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NoBaSURV-PWN – A web app for assessing the statistical confidence of past pine wood nematode surveys

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NoBaSURV-PWN was developed as part of a project '*Assessing the confidence in pest freedom gained in the past pine wood nematode surveys*'.

The project was a co-operation between

- Finnish Food Authority
- Estonian Agriculture and Food Board (EAFB)
- State Plant Service under the Ministry of Agriculture of the Republic of Lithuania (SPSMoA)
- Norwegian Scientific Committee for Food and Environment (VKM)
- Swedish University of Agricultural Sciences (SLU)

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SLU
SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES

efsa
European Food Safety Authority

VKM
Vitenskapskomiteen for mat og miljø
Norwegian Scientific Committee for Food and Environment

REPUBLIC OF ESTONIA
AGRICULTURE AND FOOD BOARD

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1) **How to make an assessment using NoBaSURV-PWN**
   - **Introduction to the app**
   - Survey design
     - Components of the survey
     - Aim of the survey
     - **Design prevalences**
     - Risk based-survey design options
   - Data & other parameter values needed
     - Number of inspected sites and samples
     - Method sensitivity
     - Initial prior probability of freedom
     - Mean time between invasions
2) **Interpretation of the results**
3) **Overview of the calculations done by the app**

The app does not currently support multiple users at the same time!

Questions are welcome at any time!

Introduction to the app

NoBaSURV-PWN

Can be used to assess

1) the confidence of each year's survey separately, i.e.,
   "**the <u>sensitivity</u> of annual surveys**"

1) the confidence accumulated in all years' surveys, i.e.,
   "**the <u>probability of pest freedom</u> after the last annual survey**"

Sensitivity & probability of freedom

Sensitivity (or confidence level) of a survey

The probability that the pest is detected in the survey if its prevalence is at or above the design prevalence

Probability of pest freedom gained in a survey

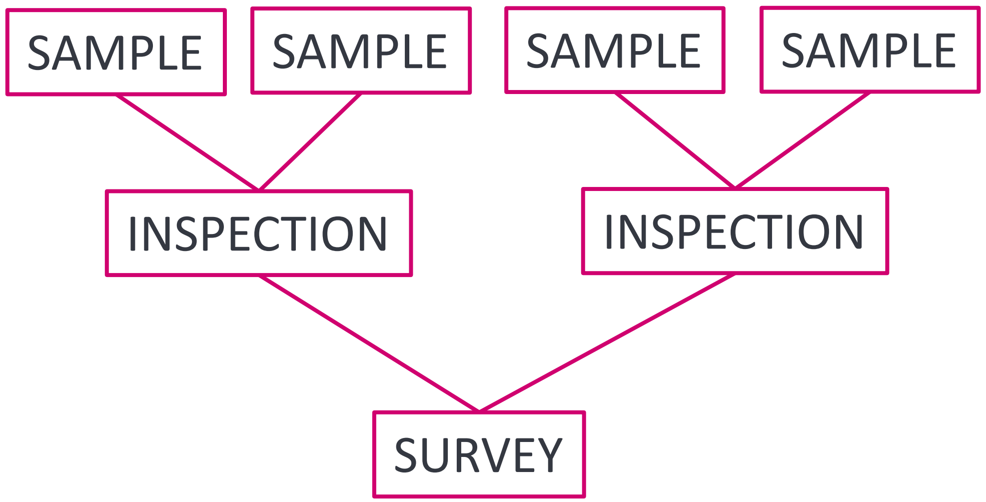
The probability that the prevalence of the pest is below the design prevalence if the pest is not detected in the surveys

Both are **measures of the statistical confidence of the survey** that indicate

how certain we can be that the prevalence of the pest is below the design prevalence

Composition of the surveys

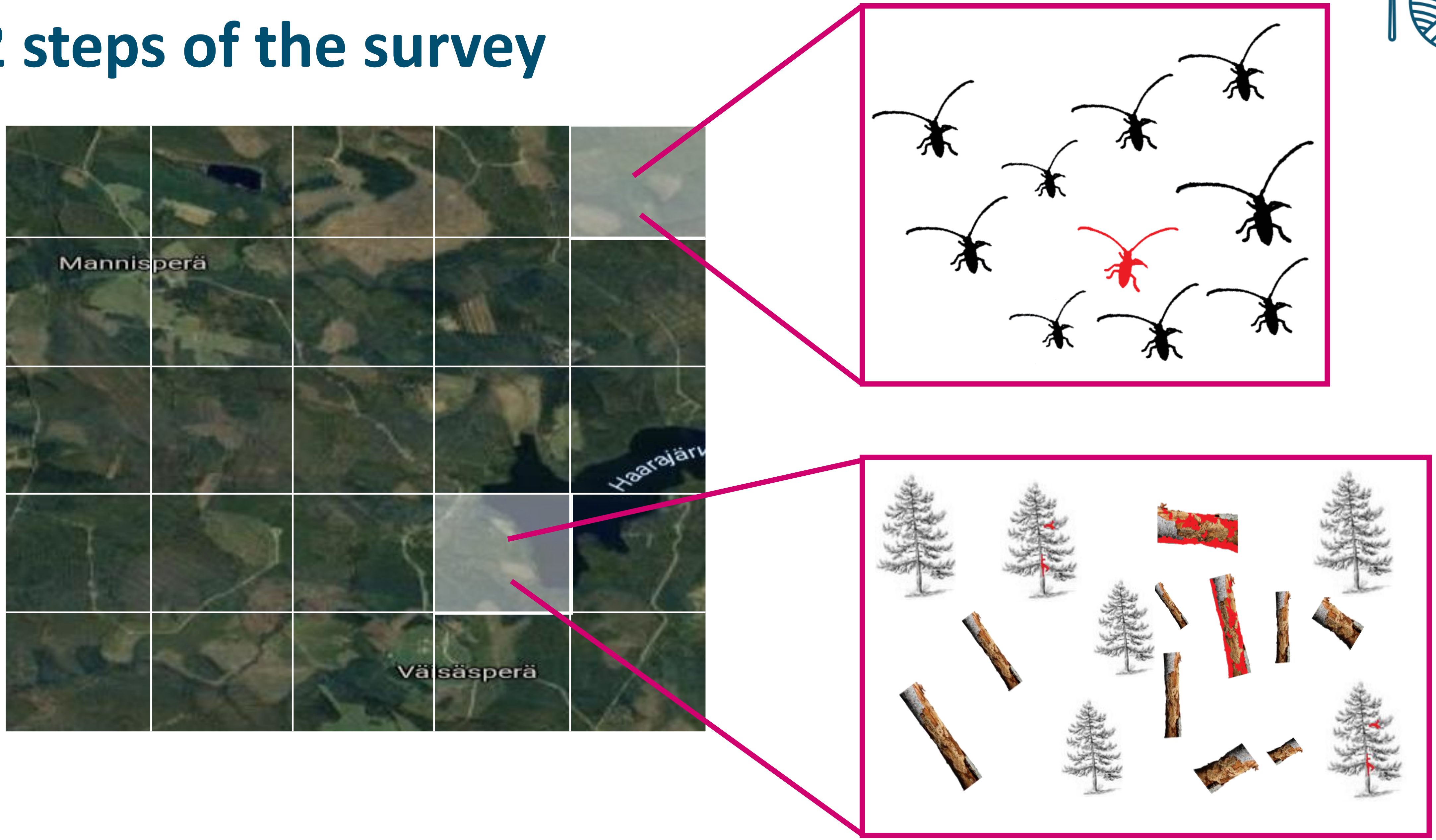
A **survey** is composed of **inspections** that each target one **inspection site**, i.e., an area with PWN host plants



In each inspection

- ≥ 1 **wood sample** is collected, or
- ≥ 1 ***Monochamus* trap** is employed, and ≥ 0 ***Monochamus* adults** are collected

2 steps of the survey



2 steps of the assessment

1st step: The sensitivity of one inspection, ***ISe***

- Inspection site level design prevalence, *DP*
- The number of samples analysed per inspection site, *n*
- Method sensitivity, *MSe*

$$ISe = 1 - e^{-n \cdot MSe \cdot dp}$$

2nd step: The sensitivity of the survey, *SSe*

- Country level design prevalence, *DP*
- The number of inspection done, *N*
- The sensitivity of one inspection, ***ISe***

$$SSe = 1 - e^{-N \cdot ISe \cdot DP}$$

The aim of a survey

Trade facilitation survey

Aims to provide evidence for pest freedom to trading partners to facilitate international trade

- Infestation assumed to be distributed throughout the country

Early detection survey

Aims to detect invasions so early that they can be eradicated

- Infestation assumed to be aggregated to one region

Design prevalence depends on the aim of the survey

Design prevalences

Design prevalence

Sets the minimum prevalence of the pest that the survey is aimed to detect

Setting design prevalence is a risk management decision!

Still, design prevalence must be **biologically plausible**,

i.e., such that the pest can reach it, given

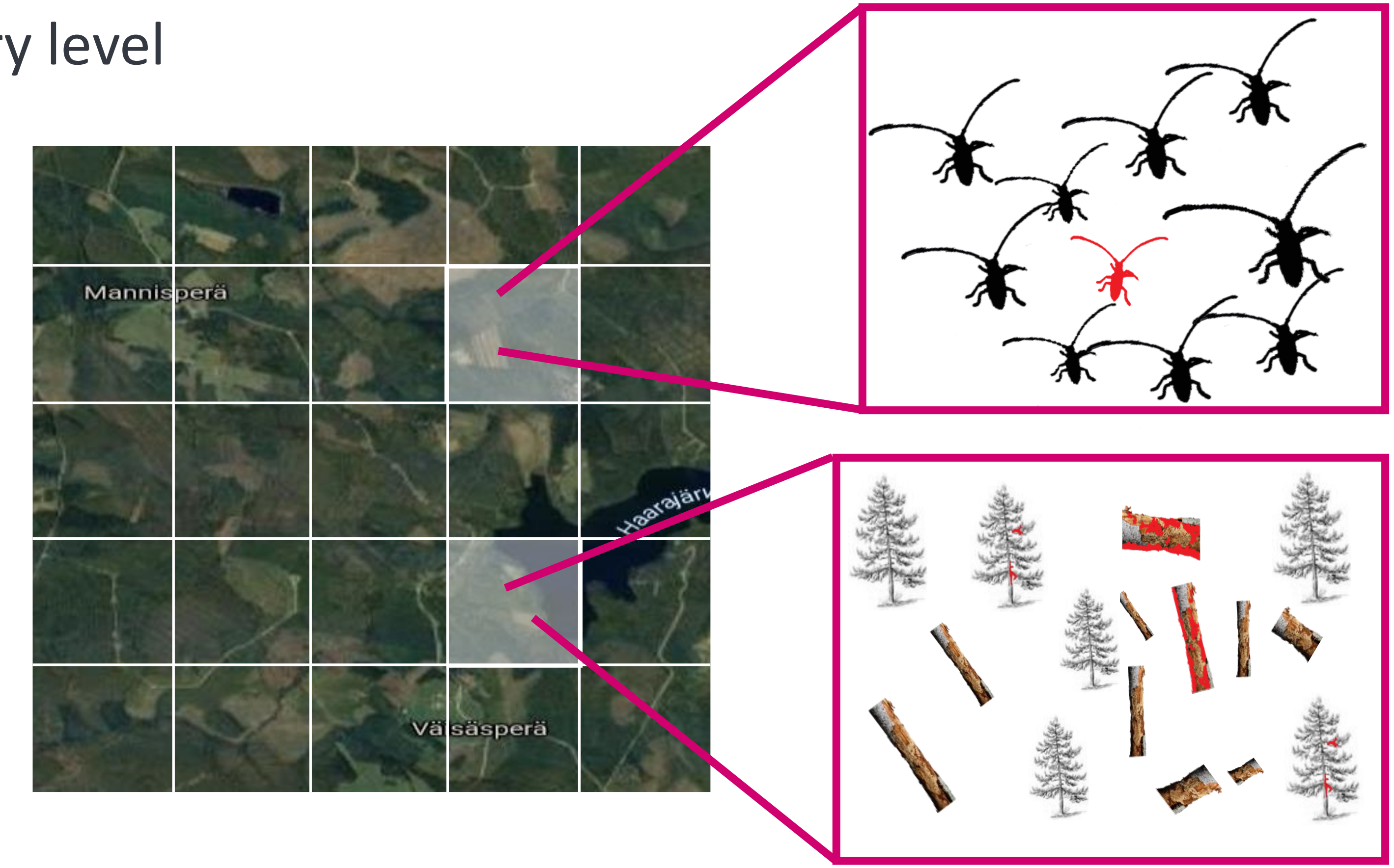
its biology and

the local conditions

Design prevalences for the two steps

Country level

Inspection site level

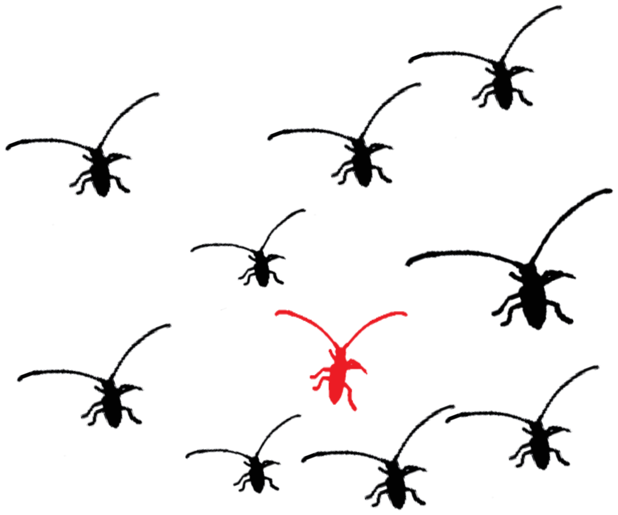


Inspection site level design prevalence

Defined separately for each survey component as the proportion of

- infested **trees and/or wood objects** considered suitable for sampling in the component
- infested ***Monochamus* adults**

Such that the design prevalence of the different components correspond to a similar infestation



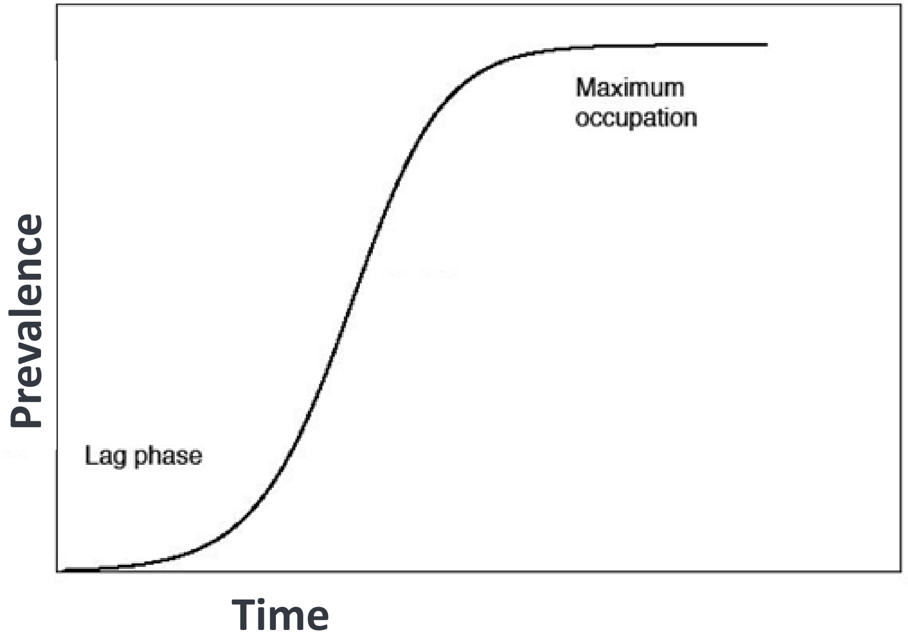
Inspection site level design prevalence

Trade facilitation survey

- Can represent an established population that has reached its maximum density
- Design prevalence ≤ observed prevalence of the same or a proxy species

Early detection survey

- Should correspond to an infestation that can still be eradicated ⇒ a population that is still growing
- Design prevalence < observed prevalence of the same or a proxy species



True vs. apparent prevalence

True prevalence = the actual proportion of the infested units in the population

Apparent prevalence = the proportion of analysed units testing positive

True prevalence = apparent prevalence × method sensitivity

Special case: *B. mucronatus* as a proxy

If *B. mucronatus* analysed **from the samples collected in the PWN surveys, with the same methods as PWN**, a given apparent prevalence is likely to result in a similar true prevalence for both species.

In such a case, **inspection site level design prevalence may be set relative to the apparent prevalence of *B. mucronatus***, without knowledge of its true prevalence.

In this approach, if the design prevalence is set

- equal to the apparent prevalence of *B. mucronatus*, it indicates that the aim is to detect a PWN prevalence that is equal to the prevalence of *B. mucronatus*
- 50% of the apparent prevalence of *B. mucronatus*, it indicates that the aim is to detect a PWN prevalence that is equal to 50% the prevalence of *B. mucronatus*

Country level design prevalence

Trade facilitation survey

- Defined as **the proportion of infested area** of the total area of the target population in the country

Early detection survey

- The user defines the **maximum acceptable size of PWN infestation at detection**, km^2
- From this the app calculates the proportion of infested area of the total area of the target population separately for each region

Country level design prevalence

Trade facilitation survey

- Can be based on
  - legislation or international standards
  - requirements of the trading partners
  - political considerations and availability of resources
- A common choice is 1%

Early detection survey

- Should correspond to an infestation that can still be eradicated, i.e., **the maximum acceptable size of infestation at detection**

Risk-based survey design options

Risk-based survey design terminology

Risk factor
A factor that affects the probability of infestation by the pest

Risk factor level
Each risk factor is categorized in two or more risk factor levels
that differ in the probability of infestation by the pest

Relative risk of the risk factor level
The ratio of the probability of infestation **per unit** in one risk factor level
to the probability of infestation **per unit** in another risk factor level

Note that although the word risk is used in these terms, the severity of impact of the infestation is not considered!

Risk-based surveys design options in NoBaSURV-PWN

Risk factor

Human activity related to international trade that increases the probability of PWN entry to the country

Risk factor levels

Option 1: Regions

Option 2: Risk areas close to entry sites and baseline areas further away from entry sites*

*Entry sites = locations in which the probability of pest entry (to the country) is elevated, e.g., industrial areas, harbours and landfills

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Data and other parameter values needed

Data needed

	Risk-based design option 1	Risk-based design option 2
Data on survey activities	• The number of inspected sites • The number of samples	• The same data as for option 1 but separately for **risk areas and baseline areas**
Data on landcover	• The area (km^2) or number of entry sites • The area of the target population (km^2)	• The area (km^2) or number of entry sites • The area of the target population separately for **risk areas and baseline areas** (km^2)

Entry sites & target population

Entry sites

- Locations where the probability of PWN entry (to the country) is elevated
- E.g., industrial areas, harbours and landfills

Target population

- The population to which the results of the survey will be generalized to
- E.g., all areas with PWN host plants

Data files

- Comma separated csv files
- Data for regions in columns, and data for years in rows
- The first row: the names of the regions (without special characters) in the same order in all files
- The first column: the years covered in the surveys in ascending order
  - Every year between the first and the last must be included in all the files, even if the survey was not done in all years)
- When the number of inspected sites or the number of samples is zero, that is indicated with 0
- Point is used as a decimal separator

Link to example files

Method sensitivity

Method sensitivity *(MSe)*

The probability that a truly positive inspection unit tests positive

$$MSe = S \times D$$

Sampling effectiveness (*S*)

The probability of selecting infested parts from an infested sampling unit

Diagnostic sensitivity (*D*)

The probability that a truly positive sample tests positive

Special case: *B. mucronatus* as a proxy

If inspection site level design prevalence is set **relative to the prevalence of *B. mucronatus*** observed in the samples analysed in the PWN surveys (see slide 19), setting the value for method sensitivity differs from the normal case

In this special case, 1 should be inserted in the field “Method sensitivity”.

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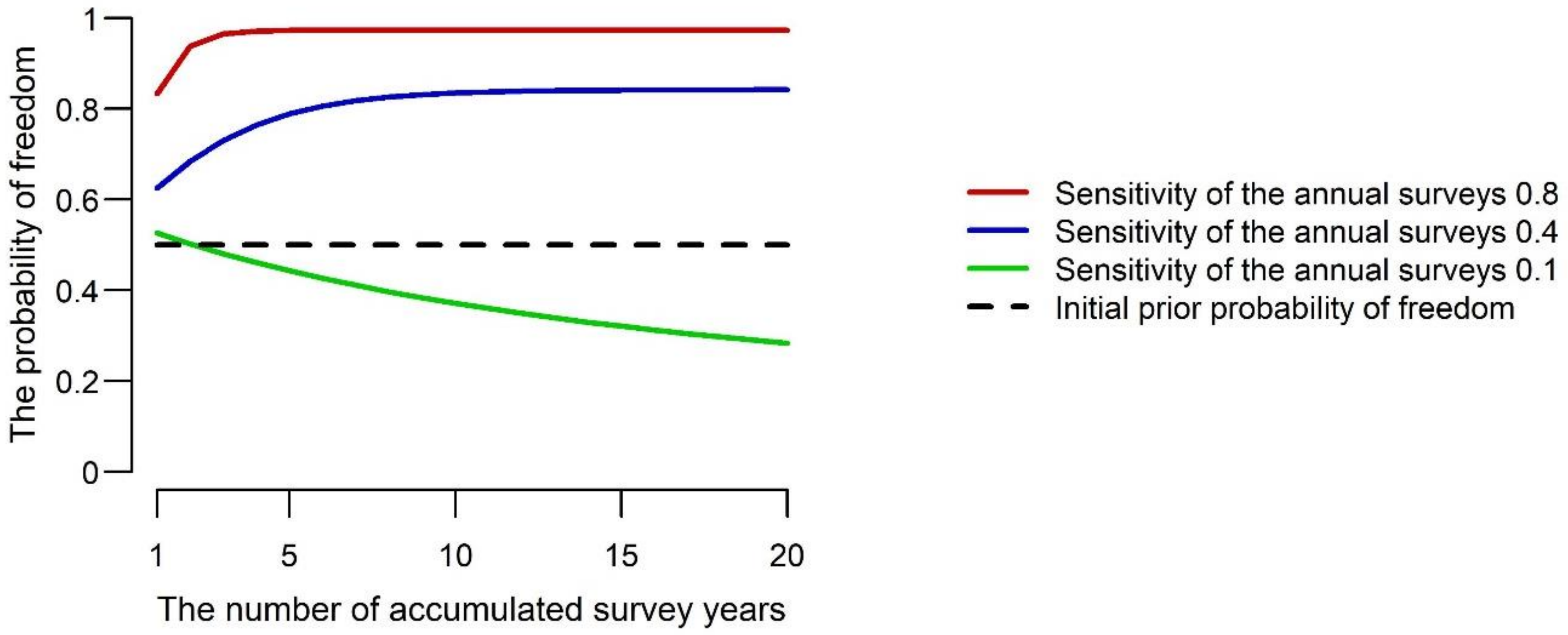
Interpretation of the results

Initial prior probability of freedom



- NoBaSURV-PWN app online
- Data on the Nordic-Baltic pine wood nematode surveys
- Final report of the project "Assessing the confidence in pest freedom gained in the past pine wood nematode surveys" includes
  - Instructions on how to make an assessment with the app
  - Technical details of the app
- The source code for NoBaSURV-PWN

- NoBa LCR - A web app for retrieving Land Cover data needed in the statistical assessment and planning of quarantine pest surveys
- A webinar on NoBa LCR 14 December 2023, 14:00-15:50 (EET, UTC+2)

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If you need help or have questions, please contact salla.hannunen@foodauthority.fi

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An overview of the calculations done by the app

Relative risk of the risk factor levels

Risk-based survey design option 1

$$RISK_j = \frac{E_j}{\sum_{j=1}^{J} E_j}$$

j = region

J = the total number of regions

E = the area or number of entry sites

Relative risk of the risk factor levels

Risk-based survey design option 2 a*

r = the radius of risk areas (m)

p = 0.804 (the shape parameter)

u = 39 760.1 m^2 (scale parameter)

$$k_D(r) = 2\pi r \cdot \frac{p}{\pi \cdot u \cdot \left[1 + \frac{r^2}{u}\right]^{p+1}}$$

⇒ k_D integrated numerically to get PWN_{risk} and $PWN_{baseline}$

$$RISK_{risk} = \frac{PWN_{risk}}{PWN_{baseline}}$$

PWN_{risk} = the predicted proportion of the PWN population in the risk areas

$PWN_{baseline}$ = the predicted proportion of the PWN population in the baseline areas

$RISK_{RISK}$ = relative risk of the risk areas

*The *'2Dt'* dispersal location kernel of *Monochamus galloprovincialis* from Etxebeste et al. (2016)

1) Sensitivity of one inspection, separately for each survey component

2) Sensitivity gained by all inspections done in a region

3) Sensitivity of the annual surveys in the entire country

4) Probability pest freedom after the last annual survey

Sensitivity of inspections, *ISe*

Assessed separately for each component

Assuming sampling form the Poisson distribution

$$ISe = 1 - e^{-n \cdot MSe \cdot dp}$$

n = the number of samples

MSe = method sensitivity

dp = inspection site level design prevalence

Sensitivity of annual surveys in the regions, *GSe*

Assessed separately for each component and risk factor level

Assuming sampling form the Poisson distribution

$$GSe = 1 - e^{-N \cdot ISe \cdot adjDP}$$

N = the number inspections

ISe = the sensitivity of inspections

adjDP = regional level design prevalence

Adjusted region level design prevalence

Trade facilitation surveys – both risk-based survey design options

adjDP = EPItf

$$EPItf_i = DP \cdot \frac{RISK_i}{\sum_{i=1}^{I} \left(PropPop_i \cdot RISK_i \right)}$$

i = risk factor level, *I* = the total number of risk factors levels

DP = the country level design prevalence

RISK = the relative risk of the risk factor level

PropPop = the proportion of the target population in the risk factor level i of the total area of the target population in the country

Adjusted region level design prevalence

Early detection surveys – risk-based survey design option 1

adjDP = DPr (region level design prevalence)

$$DPr_j = \frac{MaxInfSize_j}{Pop_j}$$

j = region

MaxInfSize = maximum acceptable area of PWN infestation at detection

Pop = the area of the target population in the region

Early detection surveys – risk-based survey design option 2

adjDP = EPIed

$$EPIed_{j,i} = DPr_j \cdot \frac{RISK_i}{\sum_{i=1}^{I}\left(PropPop_{j,i} \cdot RISK_i\right)}$$

Sensitivity of annual surveys in the regions, *GSe*

The sensitivities of the components and risk factor levels are combined to get the total survey sensitivity for each region

Calculated as the complement of the probability that, if PWN is present in the region, it is not detected in any component in any risk factor level

$$GSe_j = 1 - \prod \left(1 - GSe_{c,i,j}\right)$$

c = component

i = risk factor level

j = region

Sensitivity of annual surveys in the country, *SSe*

Trade facilitation surveys

Calculated as the complement of the probability that, if PWN is present in the country, it is not detected in any of the regions

$$SSe = 1 - \prod_{j=1}^{J} (1 - GSe_j)$$

j = region

J = total number of regions

GSe = the sensitivity of the survey in the region

Sensitivity of annual surveys in the country, *SSe*

Early detection surveys

Calculated as calculated as the probability of correctly detecting the pest in the survey given that it is present in one region

$$SSe = \frac{\sum_{j=1}^{J} GSe_j \cdot R_j}{\sum_{j=1}^{J} R_j} \qquad R_j = \frac{E_j}{\min\left\{E_j \ldots E_J\right\}}$$

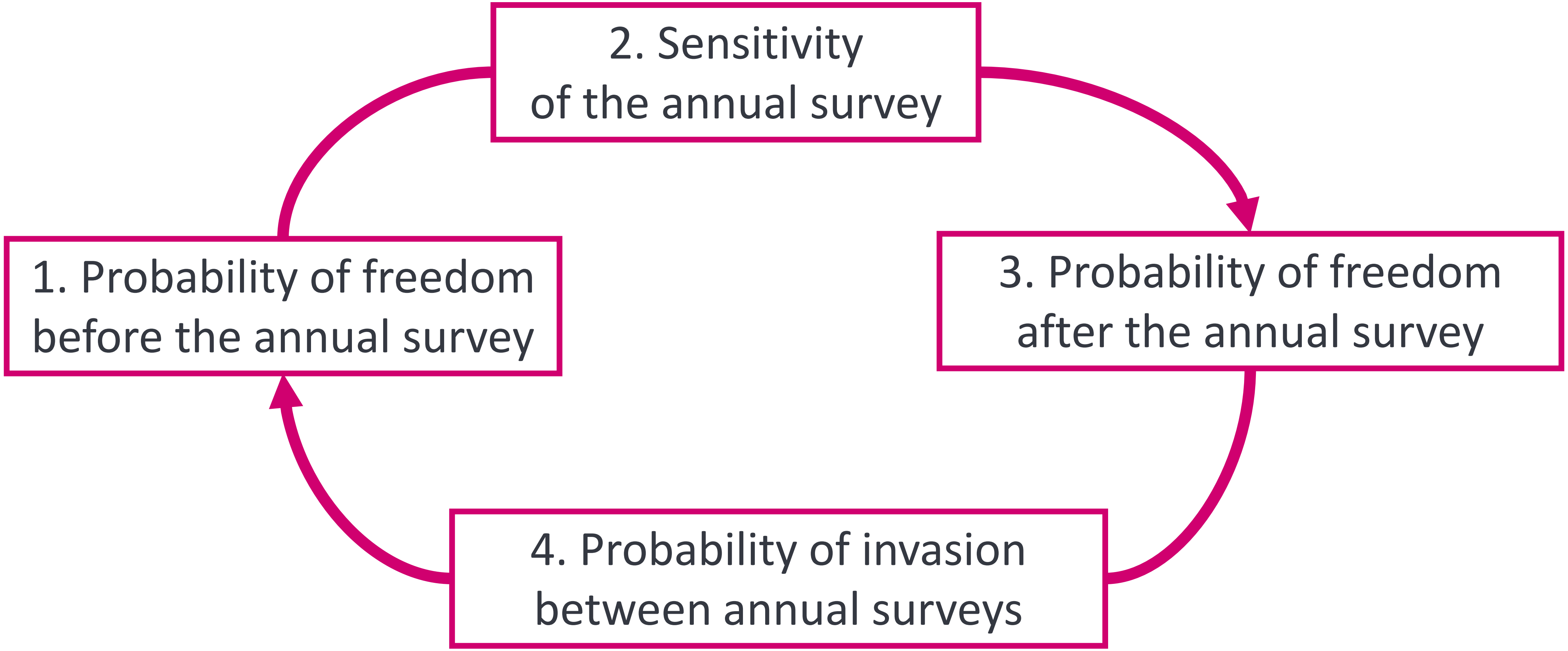
j = region

J = total number of regions

GSe = the sensitivity of the survey in a region

E = the area of entry sites in a region

The probability of pest freedom after the last annual survey



The probability of freedom after the last annual survey, *Pfree*

Updating the probability of freedom using Bayes' theorem

$$Pfree_t = \frac{PriorPfree_t}{PriorPfree_t + \left[\left(1 - PriorPfree_t\right) \cdot \left(1 - Se_t\right)\right]}$$

t = time

Se = the sensitivity of the survey at regional (= *GSe*) or country (= *SSe*) level

PriorPfree = the prior probability of freedom

The probability of freedom after the last annual survey, *Pfree*

Adjusting the prior probability freedom (*PriorPfree*) with the probability of invasion between the surveys

$$PriorPfree_t = 1 - \left[\left(1 - Pfree_{t-1}\right) + Pinv_t - \left(1 - Pfree_{t-1}\right) \cdot Pinv_t \right]$$

t = time

$Pinv_{t,j}$= the probability that the pest was introduced to the considered area after the survey conducted at time t—1

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Thank you!

Risk assessment unit

Research to support knowledge-based risk management

For more information, please contact salla.hannunen@foodauthority.fi