A model for ranking plant pests and diseases (FinnPRIO)

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Abstract

There are so many potential plant pests that all cannot be subjected to a full scale risk assessment. There is therefore a need for a faster and lighter risk assessment procedure. FinnPRIO prioritisation model estimates the risk of exotic plant pests for Finland. It follows the basic structure of risk assessment, i.e. it separately estimates the probabilities of entry, establishment and spread, and the likely impacts. The model also has a management section. The total score is calculated using the most likely figures, but also simulated using a PERT distribution, providing a scale of potential risk for each species.

Keywords: Invasive pests, plant health, prioritisation, ranking

Introduction

Growth in international trade and travel together with changes in climate and production practices have significantly increased the rate of plant pest and disease introductions to new areas. Restriction of international trade to prevent the spread of pests is acceptable as long as the measures are based on risk assessment. However, there are so many potential pests that they cannot all be subjected to a full scale risk assessment and cannot all be thoroughly monitored by the plant health officials. There is therefore a need for a risk assessment procedure that is lighter and faster than the standard full scale assessment. Such a procedure can be used to select the species for full risk assessment, and for targeting plant health inspections and information provision. We present the structure of one such model, and some preliminary results from its application.

Model structure

FinnPRIO prioritisation model estimates the risk of exotic plant pests for Finland. It follows the basic structure of risk assessment, i.e. it separately estimates the probabilities of entry, establishment and spread, and the likely impacts. The main structure of the model thus follows the TEASI-framework (Leung et al., 2012), where the invasion is broken to stages: transport, establishment, abundance, spread and impact. We have, however, simplified the model by combining establishment, abundance and spread into a single section. The model consists of discrete multiple-choice questions with different answer options yielding a different number of points. As recommended by Leung et al. (2012), also uncertainty and management are included in the model, and the model structure is multiplicative.

The entry section consists of eight potential pathways, of which the evaluator can choose up to five pathways considered important for the pest. Pathways A-E follow a common pattern of questions, and differ in terms of the host plant material that is being considered. Pathway F deals with non-plant commodities, transport and passengers, pathway G with natural spread, and pathway H with intentional spread. The section consists of two questions common to all pathways and additional pathway-specific questions (Figure 1). The answers for Q3 are conditioned on the answer to Q2 such that if the spread potential is high, the volume of import plays a lesser role in determining entry risk. The score for each pathway is the product of the individual question scores, and each pathway can potentially obtain the same amount of points. The management question (Q5) is only a modification of Q2, and the total scores are calculated both with (using Q5) and without management (using Q2). The final score for the entry section is obtained through calculation of independent probabilities.

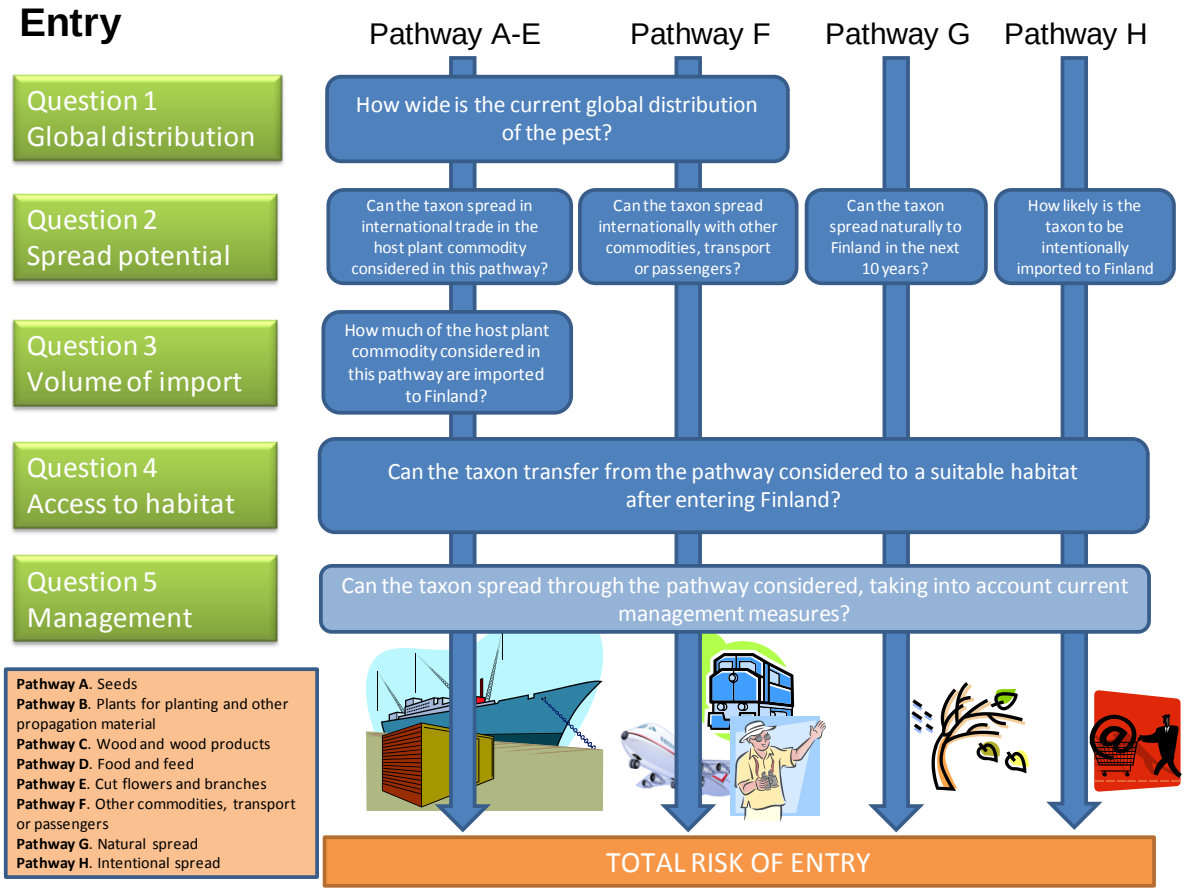

Figure 1: Structure of the Entry section.

Establishment and spread components are included in the same section. There were two main reasons for this, a theoretical and a technical one. The theoretical reason is that many characteristics of the species and of the environment affect both the establishment and the spread of the species. Therefore, we felt appropriate to deal with them together in one section. The technical reason was that if treated separately, the number of questions in individual sections would have been very low, and therefore the distribution of total points within the section would have been highly aggregated around very few numbers, making it more difficult to have distinct differences between the species.

The establishment and spread section consists of four questions (Table 1). The questions relate to host plants, climate, the rate of spread of the species in Finland, and the species' characteristics that promote establishment and spread. If the answer to either Q1 or Q2 is zero, the score for the whole section is zero.

In the impact section there are also four questions (Table 2). The questions deal with economic, environmental and to some extent social impacts. Potential human health impacts are excluded from the model. The first two questions deal with economic impacts, and the latter two questions with environmental and social impacts. Different weights can be set to economic and environmental/social impacts, and the total impact score is calculated as a weighted sum.

Table 1. The questions and available responses in the establishment and spread section.

1	How widely are the host plants growing naturally or cultivated in Finland?
2	Is the climate in Finland similar to the climate in the areas where the taxon is currently established?
3	How fast would the taxon most likely spread in Finland?
4	Does the taxon possess intrinsic traits that could help its establishment and spread into new areas?

Table 2. The questions and available responses in the impact section.

1	How significant direct economic losses would the taxon cause in Finland?
2	Would the taxon cause following indirect economic impacts in Finland? a. Would the taxon have an impact on export market? b. Does the taxon act as a vector for other invasive pests? c. Would the taxon have a significant impact on the profitability of some individual plant production sector?
3	How significant impact would the taxon have on native plants in Finland?
4	Would the taxon cause the following indirect environmental or social impacts in Finland? a. Would the taxon have a significant impact on the amount or the quality of food, building material or other goods collected from the nature? b. Would the taxon have aesthetic or cultural impacts? c. Would the taxon have impacts on plants that have an important status in Finnish nature?

The calculation of the total model score is carried out by first normalising the section scores such that they all have a maximum attainable level of 100 and a minimum of 0. The scores from the three sections are thereafter multiplied by each other. The final result of this has a maximum of one million, and the total score is therefore divided by 1000, in order to have a final score reaching a more sensible scale of 0-1000.

Uncertainty is considered in the responses of all questions. The evaluator responds to each question with a most likely score, which is the basis for all static calculations. However, the evaluator also responds with a minimum plausible score and a maximum plausible score to each question to account for uncertainty related to each question. These minimum and maximum scores are used to carry out a simulation, using a PERT-distribution, of the section scores and subsequently of the total scores. The simulation provides a range of total risk scores for the evaluated pest, therefore also indicating the level of uncertainty inherent in the score.

Results

The model was first tested with random numbers using simulation analysis to study the distributions of the section scores and the final scores that the model produces. These results were used when developing the formulae for calculating the section scores. The impact of the different questions on the final score is presented in Figure 2. The figure was obtained by setting the answer to each question at its minimum and its maximum value, one at a time, while all other responses were random. 1500 iterations were conducted for each case, and the resulting mean of the final scores was recorded. This mean was then compared to the case where responses to all questions were random. The answer to the question related to the presence of host plants was set so that in the random simulation it could not obtain a value of 0 (no host plants present) to keep the analysis meaningful. For entry, two pathways were considered (pathway A-E and pathway F).

The questions are displayed on x-axis, while their individual impact on the final score is presented on y-axis (the increase/decrease in mean total score when the individual question is set at maximum/minimum). The most influential question is the one about climate, which can nearly double the final score. The two questions that can reduce the final score to zero are the ones related to host plants (when they do not exist) and climate (when it is totally unsuitable). Random simulations were also use to create a histogram of the final scores in order to understand the potential distribution of the total scores. The analysis revealed that the model is in theory capable of discriminating well between different pests – there is much space in the higher end of the scale for the species that pose the highest risk.

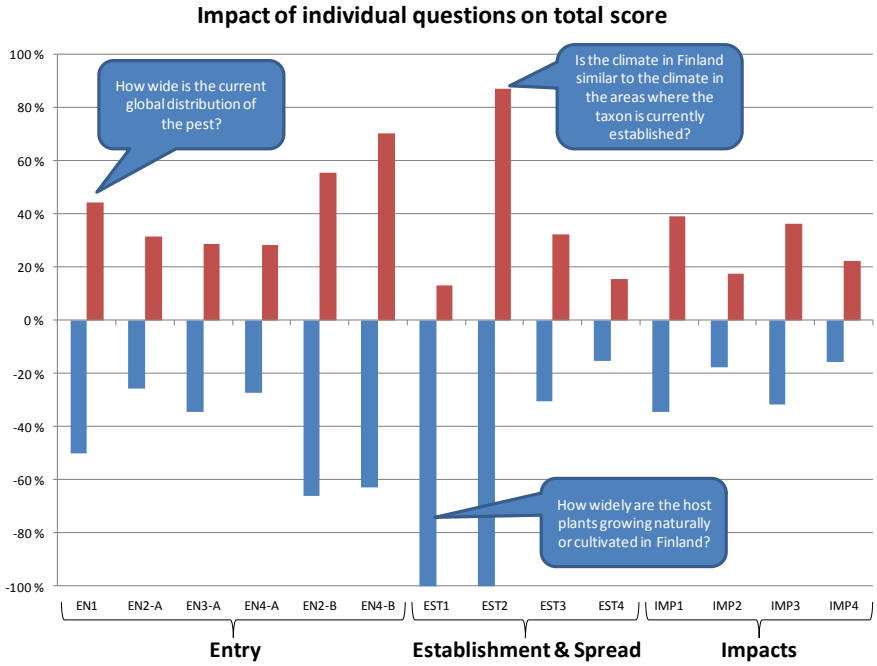

Figure 2. The impact of individual questions on the final score when other responses are random.

Thus far, 95 species have been evaluated with the model. The total scores are displayed in Figure 3. The cross indicates the median score and the horizontal bar in the middle indicates the mean score. The whiskers show the minimum and maximum plausible scores, indicating the level of uncertainty.

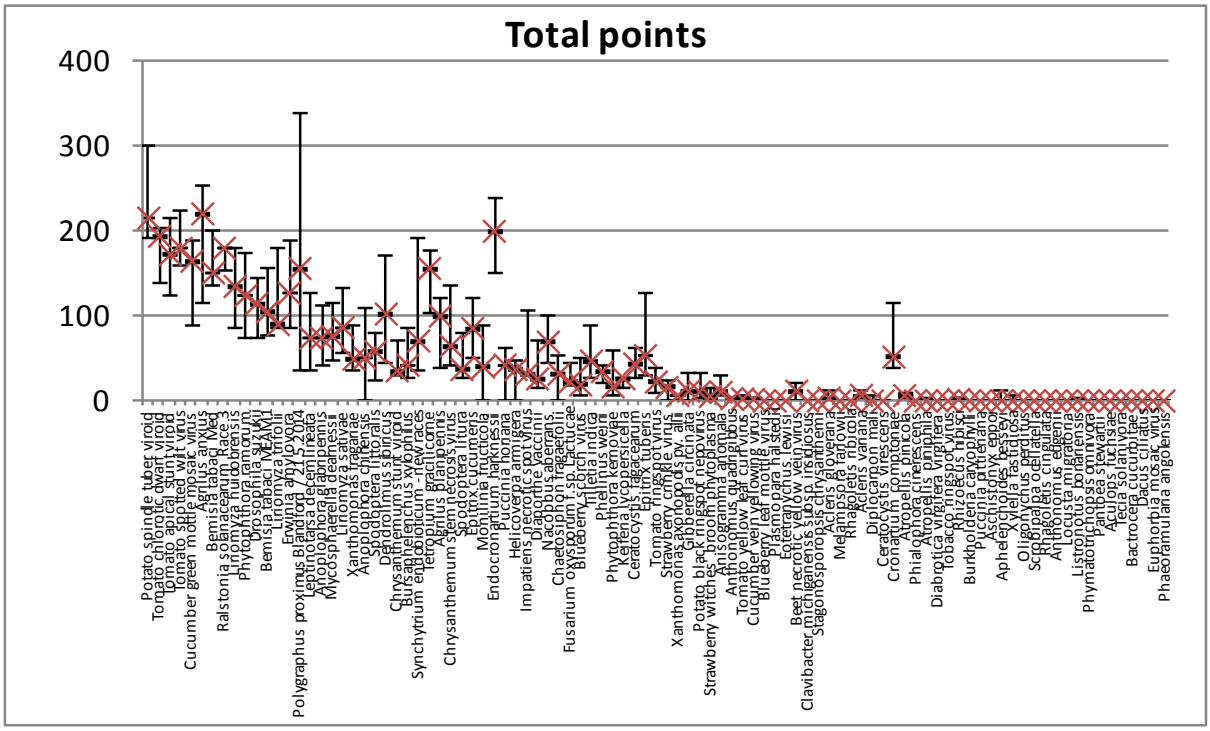

Figure 3. Total scores for 95 species that have been evaluated.

Discussion and further developments

The model is still under development, especially regarding the management section. The section will be used to construct a separate score ("controllability"), against which the total scores can be plotted. Three expert workshops, organised in September and October 2013, are also used to validate the model results. In these workshops experts were asked to assess the entry, establishment, spread and impact potential of a subset (5-10) of species.

Further analysis of the results is also ongoing, including analysis by section and potential grouping of species into different lists. In this paper we have merely presented the basic structure of the model, and further results are upcoming. We believe that the model has much potential in aiding the authorities in decisions regarding risk management policies of invasive pests.

References

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