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Screening potential pests of Nordic coniferous forests associated with the trade of ornamental plants

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Pests are spreading with the international trade

- Invasive pests are introduced into new areas especially via the **international trade of living plants**
- The **trade of ornamental plants** into the Nordic countries has increased in the last decades
- The pests that may potentially spread with this trade may also be a **threat to our native forest trees**
- **Climate warming** may enhance the **establishment** of those pests in the Nordic countries

How to prevent the introduction of new pests?

- The introduction of new pests is mitigated with **plant health regulations**
- The regulations provide lists of **quarantine pests** whose introduction is aimed to be prevented, for example, with requirements for the international trade
- However, **not all the potentially harmful pests** that could spread in international trade are **quarantine pests**
- New quarantine pests may be added to the legislation, only if **the risk of the pests** has been assessed according to the **International Standards for Phytosanitary Measures** (ISPMs)
- **Pest risk assessments** (PRAs) are normally done only for pests that are **emerging** or otherwise recognized as a potential risk based on **prescreening** or **pest prioritization**

The aim of our joint Nordic pest screening project

To identify pests of **Scots pine** (*Pinus sylvestris*) and **Norway spruce** (*Picea abies*) that could

1) be **introduced** into Finland, Sweden and Norway via **the trade of ornamental plants**, and

2) potentially **fulfil the criteria** to become **regulated as quarantine pests** in the EU and Norway

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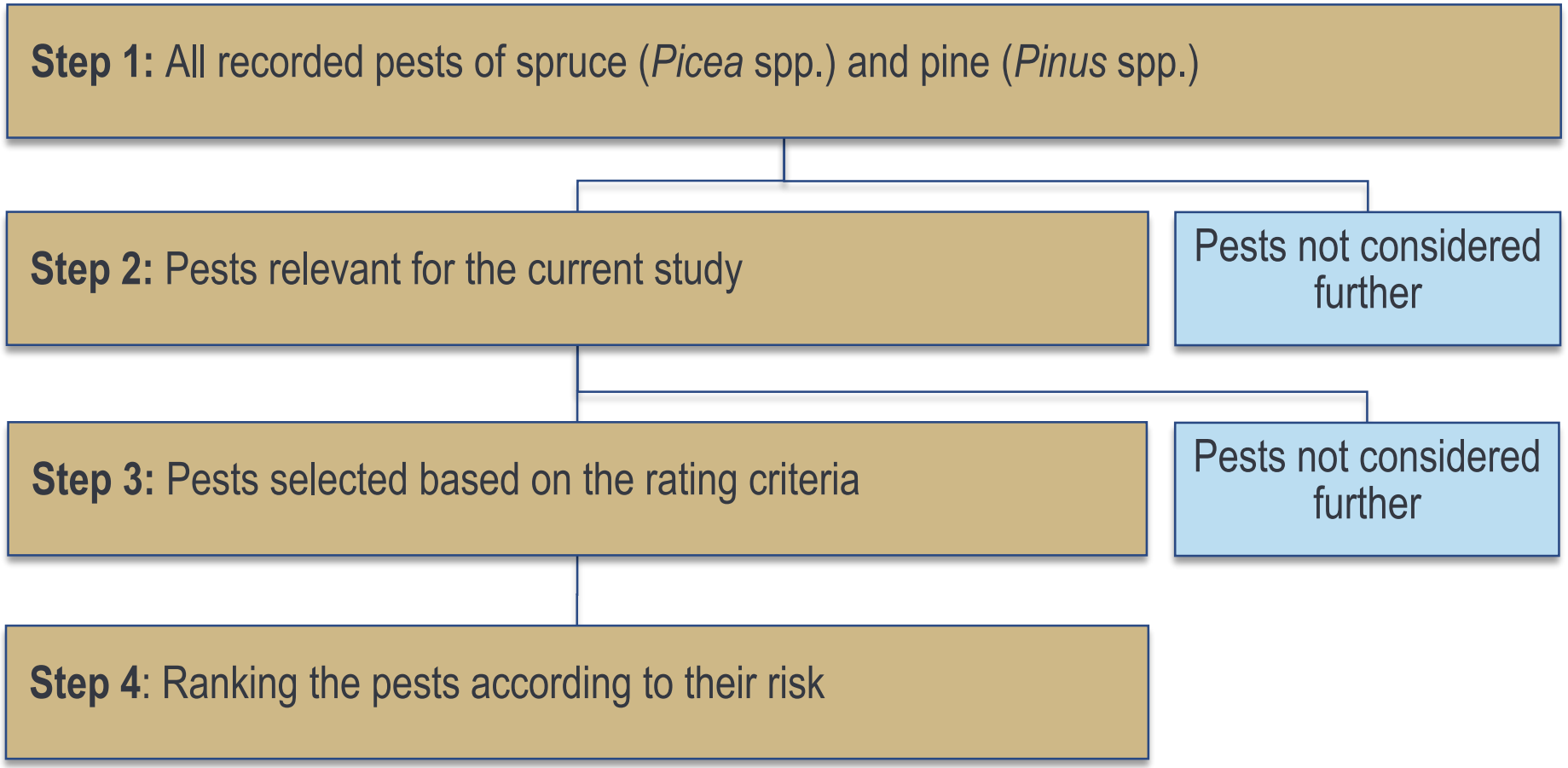
The pest screening procedure



The pest screening procedure

Step 1: All recorded pests of spruce (*Picea* spp.) and pine (*Pinus* spp.)

Step 2: Pests relevant for the current study

Pests not considered further

Step 3: Pests selected based on the rating criteria

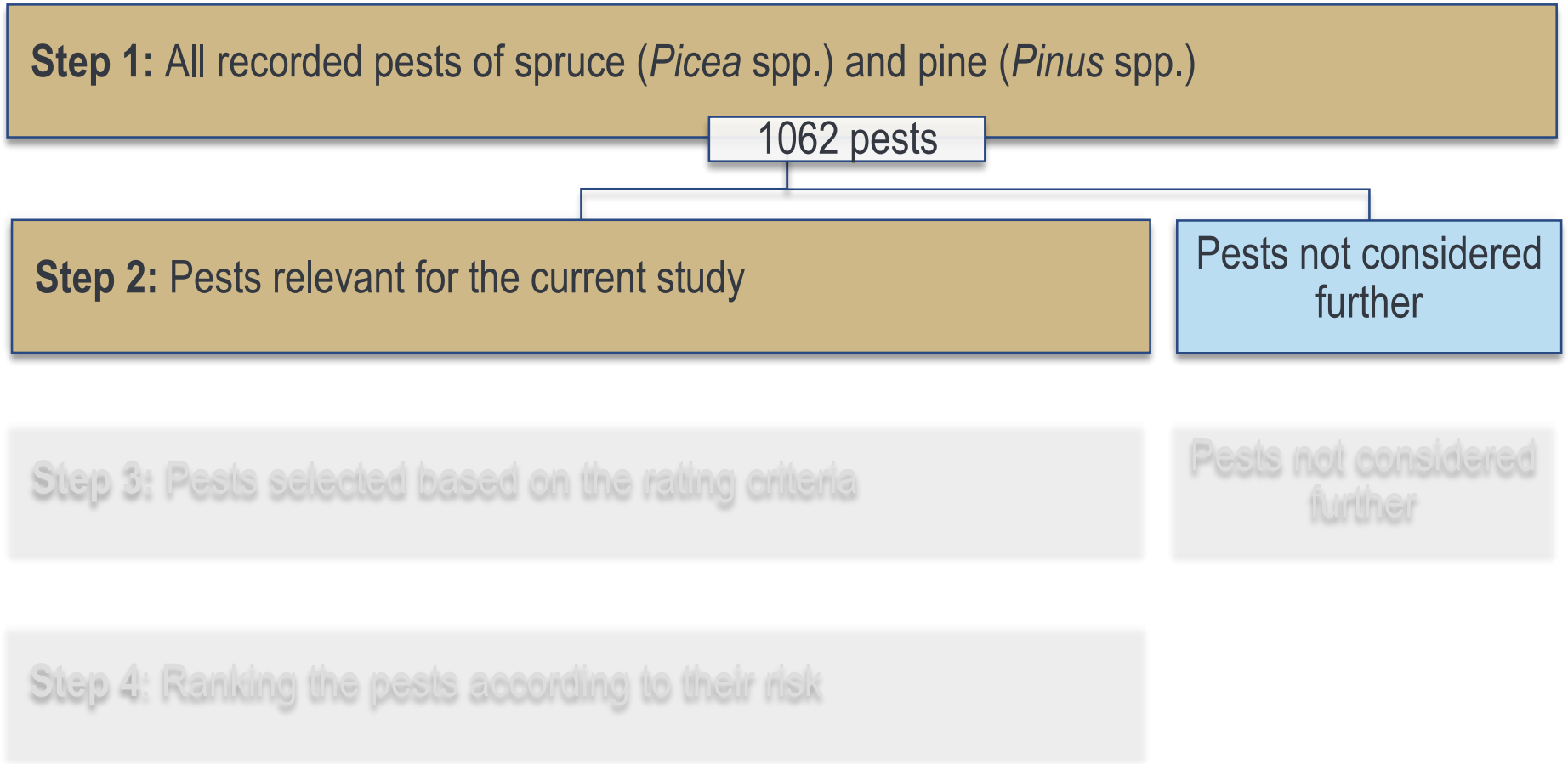
Pests not considered further

Step 4: Ranking the pests according to their risk

Step1: All recorded pests of spruce (*Picea* spp.) and pine (*Pinus* spp.)

- A list of **all recorded pests** of spruce (*Picea* spp.) and pine (*Pinus* spp.) was established using three **major pest databases**
  - EPPO Global Database
  - CABI Crop Protection Compendium
  - Pest Information Wiki

The pest screening procedure



Step2: Pests relevant for the current study

The pest list was screened to **exclude irrelevant pests** for the study based on the following criteria:

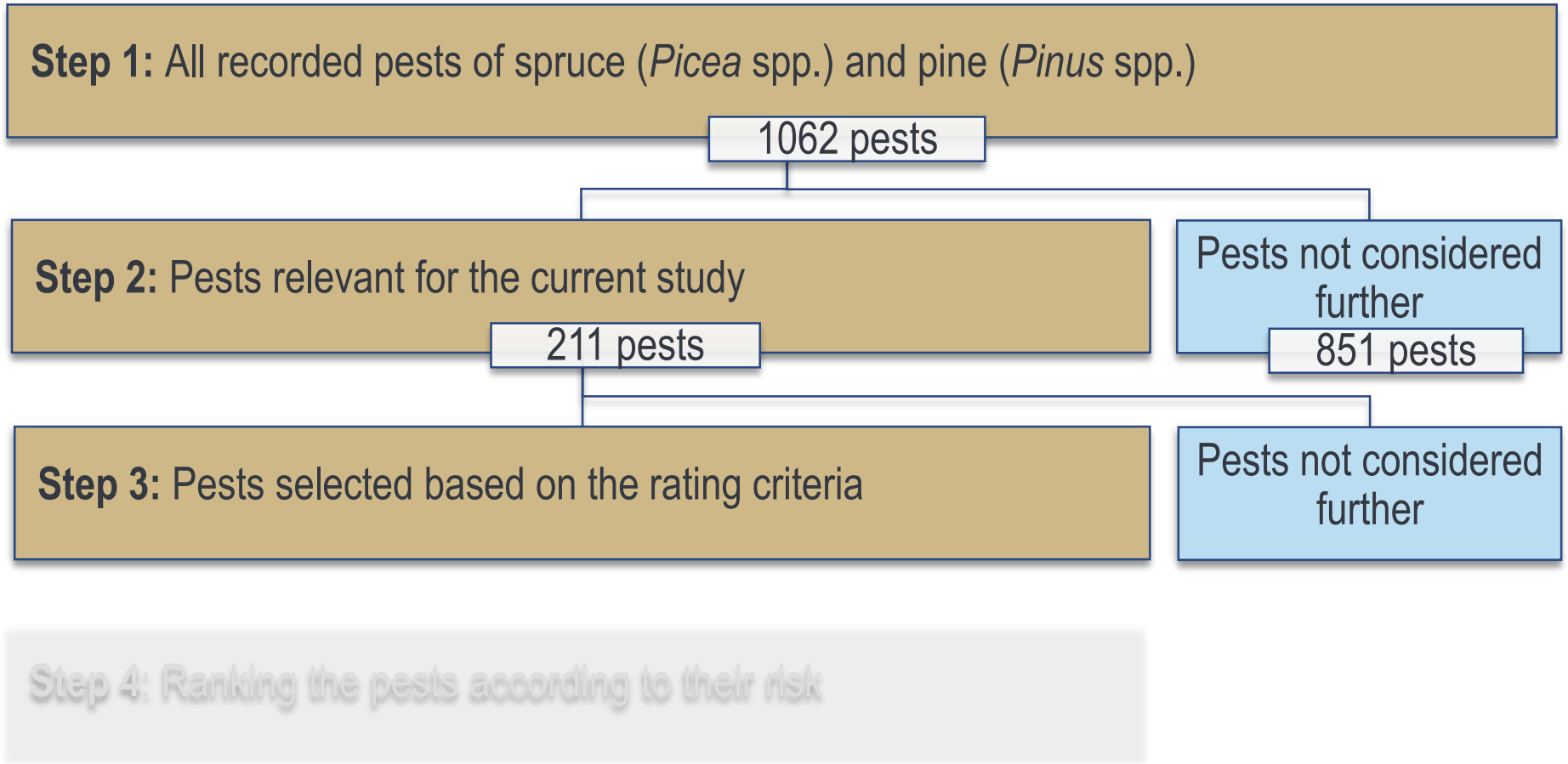
1) Pests not classified as insects, arachnids, nematodes, fungi, chromists, bacteria, viruses or viroids

2) Pests already regulated as quarantine pests in the EU and Norway

3) Pests already known to be present in Finland, Sweden or Norway

4) Pests not present in Europe and whose host plants for planting cannot be imported into EU and Norway according the current regulations

The pest screening procedure



Step3: Pests selected based on the rating criteria

To identify the most relevant pests we used the **rating criteria** suggested for **commodity studies** by **EPPO** (European and Mediterranean Plant Protection Organization) [1,2]:

1) **Likelihood** of the pests being associated with the **ornamental plants for planting**
2) Overall **host range** of the pests
3) **Climatic similarity** between the Nordic countries and the countries where the pests are known to be present
4) Recorded **direct impacts** of the pests on coniferous species
5) Recorded **interceptions** of the pests
6) Identification of **emerging** pests

[1] EPPO (2016) EPPO Technical Document No. 1074, EPPO Secretariat's approach for commodity studies. EPPO Paris.
[2] EPPO (2017) Guidelines on Pest Risk Analysis, Preparation of pest lists in the framework of commodity PRAs. PM 5/9 (1). EPPO Bulletin 47: 371–378.

Step3.3: Climatic similarity

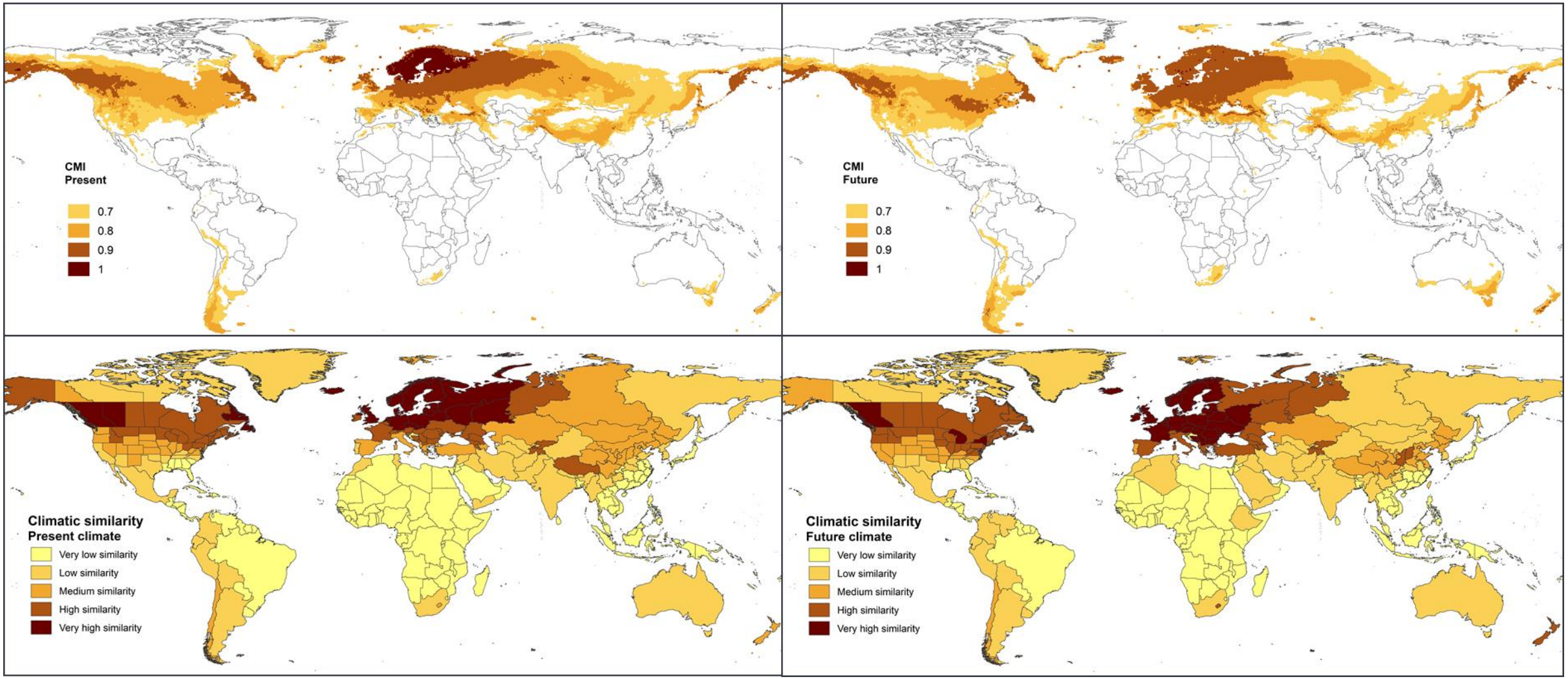
- The assessment was done both in the **present climate** and using **future climate** scenarios for the time period around 2050
- The assessment was done using the Climex software 4.0 [3]
- Future climate scenarios included [4]:
  - ACCESS1-0 rcp85
  - CNRM-CM5 rcp85
  - GFDL-ESM2M rcp85
  - NorESM1-m rcp85

[3] Kriticos et al. (2015) CLIMEX Version 4: Exploring the effects of climate on plants, animals and diseases. CSIRO, Canberra. 156 pp.
[4] Kriticos, et al. (2012) CliMond: a global high-resolution historical and future scenario climate surfaces for bioclimatic modelling. Methd. in Ecol. & Evol. 3:53–64.

Step3.3: Climatic similarity

PRESENT CLIMATE

FUTURE CLIMATE



Step3: Pests selected based on the ratings

- First, pests that have been recorded to **cause mortality** or **significant damages** to their **coniferous host** plants, and **may be carried with plants** for planting were selected

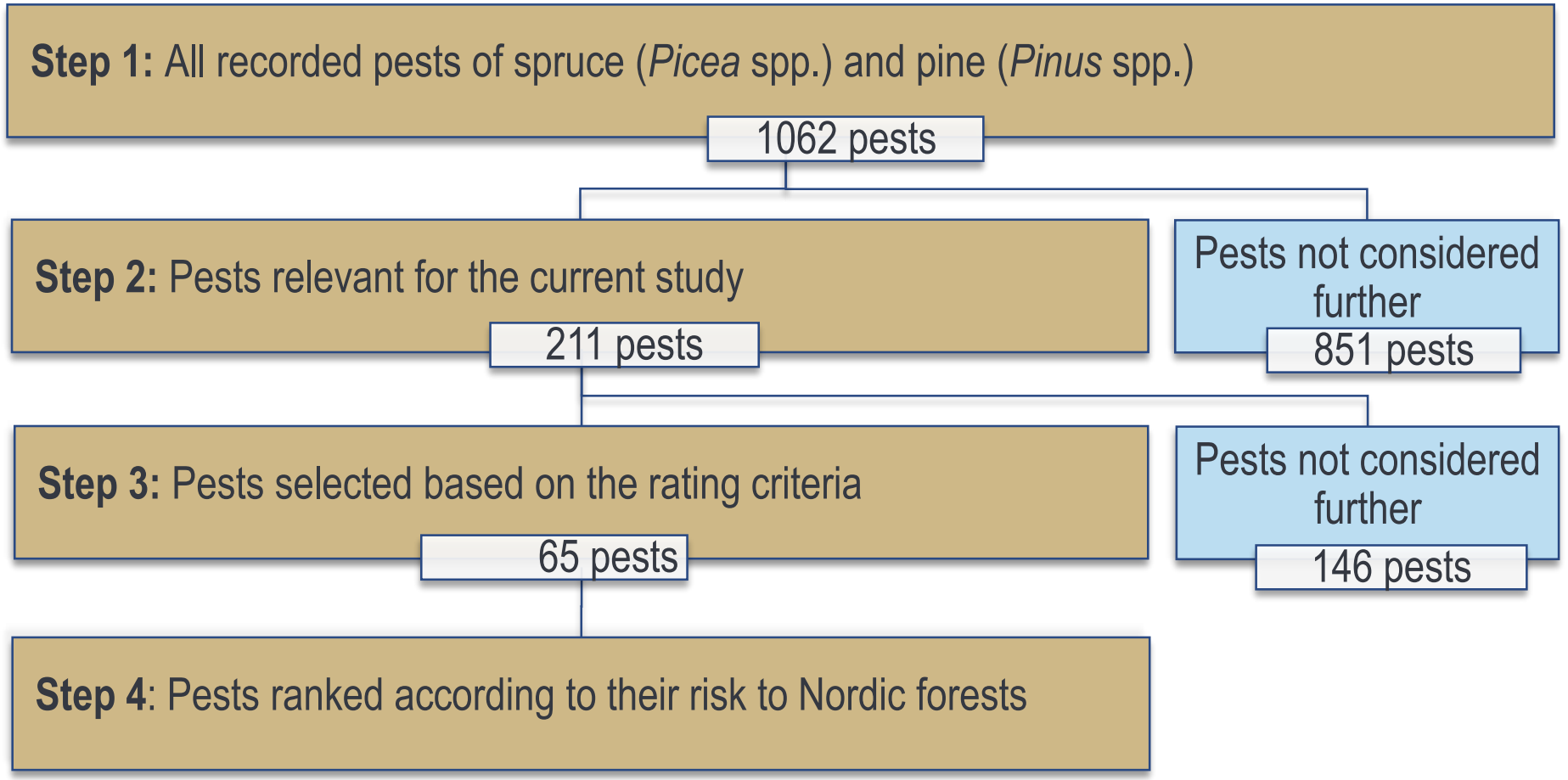
- Next, from the pests present in Europe, only pests that are known to have ***Picea abies*** and/or ***Pinus sylvestris*** as **hosts** were selected

- Then, from the pests not present in Europe, only pests that are present in countries that have a **medium to very high climatic similarity** with the Nordic countries were selected

Step3: The selected 65 pests by type and presence in Europe

Type of pest	Present in Europe	Not present in Europe	All
Arachnida	1	0	**1**
Bacteria	2	0	**2**
Chromista	2	0	**2**
Fungi	15	6	**21**
Insecta	17	21	**38**
Nematoda	1	0	**1**
Viruses and viroids	0	0	**0**
All	**38**	**27**	**65**

The pest screening procedure



Step4: Pests ranked according to their risk to Nordic forests

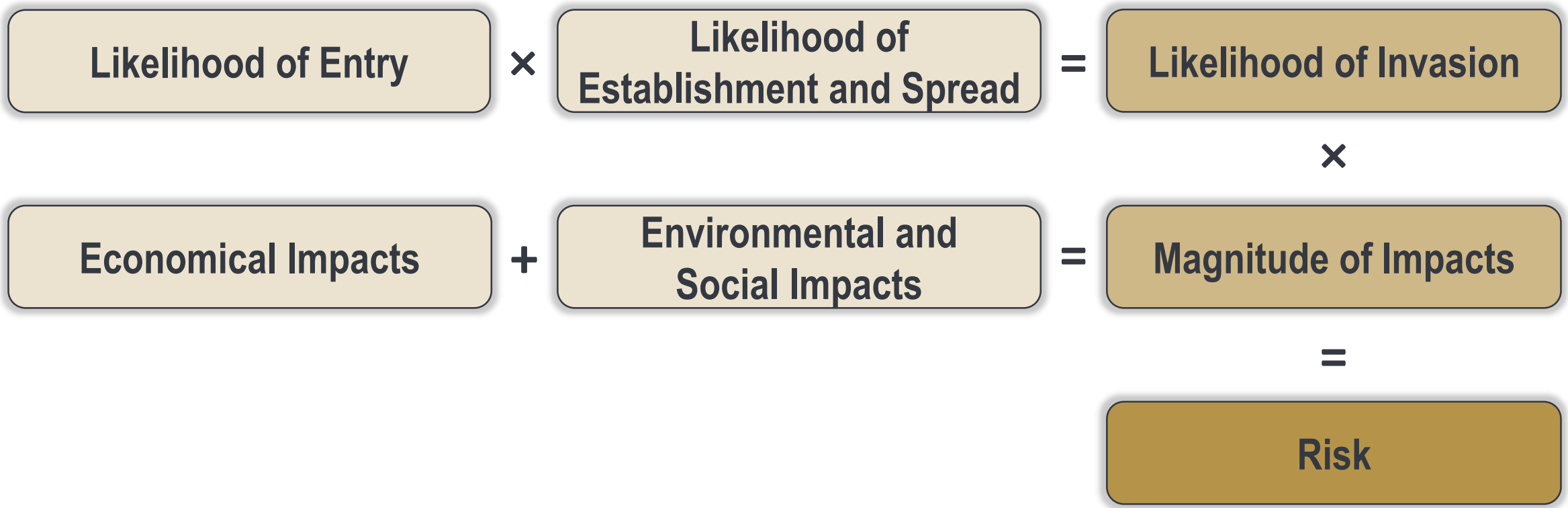
- The FinnPRIO pest risk ranking model [5] with a hypervolume approach [6] was used **to rank the pests according to their risk to Nordic coniferous forests**

- FinnPRIO is a tool for carrying out **quick**, **well structured**, **semiquantitative expert assessments**, that use **consistent criteria** and hence enable **comparison** of different pests

- The hypervolume approach is a tool to **aggregate the simulated probability distributions** of FinnPRIO assessment scores into **a simple single-dimensional priority order**

[5] Heikkilä et al. (2016) FinnPRIO: a model for ranking invasive plant pests based on risk. Biological Invasions 18(7): 1827–1842.
[6] Yemshanov et al. (2017) A new hypervolume approach for assessing environmental risks. Journal of Environmental Management 193: 188–200.

Step4: Basic structure of the FinnPRIO model



Step4: Taking into account uncertainty

- FinnPRIO consists of **18 questions** with answer options **yielding a different number of points**
- For each questions the **most likely**, **minimum** and **maximum** answer option is selected
- These are used to define **a PERT probability distribution** that describes the uncertainty of the answer
- The answers are aggregated into the **probability distributions of final scores** by specifically designed formulas, using Monte Carlo simulation

Step4: Ranking the score distributions using the hypervolume approach

- The hypervolume approach **establishes the relative order** of the score distributions using a **pairwise stochastic dominance** rule and a **hypervolume indicator**
- The stochastic dominance rule **establishes ordinal rank order** of the probability distributions of the assessment scores
- The **quantitative positions of the ranks** is then estimated using the hypervolume indicator

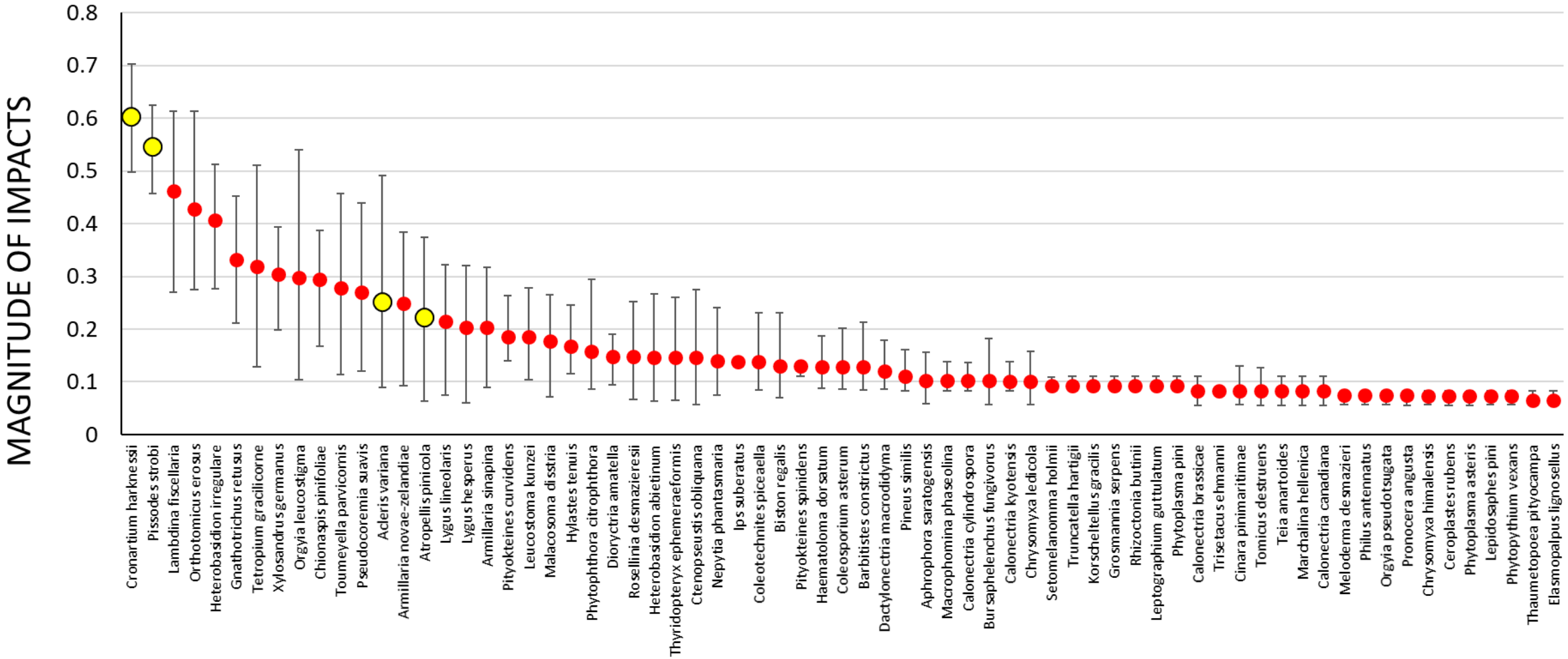
Step4:
Estimating the quarantine potential of pests

- FinnPRIO assessments and the hypervolume approach only provide **relative estimates** of the risk

- To estimate the **potential** of the pests to fulfill the criteria **to become regulated**, **impacts assessments** of four **regulated pests** on conifers were included as reference pests:

  - *Acleris variana* (Eastern black-headed budworm, threatning *Picea abies*)
  - *Atropellis pinicola* (Twig blight of pine, threatning *Pinus sylvestris*)
  - *Cronartium harknessii* (Pine-pine gall rust, threatning *Pinus sylvestris*)
  - *Pissodes strobi* (Sitka spruce weevil, threatning *Picea abies*)

Step4: Comparing the target pests and the reference pests



Step4: High ranked pests

PESTS	TYPE OF PEST	PRESENCE IN EUROPE	INVASION RANK	IMPACT RANK	RISK RANK
Dactylonectria macrodidyma	F	Yes	0.95	0.18	0.63
Leucostoma kunzei	F	Yes	0.55	0.45	0.63
Orgyia leucostigma	I	No	0.13	0.66	0.35
Truncatella hartigii	F	Yes	0.86	0.06	0.35
Xylosandrus germanus	I	Yes	0.24	0.66	0.35
Chionaspis pinifoliae	I	No	0.17	0.67	0.31
Coleosporium asterum	F	Yes	0.47	0.29	0.31
Toumeyella parvicornis	I	Yes	0.13	0.66	0.31
Armillaria novae-zelandiae	F	No	0.17	0.45	0.26
Coleotechnites piceaella	I	Yes	0.37	0.22	0.26
Haematoloma dorsatum	I	Yes	0.37	0.22	0.26
Orthotomicus erosus	I	Yes	0.10	0.96	0.26
Phytophthora citrophthora	C	Yes	0.37	0.29	0.26
Tetropium gracilicorne	I	Yes	0.17	0.76	0.26
Heterobasidion irregulare	F	Yes	0.10	0.96	0.20
Lygus lineolaris	I	No	0.17	0.33	0.20
Macrophomina phaseolina	F	Yes	0.47	0.11	0.20
Candidatus Phytoplasma asteris	B	Yes	0.55	0.03	0.20
Candidatus Phytoplasma pini	B	Yes	0.37	0.06	0.20
Armillaria sinapina	F	No	0.17	0.33	0.18
Barbitistes constrictus	I	Yes	0.31	0.18	0.18
Calonectria kyotensis	F	Yes	0.37	0.11	0.18
Lambdina fiscellaria	I	No	0.05	0.96	0.18
Lygus hesperus	I	No	0.13	0.29	0.18

Pests with high likelihood of invasion rating

Dactylonectria macrodidyma

Truncatella hartigii

PESTS	TYPE OF PEST	PRESENCE IN EUROPE	INVASION RANK	IMPACT RANK	RISK RANK
Dactylonectria macrodidyma	F	Yes	0.95	0.18	0.63
Truncatella hartigii	F	Yes	0.86	0.06	0.35

- Soil borne fungi present throughout Europe and reported around the world
- Very broad host range
- Associated with roots of seedings of both *P. sylvestris* and *P. abies* in nurseries
- *D. macrodidyma* is suggested to be a opportunistic pathogen causing disease of seedlings during certain environmental conditions
- *T. hartigii* associated with necrosis of pine seedlings and known as a pest in nurseries

Given the wide distribution of these fungi globally, they may already be present in Nordic countries, but not reported

Pests with high total risk rating

Leucostoma canker of spruce (*Leucostoma kunzei*)

PESTS	TYPE OF PEST	PRESENCE IN EUROPE	INVASION RANK	IMPACT RANK	RISK RANK
Leucostoma kunzei	F	Yes	0.55	0.45	0.63

- Widely distributed around the world
- *Picea abies* very susceptible
- Causes browning of needles and dying of the branches
- Could damage branches of young trees in ornamental nurseries
- In Canada mainly on ornamental trees and rarely in natural spruce forests

According to literature may be already present in the Nordic countries

Picture: Penn State Department of Plant Pathology & Environmental Microbiology Archives, Penn State University, Bugwood.org

Pests with high impact rating

Mediterranean pine beetle (*Orthotomicus erosus*)

- Widely distributed across the southern Europe, Asia and North Africa. Introduced into Fiji, South Africa, Swaziland and the USA.
- Breeds in *Pinus* spp. and infests pines in both plantations and natural forests.
- Capable of attacking and killing stressed trees, and these attacks occasionally develop into outbreaks.
- As other bark beetles, transmits pathogenic fungi.

PESTS	TYPE OF PEST	PRESENCE IN EUROPE	INVASION RANK	IMPACT RANK	RISK RANK
Orthotomicus erosus	I	Yes	0.10	0.96	0.26

Pictures: William M. Ciesla,
Forest Health Management International, Bugwood.org

Pests with high impact rating

Heterobasidium irregulare

PESTS	TYPE OF PEST	PRESENCE IN EUROPE	INVASION RANK	IMPACT RANK	RISK RANK
Heterobasidion irregulare	F	Yes	0.10	0.96	0.20

- Fungus originating from North America and introduced into Italy probably during World War II
- Causes root and butt rots in its host plants
- Both *Picea abies* and *Pinus sylvestris* has been shown experimentally to be susceptible
- Has a higher fruiting and saprotrophic ability than *H. annosum* and it is considered that it could add to damage caused by *H. annosum*
- Hybridization between *H. irregulare* and *H. annosum* is very common in Italy

Pests with high impact rating

The hemlock looper (*Lambdina fiscellaria*)

PESTS	TYPE OF PEST	PRESENCE IN EUROPE	INVASION RANK	IMPACT RANK	RISK RANK
Lambdina fiscellaria	I	No	0.05	0.96	0.18

- Present in North America
- Larvae feed on several coniferous trees
- Uncertainty concerning its ability to adapt to European trees
- Outbreaks occur periodically. Populations rise sharply and persist at high levels for 1 to 3 years
- Defoliation sufficient to cause tree mortality in one year
- Could have a significant impact In Nordic countries in protected areas with old forests

Pictures: Natural Resources Canada

Limitations

- **All the pests** of the target hosts **may not be recorded** in the databases
- Only **limited number of criteria** with **limited amount of information** was used to select pests further in the screening
- Outputs of pest scorings models are **simplified** and **uncertain** depictions of reality
- The assessments were carried out **without the actual trade data** of the host plants of the pests from the countries where they are present

Conclusions

There are **a lot of pests** of conifers

1) that are not yet present in Finland, Sweden and Norway, and
2) that could enter into these countries via ornamental plants

- Some of these pests **may present a significant threat** to our conifer forests and hence may **fulfil the criteria** to become **regulated as quarantine pests** in the EU and Norway

- The results can be used by the **risk managers** to decide which **pests** or **trade pathways** to prioritize for **full pest risk assessments**

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THANKS FOR YOUR ATTENTION!