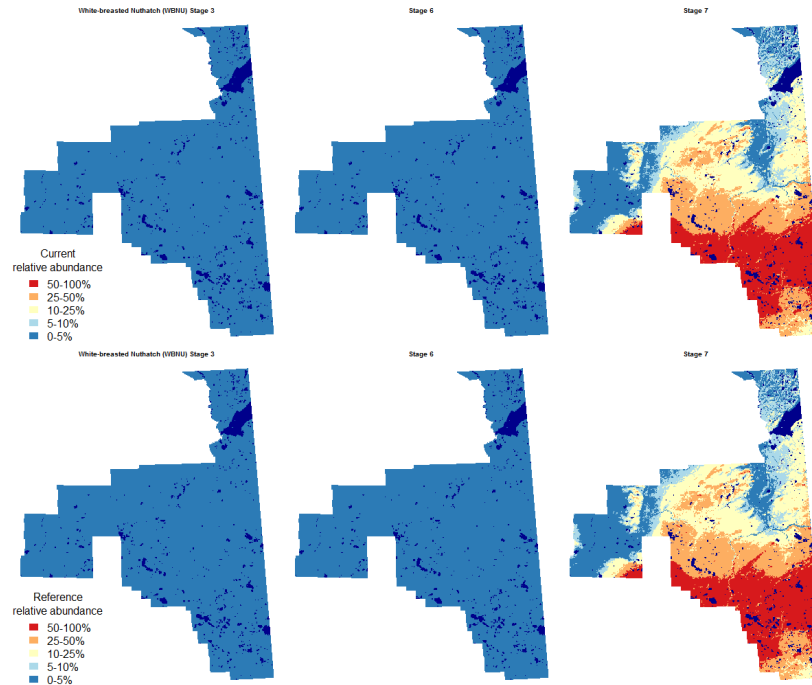
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.69.9 Maps



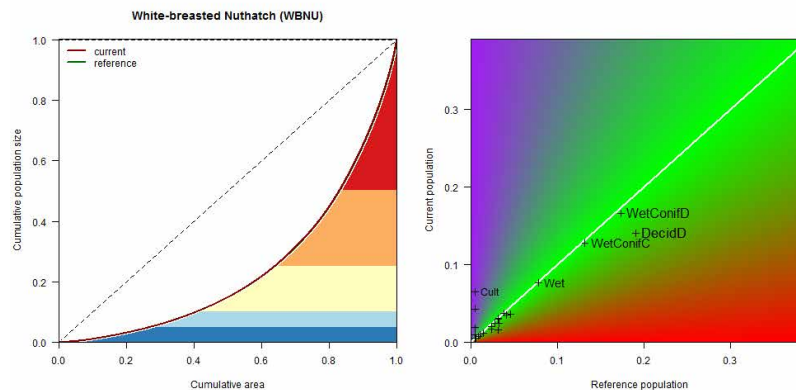
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.69.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.69.11 Population concentration



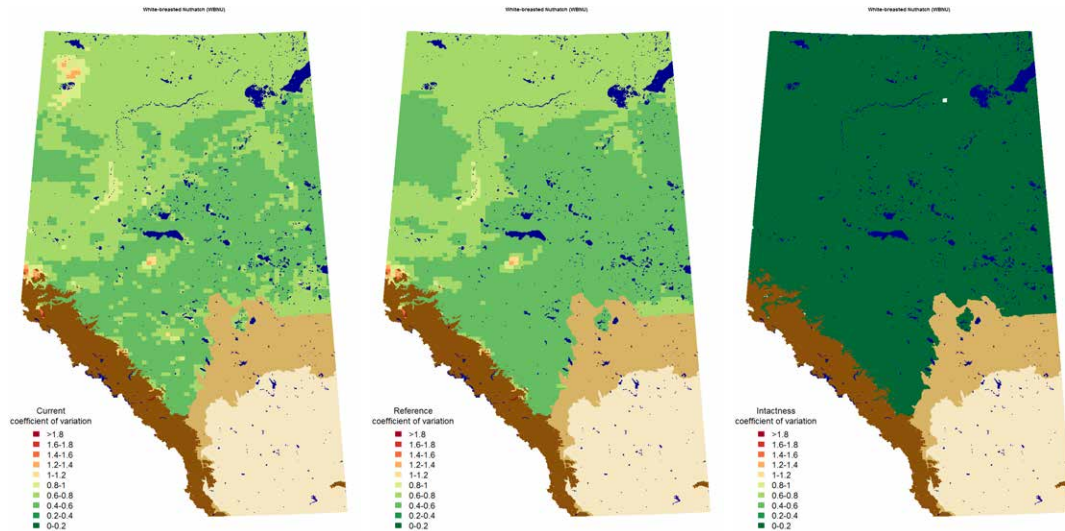
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.69.12 Potential population size

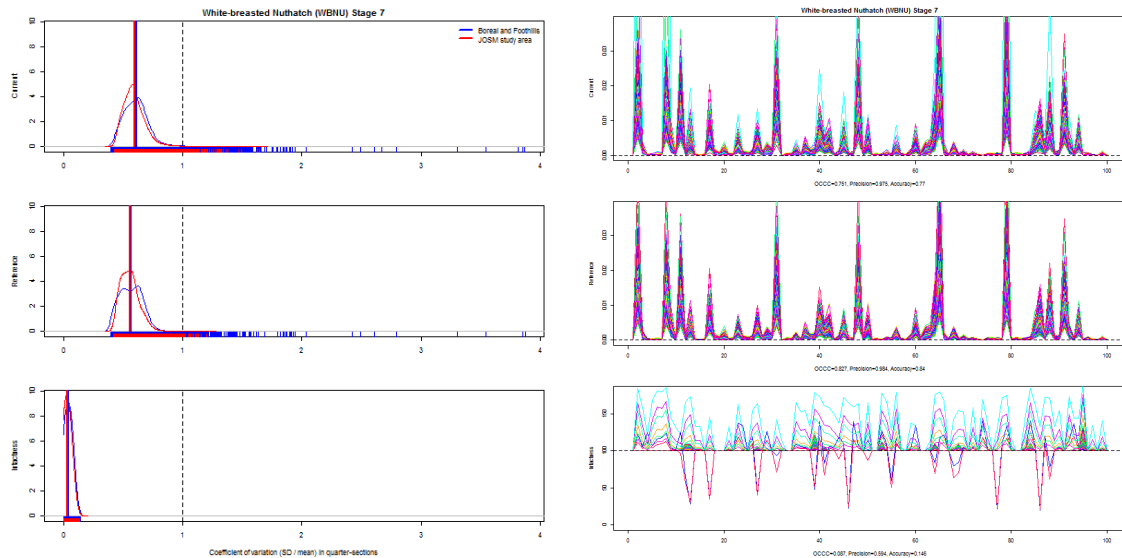
Estimated potential population size of White-breasted Nuthatch in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.0015	0.0006	0.0031	0.0020	0.0007	0.0042
WetConifD	0.0018	0.0007	0.0037	0.0019	0.0007	0.0038
WetConifC	0.0014	0.0005	0.0028	0.0014	0.0005	0.0029
Wet	0.0008	0.0003	0.0017	0.0008	0.0003	0.0017
ConifD	0.0004	0.0001	0.0008	0.0005	0.0002	0.0010
MixedD	0.0004	0.0001	0.0008	0.0004	0.0002	0.0009
PineB	0.0004	0.0001	0.0008	0.0004	0.0001	0.0008
Shrub	0.0003	0.0001	0.0005	0.0004	0.0001	0.0007
WetConifB	0.0003	0.0001	0.0007	0.0003	0.0001	0.0007
PineC	0.0003	0.0001	0.0007	0.0003	0.0001	0.0007
WetConifA	0.0003	0.0001	0.0007	0.0003	0.0001	0.0007
Grass	0.0002	0.0001	0.0003	0.0003	0.0001	0.0007
PineD	0.0003	0.0001	0.0005	0.0003	0.0001	0.0006
DecidC	0.0002	0.0001	0.0004	0.0003	0.0001	0.0005
ConifC	0.0002	0.0001	0.0004	0.0003	0.0001	0.0005
ConifA	0.0001	0.0000	0.0003	0.0002	0.0001	0.0003
DecidB	0.0001	0.0000	0.0003	0.0002	0.0001	0.0003
PineA	0.0001	0.0000	0.0002	0.0001	0.0000	0.0002
ConifB	0.0001	0.0000	0.0002	0.0001	0.0000	0.0002
DecidA	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0007	0.0003	0.0014	0.0000	0.0000	0.0000
UrbInd	0.0001	0.0000	0.0002	0.0000	0.0000	0.0000
HardLin	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0002	0.0001	0.0004	0.0000	0.0000	0.0000
HFor	0.0005	0.0002	0.0010	0.0000	0.0000	0.0000
Total	0.0108	0.0039	0.0222	0.0107	0.0039	0.0219
Loss	0.0000	0.0000	0.0000			
Gain	0.0000	0.0000	0.0001			

5.69.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.69.14 Variable selection frequencies

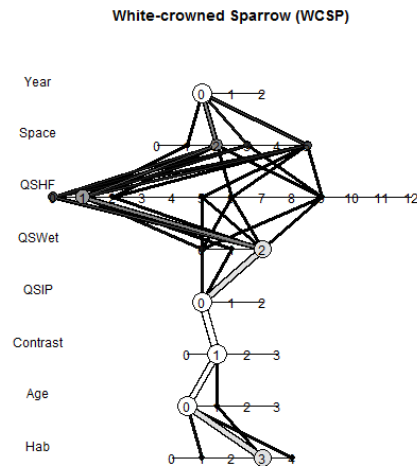
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.0	100.0	200	NULL
2.0	100.0	200	NULL
3.1	97.0	194	. + ROAD
3.2	3.0	6	. + SoftLin_PC
4.0	100.0	200	NULL
5.0	100.0	200	NULL
6.0	99.0	198	NULL
6.5	1.0	2	. + THF_QS + THF2_QS
7.4	100.0	200	. + xMAP + xPET + xMAT + xCMD
8.0	95.0	190	NULL
8.1	4.5	9	. + xYEAR
8.2	0.5	1	. + YR5F

5.70 White-crowned Sparrow (*Zonotrichia leucophrys*)

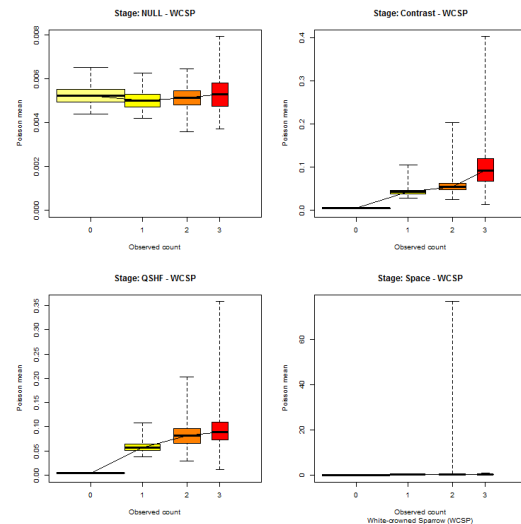
5.70.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

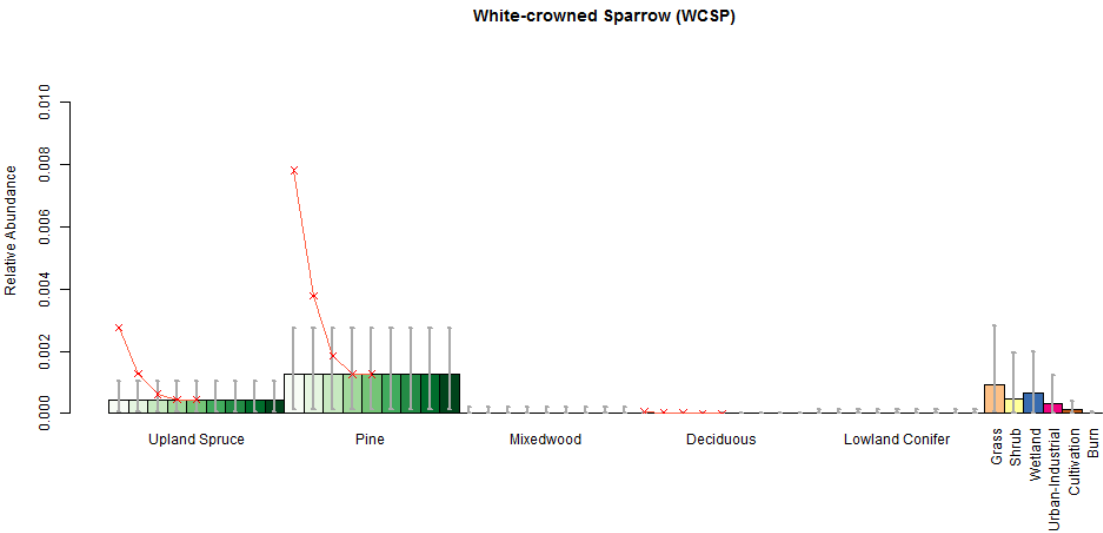


5.70.2 Cross validation

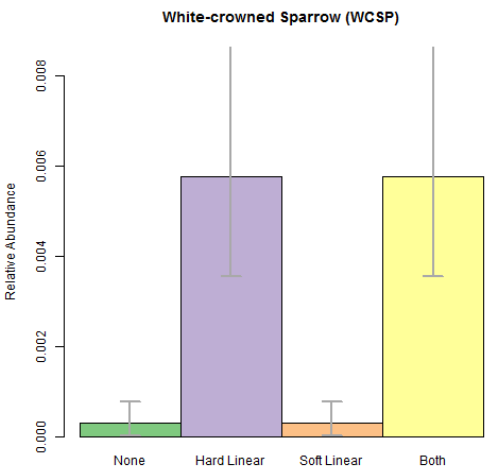
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.70.3 Point level habitat associations

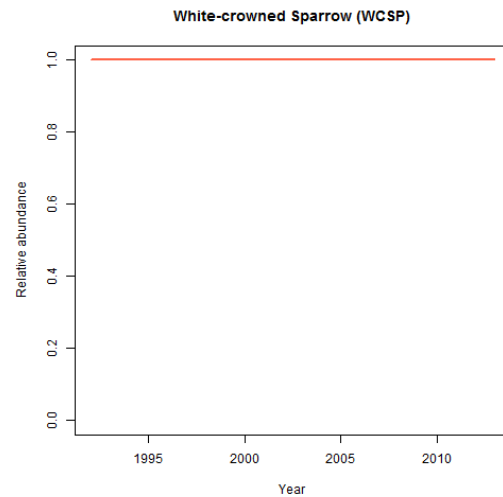


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

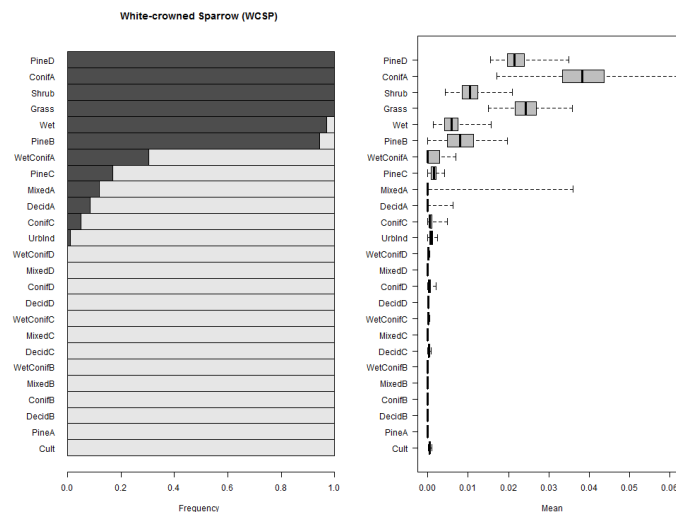


5.70.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



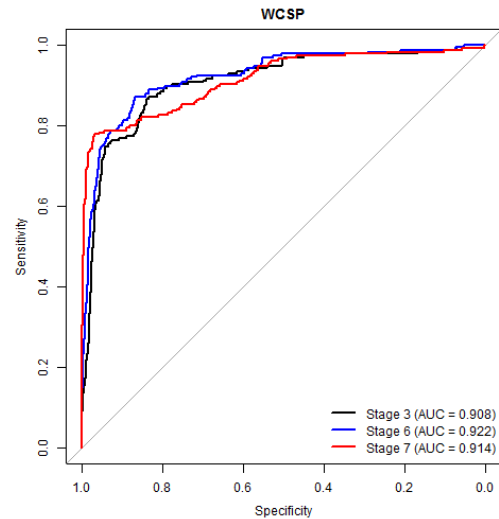
5.70.5 Habitat suitability ranking for patch delineation



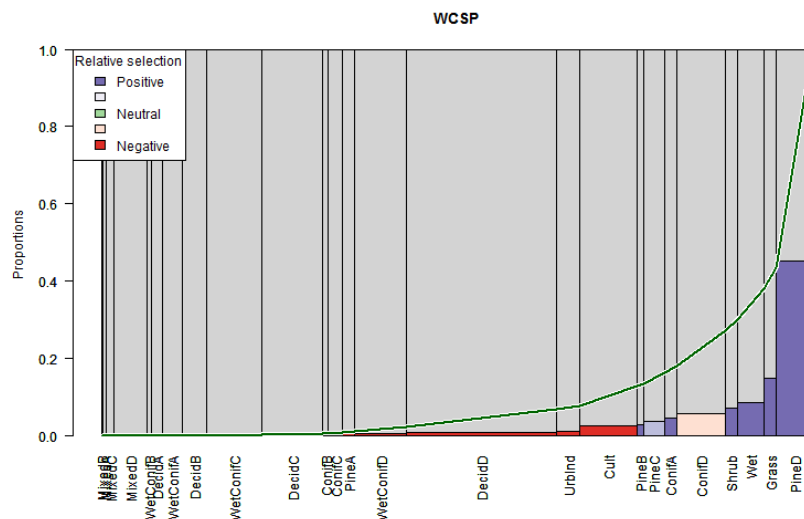
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.70.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

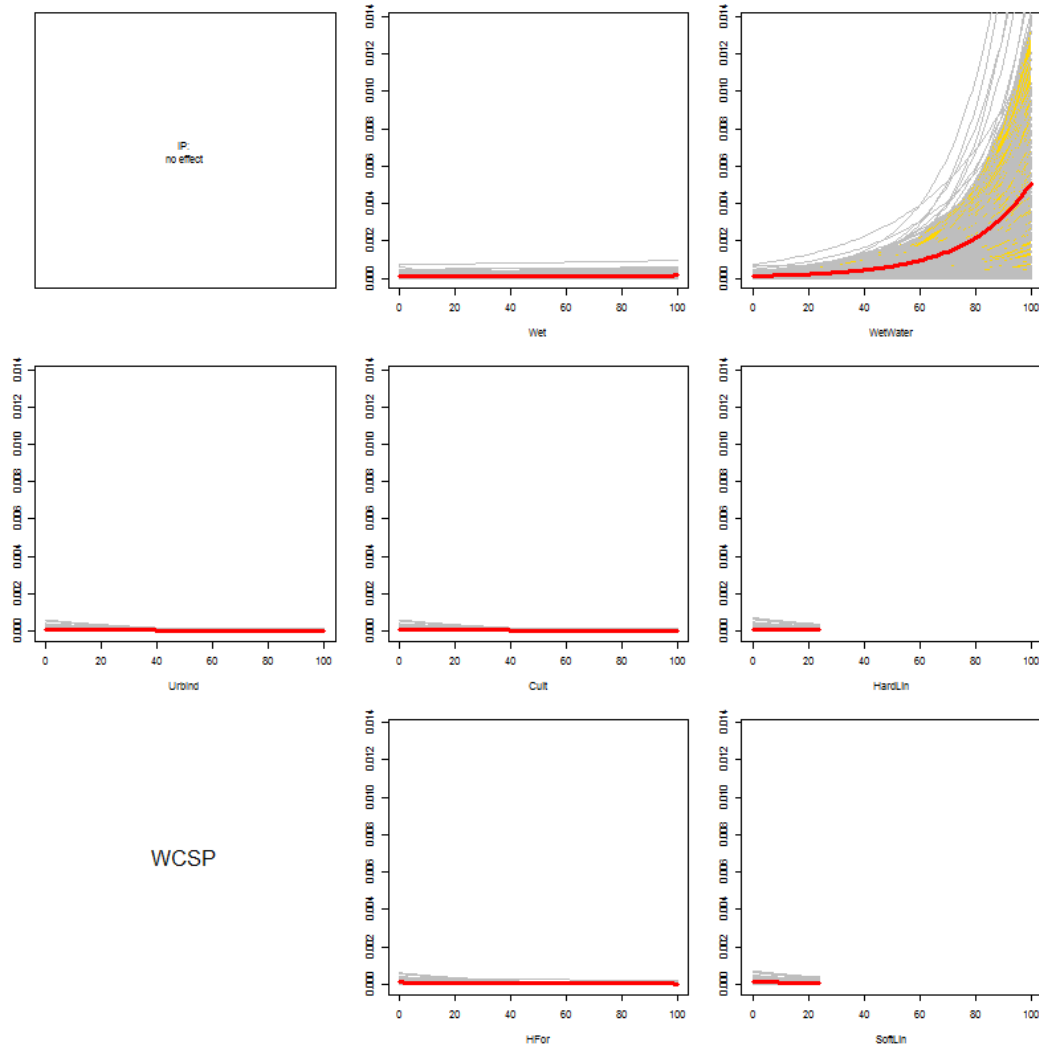


5.70.7 Relative habitat selection



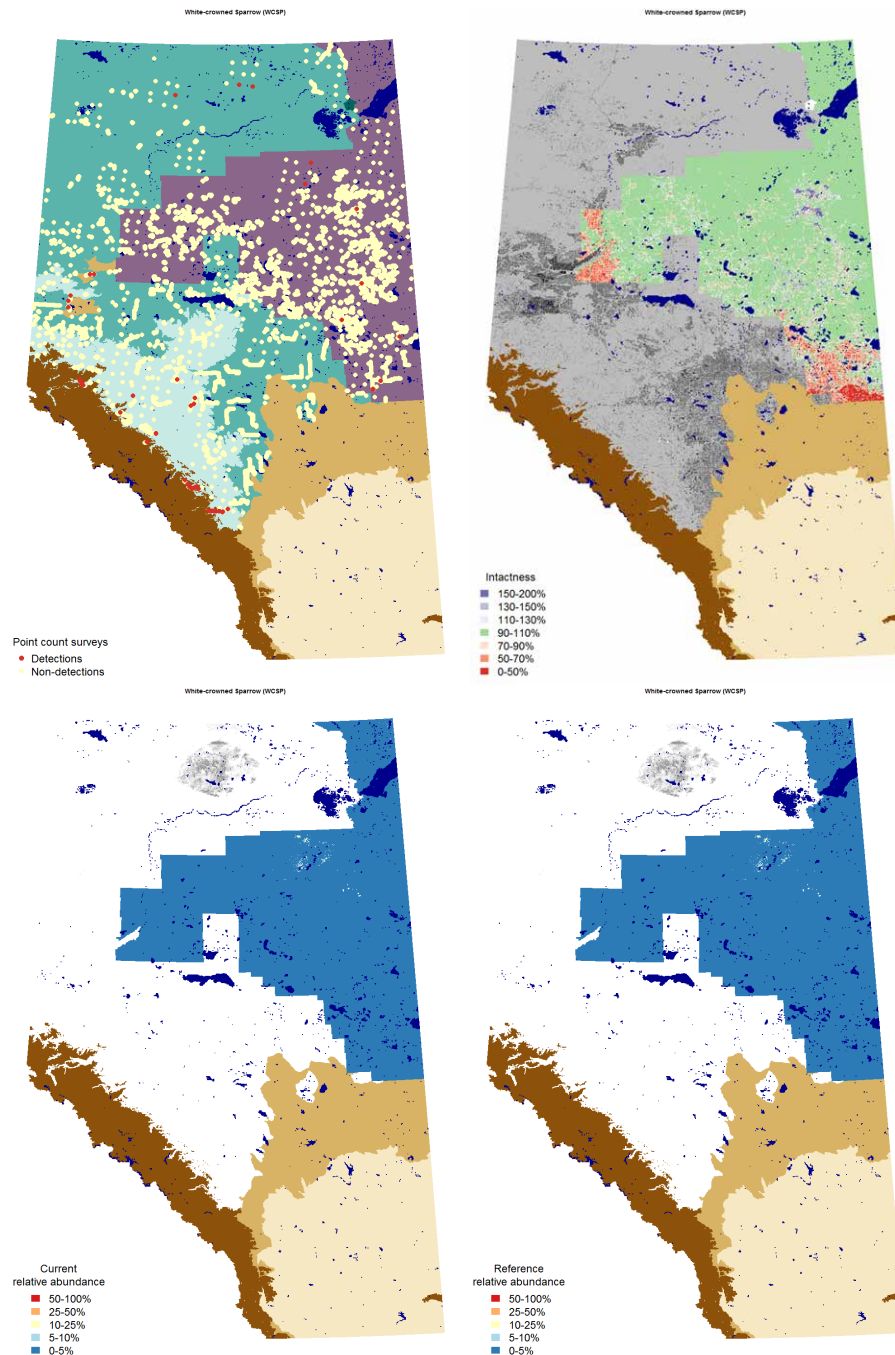
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.70.8 Quarter-section level responses



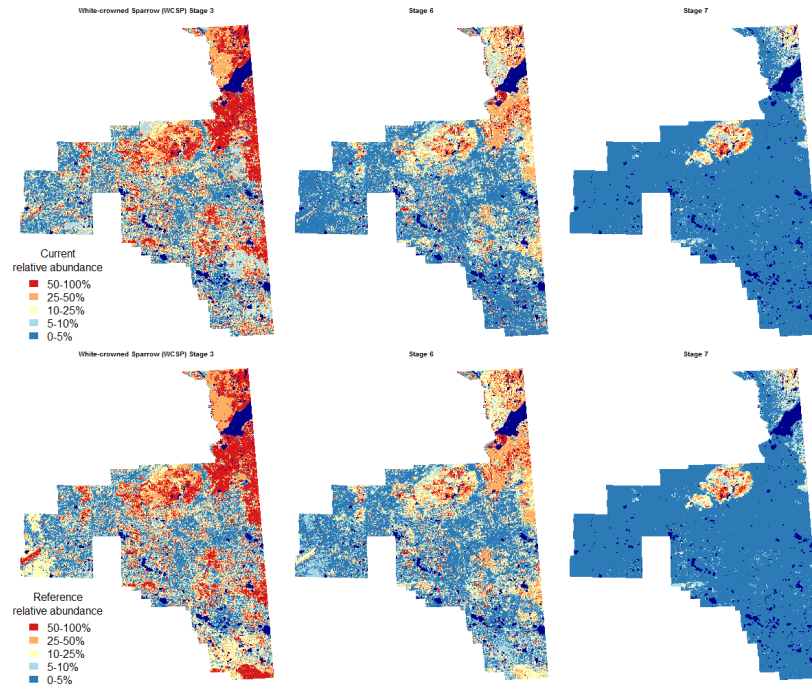
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.70.9 Maps



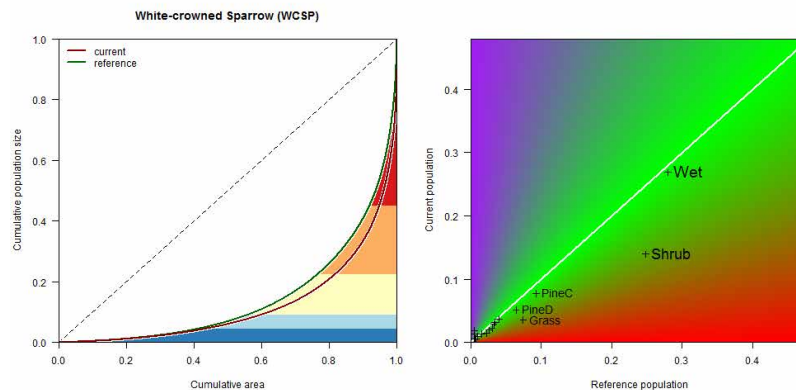
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.70.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.70.11 Population concentration



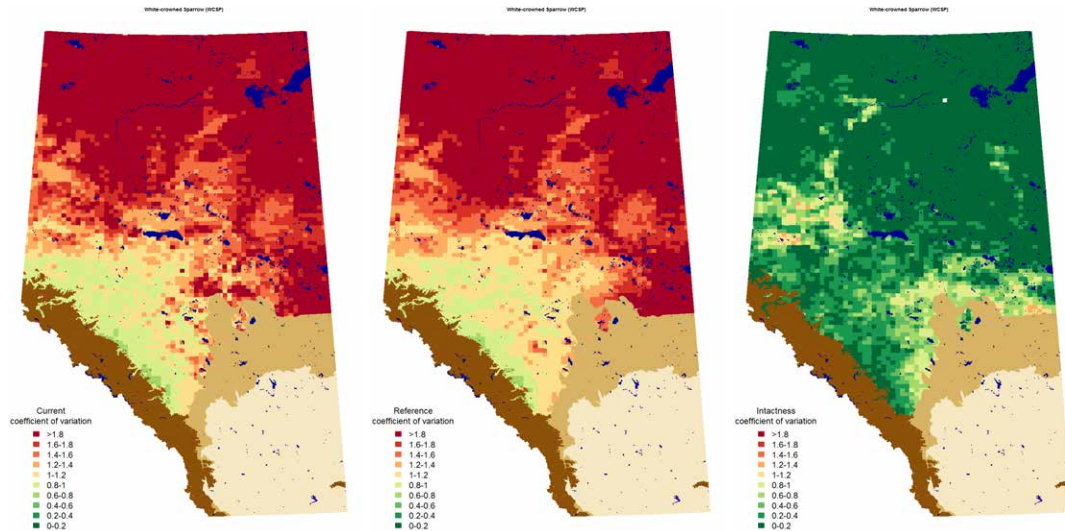
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.70.12 Potential population size

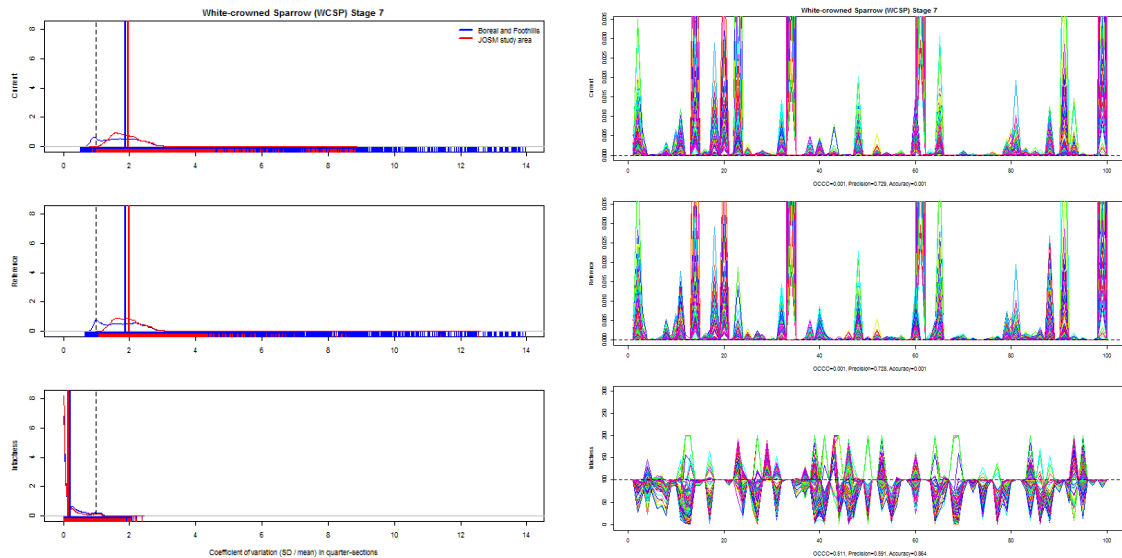
Estimated potential population size of White-crowned Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.0004	0.0000	0.0064	0.0004	0.0000	0.0054
Shrub	0.0002	0.0000	0.0033	0.0003	0.0000	0.0048
PineC	0.0001	0.0000	0.0018	0.0001	0.0000	0.0018
Grass	0.0001	0.0000	0.0008	0.0001	0.0000	0.0015
PineD	0.0001	0.0000	0.0012	0.0001	0.0000	0.0013
PineB	0.0001	0.0000	0.0009	0.0001	0.0000	0.0008
WetConifD	0.0000	0.0000	0.0007	0.0000	0.0000	0.0007
WetConifC	0.0000	0.0000	0.0007	0.0000	0.0000	0.0006
ConifD	0.0000	0.0000	0.0005	0.0000	0.0000	0.0006
ConifC	0.0000	0.0000	0.0005	0.0000	0.0000	0.0005
DecidD	0.0000	0.0000	0.0003	0.0000	0.0000	0.0004
PineA	0.0000	0.0000	0.0003	0.0000	0.0000	0.0003
WetConifB	0.0000	0.0000	0.0002	0.0000	0.0000	0.0002
ConifA	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
ConifB	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
WetConifA	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
DecidC	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
DecidB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
DecidA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedD	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MixedA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cult	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
UrbInd	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
HardLin	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000
HFor	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000
Total	0.0013	0.0000	0.0193	0.0014	0.0000	0.0194
Loss	0.0001	0.0000	0.0005			
Gain	0.0000	0.0000	0.0001			

5.70.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.70.14 Variable selection frequencies

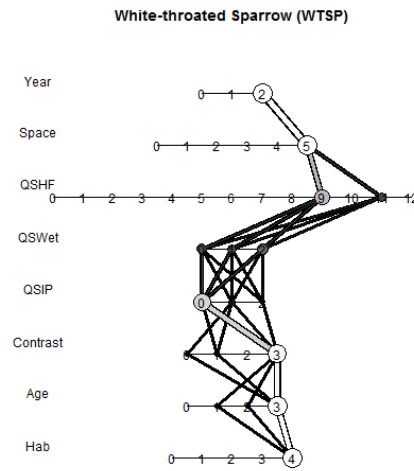
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	7.5	15	. + Habitat
1.3	88.5	177	. + Habitat + isHForC
1.4	4.0	8	. + HabitatB + isHForC
2.0	99.5	199	NULL
2.1	0.5	1	. + Age
3.1	100.0	200	. + ROAD
4.0	100.0	200	NULL
5.0	8.5	17	NULL
5.1	2.5	5	. + pWet_QS
5.2	89.0	178	. + pWetWater_QS
6.0	30.5	61	NULL
6.1	61.0	122	. + THF_QS
6.2	1.5	3	. + Lin_QS + Nonlin_QS
6.5	1.0	2	. + THF_QS + THF2_QS
6.6	2.0	4	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.9	4.0	8	. + Succ_QS + Alien_QS + Alien2_QS
7.1	0.5	1	. + xlat
7.2	52.0	104	. + xlat + xlong
7.3	18.0	36	. + xlat + xlong + xlat:xlong
7.5	29.5	59	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	100.0	200	NULL

5.71 White-throated Sparrow (*Zonotrichia albicollis*)

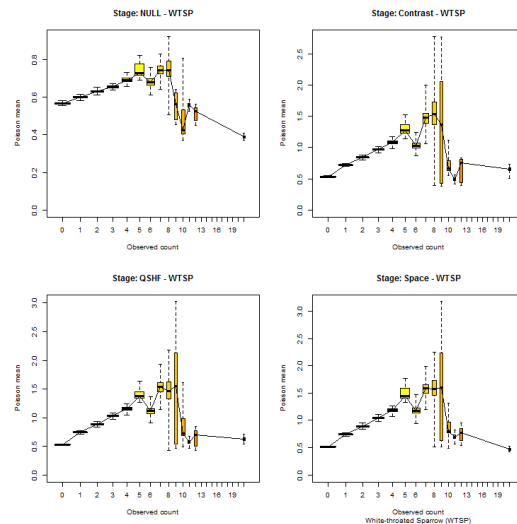
5.71.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

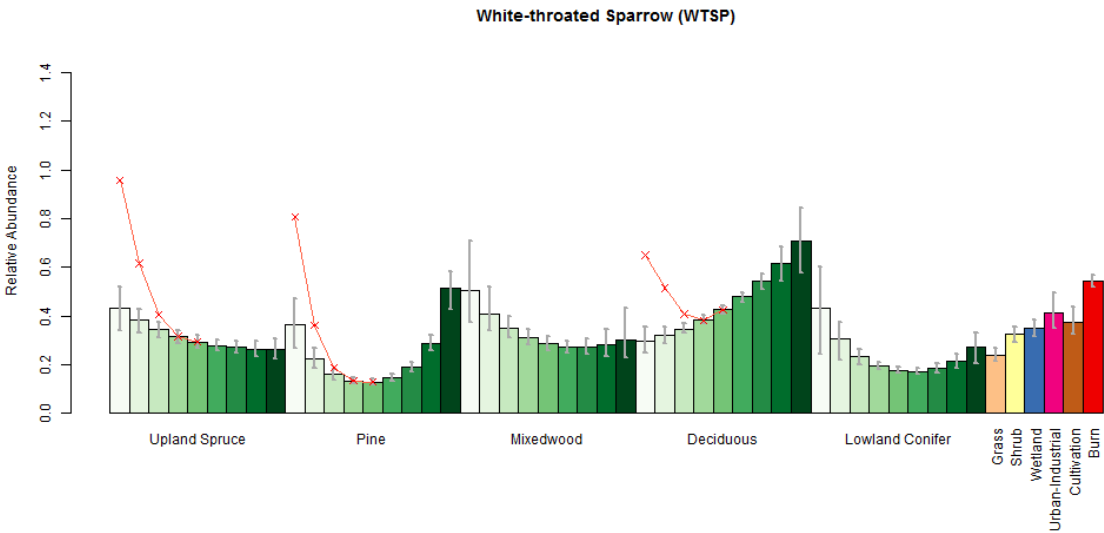


5.71.2 Cross validation

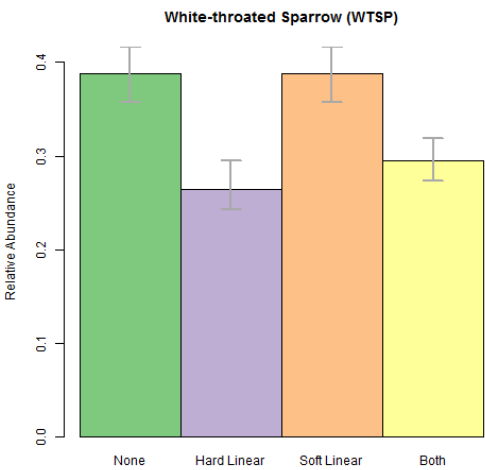
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.71.3 Point level habitat associations

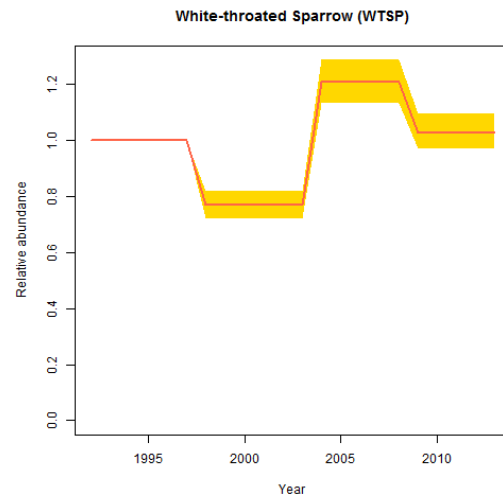


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

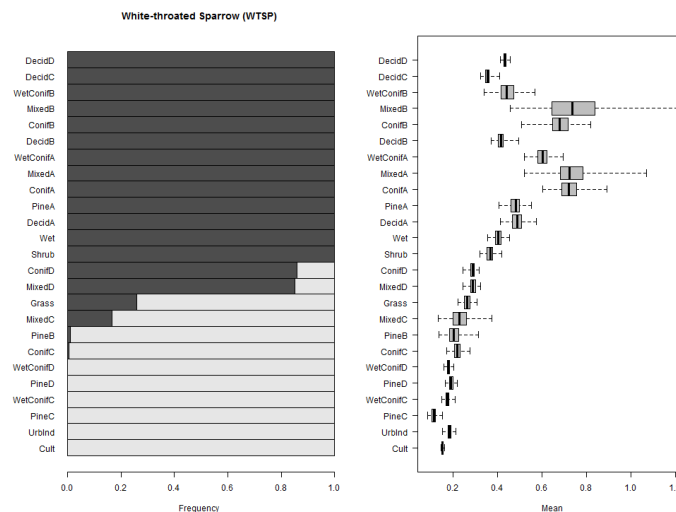


5.71.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



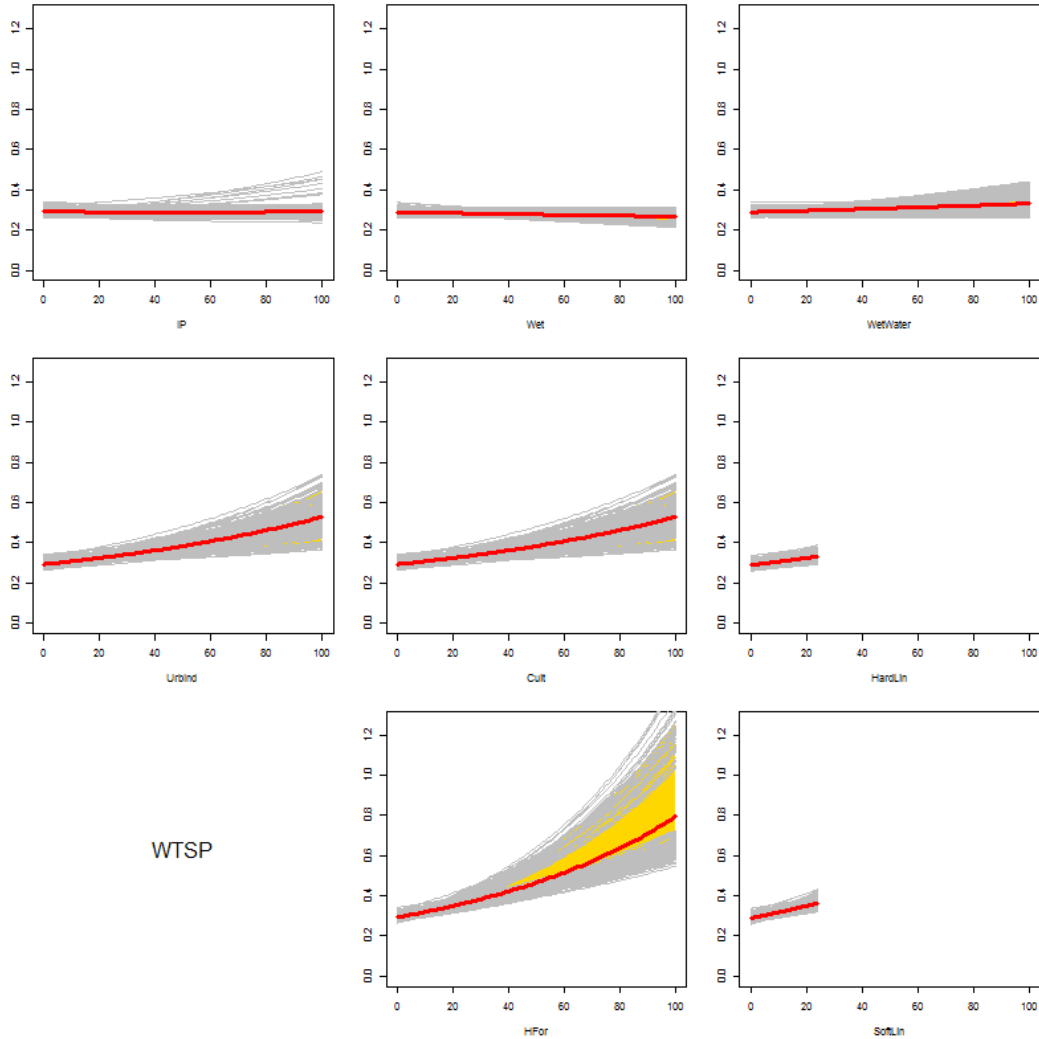
5.71.5 Habitat suitability ranking for patch delineation



Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

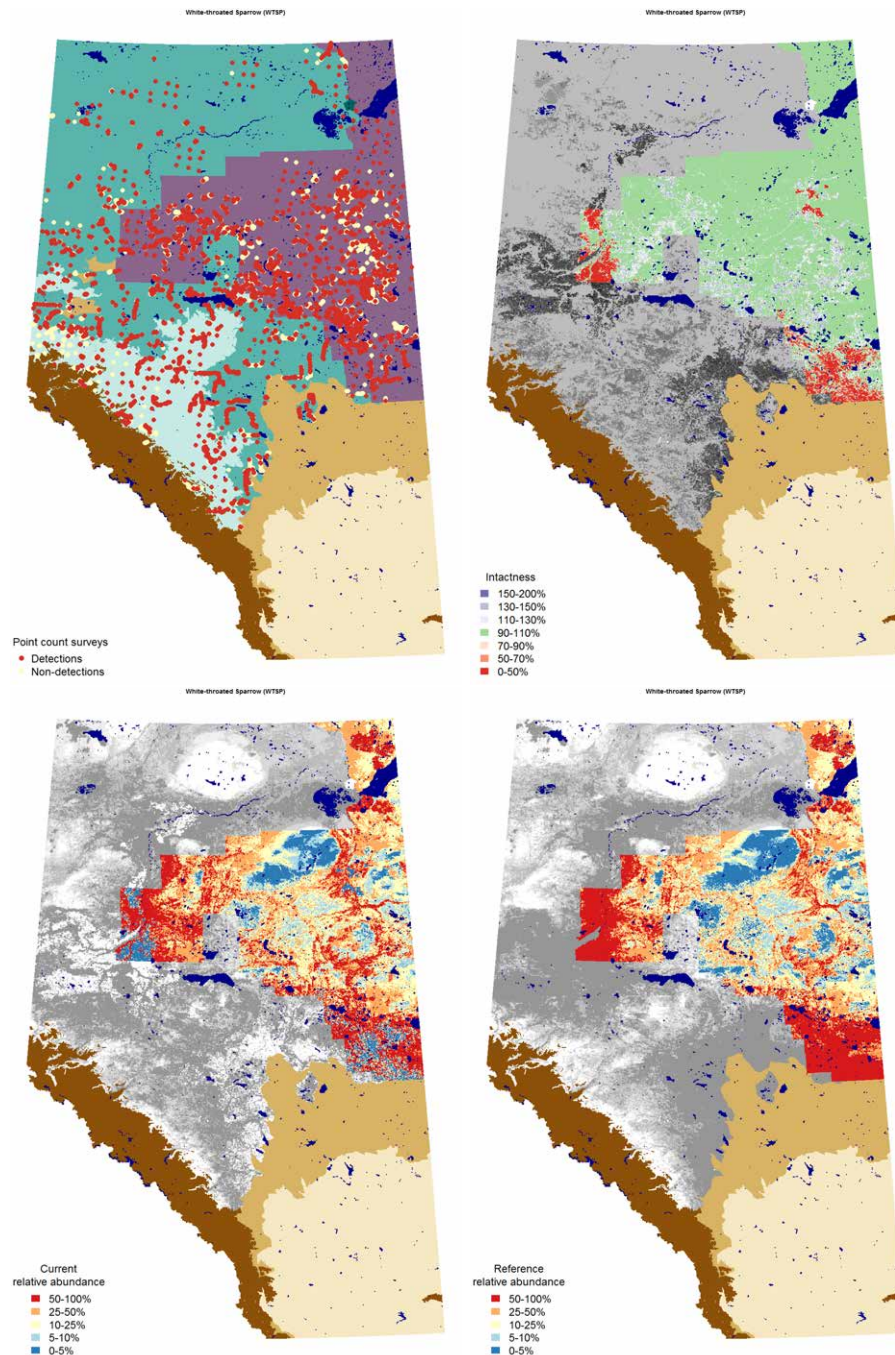
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.71.8 Quarter-section level responses



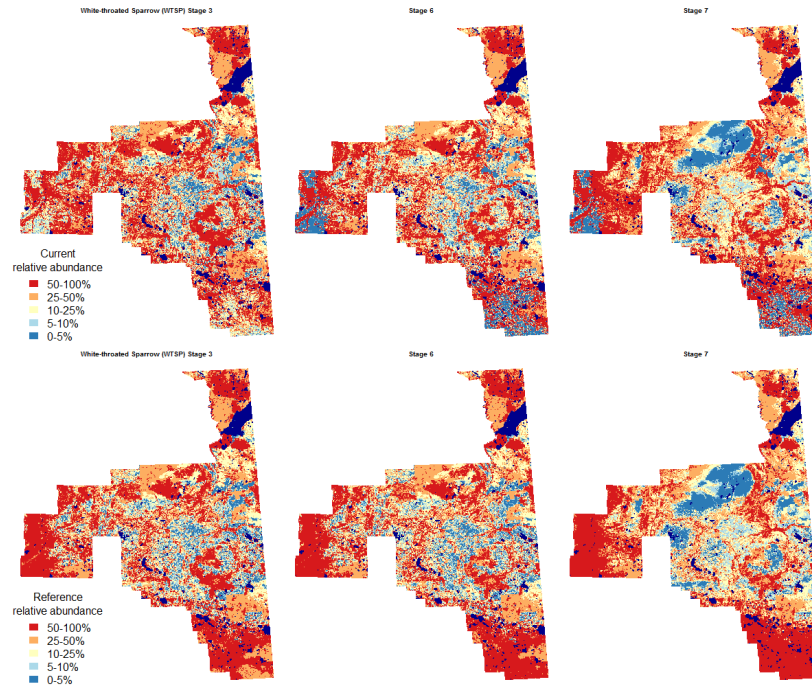
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.71.9 Maps



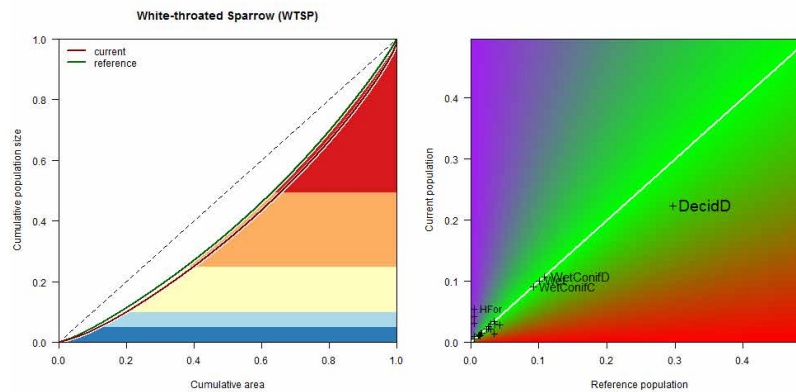
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase (>100%) and decrease (<100%). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.71.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.71.11 Population concentration



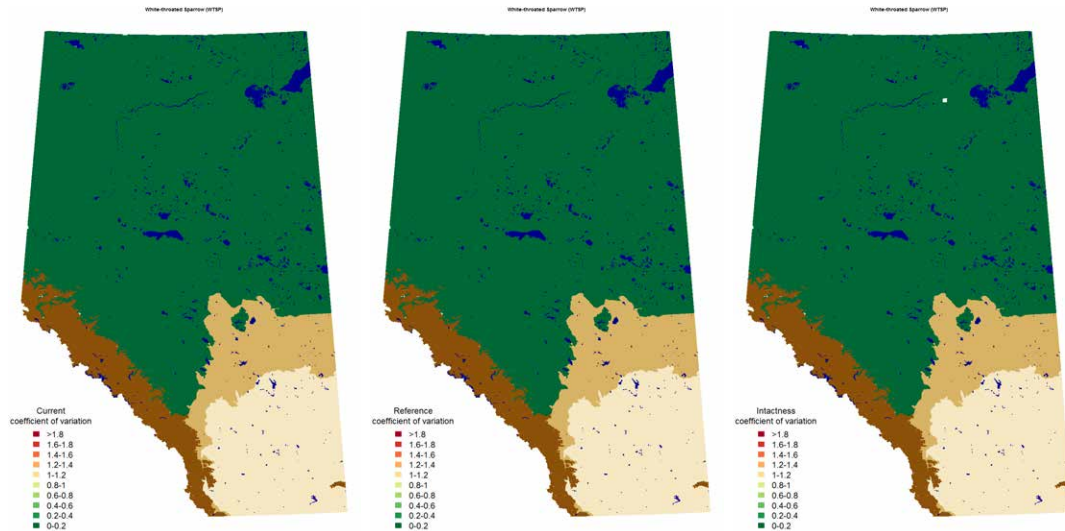
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.71.12 Potential population size

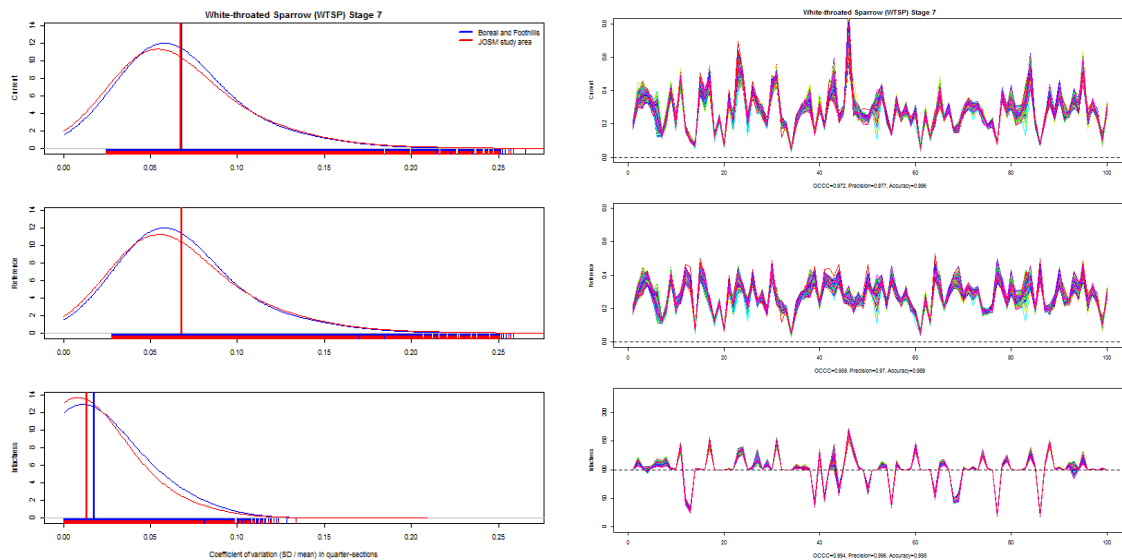
Estimated potential population size of White-throated Sparrow in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.9424	0.8991	0.9867	1.2534	1.1884	1.3161
WetConifD	0.4528	0.4320	0.4740	0.4592	0.4354	0.4822
Wet	0.4232	0.4038	0.4431	0.4256	0.4036	0.4469
WetConifC	0.3819	0.3643	0.3998	0.3913	0.3710	0.4108
Shrub	0.1221	0.1165	0.1278	0.1825	0.1730	0.1916
ConifD	0.1289	0.1230	0.1350	0.1488	0.1411	0.1562
MixedD	0.1255	0.1198	0.1314	0.1480	0.1403	0.1554
Grass	0.0563	0.0538	0.0590	0.1479	0.1403	0.1553
WetConifA	0.1452	0.1385	0.1520	0.1455	0.1379	0.1527
DecidC	0.0927	0.0885	0.0971	0.1275	0.1209	0.1339
PineB	0.1267	0.1209	0.1327	0.1273	0.1207	0.1337
WetConifB	0.1102	0.1051	0.1153	0.1127	0.1069	0.1184
ConifC	0.0938	0.0895	0.0982	0.1090	0.1034	0.1145
ConifA	0.0896	0.0855	0.0938	0.1004	0.0952	0.1055
ConifB	0.0607	0.0579	0.0636	0.0685	0.0649	0.0719
PineA	0.0641	0.0612	0.0671	0.0656	0.0622	0.0689
DecidB	0.0449	0.0429	0.0470	0.0588	0.0558	0.0617
PineC	0.0508	0.0485	0.0532	0.0550	0.0521	0.0577
PineD	0.0431	0.0411	0.0451	0.0471	0.0447	0.0495
DecidA	0.0108	0.0103	0.0113	0.0172	0.0164	0.0181
MixedA	0.0121	0.0116	0.0127	0.0163	0.0154	0.0171
MixedB	0.0109	0.0104	0.0114	0.0125	0.0119	0.0131
MixedC	0.0062	0.0059	0.0065	0.0076	0.0072	0.0080
Cult	0.1763	0.1682	0.1846	0.0000	0.0000	0.0000
UrbInd	0.0397	0.0379	0.0416	0.0000	0.0000	0.0000
HardLin	0.0048	0.0046	0.0051	0.0000	0.0000	0.0000
SoftLin	0.1304	0.1244	0.1366	0.0000	0.0000	0.0000
HFor	0.2275	0.2170	0.2382	0.0000	0.0000	0.0000
Total	4.1739	3.9821	4.3701	4.2277	4.0087	4.4393
Loss	0.3185	0.2752	0.3550			
Gain	0.2671	0.2137	0.3330			

5.71.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.71.14 Variable selection frequencies

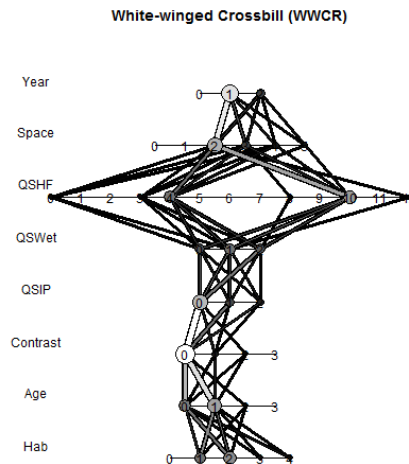
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.4	100.0	200	. + HabitatB + isHForC
2.1	0.5	1	. + Age
2.2	0.5	1	. + Age + Age2
			. + Age + Age2 + Age:isMix + Age:isPine
2.3	99.0	198	+ Age:isUplConif + Age:isWetConif +
			Age2:isMix + Age2:isPine + Age2:isUplConif
			+ Age2:isWetConif
3.0	0.5	1	NULL
3.1	2.5	5	. + ROAD
3.3	97.0	194	. + ROAD + SoftLin_PC
4.0	84.0	168	NULL
4.1	11.5	23	. + Remn_QS
4.2	4.5	9	. + Remn_QS + Remn2_QS
5.0	32.5	65	NULL
5.1	28.0	56	. + pWet_QS
5.2	39.5	79	. + pWetWater_QS
6.9	73.0	146	. + Succ_QS + Alien_QS + Alien2_QS
6.11	27.0	54	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.5	100.0	200	. + xMAP + xPET + xMAT + xCMD +
			xMAP:xPET + xMAT:xCMD
8.2	100.0	200	. + YR5F

5.72 White-winged Crossbill (*Loxia leucoptera*)

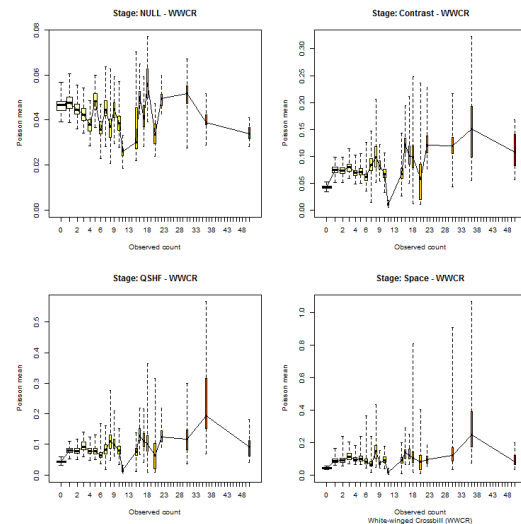
5.72.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

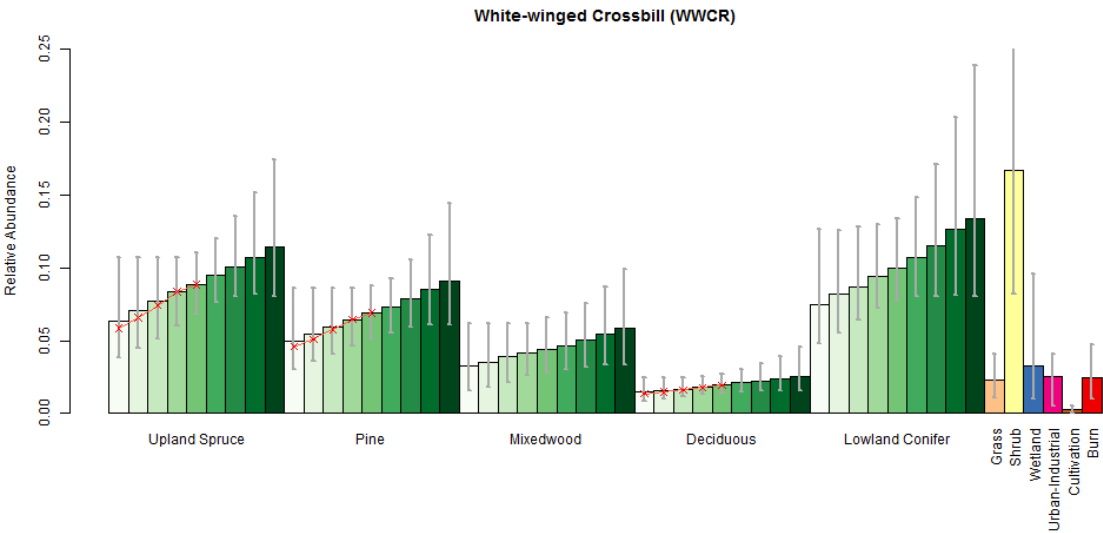


5.72.2 Cross validation

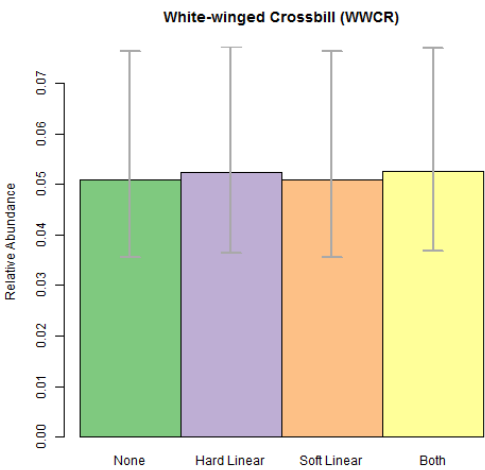
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.72.3 Point level habitat associations

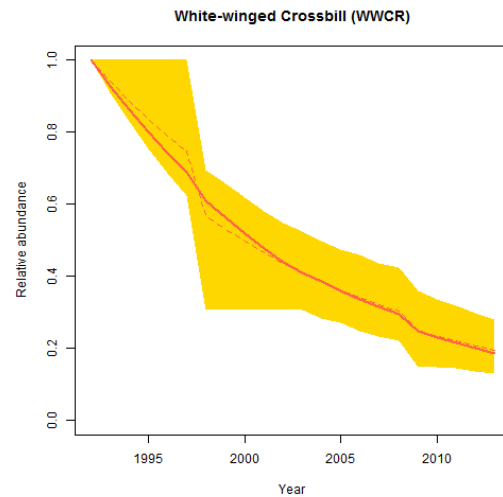


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

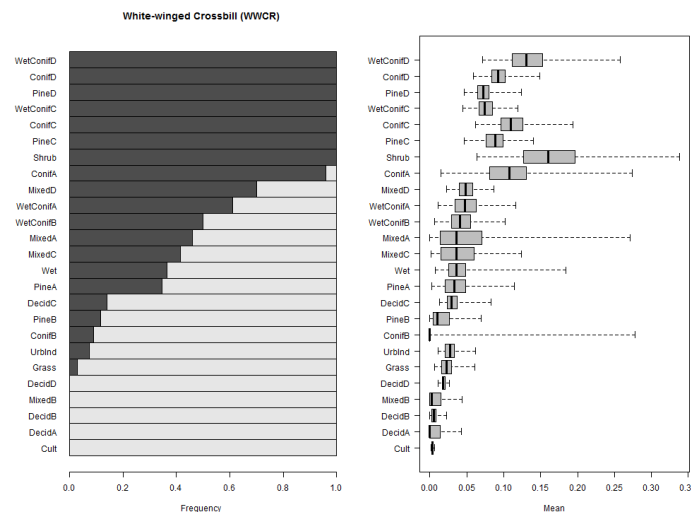


5.72.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



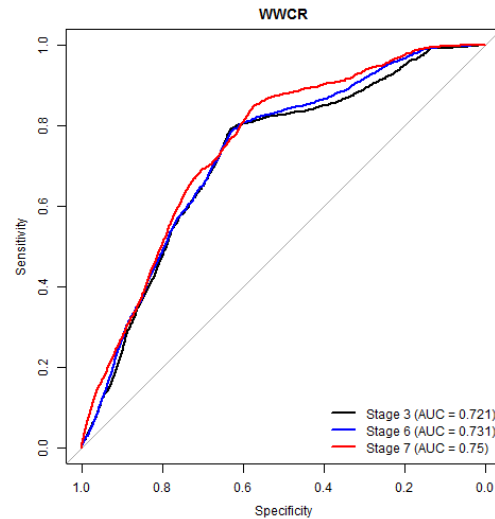
5.72.5 Habitat suitability ranking for patch delineation



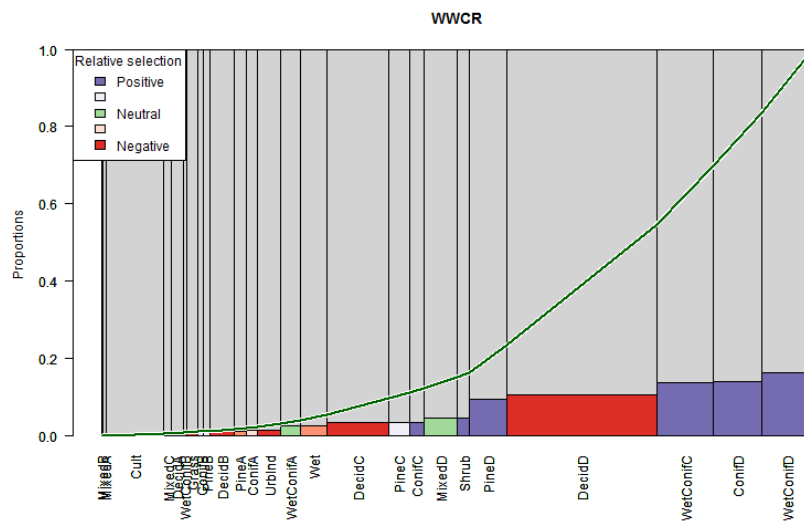
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.72.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

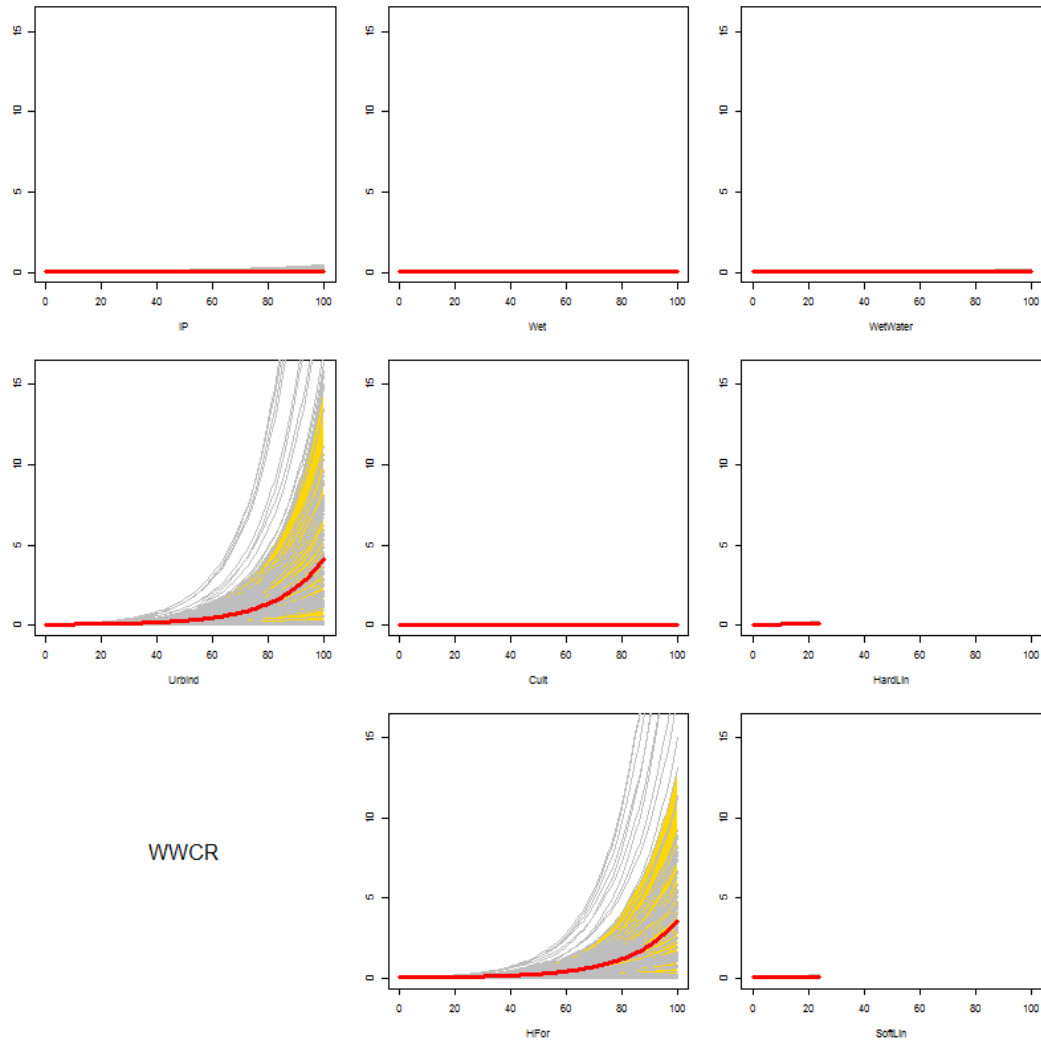


5.72.7 Relative habitat selection



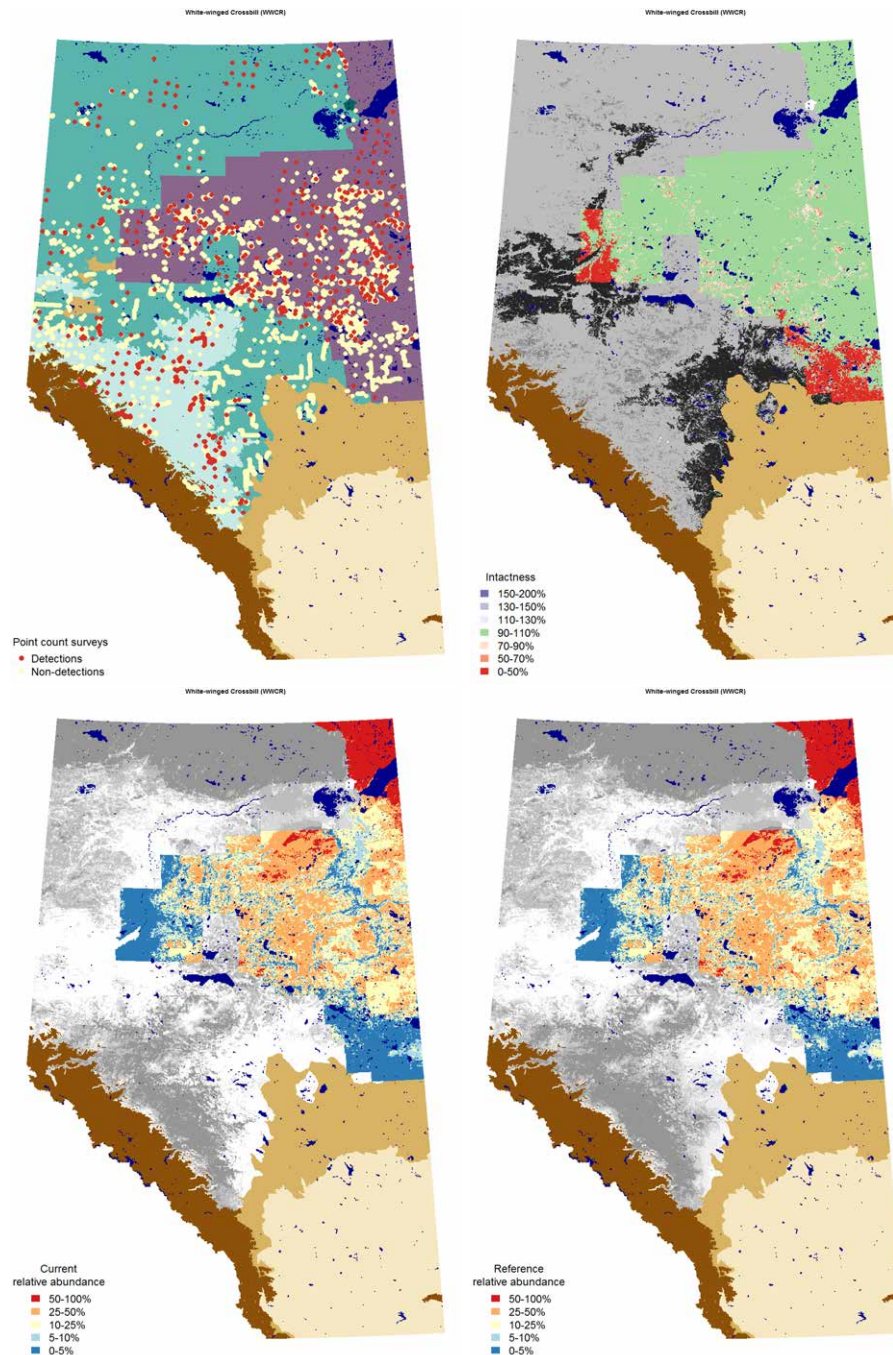
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.72.8 Quarter-section level responses



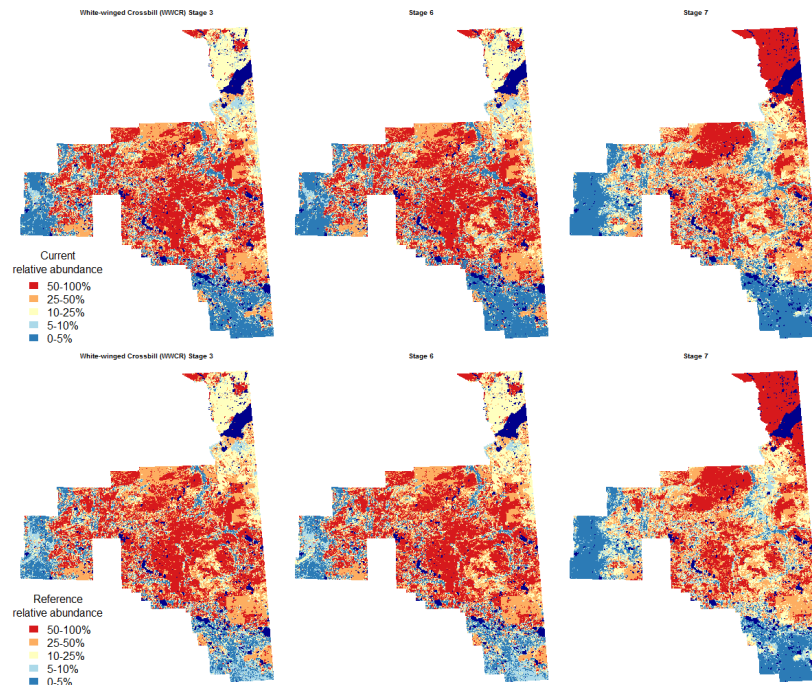
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.72.9 Maps



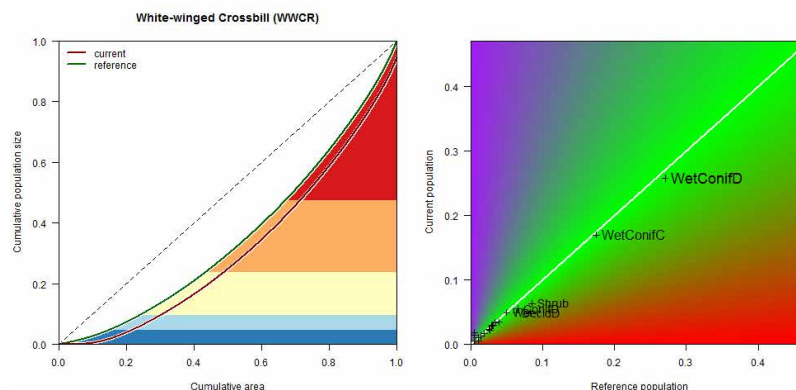
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.72.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.72.11 Population concentration



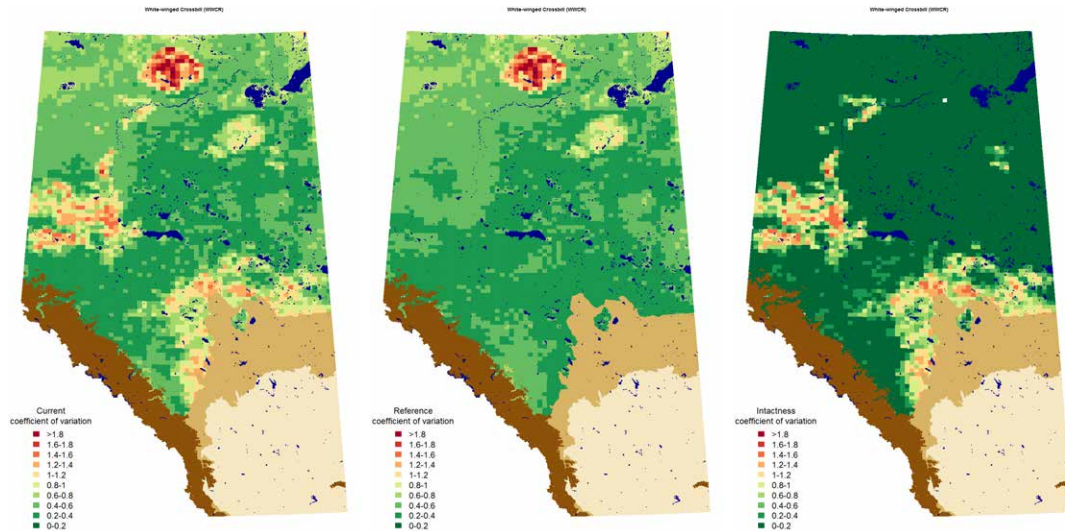
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.72.12 Potential population size

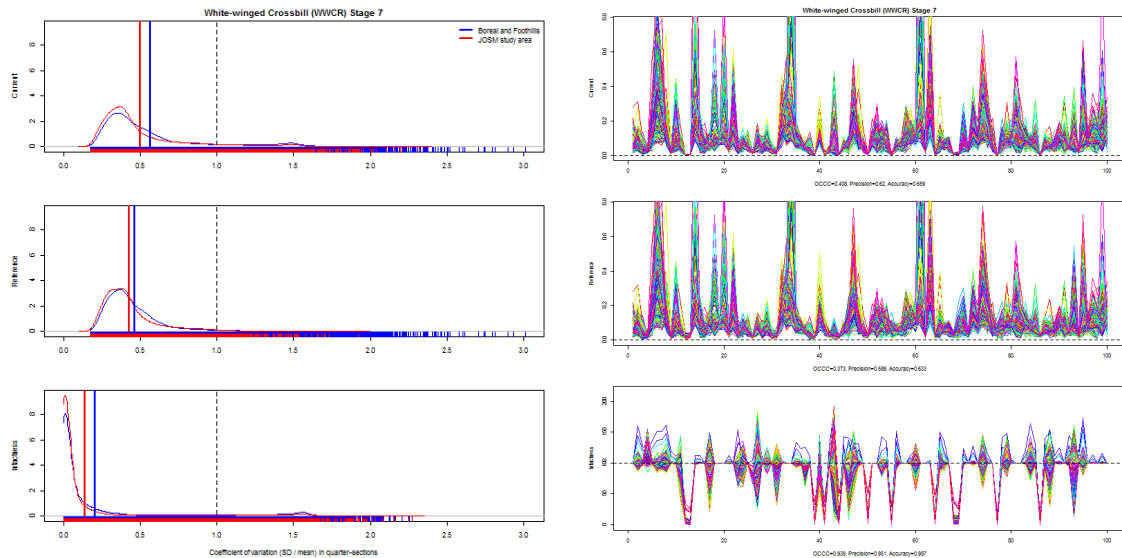
Estimated potential population size of White-winged Crossbill in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.2697	0.1988	0.4084	0.2810	0.2067	0.4218
WetConifC	0.1780	0.1312	0.2695	0.1818	0.1337	0.2729
Shrub	0.0663	0.0489	0.1004	0.0887	0.0652	0.1331
ConifD	0.0576	0.0425	0.0873	0.0687	0.0505	0.1031
DecidD	0.0507	0.0373	0.0767	0.0657	0.0484	0.0987
Wet	0.0517	0.0381	0.0782	0.0522	0.0384	0.0784
ConifC	0.0359	0.0264	0.0543	0.0409	0.0301	0.0614
WetConifB	0.0347	0.0256	0.0526	0.0355	0.0261	0.0533
PineC	0.0312	0.0230	0.0473	0.0328	0.0241	0.0492
PineB	0.0309	0.0228	0.0468	0.0310	0.0228	0.0466
WetConifA	0.0302	0.0223	0.0457	0.0307	0.0226	0.0460
MixedD	0.0232	0.0171	0.0351	0.0276	0.0203	0.0414
PineD	0.0248	0.0183	0.0376	0.0263	0.0193	0.0395
ConifA	0.0176	0.0130	0.0267	0.0200	0.0147	0.0300
ConifB	0.0133	0.0098	0.0202	0.0154	0.0113	0.0231
Grass	0.0055	0.0041	0.0084	0.0117	0.0086	0.0176
PineA	0.0109	0.0081	0.0166	0.0111	0.0082	0.0167
DecidC	0.0059	0.0043	0.0089	0.0080	0.0059	0.0120
DecidB	0.0040	0.0030	0.0061	0.0049	0.0036	0.0074
DecidA	0.0009	0.0007	0.0014	0.0014	0.0010	0.0021
MixedB	0.0012	0.0009	0.0019	0.0014	0.0010	0.0021
MixedC	0.0010	0.0007	0.0015	0.0012	0.0009	0.0018
MixedA	0.0008	0.0006	0.0012	0.0011	0.0008	0.0017
Cult	0.0026	0.0019	0.0039	0.0000	0.0000	0.0000
UrbInd	0.0046	0.0034	0.0070	0.0000	0.0000	0.0000
HardLin	0.0008	0.0006	0.0012	0.0000	0.0000	0.0000
SoftLin	0.0150	0.0111	0.0228	0.0000	0.0000	0.0000
HFor	0.0193	0.0142	0.0292	0.0000	0.0000	0.0000
Total	0.9885	0.7285	1.4968	1.0391	0.7644	1.5600
Loss	0.0686	0.0366	0.1187			
Gain	0.0135	0.0002	0.0437			

5.72.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.72.14 Variable selection frequencies

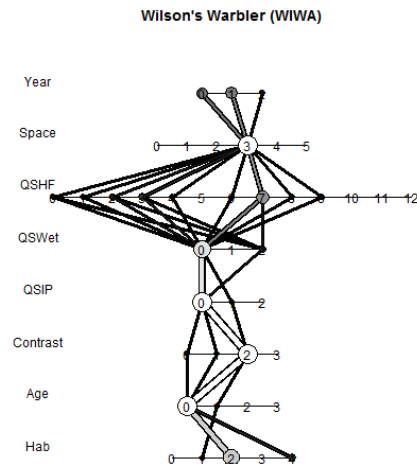
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	39.0	78	. + Habitat
1.2	48.5	97	. + HabitatB
1.3	6.0	12	. + Habitat + isHForC
1.4	6.5	13	. + HabitatB + isHForC
2.0	42.0	84	NULL
2.1	56.0	112	. + Age
2.2	2.0	4	. + Age + Age2
3.0	88.5	177	NULL
3.1	9.0	18	. + ROAD
3.2	2.5	5	. + SoftLin_PC
4.0	63.5	127	NULL
4.1	25.0	50	. + Remn_QS
4.2	11.5	23	. + Remn_QS + Remn2_QS
5.0	29.0	58	NULL
5.1	39.5	79	. + pWet_QS
5.2	31.5	63	. + pWetWater_QS
6.0	3.0	6	NULL
6.3	3.0	6	. + Succ_QS + Alien_QS
6.4	40.0	80	. + Succ_QS + Noncult_QS + Cult_QS
6.8	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.10	53.0	106	. + Succ_QS + Noncult_QS + Cult_QS + Noncult2_QS
6.12	0.5	1	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
7.2	61.0	122	. + xlat + xlong
7.3	23.0	46	. + xlat + xlong + xlat:xlong
7.4	9.0	18	. + xMAP + xPET + xMAT + xCMD
7.5	7.0	14	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	78.5	157	. + xYEAR
8.2	21.5	43	. + YR5F

5.73 Wilson's Warbler (*Cardellina pusilla*)

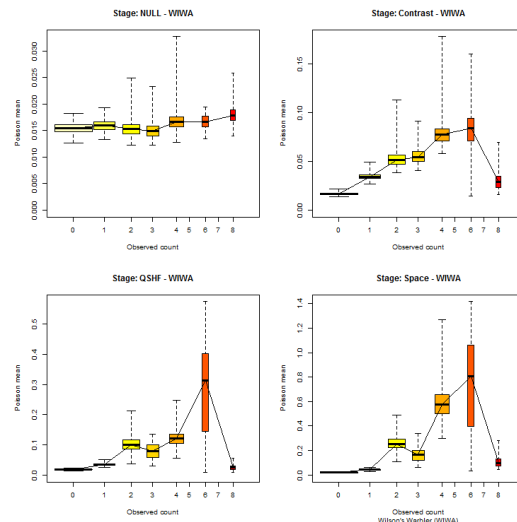
5.73.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

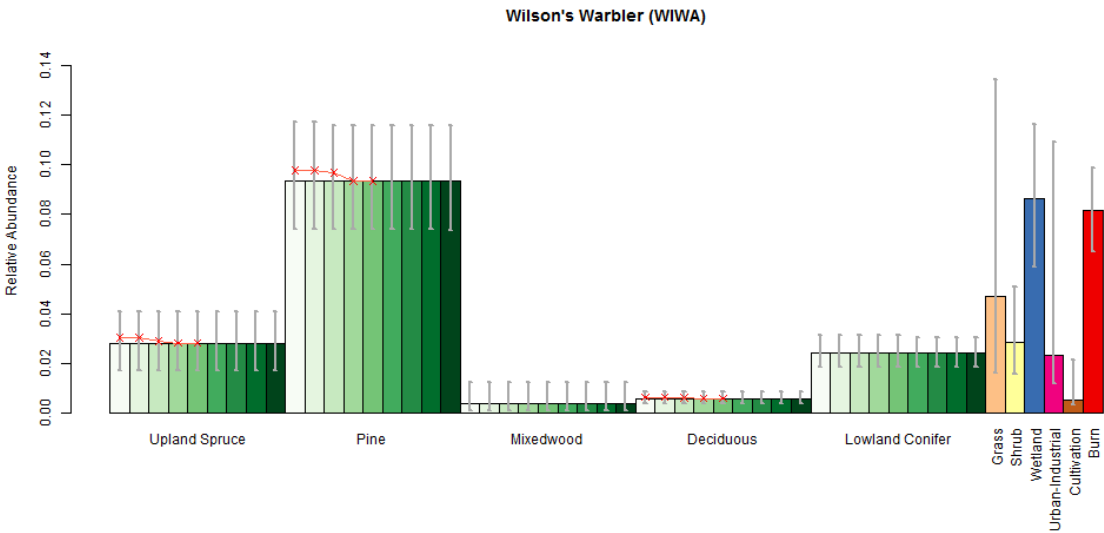


5.73.2 Cross validation

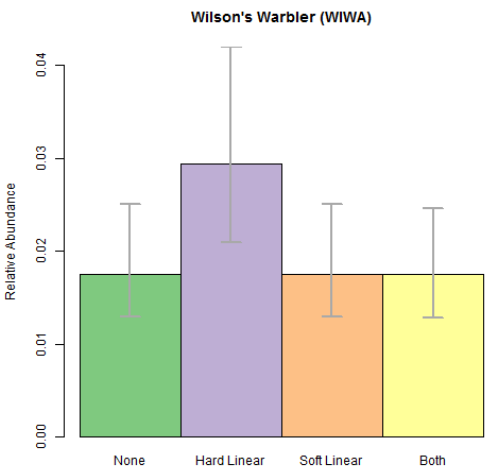
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.73.3 Point level habitat associations

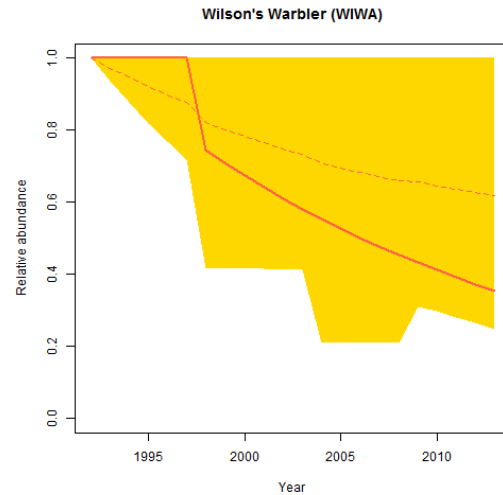


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

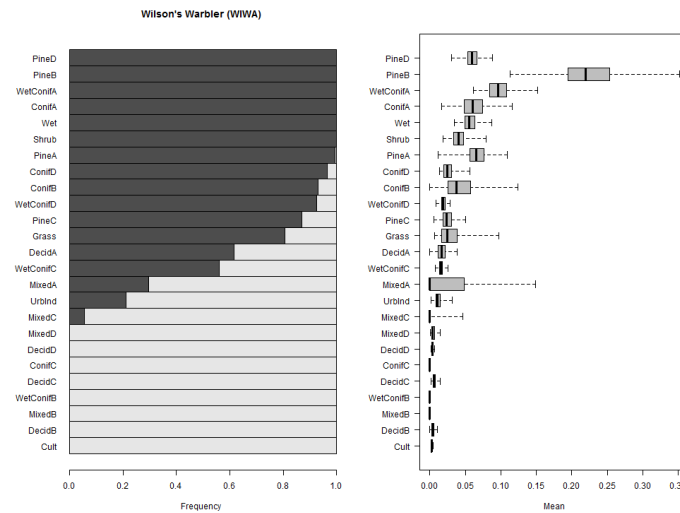


5.73.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



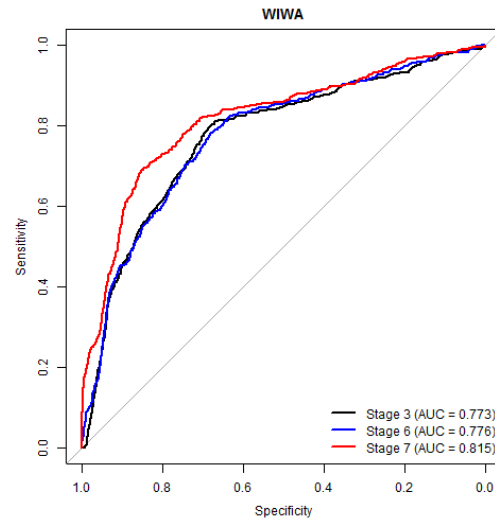
5.73.5 Habitat suitability ranking for patch delineation



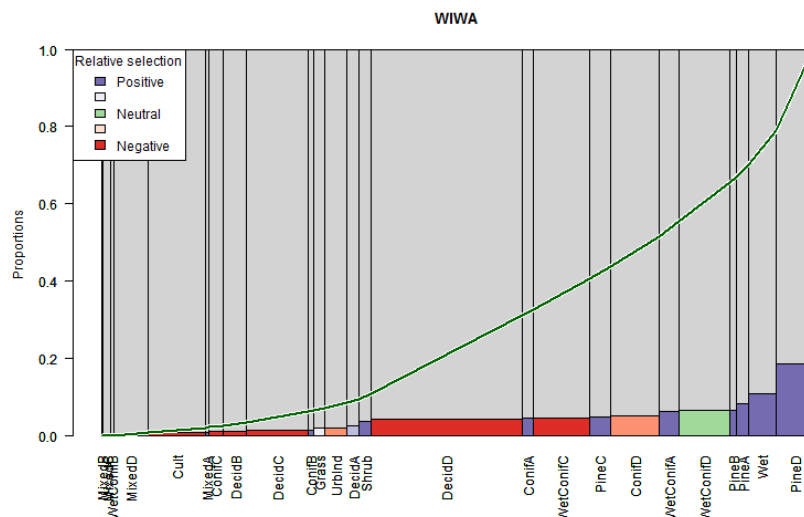
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.73.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

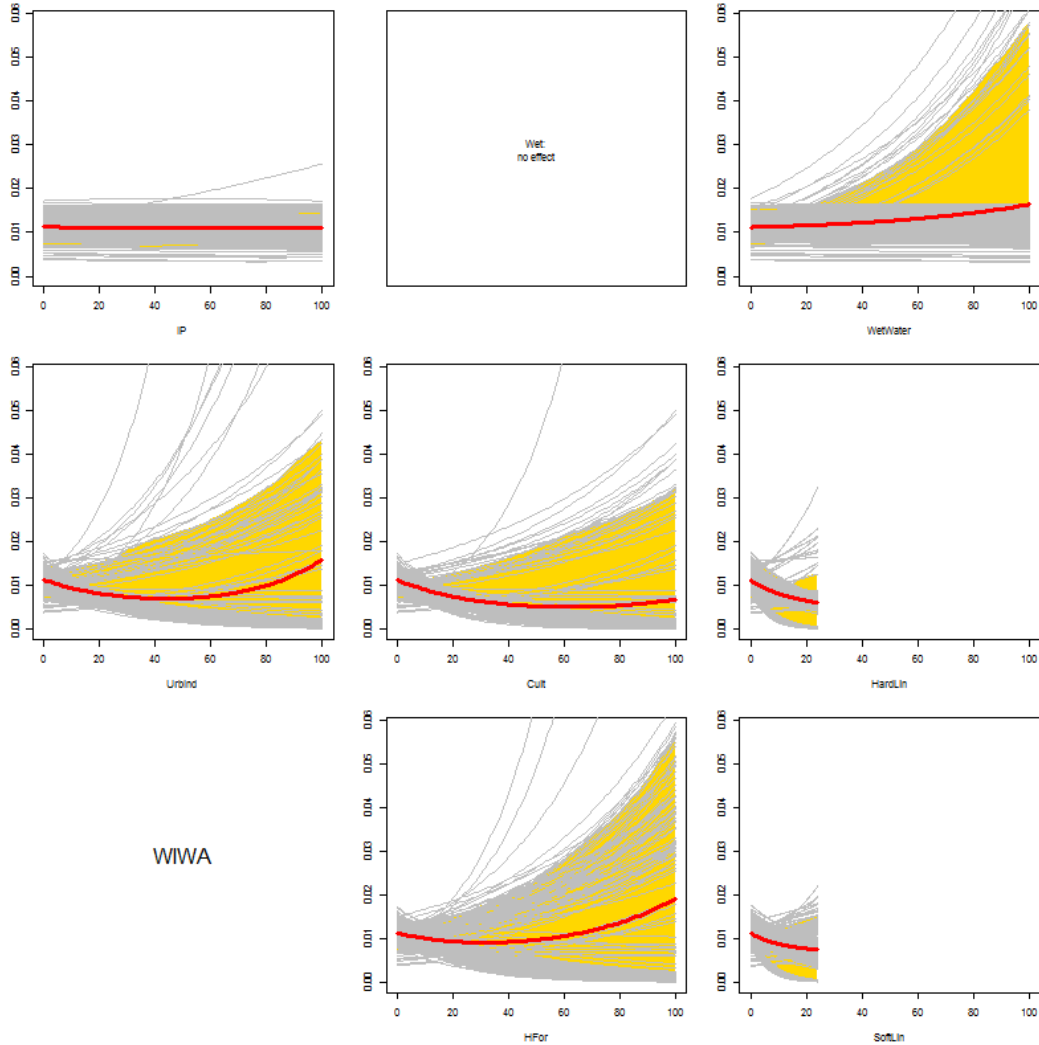


5.73.7 Relative habitat selection



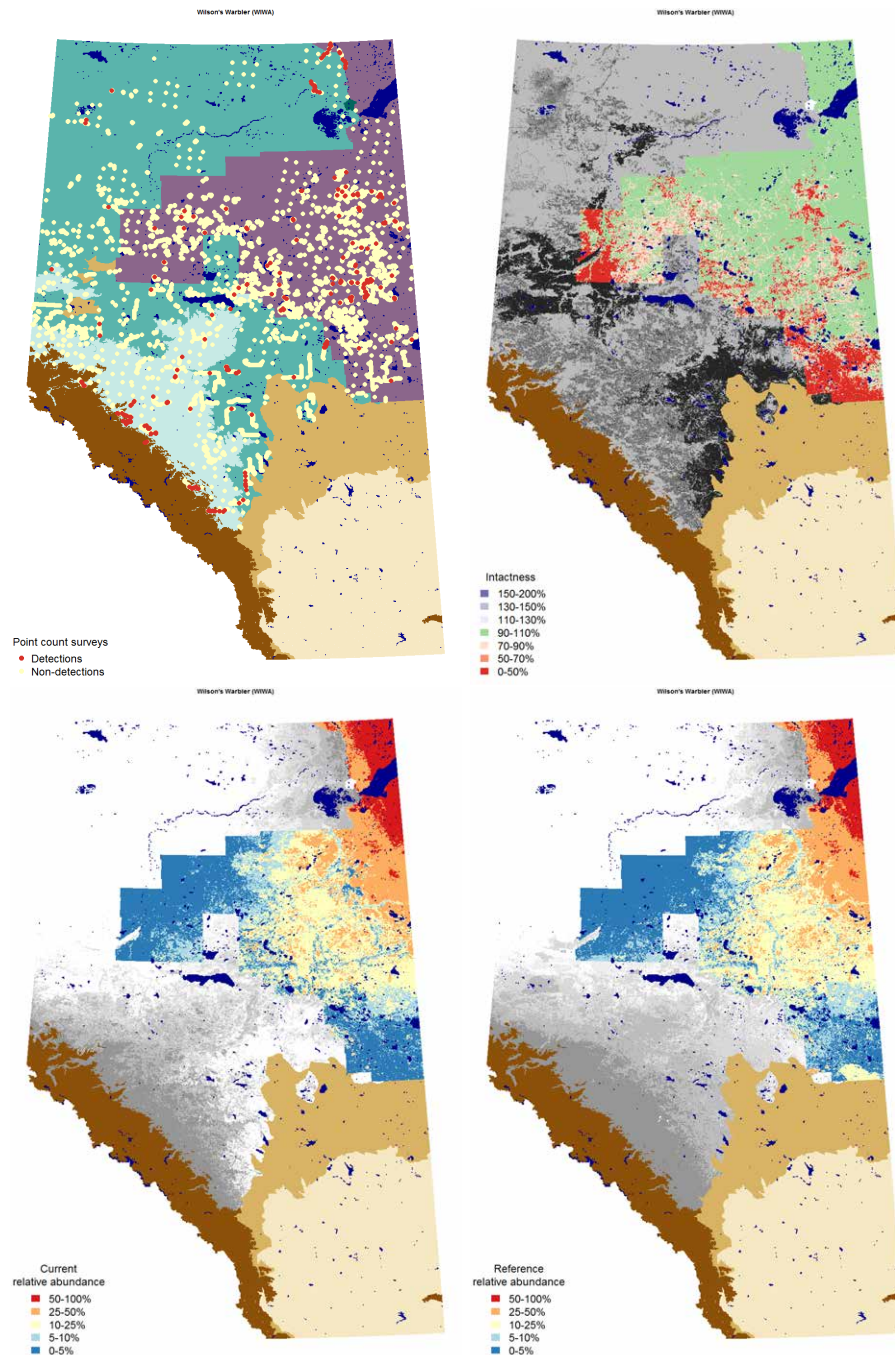
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.73.8 Quarter-section level responses



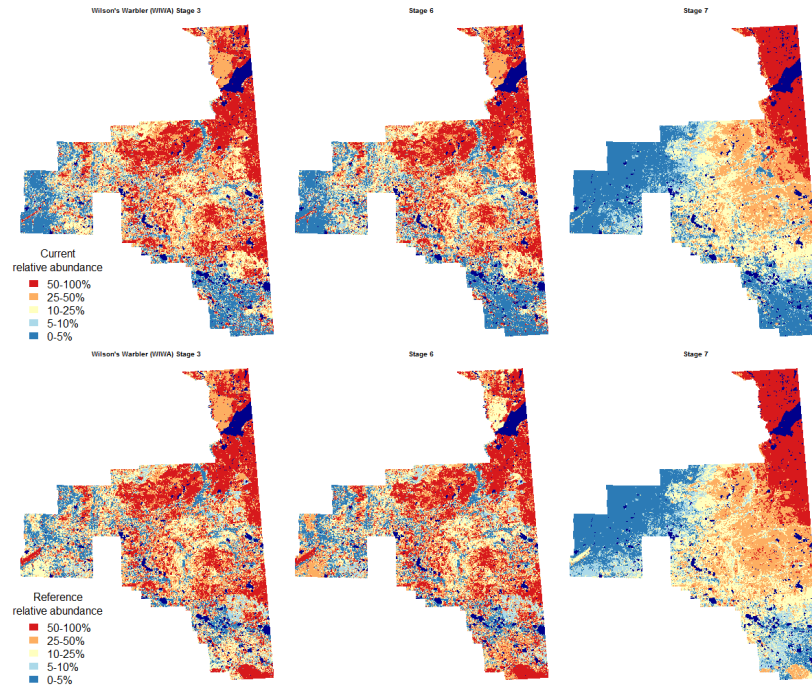
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.73.9 Maps



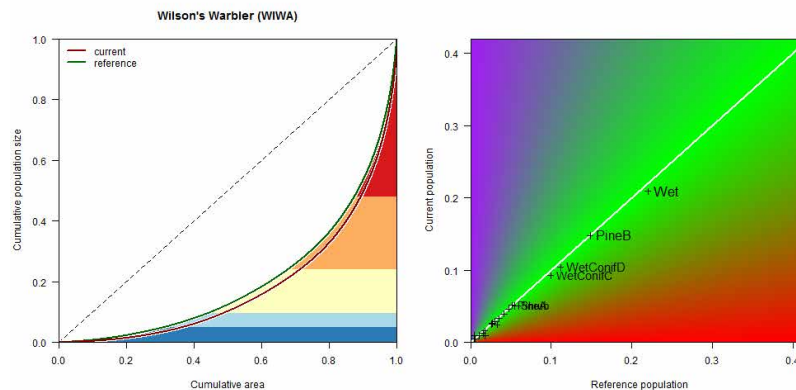
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.73.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.73.11 Population concentration



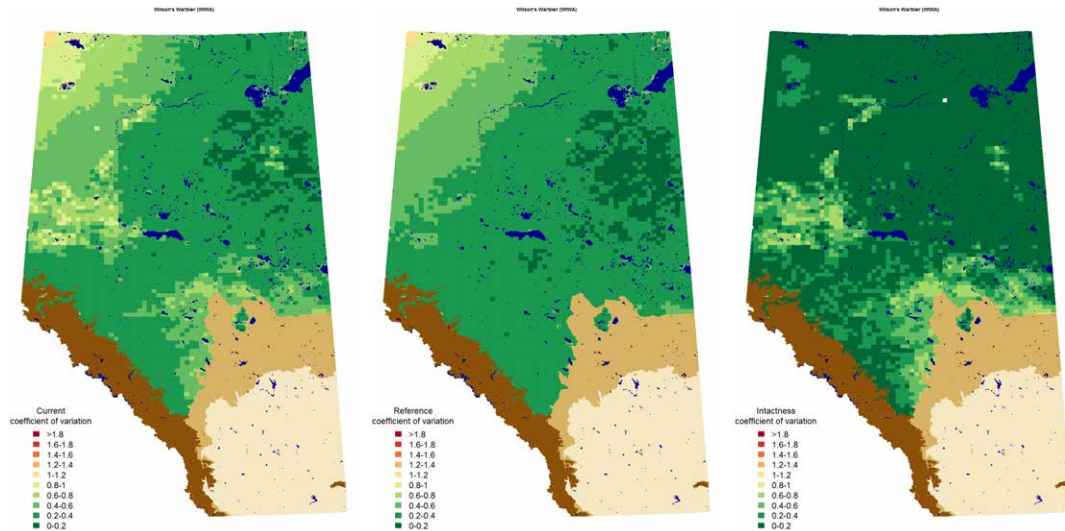
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.73.12 Potential population size

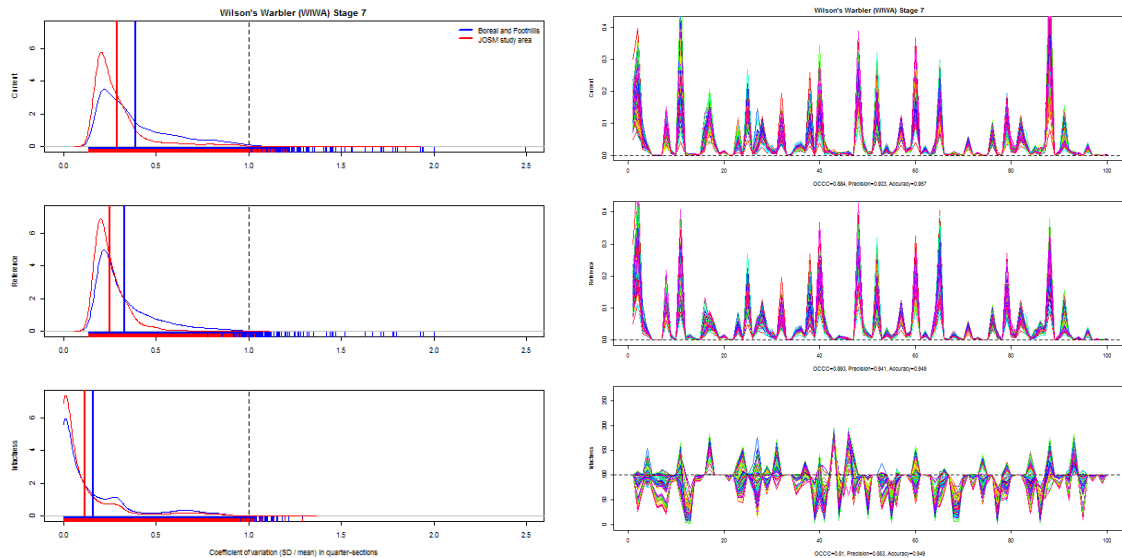
Estimated potential population size of Wilson's Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
Wet	0.1101	0.0825	0.1440	0.1150	0.0891	0.1536
PineB	0.0778	0.0583	0.1018	0.0775	0.0601	0.1036
WetConifD	0.0546	0.0409	0.0715	0.0583	0.0451	0.0778
WetConifC	0.0486	0.0364	0.0636	0.0518	0.0401	0.0692
Shrub	0.0266	0.0199	0.0348	0.0287	0.0223	0.0384
PineA	0.0269	0.0202	0.0352	0.0271	0.0210	0.0362
WetConifB	0.0244	0.0183	0.0319	0.0246	0.0191	0.0329
PineC	0.0208	0.0156	0.0272	0.0217	0.0168	0.0289
PineD	0.0172	0.0129	0.0225	0.0184	0.0142	0.0245
DecidD	0.0130	0.0097	0.0170	0.0171	0.0132	0.0228
ConifA	0.0154	0.0115	0.0201	0.0158	0.0122	0.0211
ConifB	0.0138	0.0103	0.0181	0.0140	0.0108	0.0187
WetConifA	0.0134	0.0100	0.0175	0.0139	0.0107	0.0185
Grass	0.0047	0.0036	0.0062	0.0092	0.0071	0.0123
ConifC	0.0082	0.0062	0.0108	0.0091	0.0070	0.0121
ConifD	0.0067	0.0050	0.0088	0.0081	0.0063	0.0108
DecidC	0.0050	0.0038	0.0066	0.0055	0.0043	0.0074
MixedD	0.0025	0.0018	0.0032	0.0029	0.0023	0.0039
DecidB	0.0019	0.0014	0.0024	0.0021	0.0016	0.0028
DecidA	0.0005	0.0004	0.0007	0.0007	0.0006	0.0010
MixedB	0.0005	0.0004	0.0007	0.0006	0.0004	0.0007
MixedA	0.0003	0.0002	0.0004	0.0003	0.0003	0.0004
MixedC	0.0002	0.0002	0.0003	0.0002	0.0002	0.0003
Cult	0.0023	0.0017	0.0030	0.0000	0.0000	0.0000
UrbInd	0.0047	0.0035	0.0062	0.0000	0.0000	0.0000
HardLin	0.0002	0.0001	0.0002	0.0000	0.0000	0.0000
SoftLin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HFor	0.0048	0.0036	0.0063	0.0000	0.0000	0.0000
Total	0.5050	0.3787	0.6609	0.5226	0.4049	0.6981
Loss	0.0252	0.0074	0.0404			
Gain	0.0022	0.0009	0.0099			

5.73.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.73.14 Variable selection frequencies

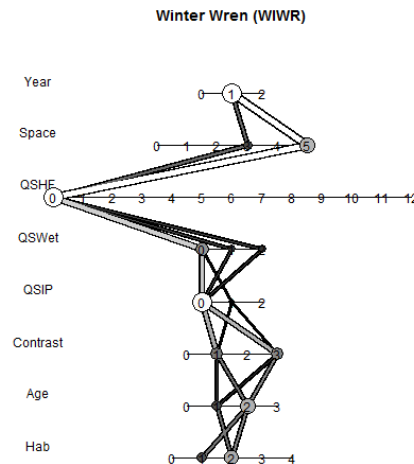
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	0.5	1	. + Habitat
1.2	79.5	159	. + HabitatB
1.4	20.0	40	. + HabitatB + isHForC
2.0	99.5	199	NULL
2.1	0.5	1	. + Age
3.0	1.0	2	NULL
3.1	1.0	2	. + ROAD
3.2	98.0	196	. + SoftLin_PC
4.0	99.5	199	NULL
4.1	0.5	1	. + Remn_QS
5.0	88.5	177	NULL
5.2	11.5	23	. + pWetWater_QS
6.0	3.0	6	NULL
6.1	2.5	5	. + THF_QS
6.2	11.5	23	. + Lin_QS + Nonlin_QS
6.3	20.0	40	. + Succ_QS + Alien_QS
6.4	1.0	2	. + Succ_QS + Noncult_QS + Cult_QS
6.6	0.5	1	. + Lin_QS + Nonlin_QS + Nonlin2_QS
6.7	57.0	114	. + Succ_QS + Alien_QS + Succ2_QS
6.8	4.0	8	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS
6.9	0.5	1	. + Succ_QS + Alien_QS + Alien2_QS
7.3	100.0	200	. + xlat + xlong + xlat:xlong
8.0	45.0	90	NULL
8.1	49.5	99	. + xYEAR
8.2	5.5	11	. + YR5F

5.74 Winter Wren (*Troglodytes hiemalis*)

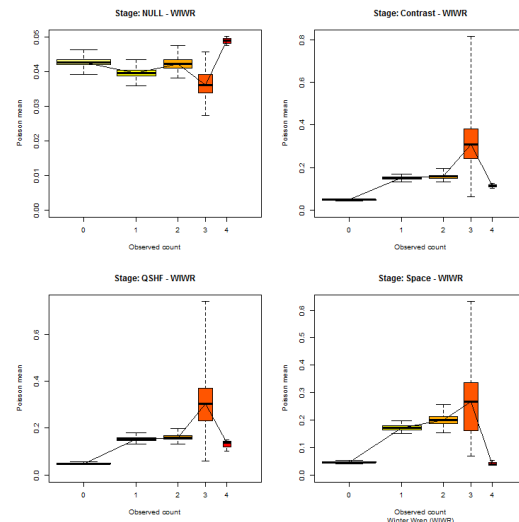
5.74.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

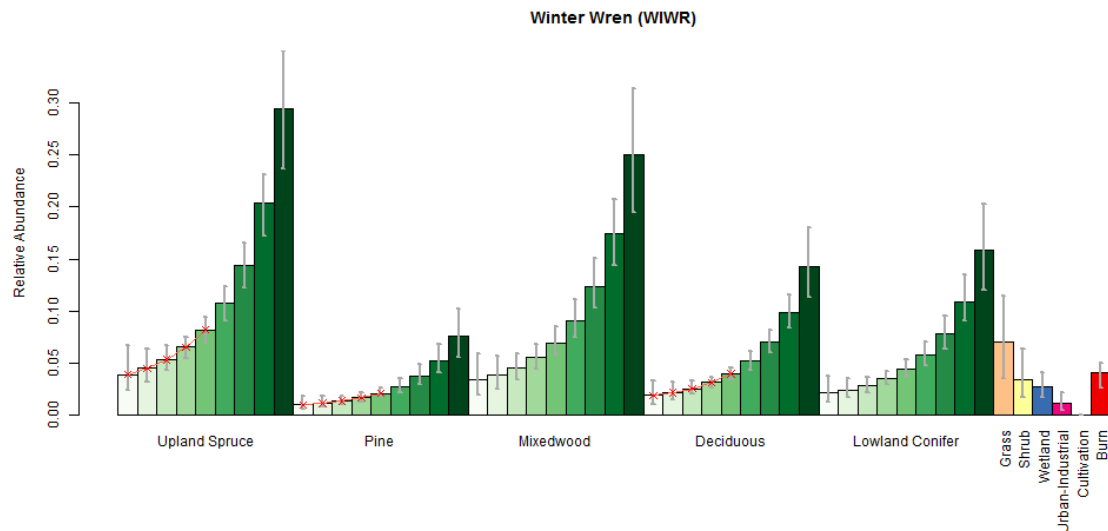


5.74.2 Cross validation

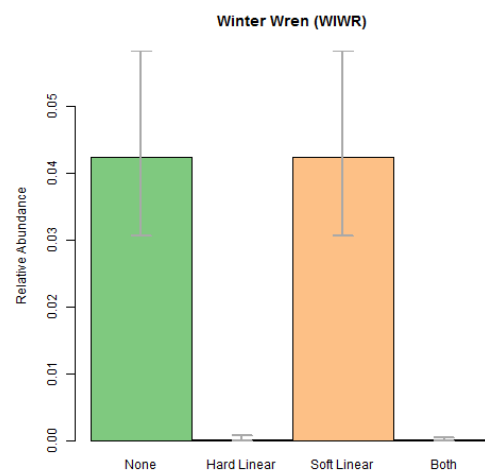
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.74.3 Point level habitat associations

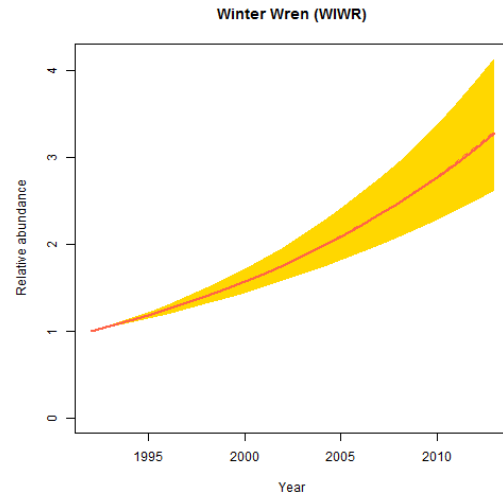


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only if it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

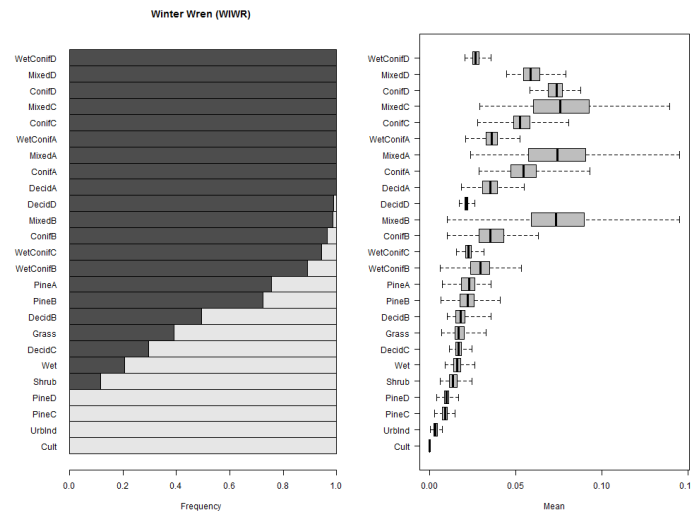


5.74.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).

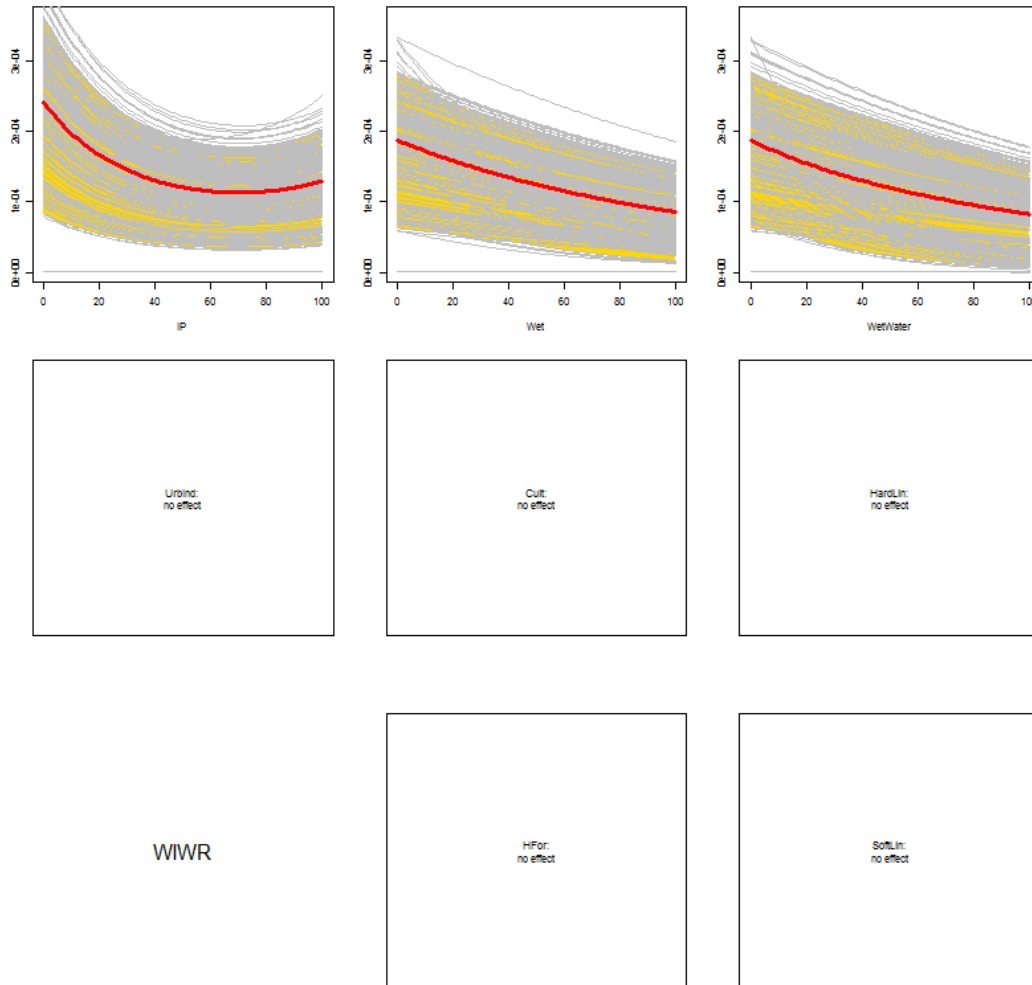


5.74.5 Habitat suitability ranking for patch delineation



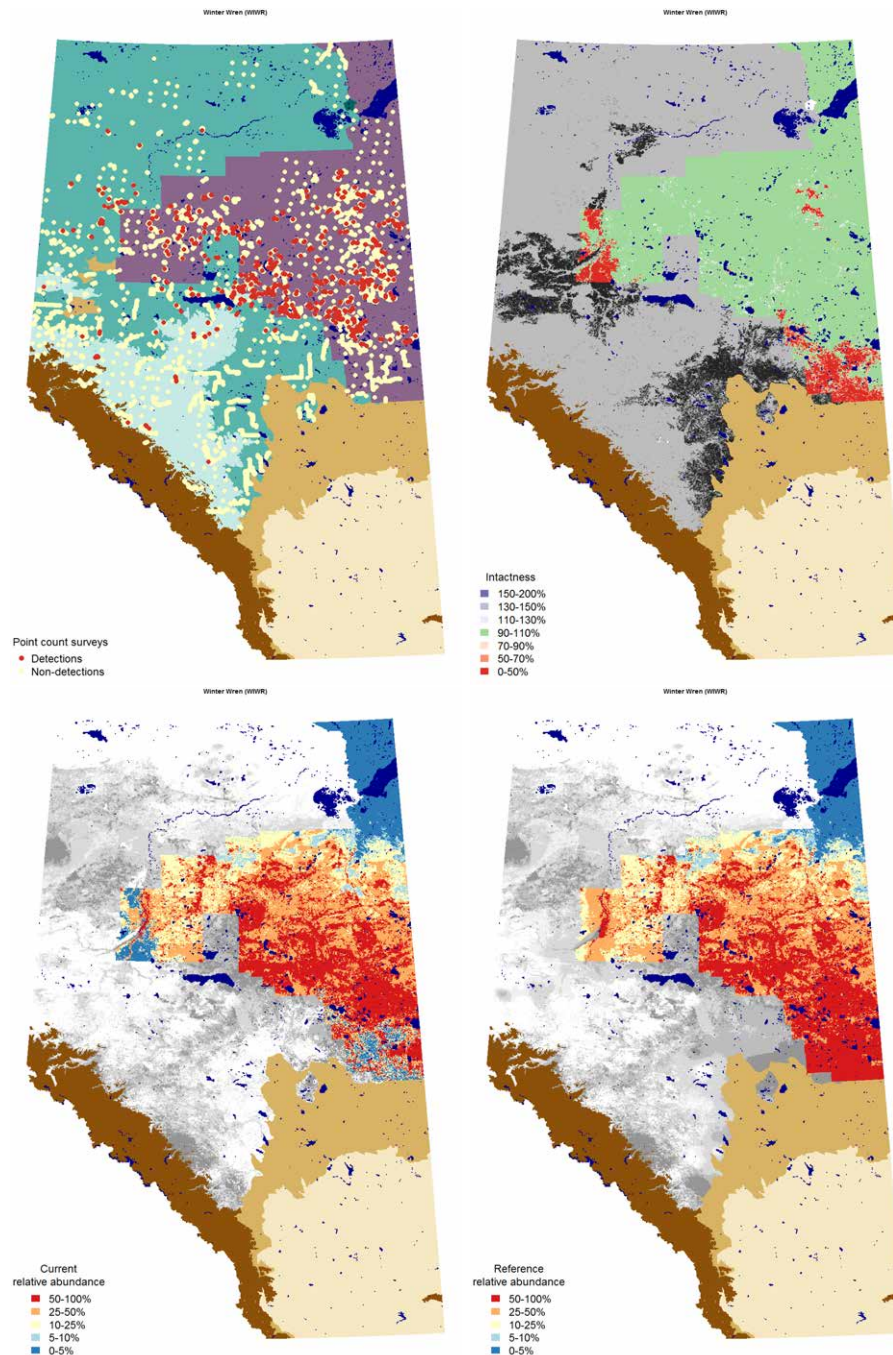
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.74.8 Quarter-section level responses



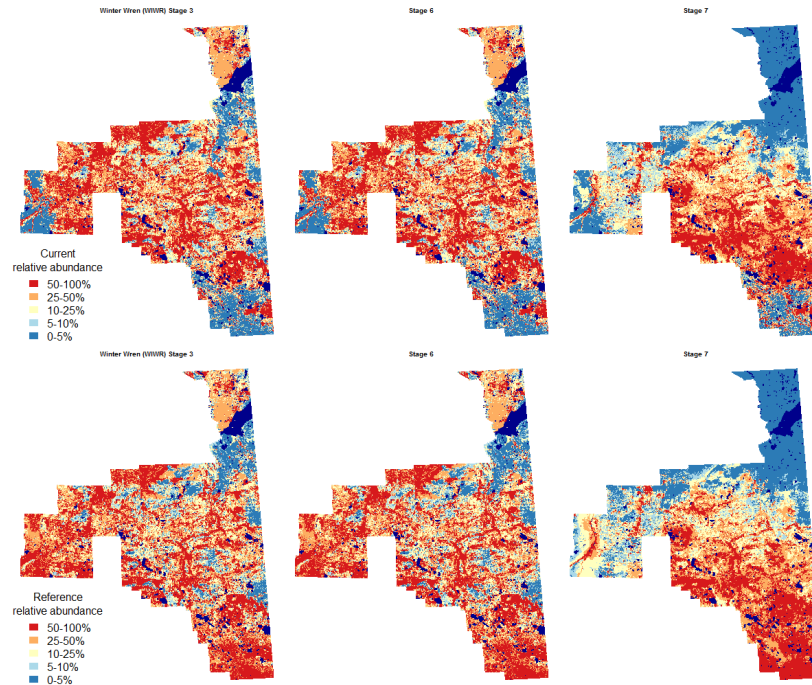
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.74.9 Maps



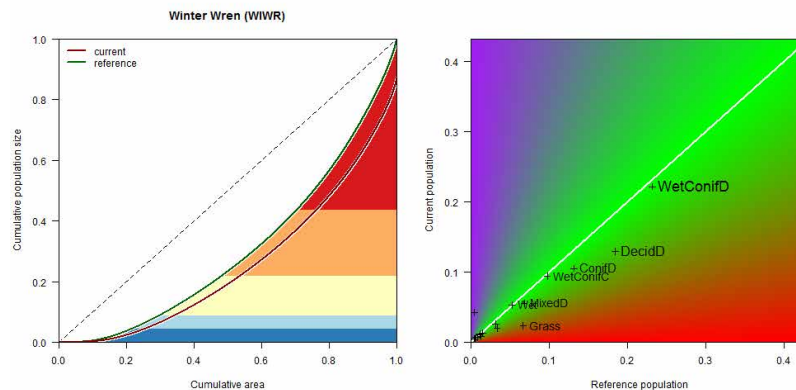
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.74.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.74.11 Population concentration



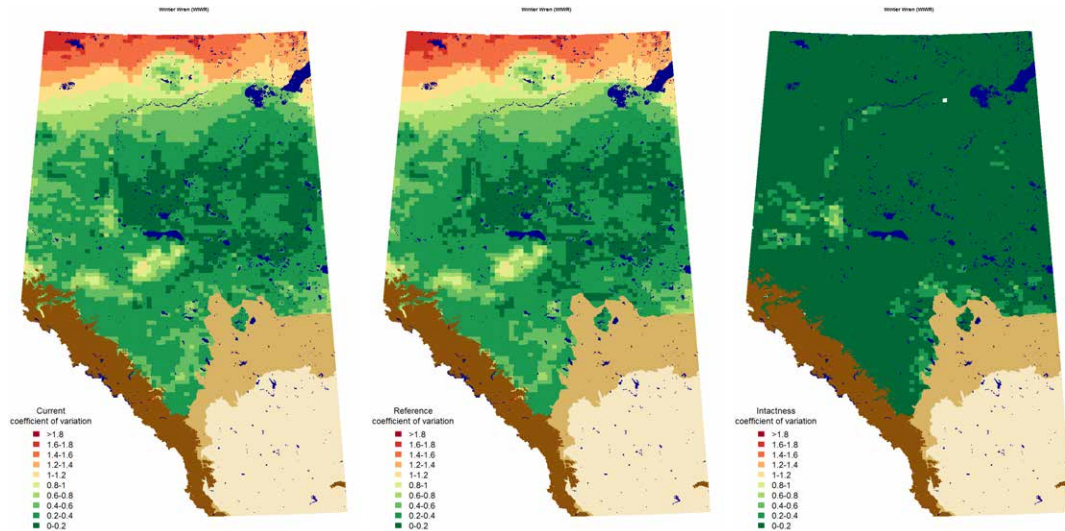
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.74.12 Potential population size

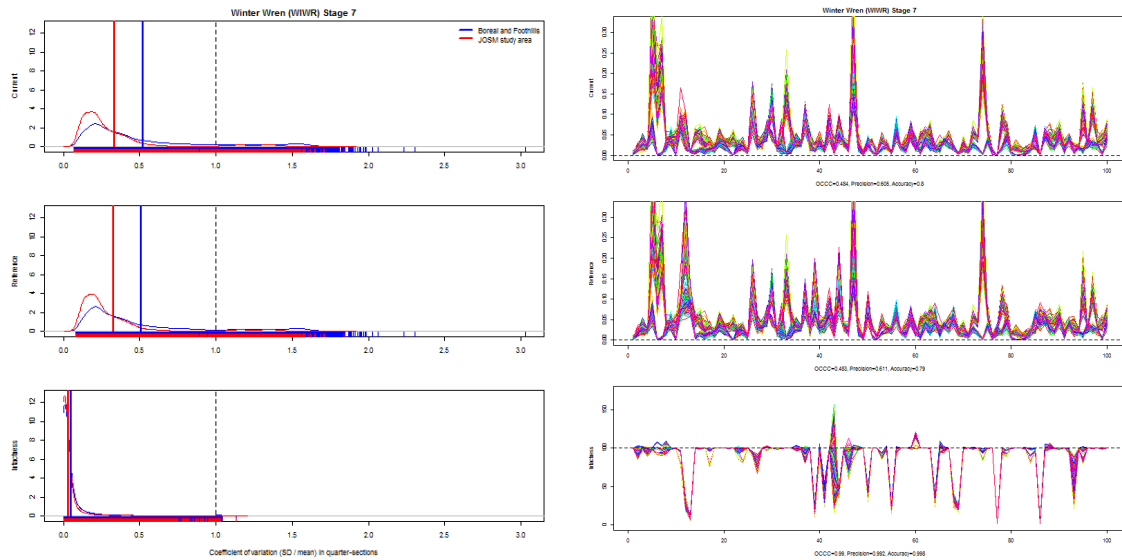
Estimated potential population size of Winter Wren in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	0.1668	0.1458	0.1961	0.1740	0.1476	0.2233
DecidD	0.0976	0.0853	0.1147	0.1382	0.1172	0.1773
ConifD	0.0792	0.0692	0.0931	0.0990	0.0840	0.1270
WetConifC	0.0706	0.0617	0.0830	0.0734	0.0623	0.0942
MixedD	0.0418	0.0365	0.0491	0.0513	0.0435	0.0658
Grass	0.0176	0.0154	0.0207	0.0504	0.0428	0.0647
Wet	0.0401	0.0351	0.0472	0.0398	0.0338	0.0511
Shrub	0.0149	0.0130	0.0175	0.0252	0.0214	0.0324
ConifC	0.0194	0.0170	0.0228	0.0239	0.0203	0.0307
PineD	0.0100	0.0087	0.0117	0.0115	0.0098	0.0148
DecidC	0.0065	0.0056	0.0076	0.0100	0.0085	0.0128
WetConifB	0.0087	0.0076	0.0102	0.0090	0.0076	0.0115
WetConifA	0.0086	0.0075	0.0101	0.0089	0.0075	0.0114
PineC	0.0079	0.0069	0.0092	0.0088	0.0074	0.0112
ConifA	0.0053	0.0047	0.0063	0.0067	0.0057	0.0086
PineB	0.0051	0.0045	0.0060	0.0052	0.0044	0.0067
ConifB	0.0038	0.0033	0.0045	0.0047	0.0040	0.0060
DecidB	0.0032	0.0028	0.0037	0.0043	0.0037	0.0055
DecidA	0.0008	0.0007	0.0009	0.0014	0.0012	0.0018
PineA	0.0013	0.0011	0.0015	0.0014	0.0012	0.0018
MixedA	0.0006	0.0006	0.0008	0.0010	0.0008	0.0012
MixedC	0.0006	0.0006	0.0008	0.0009	0.0008	0.0011
MixedB	0.0006	0.0006	0.0007	0.0008	0.0007	0.0010
Cult	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
UrbInd	0.0037	0.0032	0.0043	0.0000	0.0000	0.0000
HardLin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SoftLin	0.0003	0.0003	0.0004	0.0000	0.0000	0.0000
HFor	0.0323	0.0282	0.0380	0.0000	0.0000	0.0000
Total	0.6473	0.5657	0.7611	0.7497	0.6361	0.9619
Loss	0.1040	0.0698	0.2011			
Gain	0.0056	0.0040	0.0121			

5.74.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.74.14 Variable selection frequencies

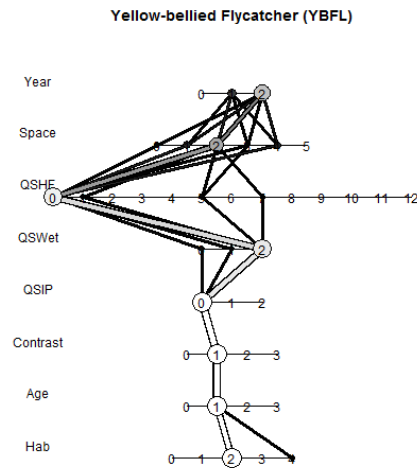
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.1	33.5	67	. + Habitat
1.2	66.5	133	. + HabitatB
2.1	30.5	61	. + Age
2.2	69.5	139	. + Age + Age2
3.1	48.0	96	. + ROAD
3.3	52.0	104	. + ROAD + SoftLin_PC
4.0	98.0	196	NULL
4.1	2.0	4	. + Remn_QS
5.0	58.0	116	NULL
5.1	22.0	44	. + pWet_QS
5.2	20.0	40	. + pWetWater_QS
6.0	100.0	200	NULL
7.3	29.0	58	. + xlat + xlong + xlat:xlong
7.5	71.0	142	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.1	100.0	200	. + xYEAR

5.75 Yellow-bellied Flycatcher (*Empidonax flaviventris*)

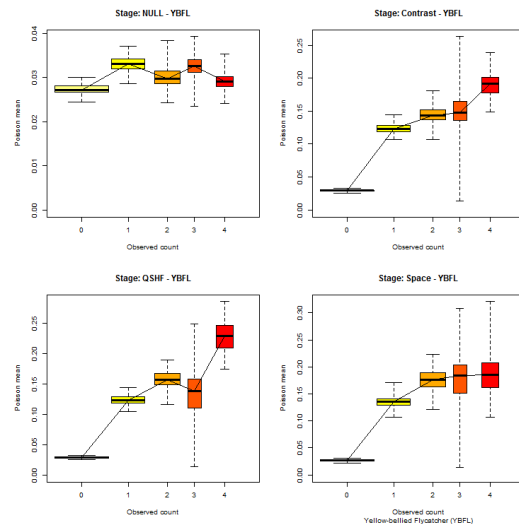
5.75.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

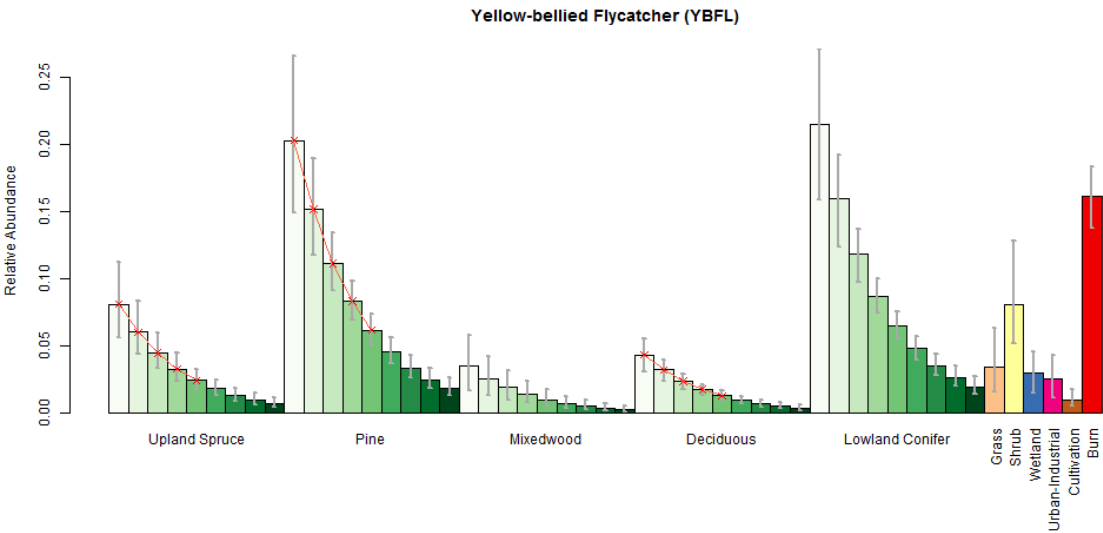


5.75.2 Cross validation

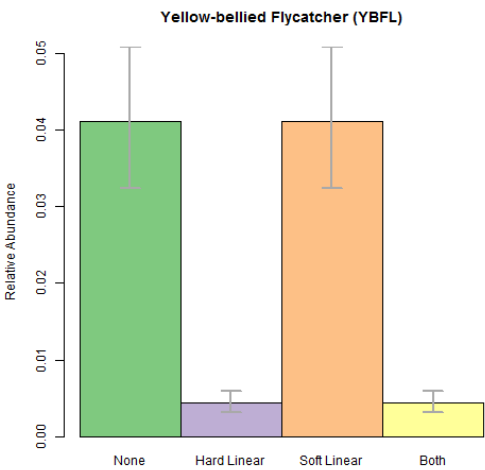
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.75.3 Point level habitat associations

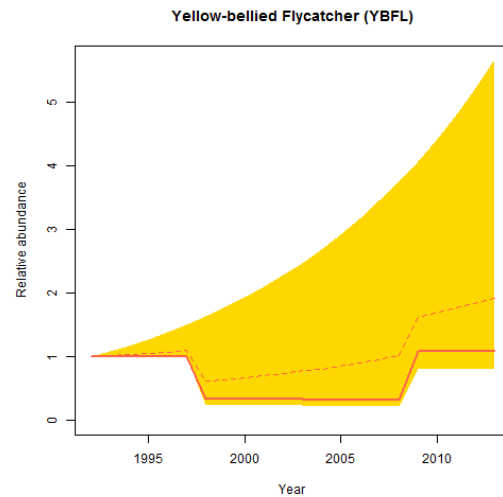


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

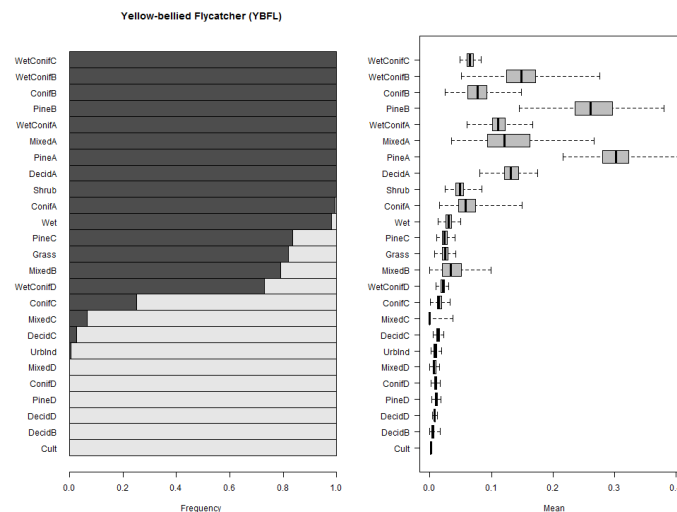


5.75.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



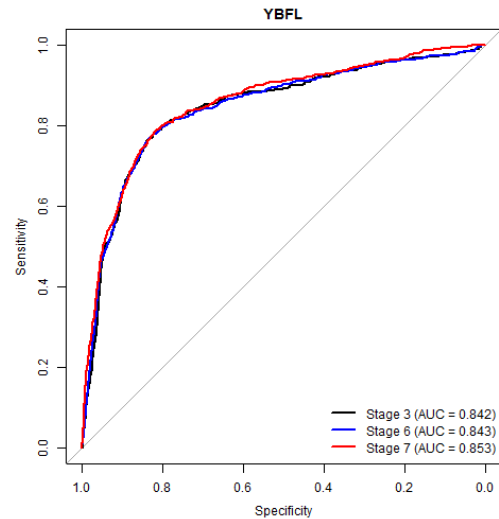
5.75.5 Habitat suitability ranking for patch delineation



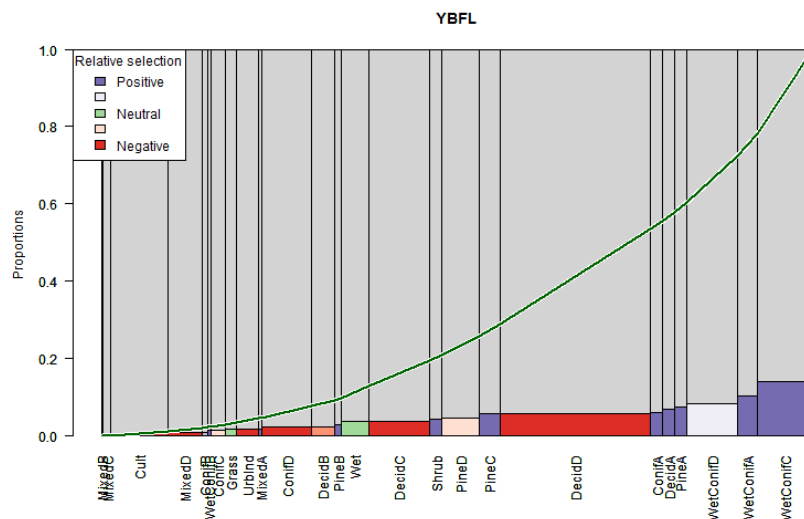
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.75.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

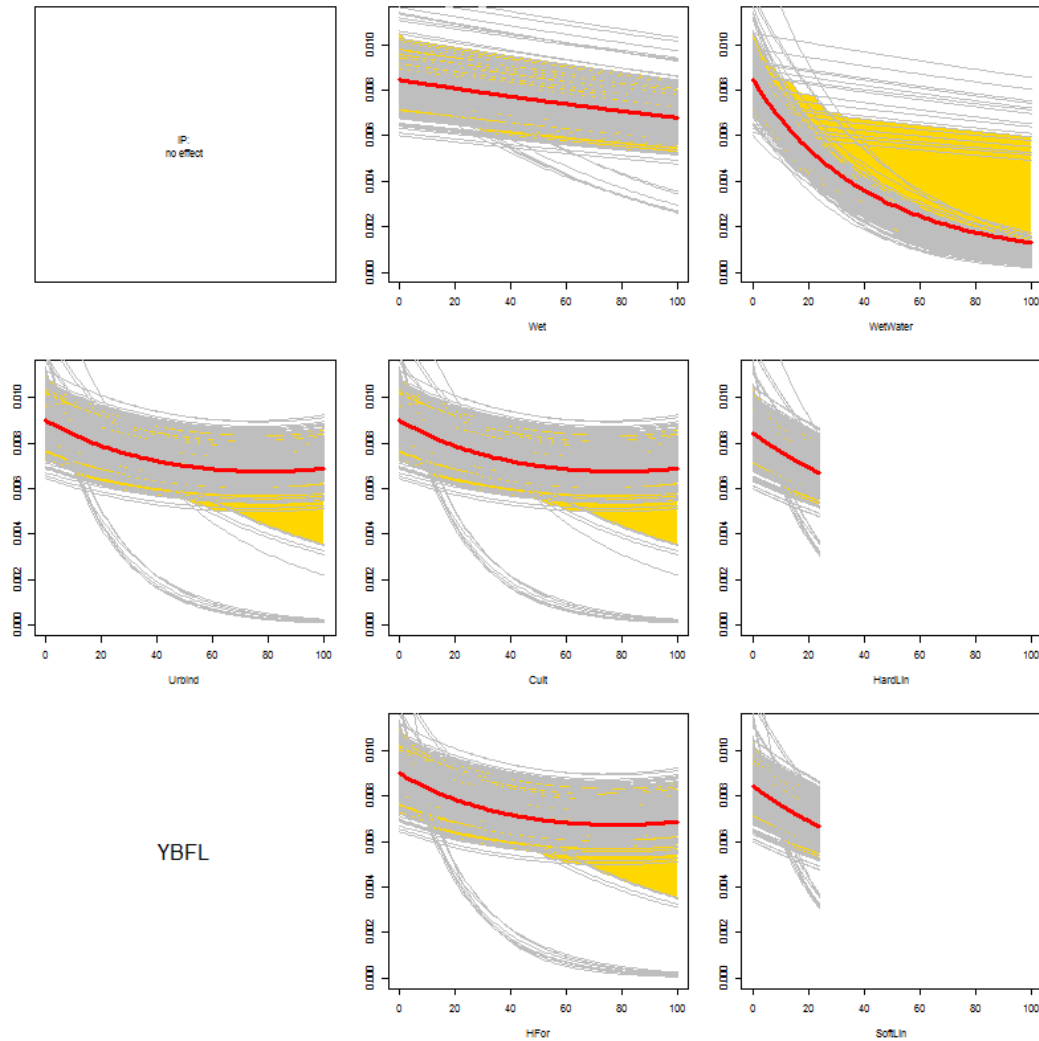


5.75.7 Relative habitat selection



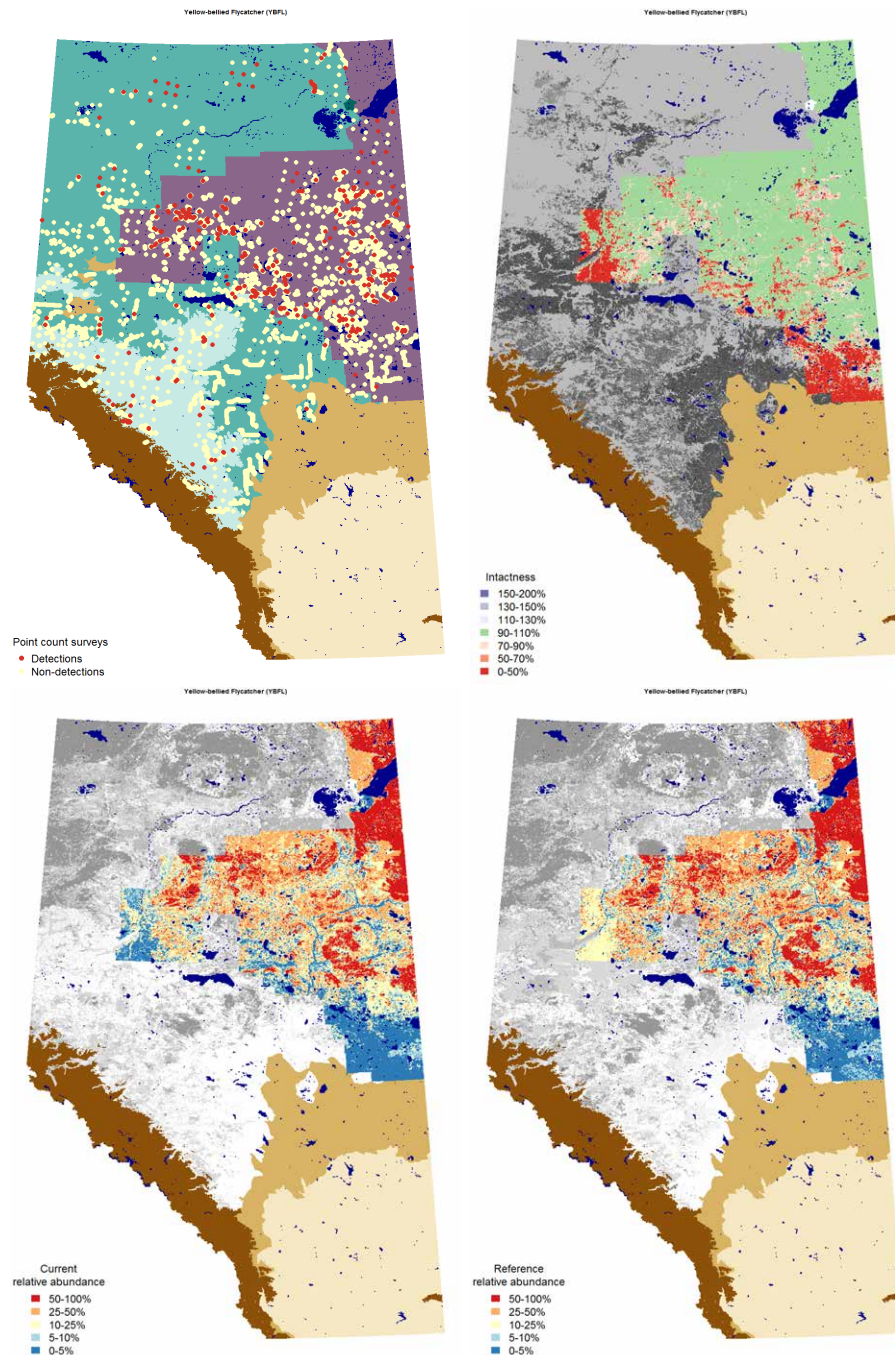
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.75.8 Quarter-section level responses



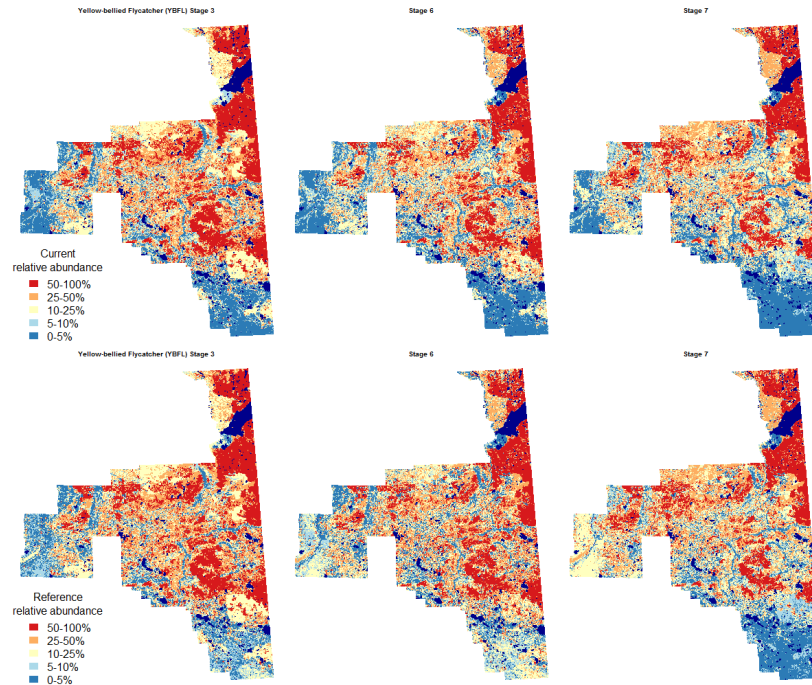
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.75.9 Maps



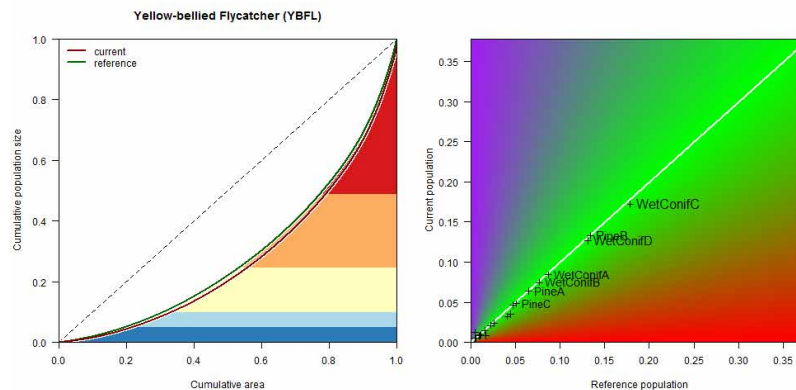
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.75.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.75.11 Population concentration



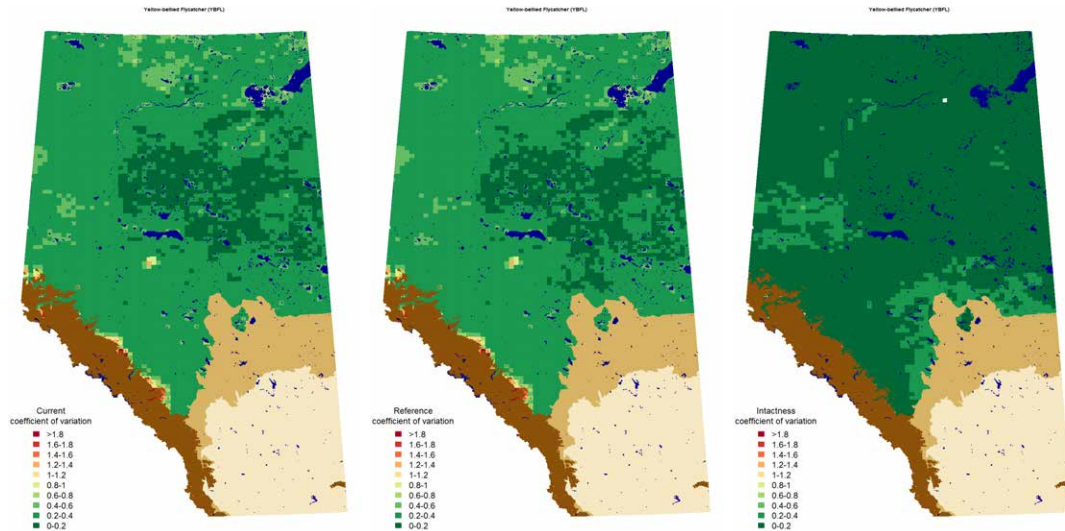
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.75.12 Potential population size

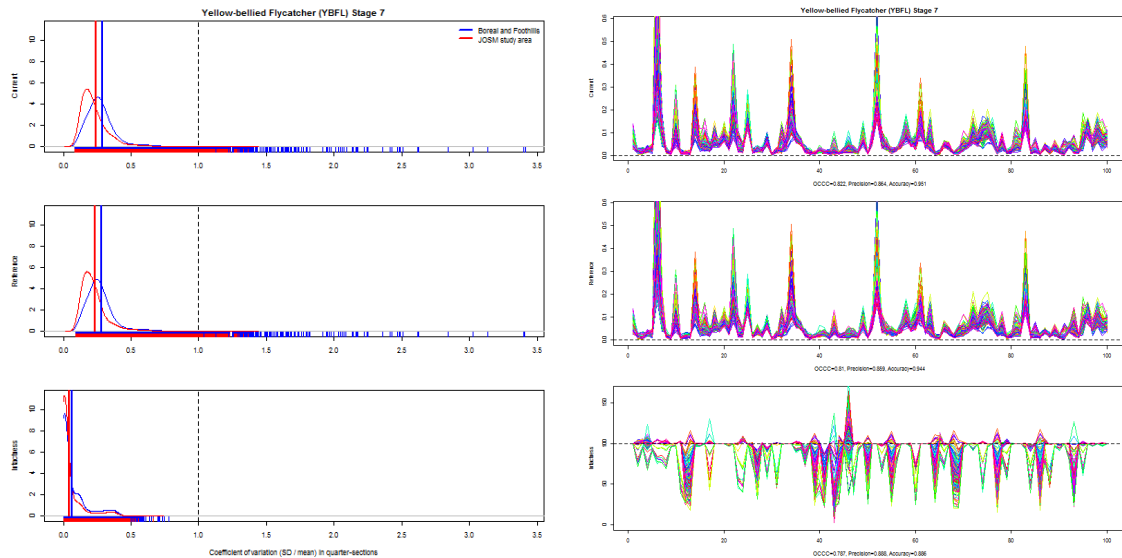
Estimated potential population size of Yellow-bellied Flycatcher in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifC	0.1765	0.1479	0.2164	0.1840	0.1536	0.2285
PineB	0.1368	0.1146	0.1677	0.1382	0.1154	0.1717
WetConifD	0.1301	0.1091	0.1595	0.1354	0.1131	0.1682
WetConifA	0.0864	0.0724	0.1060	0.0897	0.0749	0.1115
WetConifB	0.0766	0.0642	0.0939	0.0795	0.0664	0.0987
PineA	0.0654	0.0548	0.0802	0.0670	0.0560	0.0832
PineC	0.0494	0.0414	0.0606	0.0527	0.0440	0.0654
Wet	0.0476	0.0399	0.0584	0.0486	0.0406	0.0604
DecidD	0.0363	0.0305	0.0445	0.0461	0.0385	0.0573
Shrub	0.0334	0.0279	0.0409	0.0425	0.0355	0.0528
ConifA	0.0242	0.0202	0.0296	0.0268	0.0224	0.0333
PineD	0.0217	0.0182	0.0266	0.0233	0.0195	0.0290
Grass	0.0086	0.0072	0.0106	0.0177	0.0148	0.0220
ConifC	0.0146	0.0122	0.0178	0.0166	0.0139	0.0206
ConifB	0.0146	0.0122	0.0179	0.0162	0.0135	0.0201
ConifD	0.0096	0.0080	0.0117	0.0114	0.0095	0.0141
DecidC	0.0087	0.0073	0.0106	0.0108	0.0090	0.0134
DecidB	0.0080	0.0067	0.0099	0.0100	0.0084	0.0124
MixedD	0.0051	0.0043	0.0063	0.0060	0.0050	0.0075
DecidA	0.0024	0.0020	0.0030	0.0038	0.0031	0.0047
MixedA	0.0009	0.0008	0.0011	0.0013	0.0010	0.0016
MixedB	0.0011	0.0009	0.0013	0.0012	0.0010	0.0015
MixedC	0.0005	0.0004	0.0006	0.0006	0.0005	0.0007
Cult	0.0130	0.0109	0.0159	0.0000	0.0000	0.0000
UrbInd	0.0050	0.0042	0.0061	0.0000	0.0000	0.0000
HardLin	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
SoftLin	0.0124	0.0104	0.0152	0.0000	0.0000	0.0000
HFor	0.0130	0.0109	0.0160	0.0000	0.0000	0.0000
Total	1.0022	0.8398	1.2284	1.0293	0.8597	1.2789
Loss	0.0250	0.0122	0.0658			
Gain	0.0034	0.0011	0.0053			

5.75.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.75.14 Variable selection frequencies

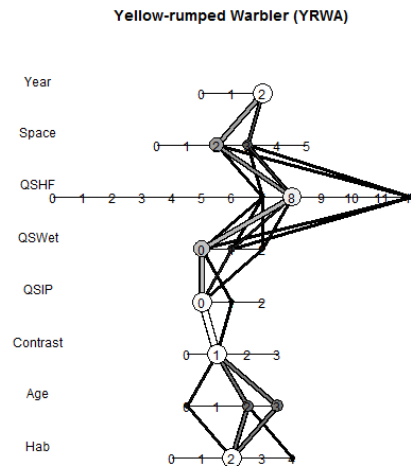
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	99.5	199	. + HabitatB
1.4	0.5	1	. + HabitatB + isHForC
2.1	100.0	200	. + Age
3.1	100.0	200	. + ROAD
4.0	100.0	200	NULL
5.0	5.0	10	NULL
5.1	3.5	7	. + pWet_QS
5.2	91.5	183	. + pWetWater_QS
6.0	94.0	188	NULL
6.1	2.0	4	. + THF_QS
6.5	3.5	7	. + THF_QS + THF2_QS
6.7	0.5	1	. + Succ_QS + Alien_QS + Succ2_QS
7.0	1.5	3	NULL
7.1	16.0	32	. + xlat
7.2	66.0	132	. + xlat + xlong
7.3	2.0	4	. + xlat + xlong + xlat:xlong
7.4	14.5	29	. + xMAP + xPET + xMAT + xCMD
8.1	24.0	48	. + xYEAR
8.2	76.0	152	. + YR5F

5.76 Yellow-rumped Warbler (*Setophaga coronata*)

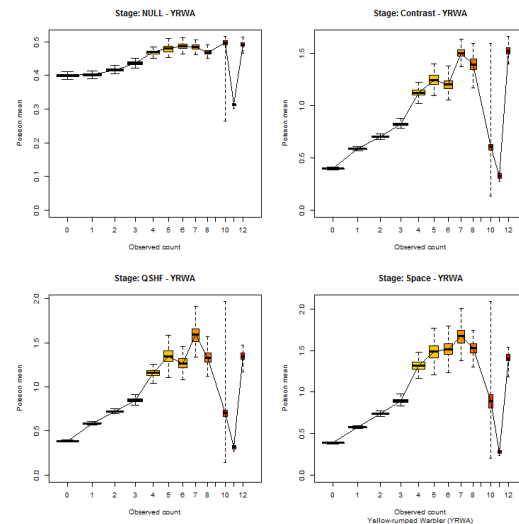
5.76.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

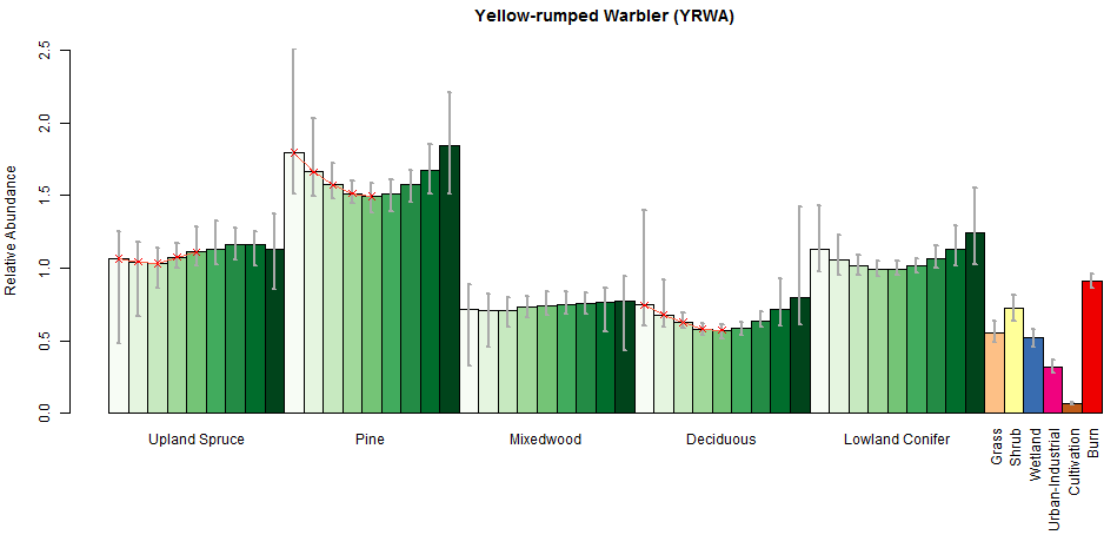


5.76.2 Cross validation

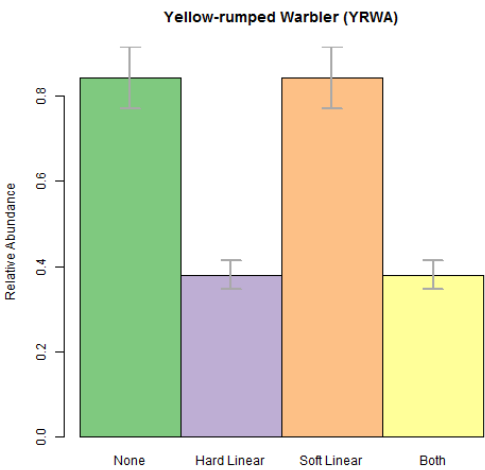
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.76.3 Point level habitat associations

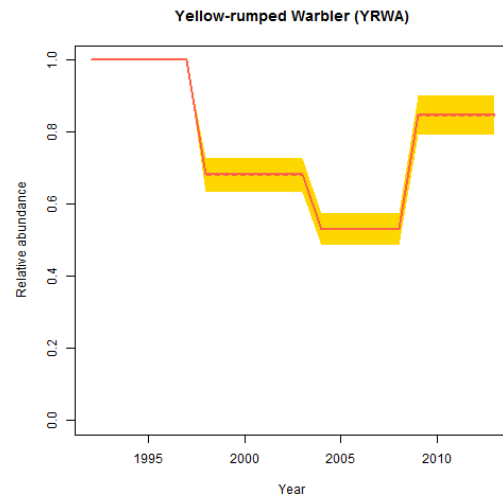


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

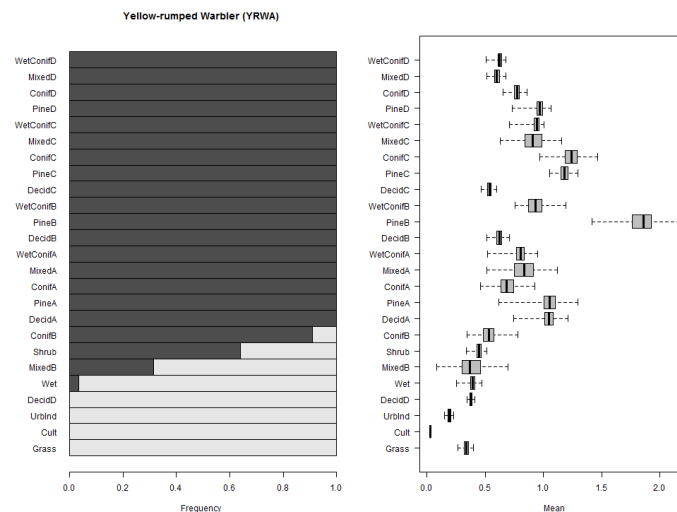


5.76.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



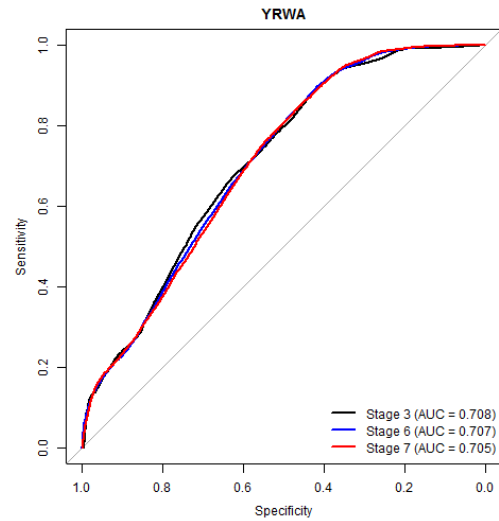
5.76.5 Habitat suitability ranking for patch delineation



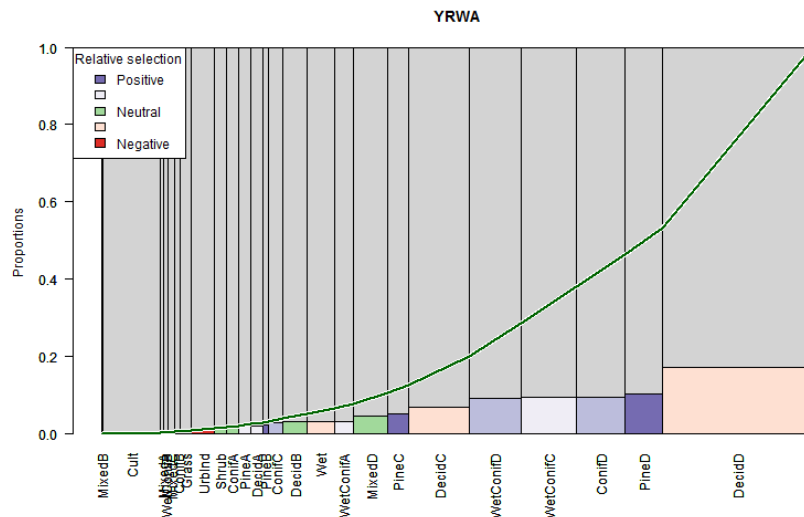
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.76.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

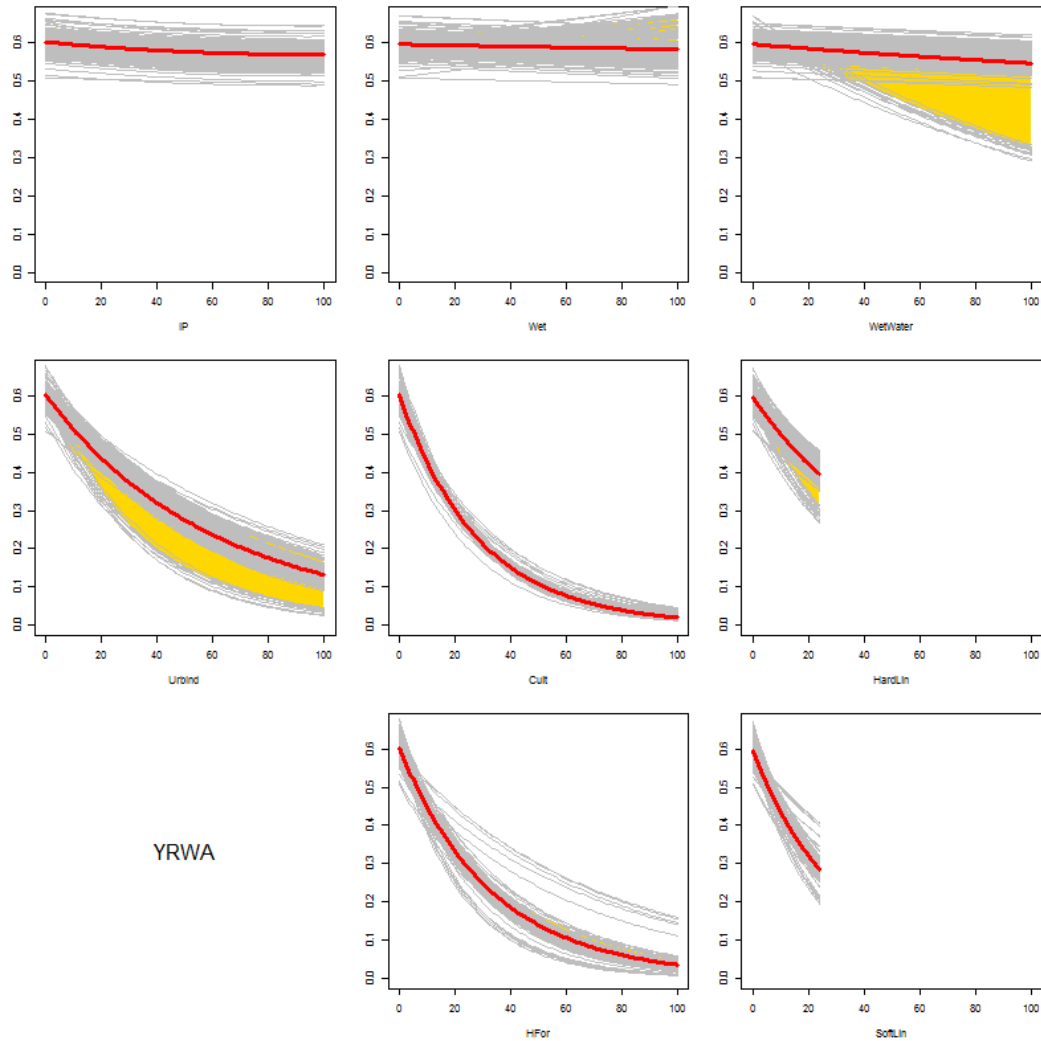


5.76.7 Relative habitat selection



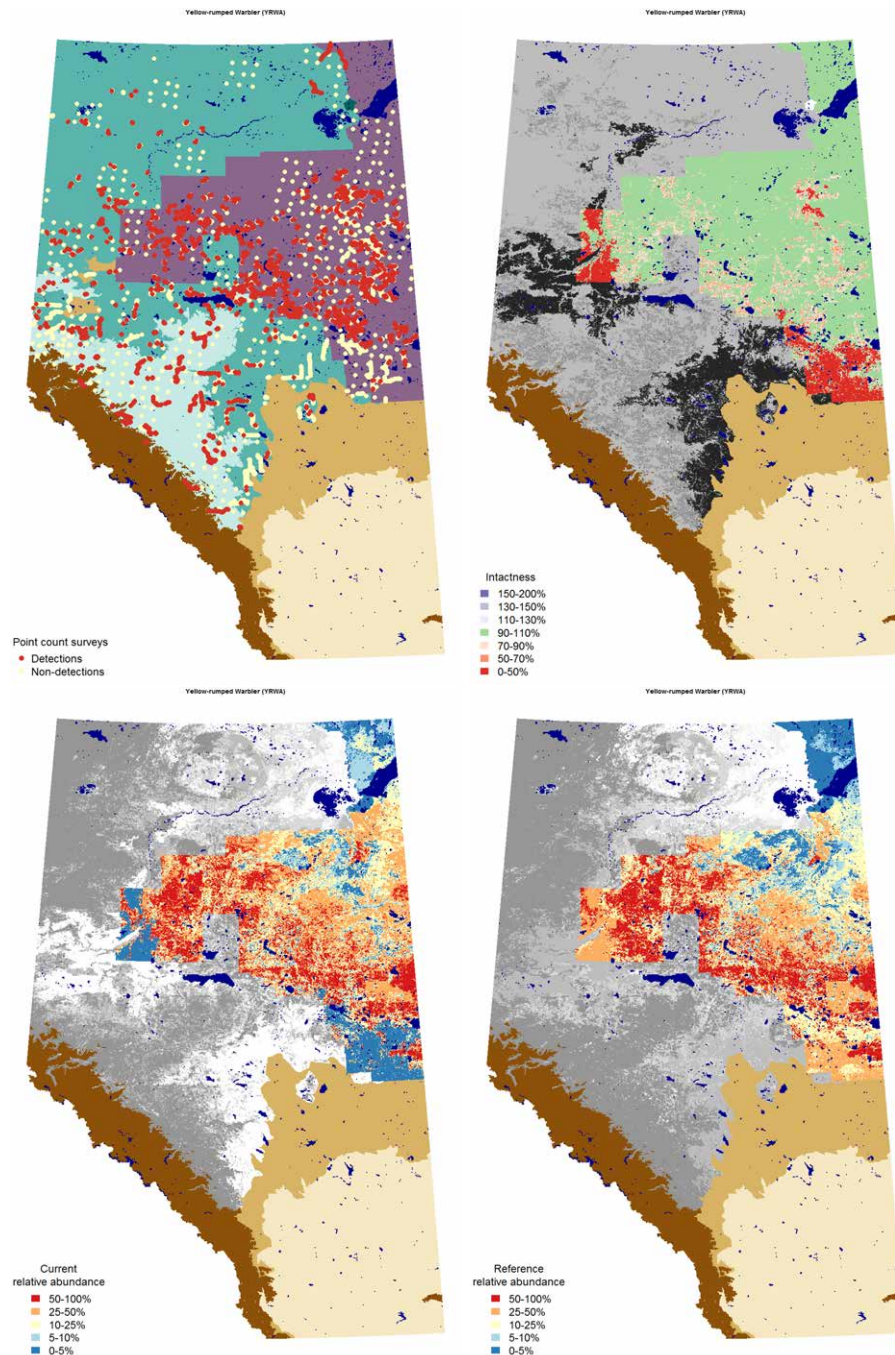
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.76.8 Quarter-section level responses



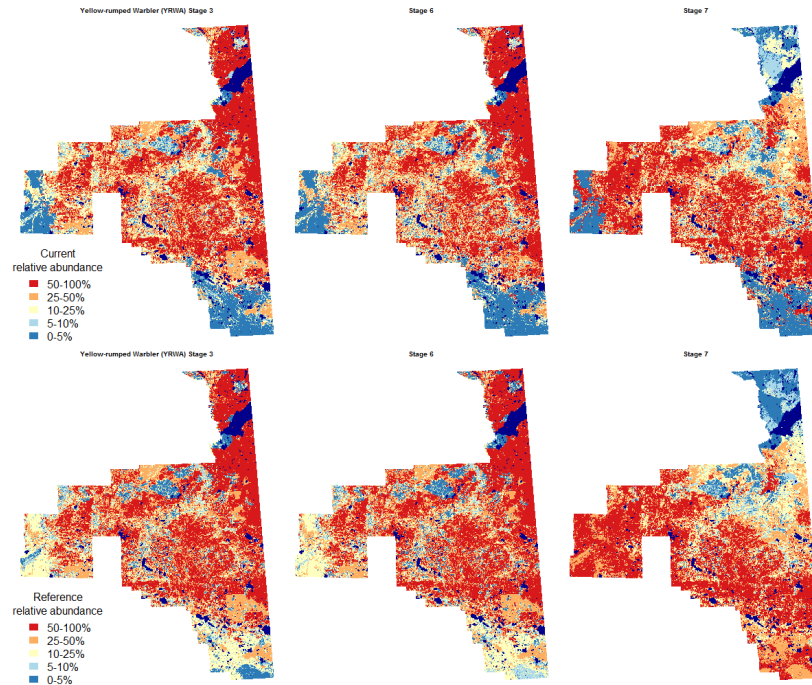
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.76.9 Maps



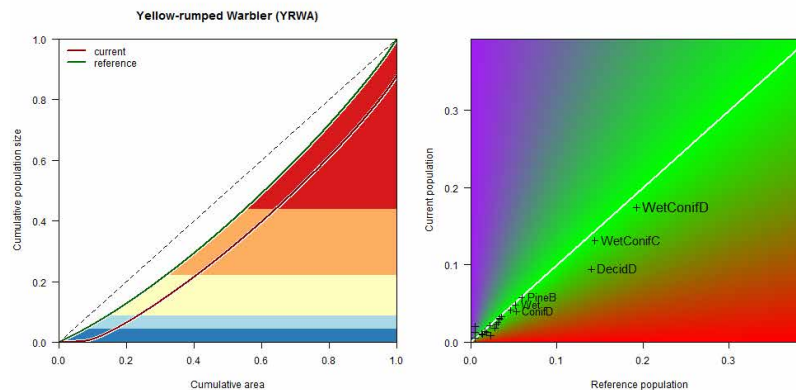
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.76.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.76.11 Population concentration



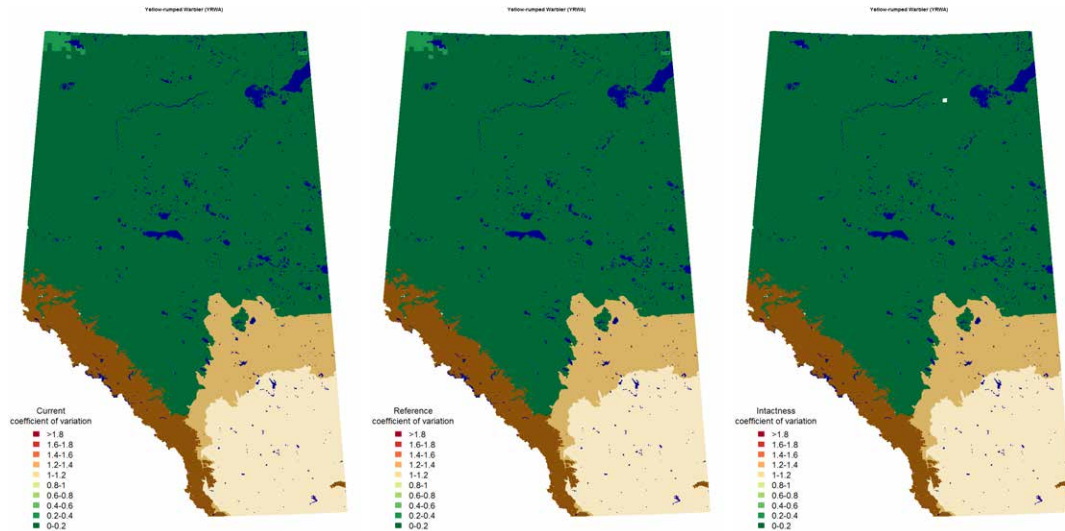
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.76.12 Potential population size

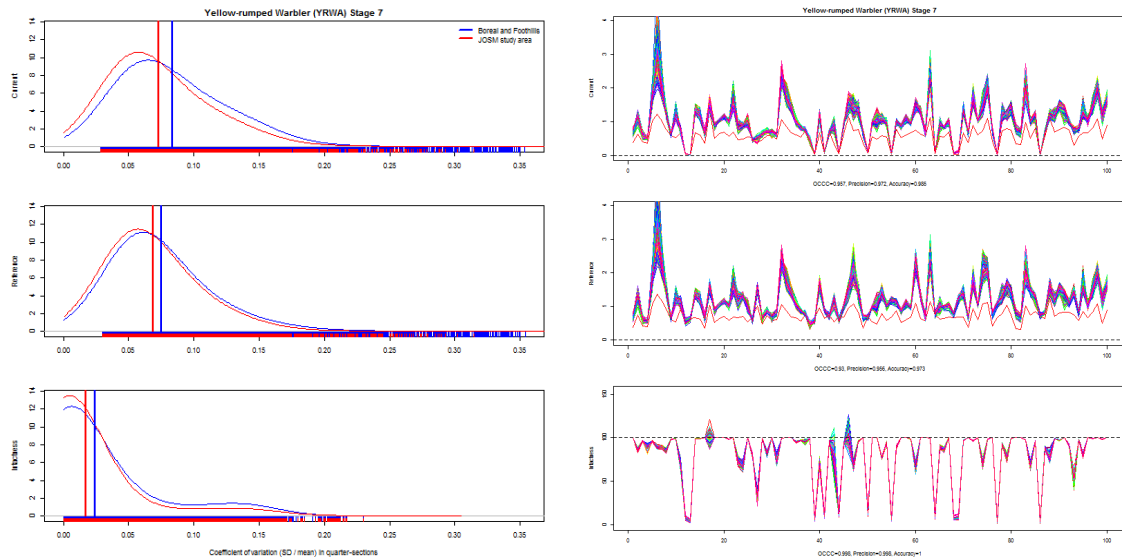
Estimated potential population size of Yellow-rumped Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
WetConifD	2.6347	2.5329	2.7431	2.9124	2.7957	3.0165
WetConifC	1.9905	1.9136	2.0724	2.1817	2.0943	2.2597
DecidD	1.4329	1.3775	1.4918	2.1151	2.0304	2.1907
PineB	0.8782	0.8442	0.9143	0.8961	0.8602	0.9281
ConifD	0.6076	0.5841	0.6326	0.8046	0.7724	0.8334
Wet	0.7295	0.7012	0.7594	0.7883	0.7567	0.8165
PineC	0.6254	0.6012	0.6511	0.7072	0.6789	0.7325
WetConifA	0.4968	0.4776	0.5172	0.5401	0.5185	0.5594
PineD	0.4464	0.4291	0.4647	0.5154	0.4948	0.5339
WetConifB	0.4768	0.4584	0.4964	0.5062	0.4860	0.5243
ConifC	0.3861	0.3712	0.4020	0.4782	0.4590	0.4953
MixedD	0.3504	0.3368	0.3648	0.4530	0.4349	0.4692
Shrub	0.2837	0.2727	0.2954	0.4297	0.4125	0.4451
Grass	0.1290	0.1240	0.1343	0.3555	0.3413	0.3682
PineA	0.3232	0.3107	0.3365	0.3398	0.3262	0.3519
DecidC	0.1880	0.1807	0.1957	0.2864	0.2749	0.2966
ConifA	0.2134	0.2052	0.2222	0.2584	0.2480	0.2676
DecidB	0.1539	0.1479	0.1602	0.2096	0.2012	0.2171
ConifB	0.1688	0.1623	0.1758	0.1978	0.1899	0.2049
DecidA	0.0456	0.0439	0.0475	0.0747	0.0717	0.0773
MixedB	0.0223	0.0214	0.0232	0.0265	0.0255	0.0275
MixedA	0.0160	0.0154	0.0166	0.0244	0.0234	0.0252
MixedC	0.0153	0.0147	0.0160	0.0200	0.0192	0.0207
Cult	0.0566	0.0544	0.0589	0.0000	0.0000	0.0000
UrbInd	0.0716	0.0688	0.0745	0.0000	0.0000	0.0000
HardLin	0.0048	0.0046	0.0050	0.0000	0.0000	0.0000
SoftLin	0.1950	0.1874	0.2030	0.0000	0.0000	0.0000
HFor	0.3094	0.2975	0.3222	0.0000	0.0000	0.0000
Total	13.2518	12.7394	13.7967	15.1211	14.5154	15.6617
Loss	1.8432	1.6765	1.9984			
Gain	0.0013	0.0004	0.0034			

5.76.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.76.14 Variable selection frequencies

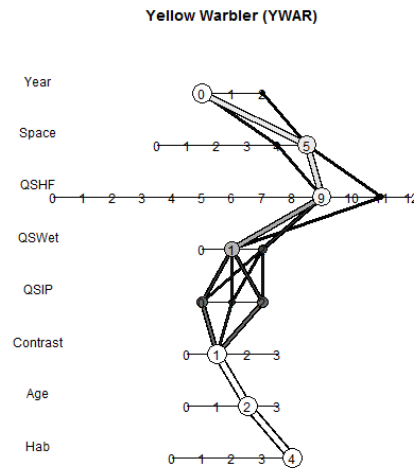
Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.2	99.5	199	. + HabitatB
1.4	0.5	1	. + HabitatB + isHForC
2.0	7.5	15	NULL
2.2	45.0	90	. + Age + Age2 . + Age + Age2 + Age:isMix + Age:isPine + Age:isUplConif + Age:isWetConif + Age2:isMix + Age2:isPine + Age2:isUplConif + Age2:isWetConif
2.3	47.5	95	
3.1	100.0	200	. + ROAD
4.0	98.0	196	NULL
4.1	2.0	4	. + Remn_QS
5.0	76.0	152	NULL
5.1	17.5	35	. + pWet_QS
5.2	6.5	13	. + pWetWater_QS
6.7	2.5	5	. + Succ_QS + Alien_QS + Succ2_QS
6.8	94.0	188	. + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS . + Succ_QS + Noncult_QS + Cult_QS + Succ2_QS + Noncult2_QS
6.12	3.5	7	
7.2	62.5	125	. + xlat + xlong
7.3	37.5	75	. + xlat + xlong + xlat:xlong
8.2	100.0	200	. + YR5F

5.77 Yellow Warbler (*Setophaga petechia*)

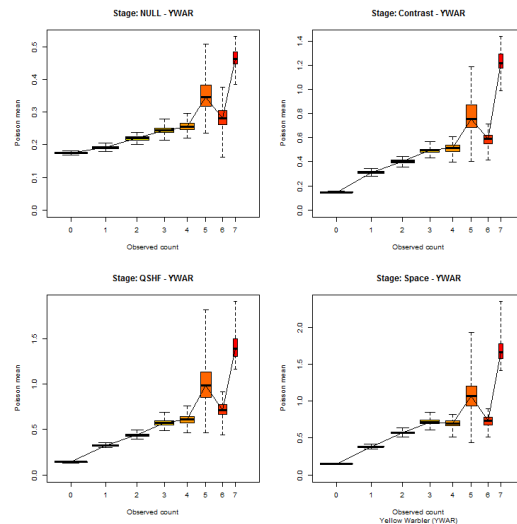
5.77.1 Model variability

The variable selection path diagram indicates the selection frequencies of predefined variable sets entering the model along the model stages (from bottom to top). Size of dots and width of the lines are proportional to selection frequencies. Lines refer to transitions between stages, model 0 indicates that the model from the previous step (below) was carried forward.

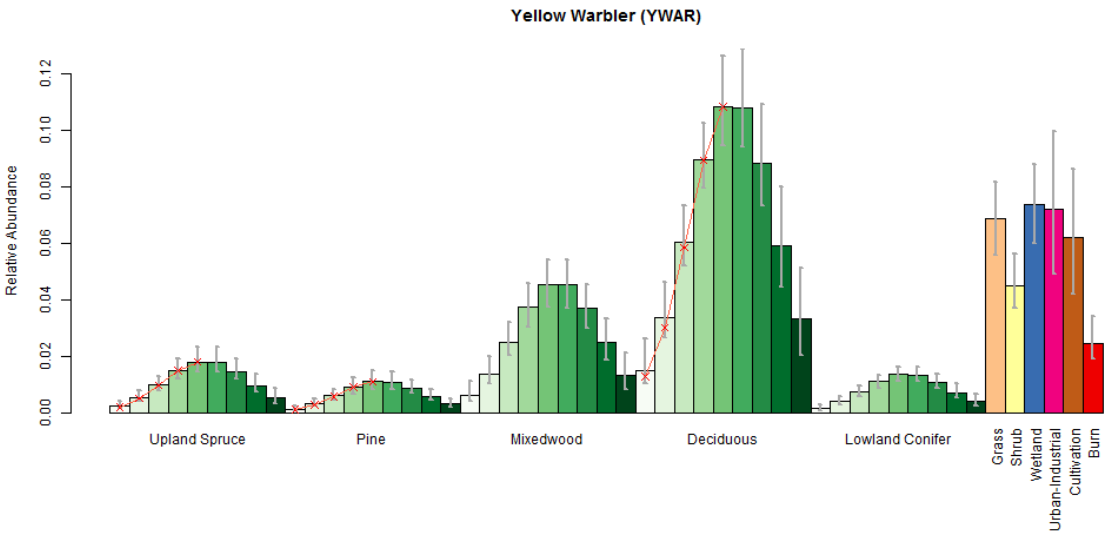


5.77.2 Cross validation

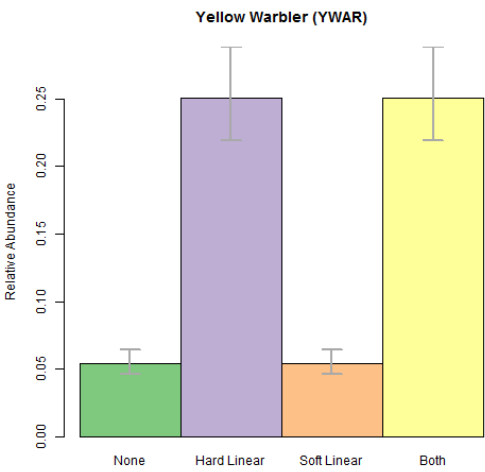
Boxplot indicating the correspondence between estimated Poisson means for point count surveys vs. observed counts. Boxplots are based on means from each bootstrap iteration using the set of surveys not used in the given bootstrap sample. Lines are medians, boxes represent interquartile range, whiskers are minimum and maximum. Widths of the boxes are proportional to the log number of observed counts in each category. Stages in variable selection represent the “NULL” model (top left) where differences are due to offsets with no covariate effects (higher sampling effort leads to higher counts); “Contrast” corresponds to the stage with all local terms (habitat classes and modifiers) considered; “QSHF” corresponds to the stage with all local and quarter-section scale terms (patch, wetness, footprint) considered; “Space” corresponds to the stage with all local, quarter-section scale and spatial (latitude/longitude, climate/productivity) terms considered (no year effect).



5.77.3 Point level habitat associations

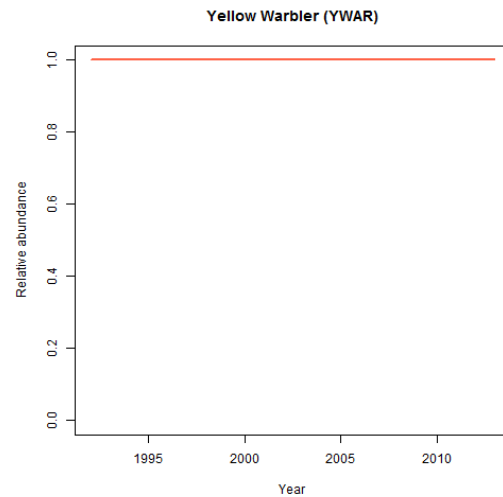


Local (point count, 150 m radius buffer) scale density estimates (“Contrast” stage, no quarter-section level and spatial terms considered, no year effect). Forested habitats (green) are plotted by 20-year age classes, non-forested habitat classes including urban-industrial and cultivation footprint types are plotted in the right hand side of the top graph. Burn is presented in the far right only of it had non-zero selection frequency in variable selection. Forestry effect is shown in red x-es and lines for harvestable stand types. Effects of linear features are removed statistically from the graph at the top. The effect of linear features (right) is presented relative to habitats without hard or soft linear features. Hard linear feature was represented by the presence of a paved/gravel road, soft linear feature was represented by the average proportion (8%) across the observations. Grey error bars represent 90% confidence intervals for the corresponding bars.

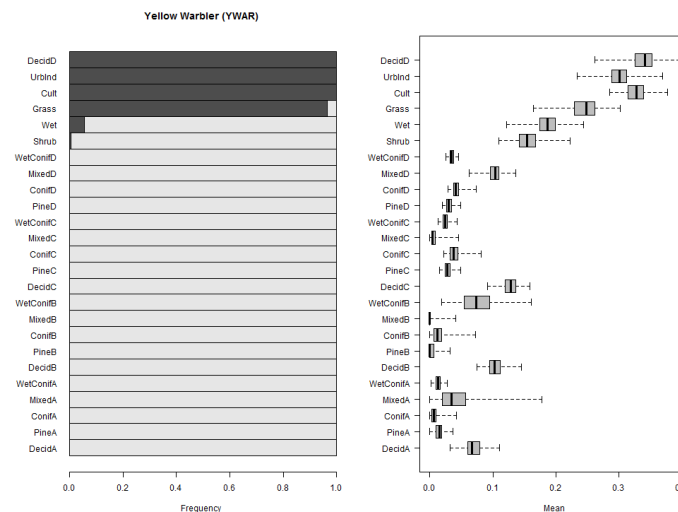


5.77.4 Year effect

Year effect was estimated as the last stage in the variable selection. Year effect is only indicative because the data set was optimized to detect spatial and habitat related, rather than temporal signals (repeated visits to same location were down-weighted). The block bootstrap included spatial and 5-year temporal blocks to ensure balanced design and to avoid possible space-time confounding. Year effect is relative to the 1st year (1993).



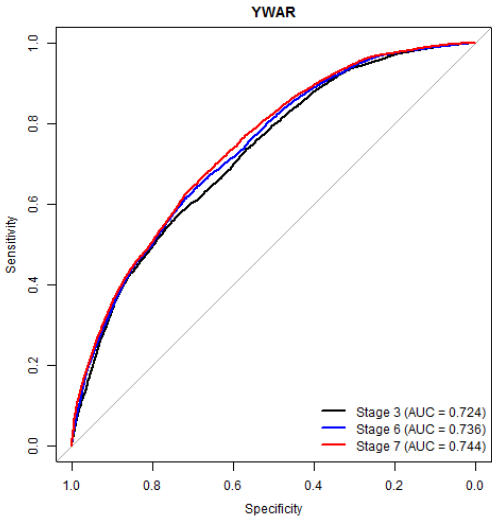
5.77.5 Habitat suitability ranking for patch delineation



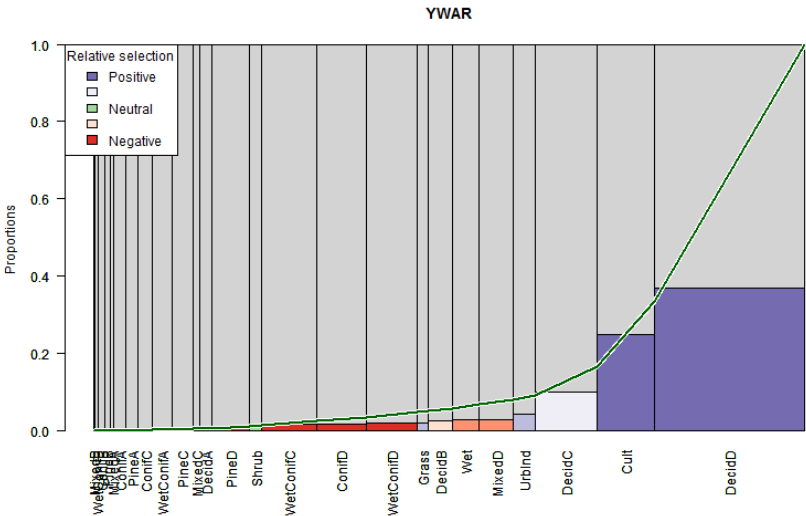
Habitat suitability was estimated independent of the variable selection process to allow for the determination of the amount of high suitability patches in the 451 m radius buffer (64 ha = area of a quarter section). High suitability habitat classes were determined based on the Lorenz-tangent based cut-off value after ranking habitats based on their estimated Poisson means. Selection frequencies (left) and boxes for Poisson means (right) are based on bootstrap. Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.77.6 Classification performance

The receiver operating characteristic (ROC) curve and area under the curve (AUC) values were constructed based on the observations (y) from the Boreal and Foothills study area as response and modeled probabilities of observing a non-zero count, $P(y > 0) = 1 - e^{-\lambda C}$, where λ is expected density per ha (median density based on 200 bootstrap iterations), and C is the correction factor based on methodology and detectability. Different colors correspond to stages of the variable selection procedure: (3) “Contrast”, all local terms; (6) “QSHF”, local and quarter-section scale terms; (7) “Space”, local, quarter-section scale and spatial terms (no year effect).

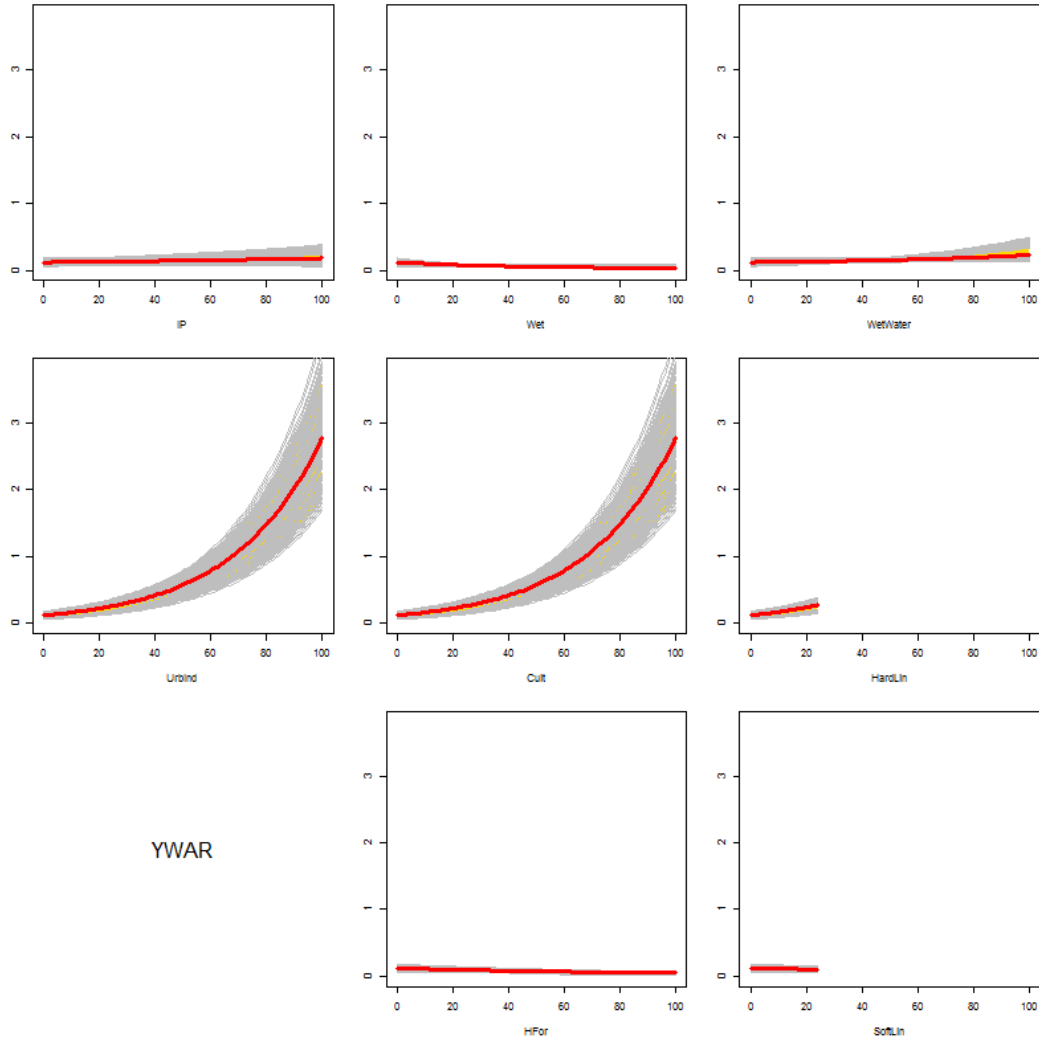


5.77.7 Relative habitat selection



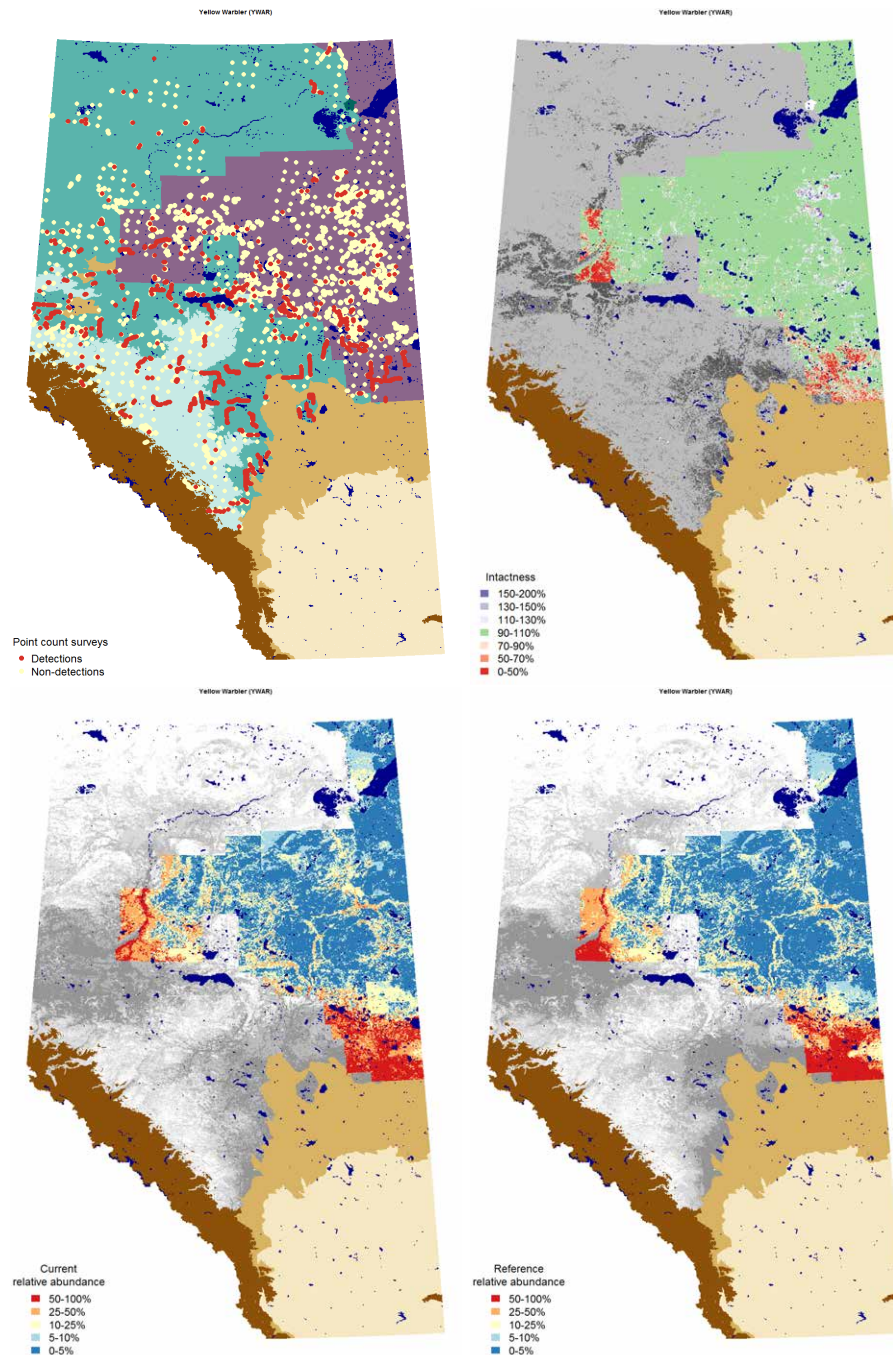
Habitat selection was quantified based on habitat characteristics at the sampling locations within the Boreal and Foothills study area. Heights of the bars correspond to proportions or the predicted population within the habitat classes. Widths represent proportional availability of the habitat classes. Bars are ordered from lowest to highest proportions. The line indicates the cumulative distribution of the bars. Coloring of the bars refer to relative selection that is positive when proportion of the population within a habitat class is higher than expected under even distribution (population proportions equal the availability of habitats). Age categories (A–D) correspond to a modified version of the avian habitat classification system by Environment Canada: A = herb/shrub stage; B = pole/sapling stage, C = young forest; D = mature and old forest.

5.77.8 Quarter-section level responses



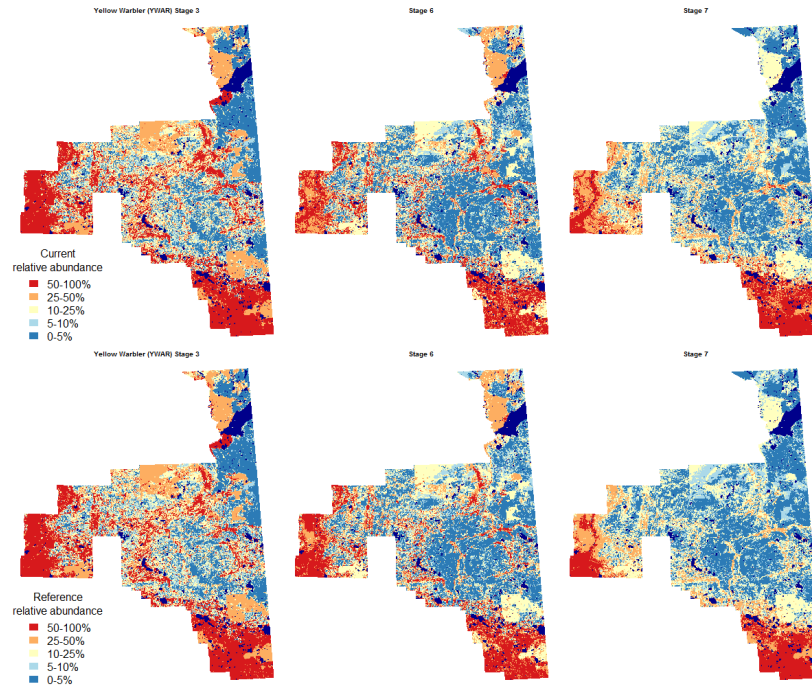
Quarter-section level responses were estimated based on the “QSHF” stage that considered local and quarter-section level terms in the model selection without spatial and year effects. Grey lines represent responses based on individual bootstrap iterations, red line is the mean, yellow region is 90% confidence region. The variation in the graph represent point count level variability (it was not statistically removed). Vertical axes represent relative abundance. Horizontal axes represents percentages in 451 m radius buffers (64 ha = area of a quarter section) around points. “IP” is amount of high suitability patches based on Lorenz-tangent based definition; “Wet” is amount of treed and non-treed wetlands; “WetWater” is amount of non-treed wetlands and open water; other graphs are for different types of human footprint. Empty boxes represent the lack of an effect (0 selection frequency).

5.77.9 Maps



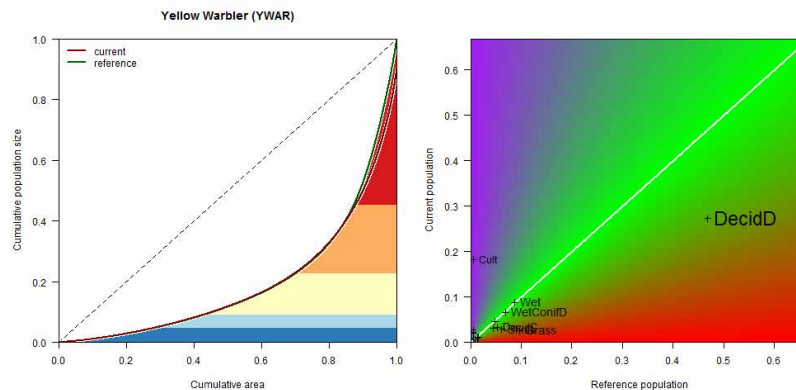
Maps show Alberta with Natural Regions in brown shades and the JOSM study area highlighted. Pixels represent quarter-sections. Detections (top left) are based on all data points used in this study. Intactness map (top right) differentiates areas of increase ($>100\%$) and decrease ($<100\%$). Current (bottom left) and reference (bottom right) abundance cut-off levels were based on cumulative distribution of pixel level mean densities, colors represent strata with increasing cumulative percentage of the potential population in Alberta. Predictive maps are based on “Space” stage of the variable selection procedure (no year effect).

5.77.10 Spatial smoothing effects



Spatial representation of quarter-section level predictive maps within the JOSM study area for current and relative abundance. Abundance percentages are based on Lorenz-tangent approach applied within the JOSM area. Stages in variable selection are: (3) “Contrast”: all local terms (habitat classes and modifiers) considered; (6) “QSHF”: all local and quarter-section scale terms (patch, wetness, footprint) considered; (7) “Space”: all local, quarter-section scale and spatial terms considered (no year effect).

5.77.11 Population concentration



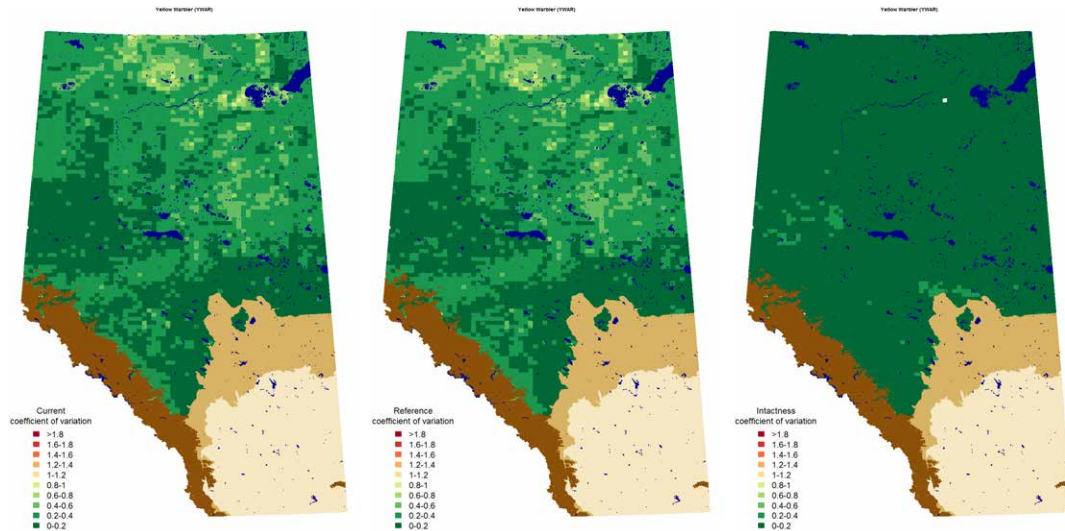
Lorenz curves (left) based on 10% of the quarter-sections in the JOSM study area. Relative change (right) is measured by deviation from diagonal. Current population is scaled by total reference abundance in both graphs. Background colors correspond to legends in distribution and intactness maps.

5.77.12 Potential population size

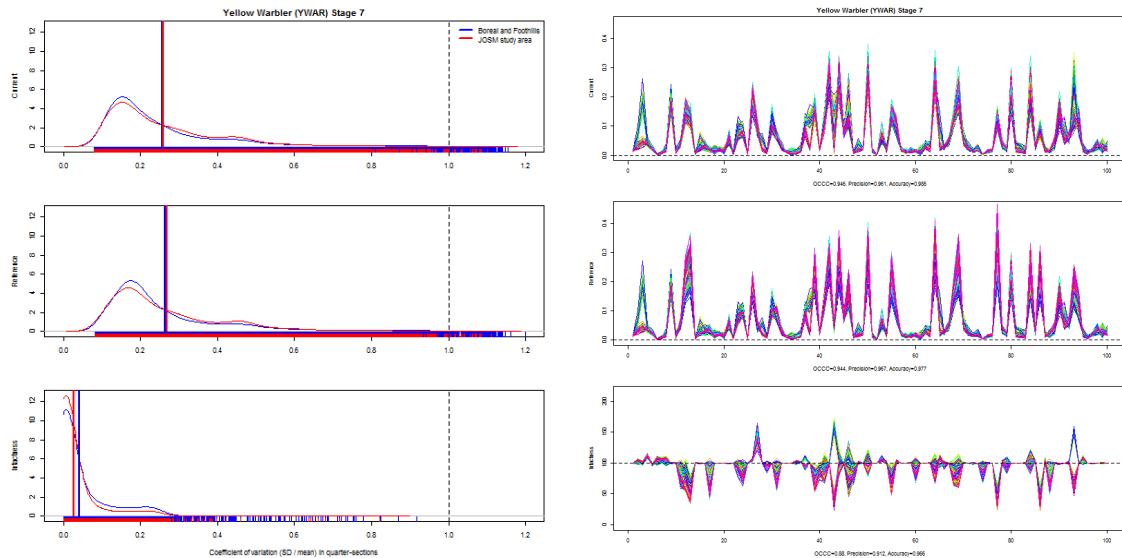
Estimated potential population size of Yellow Warbler in the JOSM study area in millions of male birds. Mean and 90% prediction limits are provided for current (natural vegetation and human footprint) and reference (human footprint backfilled) landscape conditions based on 200 bootstrap runs. Estimates are based on a 10% random sample of quarter-sections in the JOSM study area.

Land cover	Current			Reference		
	Median	5%	95%	Median	5%	95%
DecidD	0.2043	0.1749	0.2420	0.3489	0.3037	0.4014
Grass	0.0193	0.0165	0.0229	0.0717	0.0624	0.0825
Wet	0.0661	0.0566	0.0783	0.0647	0.0563	0.0745
WetConifD	0.0494	0.0423	0.0585	0.0517	0.0450	0.0595
Shrub	0.0214	0.0184	0.0254	0.0459	0.0399	0.0528
DecidC	0.0248	0.0213	0.0294	0.0389	0.0339	0.0448
WetConifC	0.0342	0.0293	0.0405	0.0356	0.0309	0.0409
MixedD	0.0229	0.0196	0.0271	0.0332	0.0289	0.0382
ConifD	0.0080	0.0068	0.0094	0.0118	0.0103	0.0136
DecidB	0.0066	0.0057	0.0079	0.0098	0.0086	0.0113
ConifC	0.0046	0.0039	0.0055	0.0065	0.0056	0.0074
PineC	0.0037	0.0031	0.0043	0.0045	0.0039	0.0052
PineD	0.0033	0.0028	0.0039	0.0041	0.0036	0.0047
WetConifB	0.0039	0.0033	0.0046	0.0040	0.0035	0.0046
PineB	0.0030	0.0025	0.0035	0.0030	0.0026	0.0034
WetConifA	0.0022	0.0019	0.0027	0.0023	0.0020	0.0027
DecidA	0.0009	0.0007	0.0010	0.0020	0.0017	0.0023
ConifB	0.0012	0.0010	0.0014	0.0014	0.0012	0.0016
MixedC	0.0007	0.0006	0.0008	0.0010	0.0009	0.0012
ConifA	0.0009	0.0007	0.0010	0.0010	0.0009	0.0012
MixedB	0.0006	0.0005	0.0007	0.0007	0.0006	0.0008
PineA	0.0006	0.0005	0.0007	0.0006	0.0006	0.0007
MixedA	0.0003	0.0003	0.0004	0.0005	0.0004	0.0006
Cult	0.1367	0.1171	0.1620	0.0000	0.0000	0.0000
UrbInd	0.0146	0.0125	0.0173	0.0000	0.0000	0.0000
HardLin	0.0074	0.0063	0.0088	0.0000	0.0000	0.0000
SoftLin	0.0160	0.0137	0.0190	0.0000	0.0000	0.0000
HFor	0.0199	0.0170	0.0236	0.0000	0.0000	0.0000
Total	0.6773	0.5798	0.8025	0.7441	0.6475	0.8559
Loss	0.0970	0.0364	0.1372			
Gain	0.0262	0.0176	0.0418			

5.77.13 Mapping uncertainty



Coefficient of variation (CV) maps for current and reference densities are based on predictions for 10% random sample of the quarter sections and 200 bootstrap iterations presented as a 10 km resolution raster for the mean current abundance (left), reference abundance (middle) and intactness (right).



Density of CV based on 10% sample and 200 bootstrap iterations.

Illustration of bootstrap variation for 100 random quarter-sections. Statistics refer to values and components of the overall concordance correlation coefficient (OCCC).

5.77.14 Variable selection frequencies

Variable selection frequencies based on bootstrap. Model stages for ID are listed in Table 2.3.

ID	Percent	Frequency	Terms
1.4	100.0	200	. + HabitatB + isHForC
2.2	100.0	200	. + Age + Age2
3.1	100.0	200	. + ROAD
4.0	42.5	85	NULL
4.1	15.5	31	. + Remn_QS
4.2	42.0	84	. + Remn_QS + Remn2_QS
5.1	71.5	143	. + pWet_QS
5.2	28.5	57	. + pWetWater_QS
6.9	96.5	193	. + Succ_QS + Alien_QS + Alien2_QS
6.11	3.5	7	. + Succ_QS + Alien_QS + Succ2_QS + Alien2_QS
7.4	7.5	15	. + xMAP + xPET + xMAT + xCMD
7.5	92.5	185	. + xMAP + xPET + xMAT + xCMD + xMAP:xPET + xMAT:xCMD
8.0	99.5	199	NULL
8.2	0.5	1	. + YR5F

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