Downscaling future land use maps to predict land use change impacts on bumble bee populations inside solar parks

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Summary

Solar parks could support insect pollinators in present day landscapes if located and managed appropriately. However, the role of solar parks under future land use change has not been explored. We use a GIS and pollinator model to predict bumble bee density inside solar parks and surrounding landscapes to address this knowledge gap and as part of this, require present day and future landcover maps of Great Britain. However, available future land use maps are coarser spatial resolution and include fewer categories than present day landcover maps. We therefore present the challenge of downscaling coarse resolution future maps for use with a pollinator model, using resampling and conditional overlay approaches.

KEYWORDS: conservation, land use change, pollinator, renewable energy, solar parks

1. Introduction

1.1. Land use change for solar parks

Land use change for renewable energy infrastructure is set to increase given decarbonisation targets, with solar photovoltaic (PV) predicted to become one of the dominant sources of renewable energy. Much solar PV is deployed as ground mounted solar parks (fields of solar panels mounted on metal supports) which currently occupy ~14,000 ha of land in the UK. The deployment of solar has somewhat outpaced the knowledge of the impacts on hosting ecosystems, but there is a growing body of evidence suggesting there could be significant benefits of managing solar parks for biodiversity and specifically, for insect pollinators.

1.2. Solar parks and pollinators

Solar parks could support pollinators through providing critical resources for feeding and reproduction, may have positive impacts on landscape heterogeneity and connectivity and could provide a range of climatic niches potentially valuable under climate warming, if managed appropriately (Blaydes *et al*., 2021). For example, solar parks managed as a resource-rich wildflower meadow could support more than four times as many bumble bees than solar parks managed as turf grass (Blaydes *et al*., 2022). The location of a solar park is also likely to have an impact, where any resources provided could be more or less valuable depending on surrounding landscape composition, configuration and proximity to other

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habitats. Given their relatively long lifespans, solar parks located and managed appropriately could safeguard suitable pollinator habitat for up to 40 years.

1.3. The role of solar parks in future landscapes

Understanding of the potential for solar parks to support pollinators in present day landscapes is emerging, but the longer-term role of solar parks has not been considered. However, future land use maps of Great Britain, grounded in the state-of-the-art UK-RCP-SSP scenarios, could help further understanding. UK-RCP-SSP projections span from 2040 to 2080 in decadal time slices at 1 km^2 resolution. Scenarios cover weak to strong climate change and future societies with high and low challenges to adaptation and mitigation (**Table 1**; Brown *et al*., 2022). Land use change differs between the scenarios, impacting the landscapes in which solar parks are currently located and therefore pollinator populations inside parks and in the surroundings.

Table 1 The main land use outcomes for each future scenario considered in this study, adapted from Brown *et al*., 2022.

Future scenario	**Main land use outcomes**
Sustainability (SSP1)	Decrease in area of intensive agriculture, greater multifunctionality of agricultural land, decrease in pastoral area, shift towards native species in forests
Middle of the Road (SSP2)	Decrease in area of intensive agriculture and pasture, increase in forest area dominated by non-native tree species
Fossil-fueled Development (SSP5)	High levels of agricultural intensification, expansion of productive land uses into natural areas

1.4. Research Challenge

We used a GIS and a pollinator model to quantify the impact of solar park management on bumble bee density in present day Great Britain and in 2050. However, the future land use maps used to represent landscapes in 2050 lack the spatial resolution needed to undertake pollinator modelling and represent broad categories of land use, not landcover. Here, we present the specific challenge of downscaling coarse resolution future land use maps, in terms of both spatial and attribute resolution, for use with the pollinator model.

2. Materials and Methods

2.1. Pollinator modelling and present day vs. future maps

A specialist model, Poll4Pop, is used to predict bumble bee density in solar parks and surrounding landscapes. The model requires a high resolution landcover raster, whereby each landcover class is scored based on floral cover and attractiveness to the pollinator group of interest (Gardner *et al*., 2020).

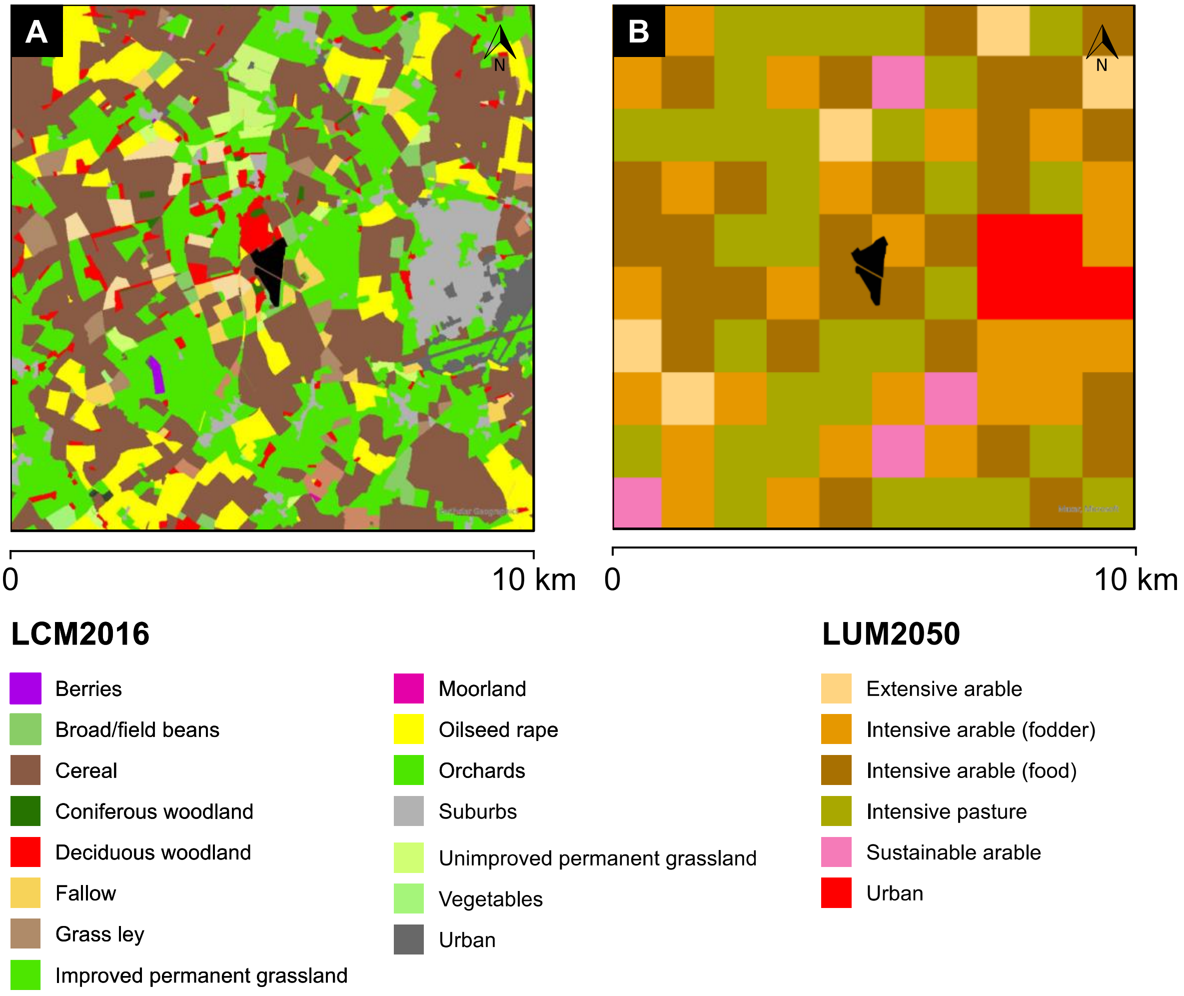
The present day landcover map used with Poll4Pop (hereafter LCM2016) is based on the UKCEH Landcover Map 2015 with Ordnance Survey orchard polygons overlaid on top and 2016 crop information derived from rural payments agency databases (Gardner *et al*., 2020). LCM2016 consists of 24 detailed landcover classes, each scored by pollinator experts, and is 10 m in resolution. In contrast, future land use maps (hereafter LUM2050) consist of 17 classes, which differ to those in LCM2016, and are 1 km in resolution **(Table 2, Figure 1)**.

Ultimately, we needed to combine aspects of the present day landcover and the future land use maps to create a new landcover raster with the detail of LCM2016, informed by the attributes of LUM2050, for use with Poll4Pop.

Table 2 LCM2016 landcover classes vs. LUM2050 land use classes, coloured by landcover group (agricultural = orange, grassland = lighter green, semi-natural = blue, urban = grey and woodland = darker green).

	LCM2016	**LUM2050**
1	Berries (excluding strawberries, raspberries)	Agroforestry
2	Broad/field beans	Bioenergy
3	Cereal	Extensive arable
4	Fallow	Intensive arable (fodder)
5	Grass ley	Intensive arable (food)
6	Oilseed rape	Sustainable arable
7	Orchards	Extensive pasture
8	Strawberry/raspberry (polytunnel)	Intensive pasture
9	Strawberry/raspberry (open)	Very extensive pasture
10	Vegetables	Unmanaged
11	Improved meadow	Urban
12	Improved permanent grassland	Multifunctional mixed woodland
13	Unimproved meadow	Native woodland (conservation)
14	Unimproved permanent grassland	Productive native broadleaf
15	Beaches, sand dunes, plane	Productive native conifer
16	Moorland	Productive non-native broadleaf
17	Salt marsh	Productive non-native conifer
18	Scrub	
19	Water	
20	Wetlands	
21	Suburban	
22	Urban	
23	Coniferous woodland	
24	Deciduous woodland	

Figure 1 A 10 km square example of (a) LCM2016 and (b) LUM2050 (scenario SSP1, Sustainability) centred on a solar park (black).



2.2. Defining landcover-land use transitions

We identified every land use transition that could take place from LCM2016 to LUM2050, yielding 408 different combinations. For each combination, we decided if it was realistic (e.g., Water in LCM2016 would be unlikely to transition to Urban in LUM2050).

A landcover class from LCM2016 was then allocated to represent each landcover class in the new landcover map. If a transition seemed unlikely (e.g. Water to Urban), we kept the original LCM2016 landcover class (e.g. Water). If a transition seemed possible (e.g. Cereal to Urban) we chose a LCM2016 landcover class to represent this in our new map (e.g. Urban). In some cases, there was no direct landcover-land use combination from LCM2016 to LUM2050 and therefore we either (i) chose the best available option based on specialist knowledge (e.g. Bioenergy in LUM2050 was represented by Cereal in LCM2016) or (ii) created new landcover classes (e.g. Multifunctional mixed woodland in LUM2050 was represented by a combination of Coniferous and Deciduous woodland in LCM2016).

2.3. Implementing land use transitions

Firstly, the 1 km resolution LUM2050 landcover maps were resampled to 10 m. A conditional raster overlay was then undertaken using the Raster Calculator tool in ArcGIS Pro (2.8) using conditional statements. The landcover-land use transition decisions were translated into syntax and the overlay ensured that the location and attribution of both LCM2016 and LUM2050 informed the transitions. For example, the example syntax below states that if a pixel in LCM2016 has a value of 30 (i.e. is Cereal) and the same pixel in LUM2050 has a value of 8 (i.e. is Urban) then the pixel in the new raster should have a value of 8 (i.e. Urban).

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NewRaster = Con(("LCM2016" == 30) & ("LUM2050" == 8), 8
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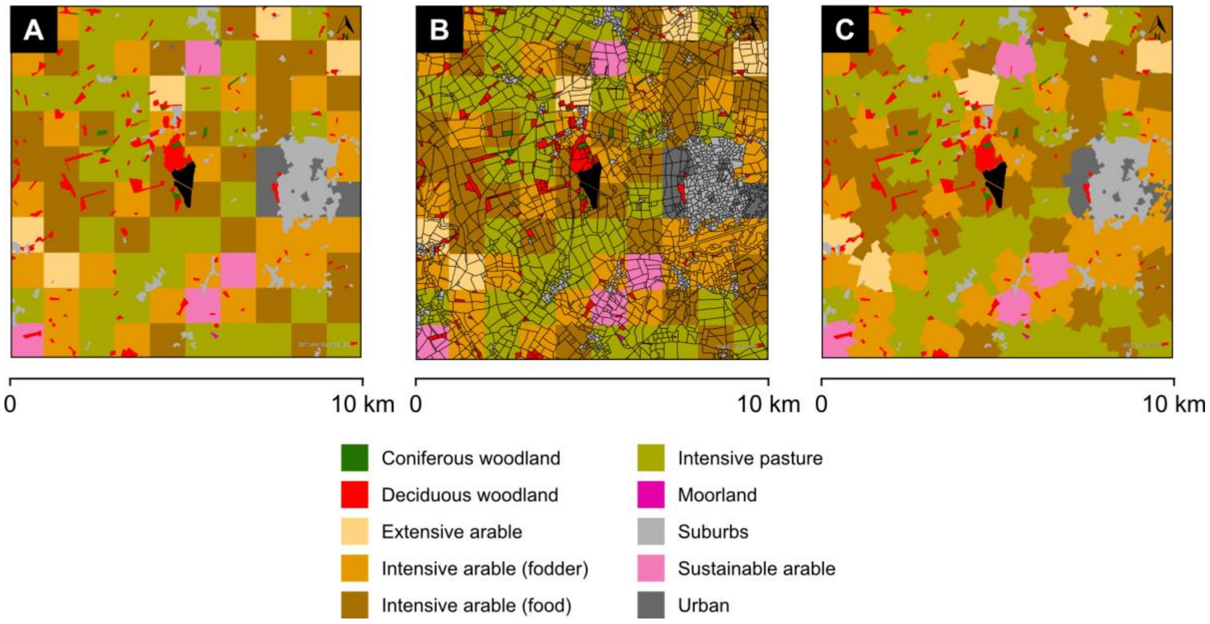
To ensure every pixel in the new landcover map had a value, each of the 408 possible landcover-land use transitions had to be incorporated into the syntax.

Due to the large number of landcover-land use transitions, 17 individual rasters were created (each considering all transitions for each class from LUM2050) and then merged into a single raster.

3. Results and Discussion

Resampling and reclassification techniques resulted in a landcover map combining the spatial resolution of LCM2016 and the attributes of LUM2050 (Figure 2). However, 1 km grid cell boundaries remained obvious, resulting in an unrealistic landscape. To address this, vector land parcels from the present day were introduced and Zonal Statistics applied to calculate the majority landcover within each land parcel (Figure 2).

Figure 2 A 10 km square example of (a) the new landcover raster, (b) the present day vector land parcels overlaid on top of the new landcover raster and (c) the new landcover raster after majority landcovers were calculated within each land parcel.



The resulting landcover map has realistic land parcel boundaries and the required spatial and attribution resolution to feed into the Poll4Pop model and can therefore drive the scenario-based analysis. Uncertainty surrounds the land use transition decisions and modelling results would likely differ if an alternative set of decisions were made. Despite this, the best available data and knowledge were used, and the methods are transparent and adaptable to similar challenges.

4. Acknowledgements

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Biographies

HB is a PhD researcher based at Lancaster University investigating the potential for solar parks to act as refuges for pollinators and boost pollination services using a combination of desk- and field-based techniques.

EG is a quantitative ecologist and modeller, based at the UK Centre for Ecology and Hydrology. She works with stakeholders to better understand how species use landscapes and how they might be affected by land-use changes.

JDW is a professor of GIScience at Lancaster University with research interests across both the natural and social sciences.

RD is a senior natural capital scientist at the UK Centre for Ecology and Hydrology. He specialises in approaches that integrate understanding across a range of environmental sectors, with research interests in integrated modelling, future analyses, natural capital and ecosystem services.

SGP is a professor of biodiversity at the University of Reading. He works with policymakers, industry and NGOs to co-develop evidence-led decision making to safeguard pollinators and pollination services.

AA is a senior lecturer in energy and environmental sciences at Lancaster University and director of Energy Lancaster. She works across disciplines and sectors to assess the impact of renewable technologies on the environment and identify ways in which ecological benefits can be maximised.