Risk ranking and prioritization of plant pests for Norway

Progress report nr. 1

Paal Krokene, Beatrix Alsanius, Jorunn Børve, Daniel Flø, Christer Magnusson, Mogens Nicolaisen, Line Nybakken, Johan A. Stenberg, Selamawit Tekle, Iben M. Thomsen, Sandra A. I. Wright, May-Guri Sæthre

Scientific Opinion of the Panel on Panel on Plant Health of the Norwegian Scientific Committee for Food and Environment

EPPO-listed plant pests were assessed and ranked according to the overall risk they pose to Norwegian plant health. Based on probability of entry, probability of establishment (including spread), and potential impact on plant health, pests were classified into five risk classes: very high, high, moderate, low, and very low risk. In this first progress report VKM has assessed 61 pests: 24 fungi, 12, nematodes, 11 insects, eight viruses, and six bacteria. None of these were assessed to pose very high risk, while one pest (*Fusarium euwallaceae*) was assessed to pose high risk. Six pests were assessed to pose moderate risk: *Dendroctonus ponderosae*, *Tuta absoluta*, *Phymatotrichopsis omnivora*, *Verticillium dahliae* hop strains, *Xanthomonas euvesicatoria* pv. *euvesicatoria*, and *Xanthomonas euvesicatoria* pv. *perforans*. The remaining pests were assessed to pose low risk (16 pests) or very low risk (38 pests) to Norwegian plant health.

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Scientific Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food and Environment
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Risk ranking and prioritization of plant pests for Norway. Progress report nr. 1.

Preparation of the opinion

The Norwegian Scientific Committee for Food and Environment (Vitenskapskomiteen for mat og miljø, VKM) appointed a project group to draft the opinion. The project group consisted of ten VKM committee members and two VKM staff members. The VKM Panel on Plant Health evaluated and approved the final opinion.

Authors of the opinion

The authors have contributed to the opinion in a way that fulfils the authorship principles of VKM (VKM, 2023). The principles reflect the collaborative nature of the work, and the authors have contributed as members of the project group and the VKM Panel on Plant Health.

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The expertise of VKM experts

Individuals working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third-party interests. The provisions on impartiality in the Norwegian Public Administration Act apply to all work carried out by VKM.

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Summary

Background: The Norwegian Food Safety Authority (NFSA) commissioned the Norwegian Scientific Committee for Food and Environment (VKM) to assess and rank plant pests that are listed in EPPO's (European and Mediterranean Plant Protection Organization) A1 and A2 lists and that are currently not regulated in Norway. The lists include plant pests that EPPO recommends member countries to regulate as quarantine pests. The objective of the commission is to support NFSA's future regulatory decision making by identifying pests that pose high risks to Norwegian plant health. The commission is an ongoing assignment, and this report presents the results of the first round of assessments. Out of 305 EPPO-listed pests that are not currently regulated in Norway (including 30 pests on the EPPO Alert List), 61 randomly chosen pests were assessed in this first progress report.

Methodology and data: Pests were assessed using FinnPRIO, a semi-quantitative, rapid and cost-effective pest ranking tool. FinnPRIO was developed in Finland and follows the steps of a standard full-scale pest risk assessment by scoring probabilities of entry, establishment and impact of a pest in a specified pest risk assessment area (i.e., Norway in this case). To guide the scoring, import statistics for relevant commodities and monetary values for different plant production sectors in Norway were retrieved from Statistics Norway and Totalkalkylen, respectively. Lists of available host plants in Norway were made by cross-referencing listed host species of each pest in the EPPO Global Database with plant species recorded in Norway. Climate suitability in Norway was modelled for each pest using the Maxent machine learning algorithm, incorporating global pest occurrence records and bioclimatic variables for both current and projected climate conditions. A retrieval-augmented generation (RAG) system was used to systematically answer FinnPRIO assessment questions by querying relevant scientific literature.

Risk classification of pests: Pests were assessed and ranked based on the total risk they pose to plant health in Norway. The total risk posed by each pest was calculated by aggregate assessments of probability of entry, probability of establishment (including spread), and potential impact on Norwegian plant health. The joint probability of entry and establishment was used as a measure of the probability of invasion. Pests were classified into five groups:

1. *Very high risk* pests pose very high risk to Norwegian plant health. These pests are considered to have both high probability of invasion and high impact of invasion.
2. *High risk* pests pose high risk to Norwegian plant health because they have either high probability of invasion combined with moderate impact, or high impact of invasion combined with moderate probability of invasion.
3. *Moderate risk* pests pose moderate risk to Norwegian plant health. These pests have intermediate combinations of probability and impact of invasion (high probability-low impact, low probability-high impact, or moderate probability and impact).
4. *Low risk* pests pose low risk to Norwegian plant health because they have low to moderate probability and impact of invasion (low probability-moderate impact or moderate probability-low impact). Impact may, for example, be low if the pests' host plants are minor crops in Norway or make up a very small proportion of natural ecosystems. Pests are also considered to have a low probability of invasion if the Norwegian plant health regulation prohibits the import of goods that can serve as

import pathways or there have been no registered imports of relevant goods in the past 10 years.

5. *Very low risk* pests have both low probability of invasion and low impact and are considered to pose very low risk to Norwegian plant health. Many pests in this group have no cultivated or natural hosts in Norway, climatic conditions are usually unsuitable for their establishment and spread, and probability of entry is usually low because potential import pathways are absent.

Key findings: VKM has so far assessed and ranked 61 EPPO-listed pests (24 fungi, 12 nematodes, 11 insects, eight viruses, and six bacteria).

Very high risk pests:

Using the risk classification outlined above, none of the 61 pests assessed in this first progress report were identified to pose very high risk to Norwegian plant health.

High risk pests:

- The fungus *Fusarium euwallaceae* (EPPO code FUSAEW) was assessed to pose high risk. This pest is vectored by an ambrosia beetle and can infest a wide range of host plants, including many that are commercially important timber and fruit trees in Norway.

Moderate risk pests:

Four pests were assessed to have moderate probability and impact of invasion:

- The moth *Tuta absoluta* (GNORAB) is a destructive pest of tomato and can establish in greenhouses in Norway. Its primary entry pathway is trade of infested tomato plants or fruits. A pest risk assessment for *T. absoluta* was published by VKM in 2017.
- The fungus *Verticillium dahliae* hop strains (VERTDH) is mainly a pest of hop plants but a range of other plants are listed as potential hosts. Some of these, such as potato, strawberry and fruit trees, are of major economic importance in Norway.
- The two bacteria *Xanthomonas euvesicatoria* pv. *euvesicatoria* (XANTEU) and *Xanthomonas euvesicatoria* pv. *perforans* (XANTPF) are pests of tomato and pepper. They can establish in greenhouses and cause significant damage to commercially important tomato production in Norway.

Two pests were assessed to have low probability of invasion but high potential impact:

- The bark beetle *Dendroctonus ponderosae* (DENCPO) can cause widespread mortality in various pine and spruce species. If the pest enters Norway, it will likely establish since it will find suitable climatic conditions and available hosts.
- The fungus *Phymatotrichopsis omnivora* (PHMPOM) is a soilborne pathogen with more than 2000 host plants, many of which are commercially important in Norway. The pest is unlikely to invade or spread in Norway due to limited dispersal potential, absence of import pathways, and unsuitable climatic conditions.

Low risk and Very low risk pests:

The 54 remaining pests were considered to pose low or very low risk because they scored low on one or more of the criteria entry, establishment, and impact. Thirty-eight pests were classified to pose very low risk (i.e., they scored low on both probability of invasion and

impact), whereas 16 were classified as low risk pests with moderate impact. No pests were classified as low risk pests with moderate probability of invasion.

Implications: The FinnPRIO risk ranking tool provides risk assessments that are rapid and limited in scope. While this is useful for screening large number of pests, more detailed risk assessments will provide firmer support for NFSA's regulatory decision making. The need for firmer support can be addressed by preparing standard pest risk assessments for the six high and moderate risk pests identified in this report that currently lack a pest risk assessment specific to Norway. The need for more detailed assessments is lower for pests that are considered to pose very low or low risk for Norwegian plant health.

Key words: Pest prioritization, pest risk ranking, plant health, quarantine pests, risk assessment

Sammendrag på norsk

Bakgrunn: Mattilsynet ba Vitenskapskomiteen for mat og miljø (VKM) om å vurdere og rangere planteskadegjørere som er oppført på EPPO (European and Mediterranean Plant Protection Organization) sine A1- og A2-lister, og som per i dag ikke er regulert i Norge. Listene inkluderer skadegjørere som EPPO anbefaler medlemsland å regulere som karanteneskadegjørere. Målet med oppdraget er å støtte Mattilsynets arbeid ved å identifisere skadegjørere som utgjør en høy risiko for norsk plantehelse. Dette er et løpende oppdrag og denne rapporten presenterer resultatene fra den første runden med artsvurderinger. Av de 305 EPPO-oppførte skadegjørerne som ikke er regulert i Norge (inkludert 30 skadegjørere på EPPO sin Alert List), er 61 tilfeldig utvalgte skadegjørere vurdert i denne første rapporten.

Metodikk og data: Skadegjørerne ble vurdert ved å bruke FinnPRIO, et semi-kvantitativt, raskt og kostnadseffektivt verktøy for rangering av skadegjørere. FinnPRIO er utviklet i Finland og følger trinnene i en standard fullskala risikovurdering («pest risk assessment») ved å score sannsynligheten for innførsel, etablering og effekt på plantehelse for en skadegjører i et spesifisert område (i dette tilfellet Norge). Som grunnlag for scoringen hentet vi importstatistikk for relevante varer og økonomiske verdier for ulike planteproduksjoner i Norge fra henholdsvis Statistisk sentralbyrå og Totalkalkylen. Lister over tilgjengelige vertsplanter i Norge ble skaffet til veie ved å koble oppførte vertsplanter for hver skadegjører i EPPO Global Database med plantearter registrert i Norge. Skadegjørernes toleranse for klimaet i Norge ble modellert ved hjelp av Maxent – en maskinlæringsalgoritme som bruker artenes globale forekomst og bioklimatiske variabler for både nåværende og fremtidige klimaforhold i Norge. Et såkalt «retrieval-augmented generation» (RAG)-system ble brukt til å besvare alle FinnPRIO-vurderingsspørsmål ved å systematisk søke i relevant vitenskapelig litteratur.

Risikoklassifisering av skadegjørere: Skadegjørerne ble rangert ut fra den totale risikoen de utgjør for plantehelse i Norge. Total risiko ble beregnet som produktet av sannsynlighet for innførsel, sannsynlighet for etablering (inkludert spredning), og skadepotensial for norsk plantehelse. Samlet sannsynlighet for innførsel og etablering ble brukt som et mål på invasjonssannsynlighet. Skadegjørerne ble klassifisert i fem grupper:

1. *Svært høy risiko*: disse utgjør svært høy risiko for norsk plantehelse og har både høy sannsynlighet for invasjon og stort skadepotensial ved invasjon.
2. *Høy risiko*: disse utgjør høy risiko for norsk plantehelse. De har enten høy sannsynlighet for invasjon kombinert med moderat skadepotensial eller moderat sannsynlighet for invasjon kombinert med stort skadepotensial.
3. *Moderat risiko*: disse utgjør moderat risiko for norsk plantehelse. De har moderate kombinasjoner av sannsynlighet for og skadepotensial ved invasjon (høy sannsynlighet-liten effekt, lav sannsynlighet-stor effekt, eller moderat sannsynlighet og effekt).
4. *Lav risiko*: disse utgjør liten risiko for norsk plantehelse. De har lav til moderat sannsynlighet for og skadepotensial ved invasjon (lav sannsynlighet-moderat skadepotensial eller moderat sannsynlighet-lite skadepotesial). Skadepotensialet kan for eksempel være lite hvis vertsplantene har liten økonomisk betydning eller marginal forekomst i naturlige økosystemer. Skadegjørere er i tillegg vurdert å ha lav sannsynlighet for invasjon dersom plantehelseregelverket forbyr import av varer som kan tjene som importveier eller det ikke er registret import av varer som kan tjene som importveier de siste ti årene.

5. *Svært lav risiko*: disse utgjør svært lav risiko for norsk plantehelse fordi både sannsynligheten for og skadepotensialet ved en invasjon er liten. Mange skadegjørere i denne gruppen har ingen kommersielle eller naturlige vertsplanter i Norge, de klimatiske forholdene er vanligvis uegnet for etablering og spredning av skadegjørerne, og importveier er fraværende.

Hovedfunn: VKM har så langt vurdert og rangert 61 skadegjørere oppført på EPPO sine lister (24 sopper, 12 nematoder, 11 insekter, 8 bakterier, og 6 virus).

Skadegjørere som utgjør svært høy risiko:

I henhold til risikoklassifiseringen beskrevet over ble ingen skadegjørere vurdert å utgjøre en svært høy risiko for norsk plantehelse.

Skadegjørere som utgjør høy risiko:

- Soppen *Fusarium euwallaceae* (FUSAEW) var vurdert å utgjøre høy risiko. Skadegjøreren overføres av en ambrosiabille og kan angripe mange ulike vertsplanter, inkludert mange kommersielt viktige tømmer- og frukttrær i Norge.

Skadegjørere som utgjør moderat risiko:

Fire skadegjørere ble vurdert å ha moderat sannsynlighet for og skadepotensial ved invasjon:

- Møllen *Tuta absoluta* (GNORAB) er en alvorlig skadegjører på tomat og kan etablere seg i veksthus i Norge. Den viktigste innførselsveien er trolig handel med infiserte tomatplanter eller frukter. VKM publiserte en risikovurdering for *T. absoluta* i 2017.

- Soppen *Verticillium dahliae* hop strains (VERTDH) er først og fremst en skadegjører på humleplanter, men flere andre planter er mulige verter. Noen av disse, som potet, jordbær og frukttrær, har stor økonomisk betydning i Norge.

- De to bakteriene *Xanthomonas euvesicatoria* pv. *euvesicatoria* (XANTEU) og *Xanthomonas euvesicatoria* pv. *perforans* (XANTPF) er skadegjørere på tomat og paprika. De kan etablere seg i veksthus og gjøre stor skade på norsk tomatproduksjon.

To skadegjørere ble vurdert å ha lav sannsynlighet for invasjon, men stort skadepotensial:

- Barkbillen *Dendroctonus ponderosae* (DENCPO) kan drepe ulike furu- og granarter i stort antall. Hvis skadegjøreren kommer til Norge vil den sannsynligvis kunne etablere seg her på grunn av egnet klima og tilgjengelige vertsplanter.

- Soppen *Phymatotrichopsis omnivora* (PHMPOM) er et jordbårent patogen som kan infisere mer enn 2000 vertsplanter, inkludert mange som er kommersielt viktige i Norge. Sannsynlighet for invasjon er liten fordi soppen har begrenset spredningspotensial, importveier er fraværende og klimaet i Norge er ugunstig.

Skadegjørere som utgjør lav eller svært lav risiko:

Femtifire av de vurderte skadegjørerne ble vurdert å utgjøre lav til svært lav risiko for norsk plantehelse fordi de scoret lavt på ett eller flere av kriteriene innførsel, etablering og skadepotensial. Av disse 54 skadegjørerne scoret 38 lavt på både sannsynlighet for og skadepotensial ved invasjon og ble vurdert å utgjøre svært lav risiko, mens 16 hadde lav sannsynlighet for invasjon, men moderat skadepotensial (disse utgjorde lav risiko). Ingen av

skadegjørerne i lav risiko-kategorien hadde moderat sannsynlighet for og lite skadepotensial ved invasjon.

Implikasjoner: FinnPRIO-verktøyet vi brukte for risikovurdering benytter en rask og forenklet metodikk og gir vurderinger som er begrenset i omfang. Selv om dette er nyttig for å screene mange skadegjørere, vil mer detaljerte risikovurderinger gi et bedre grunnlag for Mattilsynet sitt arbeid. Dette kan håndteres ved å utarbeide standard risikovurderinger for de seks skadegjørerne som er vurdert å utgjøre høy eller middels risiko, og som per i dag mangler en risikovurdering spesifikk for Norge. Behovet for mer detaljerte vurderinger er mindre for skadegjørere som utgjør svært lav eller lav risiko for norsk plantehelse.

Nøkkelord: Karanteneskadegjørere, plantehelse, prioritering av skadegjørere, risikorangering, risikovurdering

Glossary

Table 1: All definitions are according to the ISPM 5 Glossary of phytosanitary terms published on behalf of the International Plant Protection Convention (IPPC, 2024).

Term	Definition
Commodity	A type of plant, plant product, or other article being moved for trade or other purpose
Country of origin (of a consignment of plants)	Country where the plants were grown
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism
Introduction (of a pest)	The entry of a pest resulting in its establishment
Non-quarantine pest	Pest that is not a quarantine pest for an area
Pathway	Any means that allows the entry or spread of a pest
Pest	Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products
Pest categorization	The process of determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest
Pest risk (for quarantine pests)	The probability of introduction and spread of a pest, and the magnitude of the associated potential economic consequences
Pest risk (for regulated non-quarantine pests)	The probability that a pest in plants for planting affects the intended use of those plants with an economically unacceptable impact
Pest risk analysis	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it
Pest risk assessment	Evaluation of the probability of the introduction and spread of a pest and the magnitude of the associated potential economic consequences
Plants for planting	Plants intended to remain planted, to be planted or replanted
Quarantine pest	A pest of potential economic importance to the endangered area and not yet present there, or present but not widely distributed and being officially controlled
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is, therefore, regulated within the territory of the importing contracting party
Regulated pest	A quarantine pest or a regulated non-quarantine pest
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area

Background as provided by the Norwegian Food Safety Authority

The Norwegian Food Safety Authority (NFSA) is responsible for developing regulations and proposing measures to protect Norwegian agriculture and nature from serious plant pests. Many different plant pests can pose a risk to Norway, and the risk is constantly changing due to increased global trade, changes in trade patterns and cultivation practices, climate change, and lack of control measures.

To meet this challenge, NFSA needs comprehensive and up-to-date information. Through systematic and continuous monitoring of available knowledge, NFSA can collect data on new pests relevant to Norway. This information will provide NFSA with a basis for prioritizing work toward the pests considered to represent the highest risk.

Through the work of EPPO, member countries receive support for risk assessment of plant pests and relevant countermeasures. EPPO standard PM1/2 with A1 and A2 lists provides recommendations to at-risk member countries on the regulation of quarantine pests. Norway can use these recommendations as a basis for national regulations, but a follow-up analysis and assessment for Norwegian conditions are needed. NFSA has a backlog in following up EPPO's recommendations and needs support for these assessments.

With this order, NFSA aims to obtain a running overview of the risk posed by the pests on EPPO's lists for Norway. The assignment will provide NFSA with a basis for prioritizing which new pests should be included in further work aimed at regulation. NFSA's follow-up of the delivery may include ordering more detailed risk assessments for certain pests.

Terms of reference as provided by the Norwegian Food Safety Authority

The Norwegian Scientific Committee for Food and Environment (VKM) is requested to deliver the following:

Assessment and ranking of plant pests: We ask VKM to provide running assessments of the pests that EPPO recommends at-risk member countries to regulate as quarantine pests (cf. EPPO's A1 and A2 lists, as specified in EPPO standard PM1/2, last updated September 2024), and which NFSA has not yet assessed for regulation in Norway.

Scope: EPPO's A1 and A2 lists also include some parasitic and invasive plants. These groups of organisms are not included in this assignment.

The delivery should include a simple assessment of plant health risk for Norway, as well as a ranking of the pests according to plant health risk.

VKM will choose the most appropriate method and tool to assess and rank the pests according to risk.

The methodology chosen by VKM should be presented to NFSA once it has been tested on a limited number of pests, so that NFSA can provide input on criteria for risk assessment and method for ranking pests.

Reporting: We ask VKM to prepare a report every six months summarizing the results. In addition, VKM is requested to publish completed analyses of individual pests continuously. Critical findings should be immediately reported to NFSA for prompt response and action.

The report should, at a minimum, include the following points for each pest:

- The identity of the pest,
- Current knowledge of the pest’s absence or presence in Norway,
- The pest's potential for introduction, establishment, and spread in Norway, and
- Potential consequences of establishment and spread in Norway.

1 Introduction

The number of plant pests that may be introduced to Norway and pose potential threats to plant health is large. Risks are constantly evolving due to increasing global trade and changing trade patterns, shifts in agricultural production practices, climate change, and detection and control measures that are often inadequate for new and emerging pests. The Norwegian Food Safety Authority (NFSA) is responsible for developing regulations and proposing measures to protect Norwegian agriculture and natural ecosystems from serious plant pests. To do this, NFSA needs comprehensive and up-to-date information on new pests that are relevant to Norway, usually in the form of comprehensive and work-intensive pest risk assessments.

Pest risk assessment is a science-based evaluation of the probability of introduction and spread of a pest into a defined area and the magnitude of the associated potential economic consequences. The outcome of a pest risk assessment is usually documented in the form of a comprehensive report. In Norway, pest risk assessments are usually prepared by the Panel on Plant Health of the Norwegian Scientific Committee for Food and Environment (VKM). Given the very large number of potential plant pests that could be introduced into Norway, it is not efficient or even feasible to perform a comprehensive pest risk assessment for every pest.

In this assignment, VKM used FinnPRIO, a structured and simplified pest ranking tool that can be used to effectively screen and prioritize among many pests (Heikkilä et al., 2016). FinnPRIO was selected because it is one of the few peer-reviewed pest ranking models, it is developed for Nordic conditions, and it systematically quantifies uncertainty using Monte Carlo simulations. Pest risk ranking was based on the pests' potential for introduction, establishment, spread, and impact in Norway.

The scope of this assignment is limited to plant pests that are listed on EPPO's (European and Mediterranean Plant Protection Organization) A1, A2 and Alert lists and that are currently not regulated in Norway. EPPO's A1 and A2 lists include plant pests that pose a phytosanitary risk for the European and Mediterranean region and hence are recommended for regulation as quarantine pests. The A1 List contains pests that are absent in the EPPO region, whereas the A2 List contains pests that are locally present in the region. The purpose of the Alert List is to provide EPPO member countries with an early warning about pests that may present phytosanitary risk. Pests on the Alert List are not yet recommended for phytosanitary regulations but may eventually be transferred to the A1 or A2 list.

The objective of this report is to support NFSA's regulatory decision making by assessing and ranking pests according to the risk they pose to plant health in Norway.

2 Methods and data sources

2.1 Assessment and risk ranking procedures

2.1.1 Identification of EPPO-listed pests not regulated in Norway

To identify all EPPO-listed pests we queried the EPPO SQLite database, which contains data from the EPPO Global Database. On 5 September 2024, we extracted data for 223 pests listed on the EPPO A1 list (i.e., pests absent from the EPPO region), 179 pests on the EPPO A2 list (i.e., pests present in the EPPO region) and 30 pests on the EPPO Alert List, using information available in the "Categorization" table in the EPPO Global Database. From the same dataset, we extracted the subset of species that are currently not regulated in Norway. All records classified under the kingdom Plantae were excluded as these were not part of the Terms of Reference for this assignment. After this filtering, we were left with 305 species of EPPO-listed pests. Of these, 61 species were chosen at random and assessed. The results from these 61 assessments are presented in this first progress report. All data access and processing were performed in R using the "DBI", "RSQLite", "dplyr", and "tidyverse" libraries.

The 305 EPPO-listed pests that are currently not regulated in Norway belong to different taxonomic groups, where various animals make up the largest group (Figure 1). About 57% of the listed pests are insects, 7% are other animals (nematodes, mites, and snails), 13% are viruses and viroids, 12% are bacteria and phytoplasmas, and 11% are fungi and oomycetes.

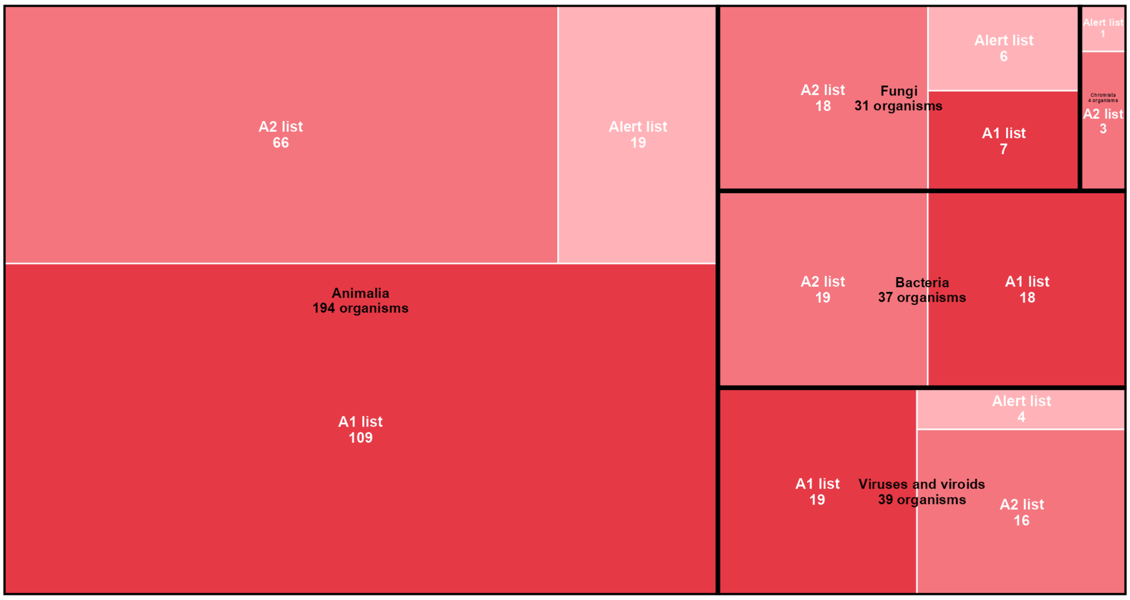

Figure 1. Overview of the 305 pests listed by EPPO that are currently not regulated in Norway. Pests are grouped by biological kingdom (black rectangles) and EPPO listing (A1, A2 and Alert list; different colour shading). All 305 pests are to be assessed by VKM, and this first report present assessments of 61 pests.

2.2 Overview of the risk ranking tool FinnPRIO

FinnPRIO is a pest ranking tool developed by the Finnish Food Safety Authority (Evira) and the Natural Resources Institute Finland (Luke) for carrying out quick, cost-efficient, and semi-quantitative expert assessments of invasive plant pests (Heikkilä et al., 2016). The model used in FinnPRIO follows the structure of a full pest risk assessment, i.e. it separately assesses the probability of entry, the probability of establishment (including spread), and the likely impacts of a pest (Figure 2). The model also includes an assessment of manageability of pests (not presented in this report), i.e., to what extent invasion can be prevented and controlled. FinnPRIO uses consistent criteria that make it possible to compare different plant pests across taxa, such as insects, fungi, viruses, bacteria, and nematodes. The model outcome is a structured risk ranking of pests based on the likelihood and consequences (impacts) of entry and establishment (including subsequent spread).

Entry is calculated as the joint probability of entry via all assessed pathways:

- Entry via pathway $_i$ = global pest distribution × transport potential × volume of trade to Norway × likelihood of transfer to a suitable habitat
- If e.g. traded volume to Norway is zero, the probability of entry = 0

Establishment (including spread) presupposes the presence of host plant(s) in Norway. Climatic and production conditions must also be suitable for the pest:

- Establishment = suitability of climate and production conditions (including availability of host plants), rate of spread of pest, and pest-specific traits promoting establishment or spread
- Otherwise, probability of establishment = 0

Probability of invasion is calculated as the joint probability of entry and establishment (including spread):

- Invasion = Entry × Establishment (including spread)

Impact of invasion is separated into economic and environmental and social impacts:

- Impact = w_1 × economic impacts + w_2 × environmental and social impacts

  w_1 = weighing coefficient of economic impacts

  w_2 = weighing coefficient of environmental and social impacts

A pest's *Total risk score* is used to rank pests and represents the aggregated scores for entry, establishment and impact.

- Total risk score = (Entry × Establishment) × Impact = Invasion × Impact

The *Manageability* module assesses the preventability of pest entry and the controllability of the pest after entry. Scores of preventability and controllability can be used to consider different risk management measures:

- Manageability = min (Preventability, Controllability)

  Preventability = max (natural spread potential, presence in the EU, detectability during inspections)

  Controllability = max (feasibility of surveillance, feasibility of eradication)

When using FinnPRIO, the evaluator answers a series of multiple-choice questions, where different answer options yield different scores. The model is accompanied by a manual explaining the different questions and answer options. Uncertainty is considered for each question and answer, as the evaluator chooses the most likely, the minimum and the maximum value. This range is used to define a PERT (Program Evaluation and Review Technique) probability distribution that quantifies the uncertainty of the answer. Monte Carlo simulations, i.e., random sampling to model the probability of different outcomes, are used to quantify uncertainties and generate score distributions for each assessed pest. These score distributions form the basis for stochastic ranking of pests based on percentile-based summaries (e.g., using the median score = the 50th percentile). For complete methodological documentation of FinnPRIO, including question structure, scoring logic, and simulation details, see Heikkilä et al. (2016).

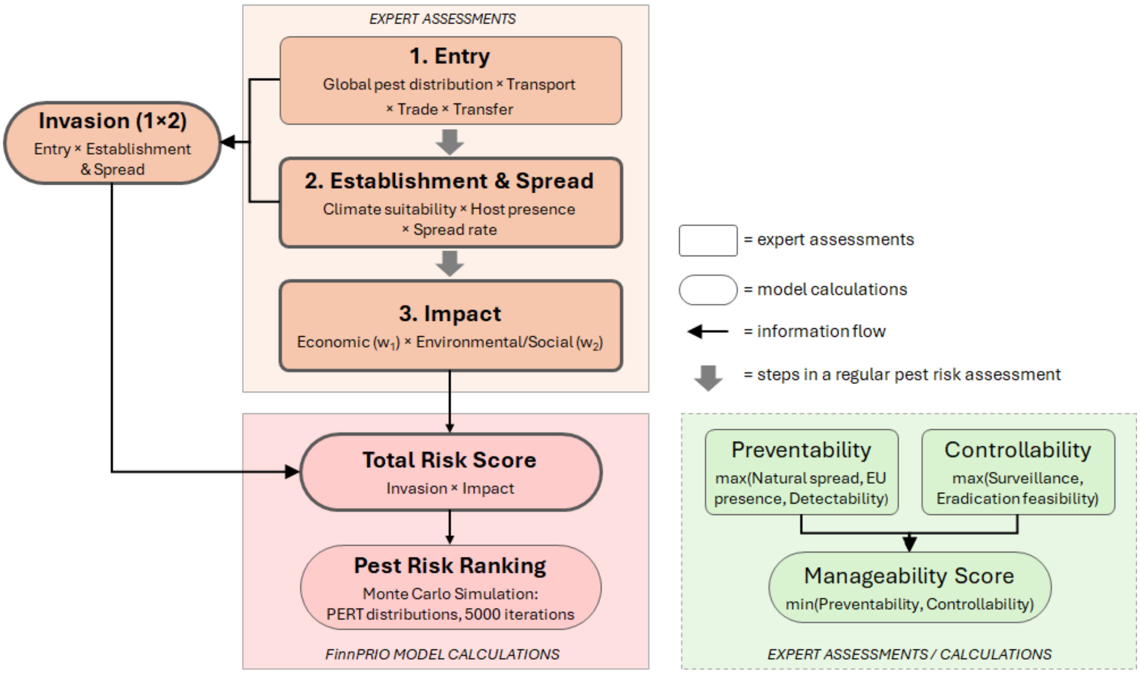

Figure 2. Overview of the FinnPRIO pest risk ranking model used in this project. FinnPRIO follows the structure of a full pest risk assessment and separately assesses a pest's potential for entry, establishment (and spread), and impact. See section 2.1.2 for more details on FinnPRIO.

Pest risk profiles can be visualized in a two-dimensional "risk space" by plotting probability of invasion against impact of invasion (Figure 3). Such "invasion probability vs. impact plots" visualize the total risk a pest is posing and is referred to as 'total risk' or 'total pest risk' in this report. Pest risk can be assessed further by plotting probability of establishment (and spread) against impact of invasion. Such "establishment probability vs. impact plots" visualize the risk a pest may pose if it is able to enter Norway, disregarding any obstacles to entry (such as current phytosanitary measures or lack of current import pathways). This conditional risk is referred to as 'risk, given pest entry' in this report.

VKM's decision to use FinnPRIO for this assessment was based on several criteria. First, FinnPRIO is one of only two pest risk ranking tools used across the EU that has been validated through publication in a peer-reviewed scientific journal (Heikkilä et al. 2016; EFSA, 2021). Thus, FinnPRIO offers a scientifically scrutinized framework with transparent methodology, unlike most other tools reviewed by the European Food Safety Authority (EFSA). Second, FinnPRIO was developed specifically for Nordic climatic conditions and has demonstrated high transferability, having been applied in Sweden as well as Finland. Third, FinnPRIO is unique in its systematic handling of uncertainty through PERT distributions and Monte Carlo simulations. Finally, the model's proven applicability across all pest taxa makes it particularly suitable for ranking diverse EPPO-listed pests relevant to Norway.

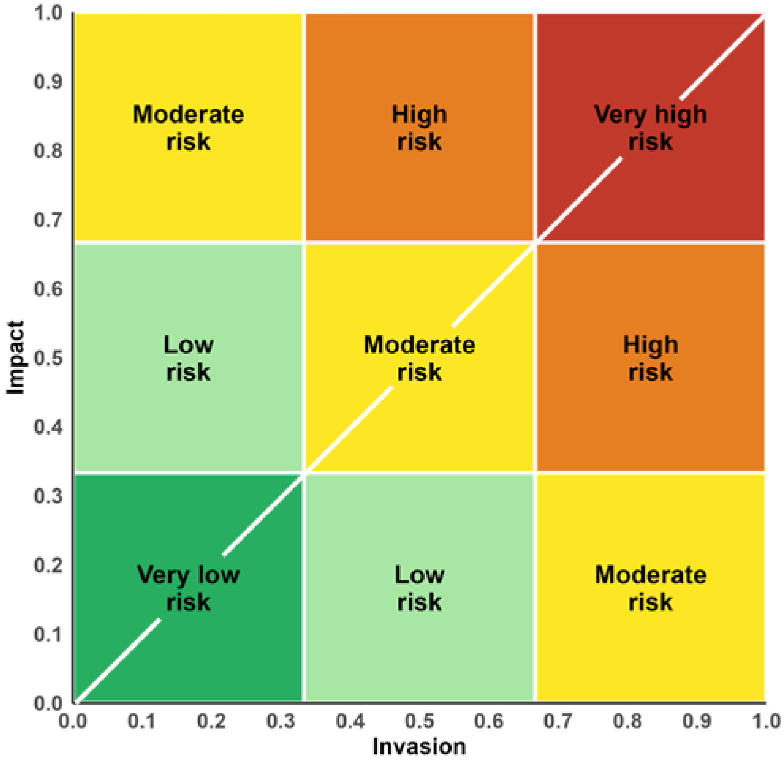

Figure 3. The five risk classes used to assess the total risk EPPO-listed pests pose to plant health in Norway. Risk classes were defined based on the probability of pest invasion (x-axis), i.e., the likelihood that a pest will enter and establish in Norway, and the impact of pest invasion (y-axis), i.e., the economic, environmental and social impacts of the pest if it enters and establishes in Norway. Threshold values for risk classes were set to 33 and 66% probability or impact. See section 2.1.3 for more details.

2.2.1 Risk classes and risk thresholds

FinnPRIO performs risk ranking of pests by considering (1) the probability of pest invasion (i.e., the likelihood that a pest will enter and establish in Norway) and (2) the impact of pest invasion (i.e., the economic, environmental and social impacts of the pest if it enters and establishes in Norway). Probability of pest invasion multiplied by pest impact equals total pest risk, as explained in section 2.1.2. To define different classes of total pest risk we first plotted probability of pest invasion on the x-axis and impact of invasion on the y-axis. We then divided each axis in three segments of similar size, with threshold values representing 33 and 66% probability or impact of invasion. The two axes now define a total "risk space" consisting of nine similarly sized squares (Figure 3). Based on the position of a pest within this risk space, pests were classified into one of five classes of total risk: *very low risk* (dark green square: invasion probability and impact are both < 0.33); (ii) *low risk* (light green squares: invasion probability is ≥ 0.33 and ≤ 0.66 while invasion impact < 0.33, or invasion probability is > 0.33 while invasion impact is ≥ 0.33 and ≤ 0.66); (iii) *moderate risk* (yellow squares: invasion probability is > 0.66 while invasion impact is < 0.33, invasion probability and impact are both ≥ 0.33 and ≤ 0.66, or invasion probability is < 0.33 while invasion impact is > 0.66), (iv) *high risk* (orange squares: invasion probability is > 0.66 while invasion impact is ≥ 0.33 and ≤ 0.66, or invasion probability is ≥ 0.33 and ≤ 0.66 while invasion impact is > 0.66); and (v) *very high risk* (red square: invasion probability and impact are both < 0.66).

Similar plots were made for 'risk, given pest entry', but here the impact of pest invasion (y-axis) was plotted against probability of establishment (not invasion). These plots visualize the risk posed by a pest assuming that the pest can successfully enter Norway. Plots of 'risk, given pest entry' were used to explore the potential risks posed by pests with a low probability of entering Norway given current phytosanitary measures and trade patterns. These plots were a supplement to the plots of total pest risk, and the latter plots formed the basis for assessing and ranking pests according to the risk they pose to plant health in Norway.

2.2.2 Assessment of pests transmitted by vectors

Many plant pests are transmitted by vectors such as nematodes or sap-sucking insects. This is particularly true for viruses, but also fungi, bacteria and nematodes may have vectors. Most of the viruses and one of the fungi assessed in this report are transmitted by insect vectors. In addition, two of the assessed nematode species are known vectors of viruses (Appendix I). Usually, a pest is associated with its vector(s) before the pest is introduced to a new area, and the two arrive at the same time. However, in some cases, the association occurs after the pest has arrived. A well-known example of such post-introduction association is Dutch elm disease. This deadly tree disease is caused by two species of ascomycete fungi from Asia that became vectored by various native species of elm bark beetles when the disease arrived in Europe and North America.

For vector-transmitted plant pests, a thorough assessment of risk associated with pest introduction must also consider potential vectors. When assessing risks, it is usually more important to consider if climatic factors and host plants are suitable for the vector than to consider the pest itself. When assessing possible introduction pathways, one should consider both infected plants and pest-carrying vectors that may enter with or without their host plant.

For pests that are associated with a broader taxonomic group of vectors, rather than just one or a few species, risk assessments should consider a wider range of vector species than just the ones the pest is associated with in its native habitat. One example is the bacteria *Xylella fastidiosa* which is transmitted by several groups of sap-sucking insects, such as spittlebugs (Cercopoidea), cicadas (Cicadoidea), and sharpshooters (Cicadellinae) (EPPO, 2025). In such cases, all the members of those insect groups that occur in Norway should be considered when assessing the risk that they may vector and spread the bacteria after introduction.

2.3 Data collection and data sources

2.3.1 Import data

Import statistics were compiled from Statistics Norway (2024) to support assessor evaluations of pest entry pathways and trade volumes when using the FinnPRIO tool. Import data for relevant commodity groups was downloaded using the StatBank API for table 08801: "External trade in goods by commodity number (HS) and country". Data retrieval was performed in R (R Core Team, 2025) using the "httr", "jsonstat" and "rjstat" libraries. Queries were submitted for the StatBank chapters 06 (live plants), 07–08 (edible plants), 09–12 (miscellaneous plant products), and 44 (wood and wood products). Import data were retrieved for the 10-year period 2014–2023.

Following data reshaping from multiple tables to one data frame and cleaning the data by removing non-informative columns, import volumes were summarized by exporting country and commodity number/code. These volumes were used to score pathway volumes in the FinnPRIO model. Each country–commodity combination was classified as 'small', 'medium', or 'large' based on the mean annual import volume, using the definitions in Heikkilä et al. (2016). 'Medium' corresponds to an annual import volume of 1-10 million kg or units, 'small' is less than 1 million and 'large' is more than 10 million. It is important to note that the exporting country recorded in trade statistics is not necessarily the country of origin where the commodities were produced, as goods are often re-exported through intermediary countries. Additionally, import volumes can vary substantially over time and between countries due to market dynamics (Økland et al., 2012; 2019).

2.3.2 Pest distributions

Information on pest distributions was compiled from multiple sources to support FinnPRIO assessments of geographic range. Sources included occurrence records from the Global Biodiversity Information Facility (GBIF), distribution data reported in scientific literature, and official distribution maps from the EPPO Global Database. Using R, distribution maps for all assessed pests were automatically downloaded from the EPPO Global Database (EPPO, 2024). This was done by iterating through a list of EPPO codes (a standardized, 5-or-6-letter code used to uniquely identify plant pests), inserting each EPPO code into a predefined URL template and generating a direct download link to the corresponding PNG-format distribution map on the EPPO website. These maps, visualizing known global and regional occurrences, were used together with other sources to support expert evaluations of the pests' current global geographic distribution area, using the definitions in Heikkilä et al. (2016). Briefly, a 'small' distribution area is smaller than about 3 000 000 km^2 (almost the size of India), 'medium' is 1-10 times that size, and 'large' is more than 10 times that size.

2.3.3 Identification of host plants present in Norway

Host plant information for all assessed pests was primarily compiled from scientific literature. This was supplemented with standardized host lists from the EPPO Global Database, accessed via the EPPO REST API. API responses were parsed in R using "httr" and "jsonlite", and host species names were extracted from the "host" component. To identify hosts that are present in Norway (both wild and domesticated species), the complete host list was cross-referenced with the Norwegian flora (extracted from Lids flora; Lid & Lid, 2005). Only host species with scientific names that matched entries in Lids flora were retained. Taxonomic synonyms were not systematically resolved, and this may have resulted in some host species being missed when nomenclature differed between EPPO and Lids flora. For each assessed pest, the output included both the total host list from EPPO and the subset of host plants occurring in Norway. These lists were exported to Excel and used in subsequent pathway evaluations within the

FinnPRIO model. The host list supported the evaluation of relevant entry pathways and helped estimate the availability of suitable hosts in Norway. In addition to wild and domesticated host plants, we also considered ornamental and agricultural host plants that are grown in Norway (see section 2.2.4).

2.3.4 Agricultural production data

To assess the potential economic impact of pest establishment in Norway, we used data from Totalkalkylen, a database compiled by the Norwegian Institute of Bioeconomy Research (https://www.nibio.no/tjenester/totalkalkylen-statistikk#groups) (NIBIO, 2024). Totalkalkylen contains statistics on production volumes and product values for all agricultural crops produced in Norway. Product value was used to estimate economic impact within the FinnPRIO model, classifying economic losses (in million euros per year) into 13 predefined intervals (Heikkilä et al., 2016).

2.3.5 Climate classification maps

To assess the potential of EPPO-listed plant pests to establish in Norway and to map their potential distribution, we compiled Köppen-Geiger climate zone maps for all assessed pests. All analyses were conducted using R, with each analysis step organized within a loop that iteratively processed each pest. Parallel processing was achieved using the "future.apply" library (Bengtsson, 2021), allowing us to analyse many pests efficiently.

Occurrence data (coordinates) for each pest was downloaded from GBIF using the "rgbif" library (Chamberlain et al., 2025). To focus on the most important terrestrial biomes, we excluded coordinates falling into areas classified as "ocean," "ET" (polar tundra), "EF" (polar ice cap), or coordinates with missing climate zone information. Each valid coordinate was assigned to a Köppen-Geiger climate zone using the "kgc" library (Bryant et al., 2017). The climate profile of each pest was then identified as a subset from a global Köppen-Geiger shapefile (Beck et al., 2018) using the "sf" library (Pebesma, 2018) and mapped using the "ggplot2" library (Wickham, 2016). Additionally, counts of species records by climate type were displayed as bar plots, highlighting the four climate types that are most widespread in Norway: oceanic climates (Cfb), subpolar oceanic climates (Cfc), warm summer humid continental/hemiboreal climates (Dfb), and subarctic/boreal climates (Dfc).

2.3.6 Species distribution modelling

To assess the potential of EPPO-listed plant pests to establish in Norway, we did species distribution modelling using the Maxent machine learning algorithm, incorporating global pest occurrence records and bioclimatic variables for both current and projected climate conditions (Phillips et al., 2004). Maxent was run using the library "SDMtune" (Vignali et al., 2020), which fits Maxent models using the "glmnet" package for regularized generalized linear models (Phillips, 2017). To streamline handling and cleaning of occurrence data, model calibration, variable selection, hyperparameter tuning, and predictions for many pests, all model steps were wrapped within a single loop that iteratively processed each pest.

Occurrence data for the assessed pests were sourced from multiple biodiversity databases, including GBIF, BISON (Biodiversity Information Serving Our Nation), iDigBio (Integrated

Digitized Biocollections), and iNaturalist. Data were retrieved using the R packages “spocc” (Owens et al., 2024) and “rgbif” (Chamberlain et al., 2025), filtering out occurrence records with invalid geographic coordinates. The initial dataset was cleaned using the “CoordinateCleaner” library (Zizka et al., 2019), which removes duplicate records, eliminates records located in country centroids, capitals, and biodiversity institutions, excludes marine records and zero-zero coordinates, and removes outlier records based on a quantile-based method. Records were also thinned to one location per raster cell using SDMtunes thinData. Only pests with at least 80 occurrences were modelled.

Environmental predictor variables were obtained from WordClim. All climate variables were obtained for both near-present (1981-2010) and future (2071-2100) 30-year-periods under the SSP585 scenario from the Max Planck Institute Earth System Model (mpi-esm1-2-hr). SSP585 is the most pessimistic and intense available emission scenario in terms of climate change effect and is characterized by the highest level of radiative forcing (8.5 W m^{-2}) by the end of this century. Raster layers (gridded maps) were processed using the “terra” library in R, including cropping, masking, and resampling to match the extent of the study area (i.e., Norway).

Background points were sampled at random within a 2000 km buffer radius around occurrence records to ensure that background environmental conditions were representative of the pests’ accessible habitat (Phillips, 2008). A total of 20,000 background points were initially sampled for each pest. After removal of duplicate and invalid points (e.g. marine coordinates), unique and valid background points were retained for modelling.

Variable selection was done using the SDMtune varSel function to refine the set of environmental predictors selected for each Maxent model. This function performs a data-driven, stepwise variable selection by evaluating the contribution of each predictor to model performance and checking for multicollinearity. varSel iteratively removes highly collinear variables that do not improve model performance (quantified by AUC: area under the curve). This eliminates redundant or less informative predictors, improves model interpretability and accuracy, and reduces model overfitting.

Following variable selection, we used optimizeModel for Maxent hyperparameter tuning. This function systematically searches various Maxent settings, exploring different regularization multipliers and feature class combinations to identify the configuration that maximizes model performance on validation data. Regularization multipliers control model complexity while feature classes (e.g., combinations of linear, quadratic, product, hinge, and threshold features) determine the types of response curves the model can fit. By testing these combinations, optimizeModel theoretically finds an optimal balance between model fit and complexity, yielding the best AUC performance while avoiding overfitting.

Maps of future projections of species distributions were generated by applying the optimized Maxent model to future climate scenarios (SSP585, 2071-2100). These maps were used to assess potential shifts in distribution under climate change. The final model outputs were visualized using the ggplot2 library (Wickham, 2016). Additionally, binary species distribution maps (presence, absence) were generated to highlight potential range expansion or contraction under projected future climatic conditions.

The generated species distribution models supported assessor evaluations of climate suitability and potential establishment areas in Norway. However, model outputs were interpreted as supporting evidence rather than definitive predictions. While species distribution models were generated for all the pests with sufficient occurrence data, not all species are equally suitable for species distribution modelling. For example, viruses and other vector-transmitted pathogens may be limited by vector distribution rather than by climate, and pests restricted to controlled greenhouse environments are not exposed to ambient climatic conditions. Therefore, each species-model combination was assessed individually to determine if model outputs were relevant and reliable for the specific pest.

2.3.7 Literature search and selection

An automated literature retrieval workflow was implemented in R to collect and organize scientific literature for all assessed pests. This workflow integrated multiple bibliographic APIs in R, including EuropePMC (Jahn, 2023), PubMed (Winter, 2017), CrossRef (Chamberlain, 2022), and OpenAlex (Aria et al., 2024). It operated using species-specific queries derived from the EPPO Global Database. For each pest, the scientific name and EPPO code were read from a master species list. Then, synonyms and common names were retrieved using the EPPO REST API. All names were merged with the scientific name to form a string of search terms. For each term, structured queries were sent to the respective APIs. Results were filtered to retain only records that contained Digital Object Identifiers (DOIs) and had titles and abstracts that matched the search term, i.e. contained the species names. The returned data included title, DOI, and source database. Additional constraints were applied in the OpenAlex queries, limiting search results to articles published from 2000 onwards and having more than five citations. These constraints were not applied to other databases, which generally returned fewer results. Lists of retrieved articles were deduplicated based on DOI. All entries were then compiled into a single RIS file per pest. Full-text PDFs were retrieved using the CrossRef API via the rcrossref R package (Chamberlain, 2025). For pests where this automated search provided sparse or no results, we did manual literature searches using the CABI Compendium, the EPPO Global Database, and pest risk assessment reports from EFSA.

2.3.8 Use of large language models – PaperQA2

FinnPRIO requires users to answer up to 40 multiple-choice questions for each assessed pest species. To automate literature-based answering of FinnPRIO questions, we deployed PaperQA2 (Skarlinski et al., 2024), a retrieval-augmented generation (RAG) framework optimized for scientific documents. PaperQA2 was implemented in Python using the "paperqa" package. Document-level processing, question formulation, querying, and output storage were executed programmatically. Relevant literature on each pest was collected as described in section 2.2.7 and stored in species-specific folders containing PDF files of peer-reviewed publications, reports, and grey literature. All documents were loaded asynchronously and indexed using PaperQA2's internal full-text engine. Each file was segmented into 1000-character chunks with 250-character overlaps and embedded (i.e., converting text into a numerical representation) using OpenAI's text-embedding-3-small model. The indexed documents were queried using a structured list of predefined FinnPRIO questions covering the taxonomy of each pest, its host range, geographic distribution, entry and spread pathways, establishment potential, ecological and economic impacts, and management options relevant to Norway. Answers were generated using OpenAI's GPT-4o-mini model with a low temperature setting (0.1) to prioritize precise answers. For each question, up to 25 document chunks were retrieved and re-ranked based on how well their content matched the meaning and context of the question. The 10 best chunks were retained for answer synthesis. Answer outputs were limited to approximately 300 words per question. The final answers, along with references and the number of retrieved contexts per query, were stored in a separate Microsoft Word document for each pest. The document was time-stamped and saved within the same directory as the input files. The RAG-generated answers were used to support the assessors in their pest evaluations and served as input to answering the FinnPRIO questions. When RAG-generated answers contained unexpected claims or lacked sufficient supporting context, they were cross-checked by experts against the original references.

3 Results

A total of 61 pests were assessed and ranked in this first progress report. These included 24 fungi, 23 animals (12 nematodes and 11 insects), eight viruses, and six bacteria. Below we first present the total risk score for all pests (section 3.1), before we explore the pests' total risk profile by plotting invasion probability vs. impact of invasion (section 3.2) and their conditional risk profile ('risk, given pest entry') by plotting establishment (and spread) probability vs. impact of invasion (section 3.3). Finally, in section 3.4 we group the 61 assessed pests by the five classes of total pest risk defined in section 2.1.3.

3.1 Total risk score for all pests

The total risk score sums up the overall risk presented by each pest and expresses this as a single number between zero and one (total risk score = probability of invasion × impact of invasion). Almost half of the assessed pests, 29 out of 61, had a total risk score of zero. This is because they scored zero on one or more of the components of total risk: probability of pest entry, probability of pest establishment (including spread), and impact of pest invasion. The remaining 32 pests had total risk scores that ranged from 0.0001 to 0.3591 (Figure 4). Details on the probability and potential impact of invasion for all assessed pests are given in Appendix I.

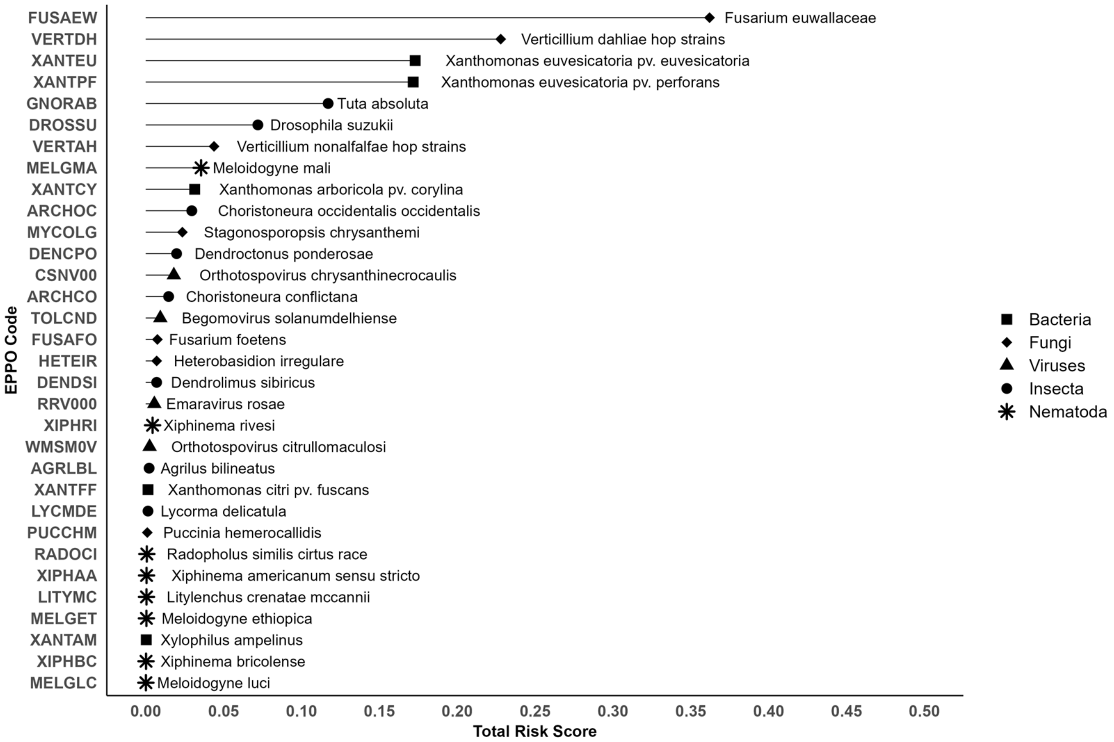

Figure 4. Total risk score for 32 assessed plant pests with a score > 0. Total risk score was calculated as the product of probability of invasion and impact of invasion. Pest risk was scored using the FinnPRIO risk ranking model. FinnPRIO follows the structure of a full pest risk assessment and scores a pest's potential for invasion (i.e., entry, establishment, and spread) and impact in Norway (see section 2.1.2 for more details on FinnPRIO).

3.2 Total pest risk: invasion probability vs. impact of pest invasion

The total risk score for each pest was dissected and explored by plotting its two main components, probability of invasion and impact of invasion, against each other. The probability of pest invasion is the likelihood that a pest will enter and establish in Norway, and the impact of pest invasion is the economic, environmental and social impacts of the pest if it enters and establishes in Norway. Thus, 'invasion probability vs. impact-plots' visualize a pest's total risk profile and can, for example, reveal whether a low total risk score is due to a low probability of invasion, a low impact of invasion, or both. Below we present the total risk profile of five different groups of pests: insects (Figure 5), fungi (Figure 6), nematodes (Figure 7), viruses (Figure 8), and bacteria (Figure 9). Based on these plots we identified one high risk pest (a fungus; Figure 6) and six moderate risk pests: two insects (Figure 5), one fungus (Figure 6), and three bacteria (Figure 9). These seven pests are presented in more detail in section 3.4.2 and 3.4.3.

The total risk profile of individual pests can lean towards high scores on probability of invasion or high scores on impact of invasion. Two special cases along this continuum are pests that score low or high on both values. This corresponds to the very low and very high risk class, respectively (Figure 3). Other pests may have a relatively high probability of invasion and less impact on plant health. Such 'higher probability-lower impact pests' correspond to the three squares below the diagonal line in Figure 3. These pests often have several relevant import pathways, but their host plants are minor crops in Norway or make up a very small proportion of natural ecosystems. Among the 61 pests assessed in this report, we did not identify any pests with a 'higher probability-lower impact' profile. Some pests have a relatively high impact and low probability of invasion. Such 'lower probability-higher impact pests' correspond to the three squares above the diagonal line in Figure 3. These pests often have no import pathways but are pests on important cultivated or naturally occurring plants in Norway. Among the pests assessed in this report we identified 19 pests with a 'lower probability-higher impact' profile. The small subset of these pests that pose moderate or high total risk (three pests) is presented in more detail in section 3.4.2 and 3.4.3. Finally, some pests have moderate scores on both parameters (corresponding to the moderate risk square at the centre of Figure 3). We identified three pests with this 'moderate-moderate' risk profile, and these are presented in more detail in section 3.4.3

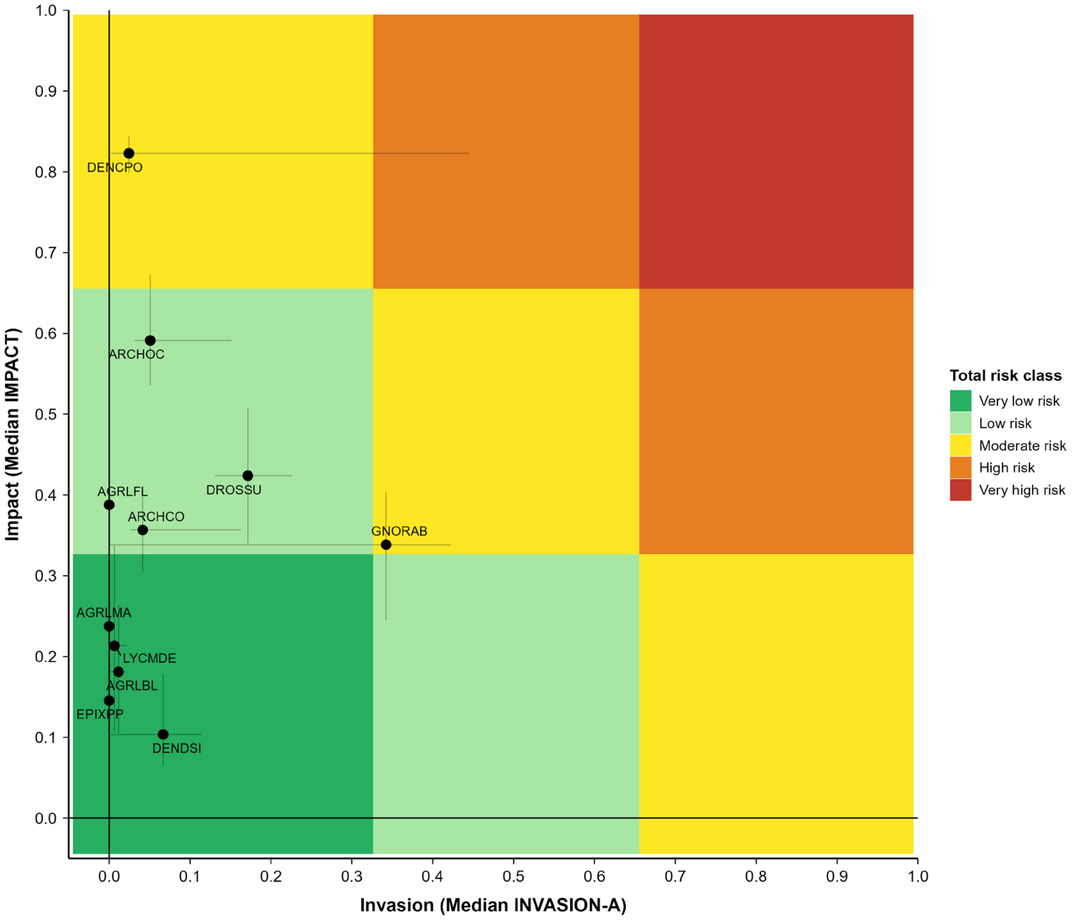

Figure 5. Total risk profile of 11 EPPO-listed insect pests, illustrating their estimated probability of invasion (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. The total risk score of each pest is defined as the probability of pest invasion multiplied by pest impact. Background colouring indicates five classes of total risk. Black circles represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

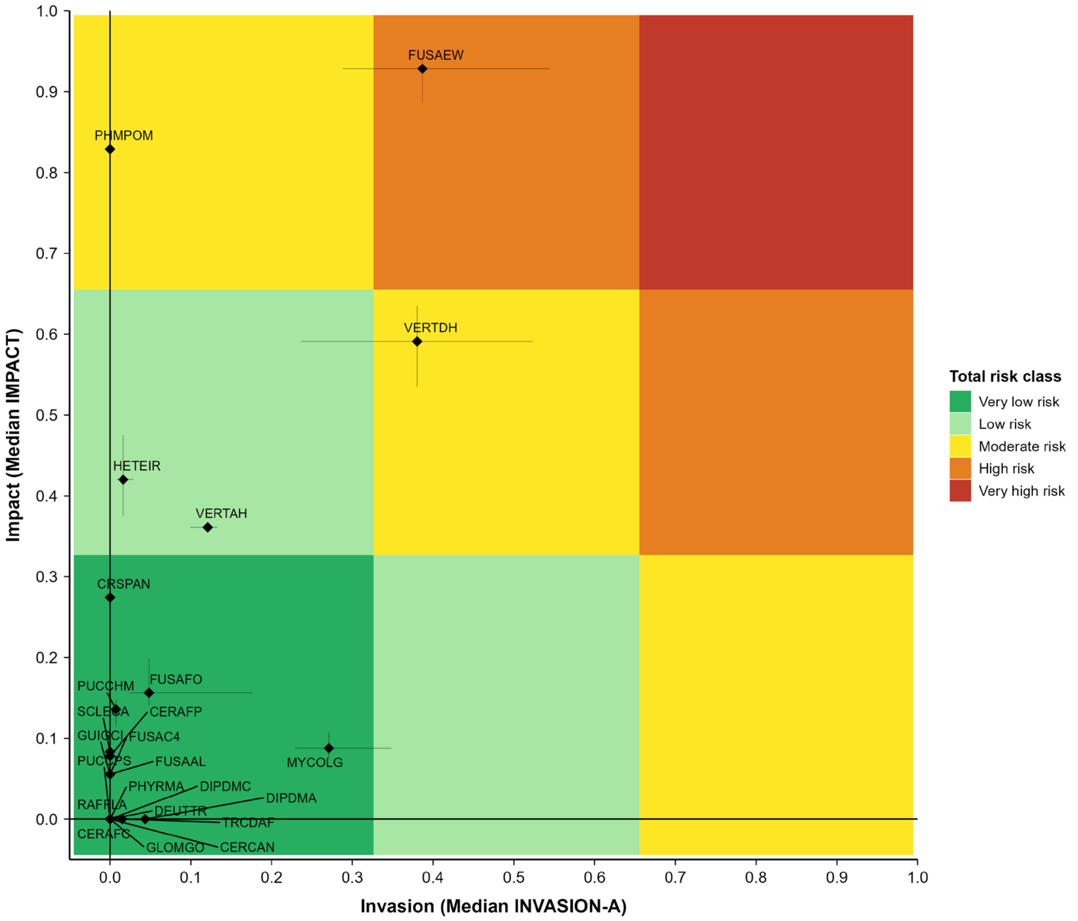

Figure 6. Total risk profile of 24 EPPO-listed fungal pests, illustrating their estimated probability of invasion (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. The total risk score of each pest is defined as the probability of pest invasion multiplied by pest impact. Background colouring indicates classes of total risk. Black diamonds represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

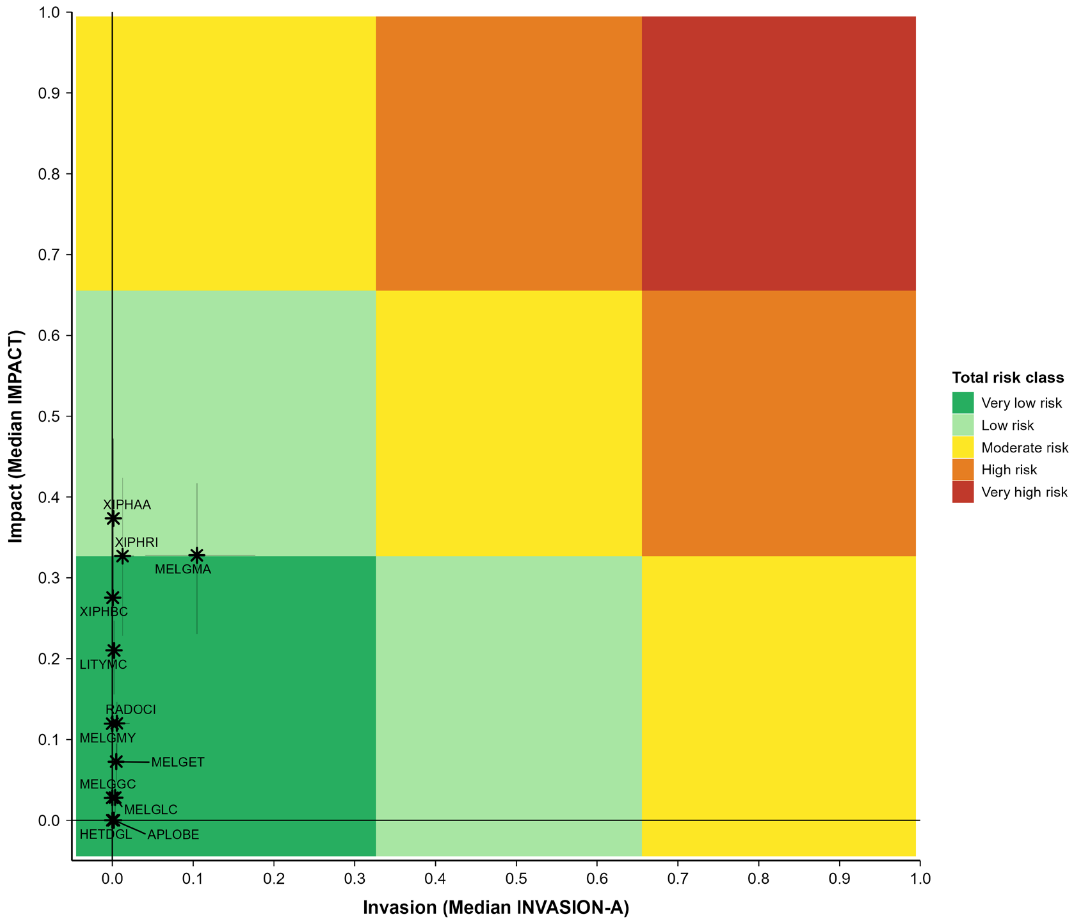

Figure 7. Total risk profile of 12 EPPO-listed nematode pests, illustrating their estimated probability of invasion (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. The total risk score of each pest is defined as the probability of pest invasion multiplied by pest impact. Background colouring indicates classes of total risk. Black asterisks represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

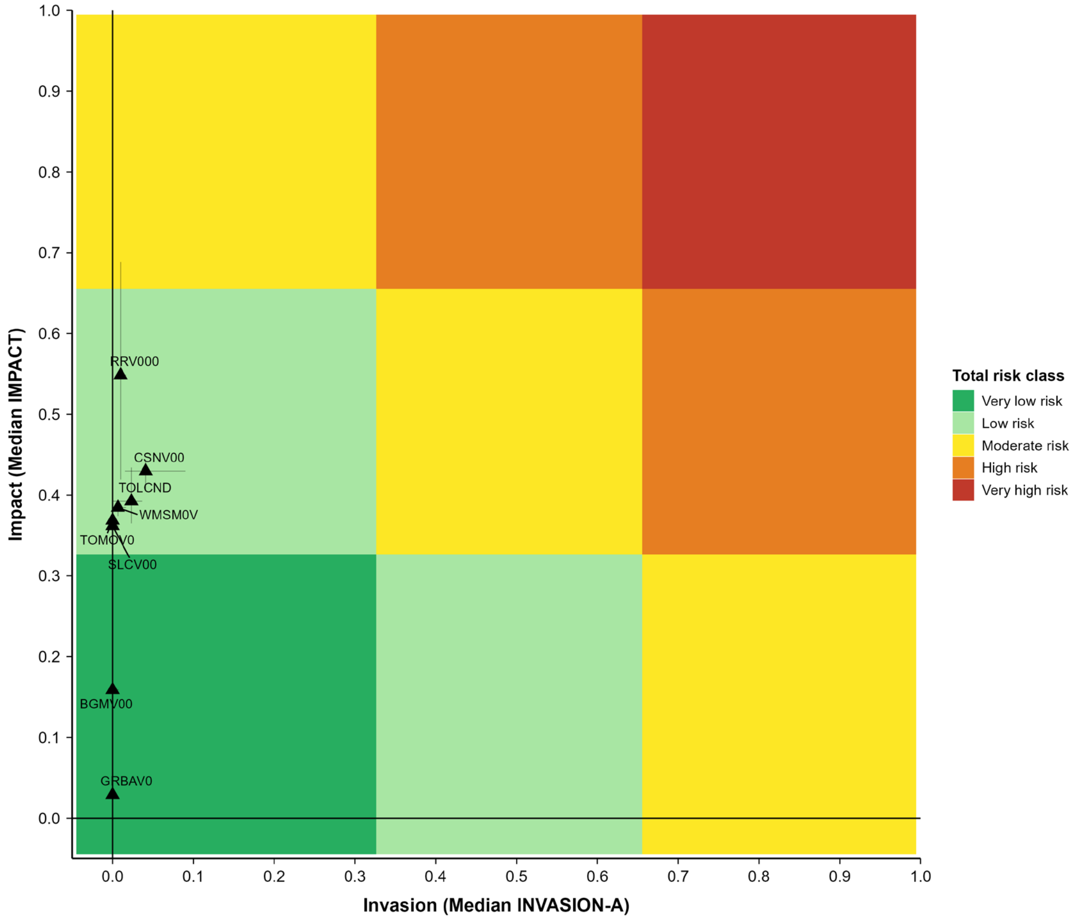

Figure 8. Total risk profile of eight EPPO-listed virus pests, illustrating their estimated probability of invasion (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. The total risk score of each pest is defined as the probability of pest invasion multiplied by pest impact. Background colouring indicates classes of total risk. Black triangles represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

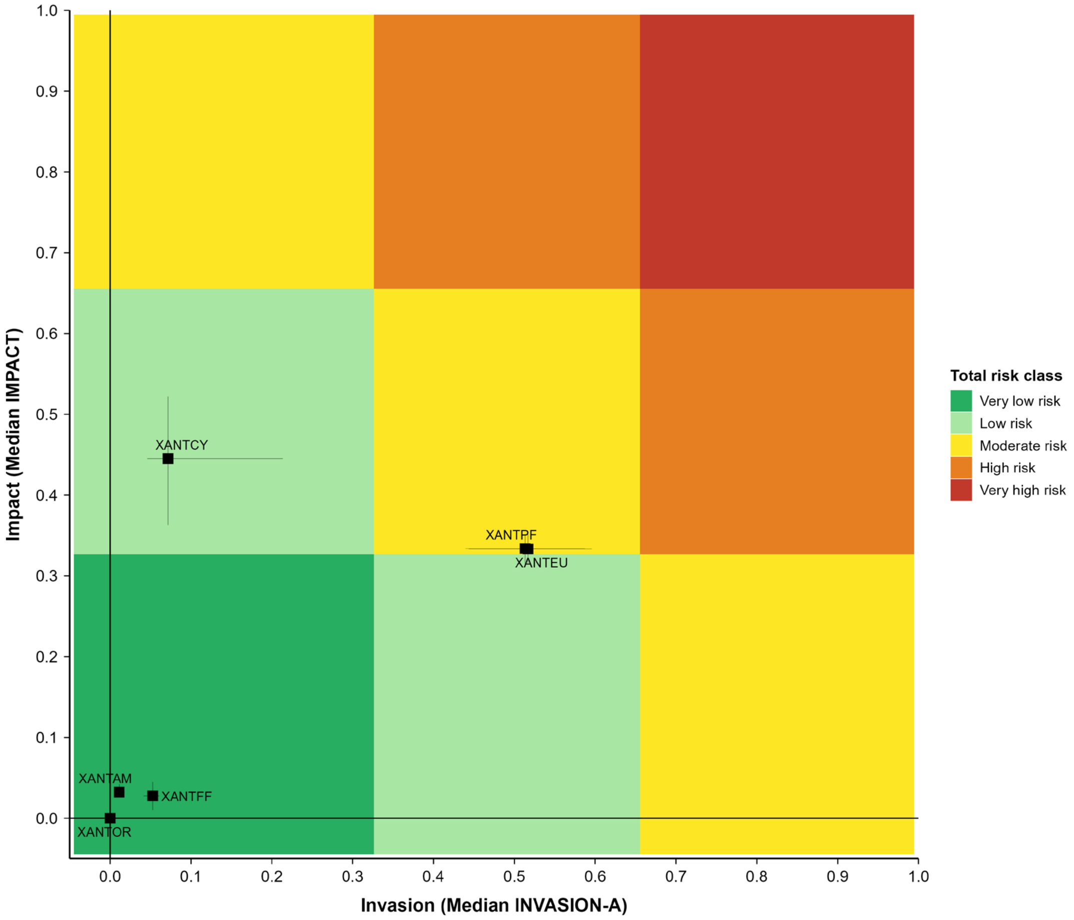

Figure 9. Total risk profile of six EPPO-listed bacteria pests, illustrating their estimated probability of invasion (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. The total risk score of each pest is defined as the probability of pest invasion multiplied by pest impact. Background colouring indicates classes of total risk. Black squares represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

3.3 Risk, given pest entry: probability of pest establishment vs. impact

Changes in regulatory restrictions, trade patterns, pest distributions and other factors affect the probability that a pest will enter a pest risk assessment area. Therefore, in addition to profiling total pest risks (i.e., plotting invasion probability vs. impact of invasion), we also explored the pests' conditional risk profile by plotting establishment (and spread) probability vs. impact of invasion. These plots visualizing 'risk, given pest entry' can identify pests that are unlikely to enter Norway under current conditions but that might establish and have large impacts on plant health if they enter.

Like total risk, invasion probability is the product of two components: the probability of pest entry and the probability of pest establishment (including spread). As explained in section 2.1.2, plotting probability of establishment against impact of invasion highlights the potential impact a pest may have if we assume it is able to enter Norway (i.e., assuming that the probability of pest entry is 1). Establishment probability is determined by factors such as suitability of climatic conditions, availability of suitable host plants, and pest-specific traits promoting establishment and/or spread. Below we present risk, given pest entry for five different groups of pests: insects (Figure 10), fungi (Figure 11), nematodes (Figure 12), viruses (Figure 13), and bacteria (Figure 14). These plots have the same background colouring as the plots showing total pest risk (Figure 5-9), but in Figure 10 to 14 the colours show conditional risk.

One insect pest (*Dendroctonus ponderosae*, DENCPO) was assessed to pose very high risk to Norwegian plant health, given pest entry (Figure 10). See section 3.4.3 for more details on this pest. Four other insect pests were classified as posing moderate risk, given pest entry (Figure 10). The two insect pests that posed the greatest total risk (*D. ponderosae* and *Tuta absoluta*, GNORAB; section 3.4.3) were also among the pests that posed the greatest risk, given pest entry. In addition, three other pests showed up in the plot of risk, given pest entry: *Choristoneura occidentalis occidentalis*, ARCHOC; *Choristoneura conflictana*, ARCHCO and *Agrilus fleischeri*, AGRLFL. See Appendix I for more details on these additional pests.

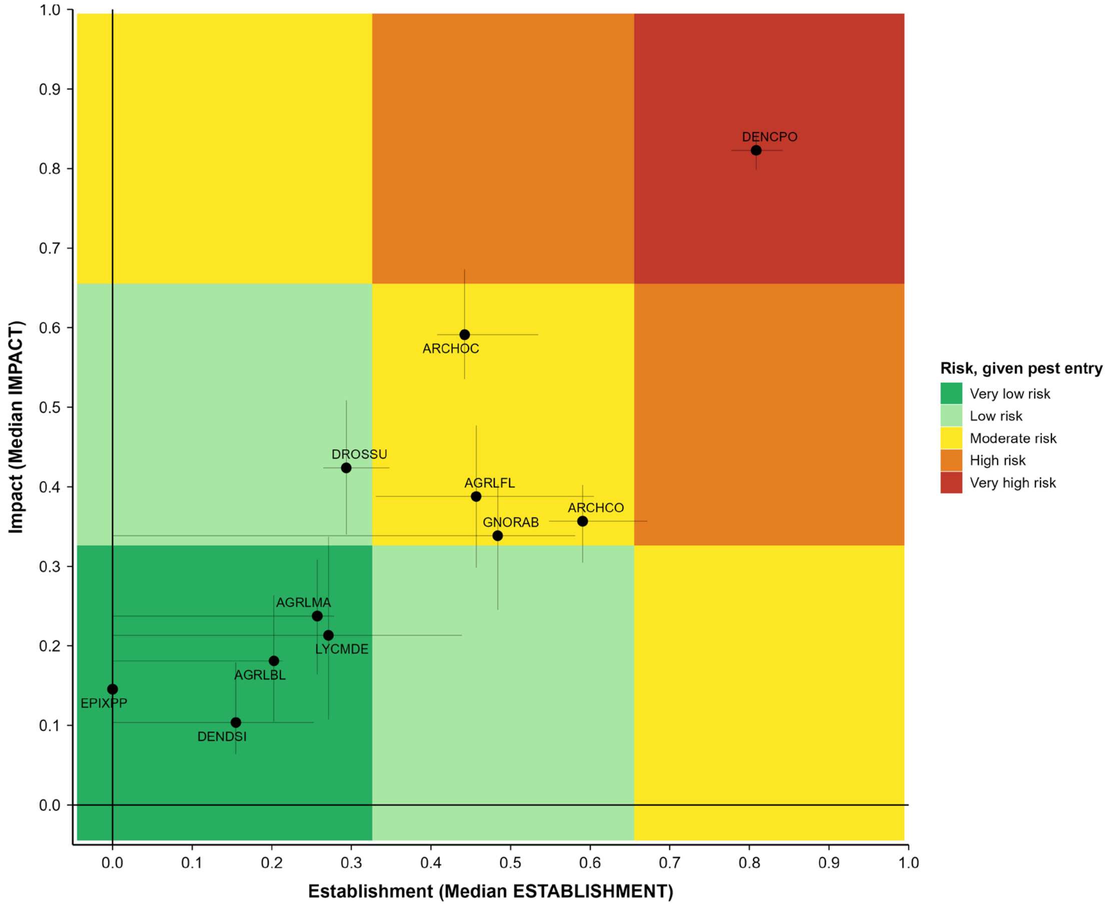

Figure 10. Conditional risk profile ('risk, given pest entry') of 11 EPPO-listed insect pests, illustrating their estimated probability of establishment (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. Probability of pest establishment is one of two components of pest invasion probability: P(establishment) × P(entry) = P(invasion). Background colouring indicates five classes of risk, given pest entry. Black circles represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

Among the assessed fungal pests, one pest (*Fusarium euwallaceae*, FUSAEW) posed very high risk to Norwegian plant health, given pest entry (Figure 11). See section 3.4.2 for more details on this pest. The three fungal pests that posed the greatest total risk (*F. euwallaceae*; *Phymatotrichopsis omnivore*, PHMPOM and *Verticillium dahliae* hop strains, VERTDH; section 3.4.3) were also among the pests posing the greatest risk, given pest entry. In addition, two other pests showed up in the plot of risk, given pest entry: *Heterobasidion irregulare*, HETEIR and *Verticillium nonalfalfae* hop strains, VERTAH. See Appendix I for more details on these additional pests.

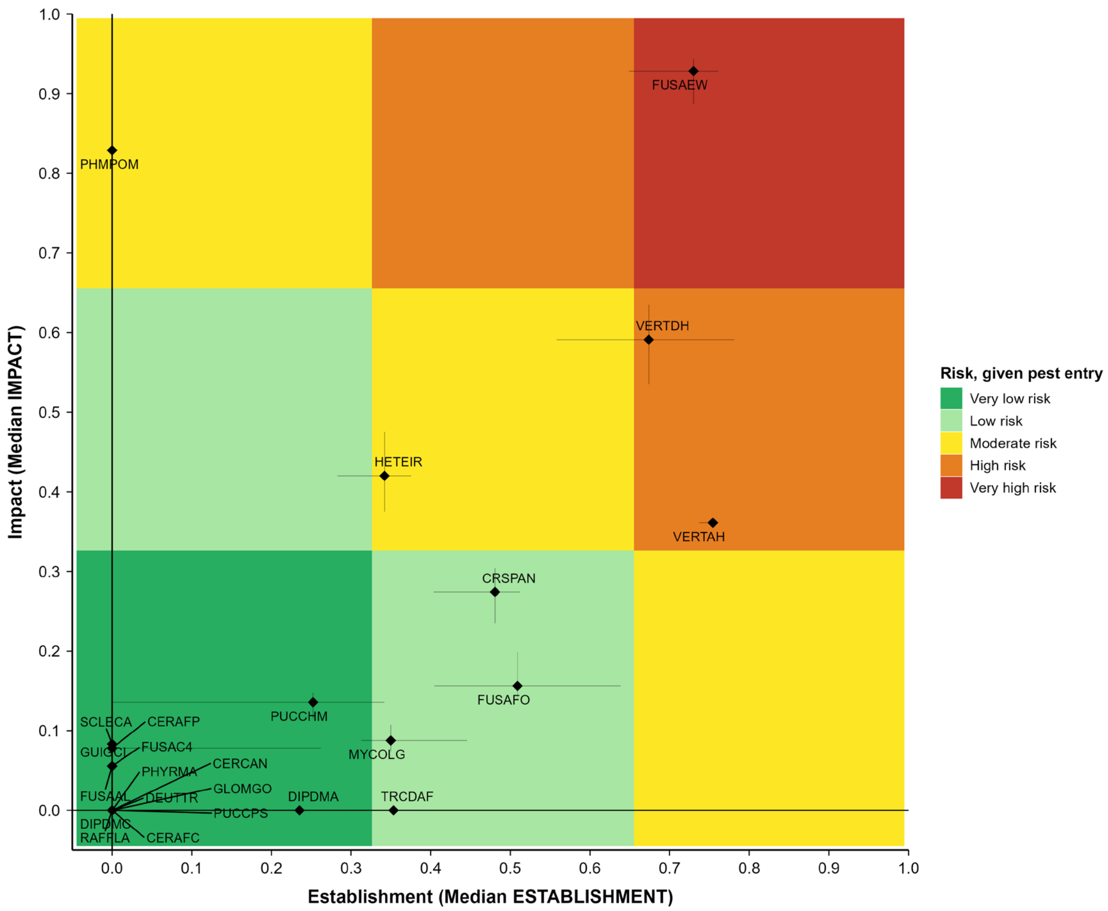

Figure 11. Conditional risk profile ('risk, given pest entry') of 24 EPPO-listed fungal pests, illustrating their estimated probability of establishment (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. Probability of pest establishment is one of two components of pest invasion probability: P(establishment) × P(entry) = P(invasion). Background colouring indicates five classes of risk, given pest entry. Black diamonds represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

Among the assessed nematode pests, one pest was assessed to pose moderate risk to Norwegian plant health, given pest entry (Figure 12). This pest (*Meloidogyne mali,* MELGMA), was not among the pests that posed the greatest total risk. See Appendix I for more details on *M. mali*.

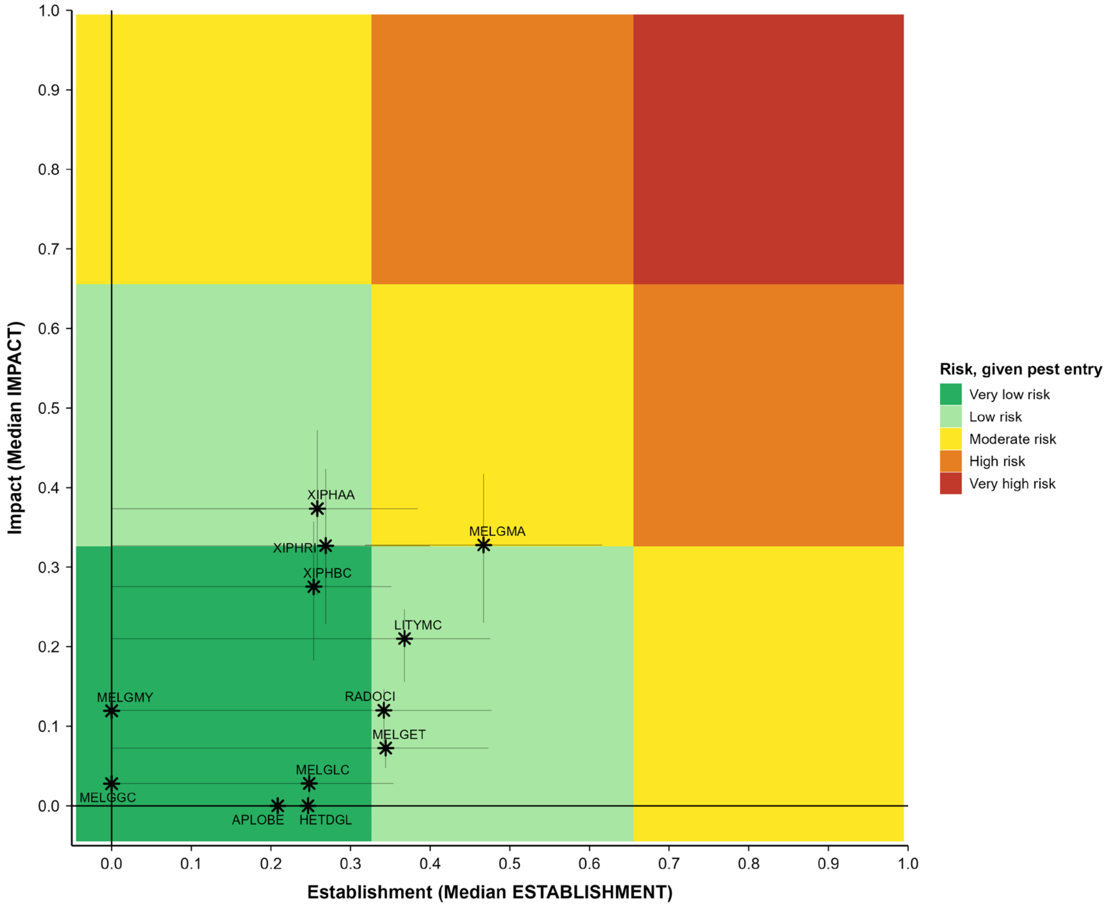

Figure 12. Conditional risk profile ('risk, given pest entry') of nine EPPO-listed nematode pests, illustrating their estimated probability of establishment (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. Probability of pest establishment is one of two components of pest invasion probability: P(establishment) × P(entry) = P(invasion). Background colouring indicates five classes of risk, given pest entry. Black asterisks represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

Among the assessed viruses, two pests (*Emaravirus rosae*, RRV000 and *Orthotospovirus chrysanthinecrocaulis*, CSNV00) posed moderate risk to Norwegian plant health, given pest entry (Figure 13). These viruses were not among the pests that posed the greatest total risk. See Appendix I for more details on *E. rosae* and *O. chrysanthinecrocaulis*.

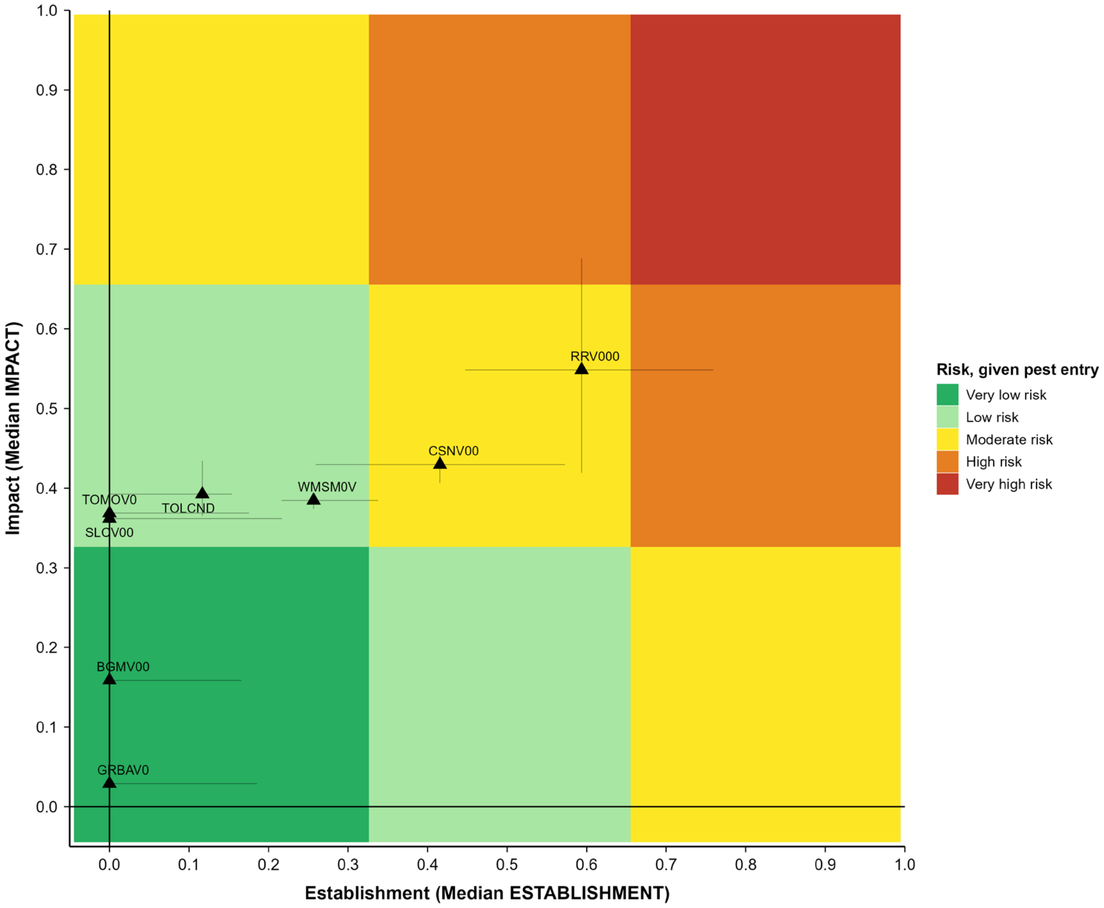

Figure 13. Conditional risk profile ('risk, given pest entry') of eight EPPO-listed virus pests, illustrating their estimated probability of establishment (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. Probability of pest establishment is one of two components of pest invasion probability: P(establishment) × P(entry) = P(invasion). Background colouring indicates five classes of risk, given pest entry. Black triangles represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

Among the assessed bacterial pests, two pests (*Xanthomonas euvesicatoria* pv. *euvesicatoria*, XANTEU and *X. euvesicatoria* pv. *perforans*, XANTPF), were assessed as posing high risk to Norwegian plant health, given pest entry (Figure 14). For more details on these pests, see section 3.4.3. Another bacterial pest (*X. arboricola* pv. *corylina*, XANTCY) was classified as posing moderate risk, given pest entry (Figure 14). See Appendix I for more details on these pests.

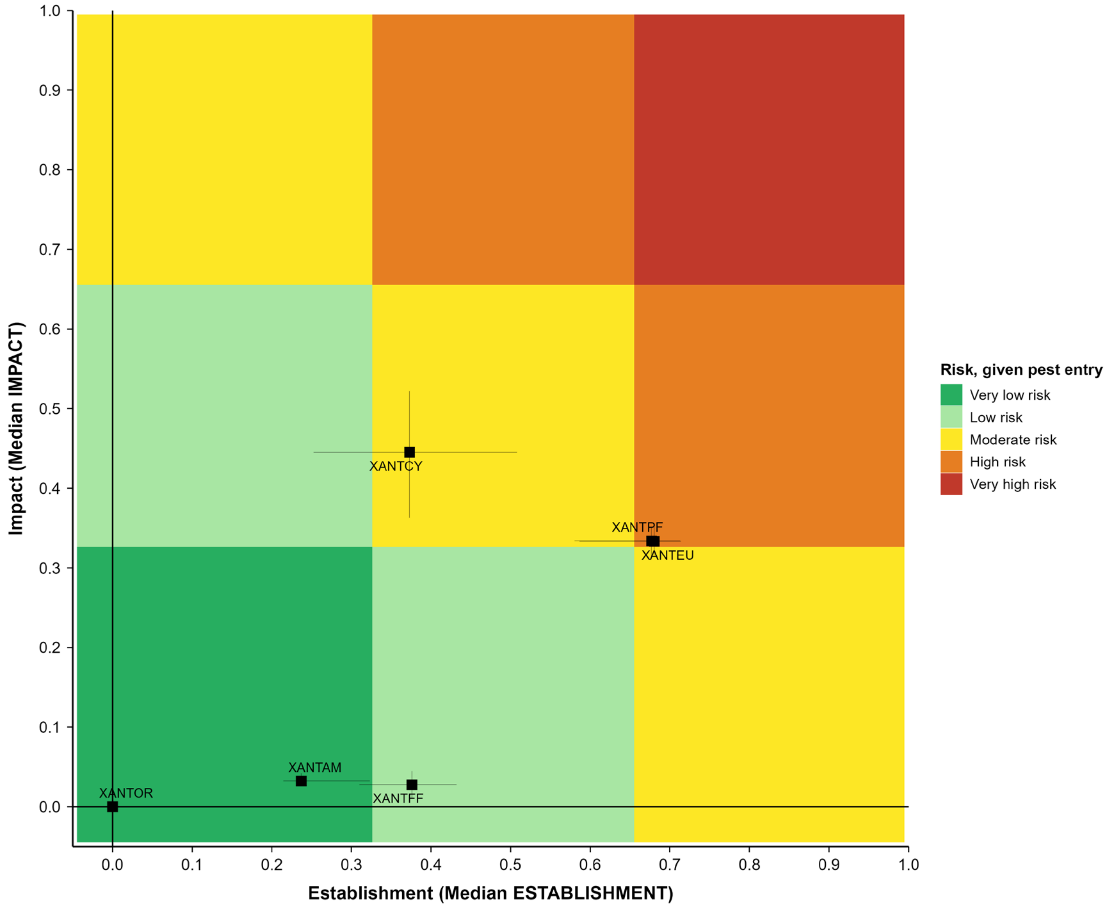

Figure 14. Conditional risk profile of six EPPO-listed bacterial pests, illustrating their estimated probability of establishment (x-axis) and potential impact (y-axis) as assessed using the FinnPRIO risk rating model. Probability of pest establishment is one of two components of pest invasion probability: P(establishment) × P(entry) = P(invasion). Background colouring indicates five classes of risk, given pest entry. Black squares represent the median risk value for each pest, labelled with EPPO code. Horizontal and vertical error bars show parameter range (minimum to maximum) derived from Monte Carlo simulations, reflecting uncertainty in individual FinnPRIO question scores. For definitions of EPPO codes, refer to Appendix II.

3.4 Risk classification of all assessed pests

Based on the total risk profiles presented in Figures 5 to 9, we here summarize the risk classification of all the 61 pests assessed in this report. The pests are grouped by the total risk they pose to Norwegian plant health, according to the five risk classes defined in Section 2.1.3.

3.4.1 Very high risk pests

None of the 61 assessed pests were considered to pose very high risk to Norwegian plant health, i.e., no pests were considered to simultaneously have a high probability and a high impact of invasion. Pests with high invasion probability have one or more entry pathways, such as import of commodities with a high likelihood of pest presence, and high survival and probability of being transferred to a suitable habitat upon arrival in Norway. Pests with a high probability of invasion can also find suitable host plants and climatic conditions in Norway and are thus well adapted to establish and spread. High impact-pests have large economic, environmental and/or social impacts.

3.4.2 High risk pests

High-risk pests have many of the same characteristics as pests posing very high risk, but to a lesser degree. One pest, the fungus *Fusarium euwallaceae* (FUSAEW), was assessed to pose high risk to Norwegian plant health. The fungus is vectored by an ambrosia beetle and can infest a wide range of host plants, including many that are commercially important timber and fruit trees in Norway.

3.4.3 Moderate risk pests

Six pests were assessed to pose moderate risk to Norwegian plant health. These pests have intermediate combinations of probability and impact of invasion (high probability-low impact, low probability-high impact, or moderate probability and impact). The moderate risk pests included two insects, two fungi, and two bacteria.

Four moderate risk pests were assessed to have moderate probability and impact of invasion (Appendix I). These 'moderate probability-moderate impact' pests include:

- The moth *Tuta absoluta* (GNORAB), which is a destructive pest of tomato and can establish in greenhouses in Norway. Its primary entry pathway is trade of infested tomato plants or fruits. A pest risk assessment for *T. absoluta* was published by VKM in 2017 (VKM, 2017).
- The two bacteria *Xanthomonas euvesicatoria* pv. *euvesicatoria* (XANTEU) and *Xanthomonas euvesicatoria* pv. *perforans* (XANTPF), which are pests of tomato and sweet pepper. They can establish in greenhouses and cause significant damage to tomato production in Norway.
- The fungus *Verticillium dahliae* hop strains, which is mainly a pest of hop plants but has a range of other plants listed as potential hosts. Some of these, such as potato, strawberry and fruit trees, are of major economic importance in Norway.

Two pests were assessed to have low probability of invasion but high potential impact (Appendix I). These 'lower probability-higher impact' pests include:

- The bark beetle *Dendroctonus ponderosae* (DENCPO), which can cause widespread mortality in various pine and spruce species. If the pest enters Norway, it will likely establish due to suitable climate and available hosts.
- The fungus *Phymatotrichopsis omnivora* (PHMPOM) is a soilborne pathogen with more than 2000 host plants, including many that are commercially important crops in Norway. The pest is unlikely to invade or spread in Norway due to limited dispersal potential, absence of import pathways, and unsuitable climatic conditions.

3.4.4 Low risk pests

Pests considered to pose low risk to Norwegian plant health made up the second largest group of assessed pests (16 out of 61 pests). These pests were considered to have low to moderate probability of invasion and low to moderate impact of invasion. The low risk pests included four insects, three nematodes, two fungi, six virus, and one bacterium. See Appendix I for details on the probability and potential impact of invasion for each of the 16 low risk pests.

3.4.5 Very low risk pests

Most of the assessed pests, 38 out of 61, were considered to pose very low risk to Norwegian plant health, i.e. they were considered to have both a low probability of invasion and a low impact of invasion. These pests included 19 fungi, nine nematodes, two viruses, five insects, and three bacteria. They all scored low on one or more of the criteria entry, establishment, and impact. See Appendix I for details on the probability and potential impact of invasion for each of the 38 very low risk pests.

3.4.6 Risk classification by EPPO listing

Among the 61 assessed pests, 19 were listed in the EPPO A1 list (i.e., pests absent from the EPPO region), 36 in the EPPO A2 list (i.e., pests present in the EPPO region), and six in the EPPO Alert List (an early warning-list of pests that may present phytosanitary risk but are not yet recommended for phytosanitary regulations). The six pests that were assessed to pose moderate risk to Norwegian plant health were from the A1 list (two pests) and A2 list (four pests). The single pest assessed to pose high risk was from the A2 list. See Appendix I for a complete overview of all 61 assessed pests.

3.4.7 Distribution of pests based on total risk

The main risk metric of the FinnPRIO risk-ranking model, total risk score, is calculated as the product of probability of entry, probability of establishment, and potential impact. Thus, a low score on any of these parameters will dramatically reduce a pest’s total risk score. The distribution of the 61 assessed pests across risk classes is presented in Table 2. Most of the pests were classified to pose very low (38 pests) or low (16 pests) risk to plant health in Norway. For a pest to be classified as posing very high risk, it must have high scores on entry, establishment and impact, and none of the assessed pests were in the highest risk class. Most high-impact plant pests that are highly damaging in their native or introduced range had low to moderate risk scores in Norway, usually because they have a low probability of entry and/or establishment.

Table 2: Distribution of the 61 assessed pests according to the total risk they pose to Norwegian plant health.

Risk class	Number of species	Percentage (%)
Very high risk species	0	0.0
High risk species	1	1.6
Moderate risk species	6	9.8
Low risk species	16	26.2
Very low risk species	38	62.3
Total	61	100.00

4 Uncertainties

Knowledge about factors such as general pest biology, host range, environmental requirements, pathways of movement, import volumes of relevant commodities, and current global distribution is crucial for accurate pest risk assessments. For many pests this information is missing or incomplete. The FinnPRIO risk ranking model handles such uncertainty by letting the evaluator choose the most likely, minimum, and maximum answer options. This answer range is then used to calculate an error-range that are displayed in plots of probability of invasion, probability of establishment, and potential impact of invasion (e.g. Figure 5 and 10). Some assessments are also associated with unavoidable, inherent uncertainty, such as projecting how climate change may change future distribution areas of pests. Due to lack of precise knowledge, the estimated probabilities and impacts for some of the assessed pests come with wide error-ranges.

The commodity import statistics used in our assessments have very broad categorization of goods, such as “wood chips or wood shavings derived from hardwood species”. This makes it challenging to find information about import volumes of specific goods. In addition, imported goods may originate from a different country than the country of dispatch to Norway. However, the import statistics do not differentiate between country of dispatch and country of origin but present the country of dispatch as the exporting country. This imprecision in the data introduces uncertainty when assessing probabilities of pest entry to Norway. Furthermore, when the recorded import volume for a specific commodity is zero, this may be due to either regulatory restrictions or historical trade patterns, and these have different implications for future risk. If imports are affected by phytosanitary regulations, the probability of pest entry is likely to remain low. However, if zero import volume simply reflects historical trade patterns the probability of pest entry is more uncertain, as new trade flows could emerge rapidly, particularly for commodities that are not explicitly regulated. Recent experience has shown that import volumes of timber and wood products to Norway can vary substantially between years and between exporting countries, and new trade flows from previously insignificant source regions can emerge rapidly (Økland et al., 2012; 2019). Our assessments in the current report were based on import statistics from the 10-year period 2014-2023, which will not fully capture abrupt shifts in trade patterns. Consequently, pests that currently have a low score on entry probability due to low trade rather than regulatory restrictions may warrant closer monitoring if trade patterns should change.

Reliable comparisons of pest risk between species and between higher taxonomic groups of pests require that all individual evaluators have a similar understanding of the questions asked in the FinnPRIO model and their corresponding answer options/scores. The use of multiple individual assessors may introduce subjective biases, particularly when the knowledge about pests is incomplete or missing. Potential bias is especially critical when, as was done in this assignment, each pest is assessed by a single evaluator only. To reduce potential biases, we plan to implement an internal review process where two other project members review the answer scores made by the main evaluator of each pest. This will ensure that the final risk assessments are comparable between and within different taxonomic groups of pests.

Although the FinnPRIO risk ranking model follows the same structure as a full pest risk assessment, FinnPRIO outcomes may have certain shortcomings and limitations compared to a full pest risk assessment. Scoring models, like FinnPRIO, that assign numerical values to qualitative judgments, often produce different results than full-scale pest risk assessments, which allow for detailed justifications and expert reasoning. Also, due to the fixed question structure of the FinnPRIO model, species-specific factors that fall outside the predefined questions cannot be incorporated into the risk score, unlike in a standard pest risk assessment where additional sections can be added when needed.

The FinnPRIO model and its question-specific user manual were originally designed for ranking risks posed by invasive plant pests in Finland. Hence, certain adjustments may be required when the model is applied to countries that differ markedly from Finland in terms of climate, environmental conditions, or trade patterns. Such modifications may include rescaling answer options related to trade volume, distribution areas of host plants, and direct economic impacts. No modifications were done by VKM when using the FinnPRIO model to rank pest risks for Norway in this report. Our rationale for sticking to the Finish model parameters was that we consider Finland and Norway to be sufficiently similar in terms of trade patterns and volumes, climate, host plant occurrence, overall size, and the size of the economy.

The FinnPRIO model allows for crude assessments of environmental and societal impacts of plant pests using qualitative categories or binary (yes or no) questions, rather than precise monetary values. This avoids the challenge of assigning economic values to ecosystem health or cultural resources, which are usually very difficult to quantify.

5 Conclusions with answers to the terms of reference

The Norwegian Food Safety Authority asked VKM to provide a simplified assessment of the risks posed to Norwegian plant health by pests that are recommended for regulation as quarantine pests by EPPO. VKM was also asked to rank the assessed pests according to the risk they pose. The assessments and ranking were to be limited to pests that have not yet been regulated or assessed for regulation in Norway. In Appendix I, we answer the terms of reference by summarizing (1) the identity of all the 61 pests that were assessed in this report, (2) the current knowledge of the pests' absence or presence in Norway, (3) the pests' potential for introduction and establishment in Norway (i.e., the probability of pest invasion), and (4) the potential consequences of pest establishment and spread in Norway (i.e., the impact of pest invasion). The risk posed by each of the 61 assessed pests is classified according to the five risk classes defined in section 2.3.1 (very high, high, moderate, low, very low).

The FinnPRIO risk ranking tool that was used in this assignment provides risk assessments that are rapid and limited in scope. While this is useful for screening large numbers of pests, more detailed risk assessments will provide firmer support for NFSA's regulatory decision making. The need for firmer support can be addressed by preparing standard pest risk assessments for the six high and moderate risk pests identified in this report that currently lack a pest risk assessment specific to Norway. The need for more detailed assessments is lower for pests that are considered to pose very low or low risk for Norwegian plant health.

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Appendix I - Summary of FinnPRIO pest risk assessments

Summary of pest risk assessments.xlsx:
https://vkm.no/download/18.5f5d6e1c19c1e6691c8eaa5/1770200428962/Summary%20of%20pest%20risk%20assessments.xlsx

Appendix II – List of 61 assessed pests with conclusions of pest risk assessment

EPPO code	Scientific name	EPPO list	Conclusion
AGRLBL	*Agrilus bilineatus*	A2	Very low risk
AGRLFL	*Agrilus fleischeri*	A2	Low risk
AGRLMA	*Agrilus mali*	A2	Very low risk
APLOBE	*Aphelenchoides besseyi*	A2	Very low risk
ARCHCO	*Choristoneura conflictana*	A1	Low risk
ARCHOC	*Choristoneura occidentalis occidentalis*	A1	Low risk
BGMV00	*Begomovirus costai*	A1	Very low risk
CERAFC	*Ceratocystis ficicola*	Alert	Very low risk
CERAFP	*Ceratocystis platani*	A2	Very low risk
CERCAN	*Pseudocercospora angolensis*	A1	Very low risk
CRSPAN	*Anisogramma anomala*	A1	Very low risk
CSNV00	*Orthotospovirus chrysanthinecrocaulis*	A1	Low risk
DENCPO	*Dendroctonus ponderosae*	A1	Moderate risk
DENDSI	*Dendrolimus sibiricus*	A2	Very low risk
DEUTTR	*Plenodomus tracheiphilus*	A2	Very low risk
DIPDMA	*Stenocarpella maydis*	A2	Very low risk
DIPDMC	*Stenocarpella macrospora*	A2	Very low risk
DROSSU	*Drosophila suzukii*	A2	Low risk
EPIXPP	*Epitrix papa*	A2	Very low risk
FUSAC4	*Fusarium oxysporum* f. sp. *cubense* Tropical race 4	A2	Very low risk
FUSAEW	*Fusarium euwallaceae*	A2	High risk
FUSAFO	*Fusarium foetens*	A2	Very low risk
FUSAAL	*Fusarium oxysporum* f. sp. *albedinis*	A2	Very low risk
GLOMGO	*Colletotrichum gossypii*	A2	Very low risk
GNORAB	*Tuta absoluta*	A2	Moderate risk
GRBAV0	*Grablovirus vitis*	A1	Very low risk
GUIGCI	*Phyllosticta citricarpa*	A1	Very low risk
HETDGL	*Heterodera glycines*	A2	Very low risk
HETEIR	*Heterobasidion irregulare*	A2	Low risk
LITYMC	*Litylenchus crenatae mccannii*	Alert	Very low risk
LYCMDE	*Lycorma delicatula*	A1	Very low risk
MELGET	*Meloidogyne ethiopica*	A1	Very low risk
MELGGC	*Meloidogyne graminicola*	A2	Very low risk
MELGLC	*Meloidogyne luci*	A2	Very low risk
MELGMA	*Meloidogyne mali*	A2	Low risk
MELGMY	*Meloidogyne enterolobii*	A2	Very low risk
MYCOLG	*Stagonosporopsis chrysanthemi*	A2	Very low risk
PHMPOM	*Phymatotrichopsis omnivora*	A1	Moderate risk

PHYRMA	*Phyllachora maydis*	Alert	Very low risk
PUCCHM	*Puccinia hemerocallidis*	A2	Very low risk
PUCCPS	*Austropuccinia psidii*	Alert	Very low risk
RADOCI	*Radopholus similis* citrus race	A1	Very low risk
RAFFLA	*Harringtonia lauricola*	Alert	Very low risk
RRV000	*Emaravirus rosae*	A1	Low risk
SCLECA	*Ciborinia camelliae*	A2	Very low risk
SLCV00	*Begomovirus cucurbitapeponis*	A2	Low risk
TOLCND	*Begomovirus solanumdelhiense*	A2	Low risk
TOMOV0	*Begomovirus solanumvariati*	A1	Low risk
TRCDAF	*Trichoderma afroharzianum*	Alert	Very low risk
VERTAH	*Verticillium nonalfalfae* hop strains	A2	Low risk
VERTDH	*Verticillium dahliae* hop strains	A2	Moderate risk
WMSMOV	*Orthotospovirus citrullomaculosi*	A1	Low risk
XANTAM	*Xylophilus ampelinus*	A2	Very low risk
XANTCY	*Xanthomonas arboricola* pv. *corylina*	A2	Low risk
XANTEU	*Xanthomonas euvesicatoria* pv. *euvesicatoria*	A2	Moderate risk
XANTFF	*Xanthomonas citri* pv. *fuscans*	A2	Very low risk
XANTOR	*Xanthomonas oryzae* pv. *oryzae*	A1	Very low risk
XANTPF	*Xanthomonas euvesicatoria* pv. *perforans*	A2	Moderate risk
XIPHBC	*Xiphinema bricolense*	A1	Very low risk
XIPHRI	*Xiphinema rivesi*	A2	Low risk
XIPHAA	*Xiphinema americanum* sensu stricto	A1	Low risk