Näkökulmia tautien ja tuholaisten priorisointiin

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Tiivistelmä

Yhteiskunnan käytössä olevat resurssit ovat niukat: valtiolla ei ole esimerkiksi varaa tuottaa täydellistä bioturvallisuutta. Tästä syystä resurssien käyttöä tulee kohdentaa ja priorisoida. Kohdentamista ja priorisointia tapahtuu koko ajan kaikilla hallinnonaloilla: koska rahat eivät riitä kaikkeen, jollakin tietyillä perusteilla valitaan mihin resurssit kohdistetaan. Priorisointi voi perustua kustannushyötylaskelmiin ja riskinarviointiin, mutta useammin kuitenkin eri tahojen näkemyksiin siitä, mikä on tärkeää.

Erilaisten ympäristöriskien rankkaaminen on lisääntynyt viime vuosina. Myös bioturvallisuuteen liittyen näyttäisi olevan poliittista tilausta priorisoinnille. Esimerkiksi Euroopan Unionissa on pyrkimys eläintautipolitiikan yhteydessä eläintautien ja niiden hallintakeinojen priorisointiin niiden terveydellisten ja taloudellisten vaikutusten perusteella. Ongelma tällaisten mallien puuttuessa on se, että resurssien allokointi voi olla tehotonta. Koska jonkinlaista resurssien jakamista tehdään joka tapauksessa, jos se ei perustu riskinarviointiin, se perustuu johonkin muuhun. Esimerkiksi Australiassa liian moni laji on julistettu rikkakasviksi verrattuna niiden hallintaan tai hävittämiseen käytettävissä oleviin resursseihin. Alueet ovat keskittyneet eri lajeihin eri syistä, mukaan lukien pitkä torjuntahistoria, suuri näkyvyys, poliittinen paine, oletetut vaikutukset, torjuntatoimenpiteisiin saatu apu, lajiin liittyvä tietotaito sekä maataloudellinen paine (Virtue 2007). Taloustieteeseen perustuva priorisointi ei juuri ole vaikuttanut valintoihin. Myöskään eläintautien tapauksessa riski ei selitä kaikkia hallintaratkaisuja (Rosengren ja Heikkilä 2009).

Akateemisessa kirjallisuudessa on useita malleja ja kehikkoja, joita on kehitetty tautien ja tuholaisten priorisointiin. Näiden mallien avulla on mahdollista rankata biologisia vaaroja niiden aiheuttaman riskin mukaan. Tässä tutkimuksessa käydään läpi näitä malleja ja niiden ominaisuuksia. Tutkimus käsittää kaikki bioturvallisuuden osa-alueet (ihmistaudit, eläintaudit, kasvintuhoojat ja –taudit sekä vieraslajit) ja tehty kirjallisuuskatsaus kattaa yli 70 priorisointitutkimusta. Maantieteellisesti näistä suurin osa sijoittui Pohjois-Amerikkaan, Eurooppaan sekä Australiaan ja Uuteen Seelantiin. Suurin osa tutkimuksista käsittelee ympäristön terveyttä, jonka jälkeen tulivat ihmisten terveys, kasvinterveys ja eläinten terveys. Suurin osa tutkimuksista on julkaistu viimeisen viiden vuoden aikana.

Kirjallisuuskatsauksen keinoin selvitetään mihin tekijöihin priorisointimalleissa tulee kiinnittää huomioita. Tässä artikkelissa keskitytään seuraaviin: kysymysten lukumäärä, huomioon otetut tekijät, pisteskaalat, painotus, sekä kokonaispisteiden muodostus. Vaikka mallien tulokset ovat yleensä aikaan ja paikkaan sidottuja, itse malleista voimme oppia paljon. Priorisointimallin avulla on mahdollista käyttää ekologista ja taloudellista tutkimustietoa tukemaan biologisiin vaaroihin liittyvää päätöksentekoa.

Asiasanat: bioturvallisuus, priorisointi, kirjallisuuskatsaus

Introduction

The resources available for the society are scarce. The state cannot, for instance, provide perfect biosecurity, and resources need to be targeted and prioritised. In practice, prioritisation is often based on opinions and views of different agents regarding what is important rather than on risk assessment or cost benefit analysis. Using economics and risk assessment it is possible to turn prioritisation into a transparent process that assists in targeting the societal resources as sensibly as possible.

Morgan et al (2000) note that ranking of environmental risks in general has increased in recent years in for instance the US, Canada and New Zealand. Also in terms of biosecurity, there seems to be political demand for such prioritisation. Within the European Union there is a desire to harmonise animal health policy and search for a common framework to analyse animal trade, import, disease, health and welfare policies. The objective is to produce a scheme that can be used to classify and prioritise animal diseases and their management based on their health and economic impacts (European Commission 2006). Similar plans exist in relation to plant health and invasive species, and for instance risk-based surveillance is becoming more popular (McKenzie et al 2007), but these trends have not yet materialised as visibly as in the case of animal health.

Despite the few initiatives, in a literature review done for the UK animal disease prioritisation, it was noted that many organisations do not use any such method to support decision-making (Gibbens et al. 2006). In a review of 113 lists of invasive plants from 16 countries, in nearly 20% there was no explanation as to why the species were on the list, in two thirds there were single sentences that used vague terms such as “harmful” or “causes harm”, and in the rest there were several criteria. Ranking was done on less than 10% of the lists and 14% used choice questions the answers to which determined which species were selected on the list (Fox and Gordon 2004).

The problem when such prioritisation studies do not exist is that resource allocation is likely to be inefficient. For instance Virtue (2007) points out that in Australia too many species have been declared weeds compared to the resources available for their effective management or eradication. He further points out that species have been targeted for different reasons in different areas, including long history of control, large visibility, political pressure, suspected impacts, help received in management, knowhow related to the species and pressure from agriculture. Economics-based prioritisation has not impacted on the choices in any significant way (Virtue 2007). Similarly, risk is not the primary determining factor in control of many animal diseases (Rosengren and Heikkilä 2009).

Still, in academic literature various models and frameworks have been developed to prioritise pests and diseases. These models can be used to rank biological hazards according to the risk presented by them. This study reviews and discusses such models and the properties associated with them. The study reports the results of a literature review, in which over 70 prioritisation studies were assessed. The scope of the models discussed includes all aspects of biosecurity (human diseases, animal diseases, plant pests and diseases, and invasive alien species). The geographical location of these studies has included primarily North America (25 studies), Europe (24) and Australia and New Zealand (15). Most of the studies have concentrated on environmental health (38 studies), followed by human health (17) and plant health (14), although it sometimes is difficult to separate environmental and plant health. Most of the studies (38) have been conducted in the past five years.

Using these models, this study discusses the factors that should be taken into account when making prioritisations. Here we concentrate on the number of questions, the factors and impacts accounted for, point scales, weighting, and aggregation of points. Although the rank order is usually time and place specific and thus cannot be directly applied elsewhere, we can learn a great deal from the prioritisation models themselves. Using such a tool, it is possible to better utilise ecological and economic information in decision-making related to biological hazards.

Prioritisation

Hiebert and Stubbendieck (1993) note that one reason for analytical ranking is to involve the scientists in the process. If the used framework is consistent and logical, scientists can be involved without endangering scientific credibility in the face of uncertain information. Lacking an analytical model, the decisions would be based on an opinion of an individual or a group, or on what has been done before. History, Hiebert and Stubbendieck (1993) argue, is partially correct, but is not based on established criteria, its basis is not documented, and it cannot be used to ensure that all important aspects have been taken into account. Decisions made on such basis are difficult to defend if they are challenged.

Even though ecological theory cannot fully predict invasions, potentially harmful species can be predicted to some extent (Weber and Gut 2004). There is, however, no objectively correct way to carry out prioritisation. A ranking system should have the following properties (after Daehler et al 2004; Virtue 2007): 1) components have a scientific basis that should be mathematically simple but logical; 2) the scheme should be fully transparent; 3) the questions should be understandable and generic enough to allow application to a range of circumstances; 4) the evaluation process should minimise the impact of subjective views and should be repeatable such that two persons evaluating the same organism end up in a similar outcome; 5) there should be as few questions as possible, but the comparison needs to be robust; and 6) there should be a possibility to use all available data. In addition, the time and cost requirements should be modest. There are a few prioritisation frameworks, which have been fairly widely used, some of which are listed in Table 1.

System	**Original application**	**Used also for/in**
Australian Weed Risk Assessment	Weeds in Australia	Weeds in Australia and New Zealand, Hawaii, Florida, Chicago, Spain, Italy, Czech Republic, Central Europe, Japan and Tanzania. Also used for fish in the UK.
Risk Ranger	Food safety	Food safety in the EU and in Australia.
Tucker-Richardson model	South African fynbos ecosystem	Plant health in Hawaii
Reichard-Hamilton decision tree	Weeds in North America	Plant health in Hawaii, Chicago, Iowa and the Czech Republic.

Table 1. Some widely used prioritisation models.

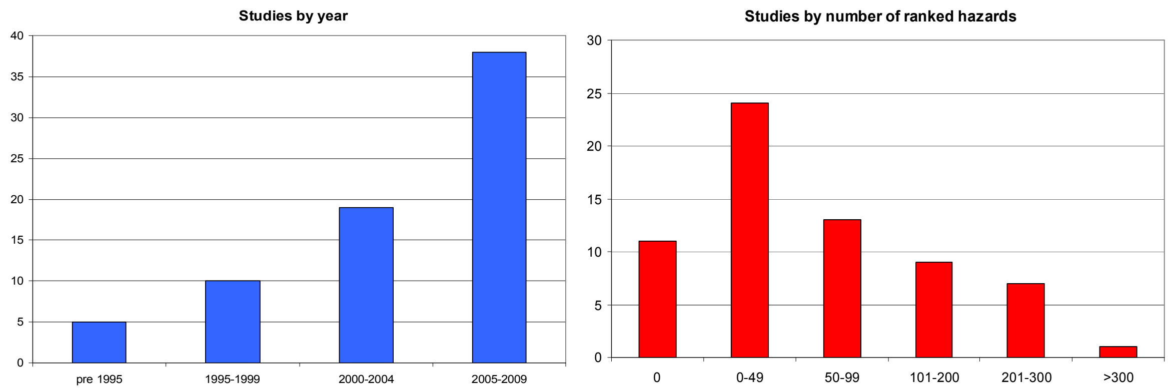

Figure 1. Reviewed studies by year of publication and the number of ranked hazards.

70 distinct prioritisation studies were reviewed for this article (full lists of references available from the author). However, in some studies more than one evaluation framework were used, and hence there are 73 cases that are summarised here. The maximum number of ranked organisms was 851, while the mean was 88 and the median 43 organisms. Most of the studies are from the past five years (Figure 1).

A prioritisation framework can be roughly divided into six phases (applied from Doherty 2000): 1) establish the evaluation criteria; 2) divide the evaluation criteria into sub-criteria/questions; 3) determine the points given to each sub-criteria/question; 4) design the aggregation of points; 5) rank the organisms based on the points; 6) fine tune the results by for instance determining the cut-off point (e.g. for surveillance) or organise the organisms into different classes.

Hazard ranking often follows the basic structure of risk assessment, and includes the evaluation of release, exposure and impacts. It is typically based on separate components that together form the ranking order. These components include the probability of entry (or invasion or introduction or outbreak), the probability of establishment (or spread or invasiveness), and the likely consequences, which may or may not be measured in monetary terms. As illustrated in Figure 2, it is most often entry of the organism that is missing from the assessment. This reflects primarily the fact that many of the assessments are for species that are proposed for intentional introduction, in which case entry becomes irrelevant. Figure 2 only captures whether there are any questions related to impacts, not how extensive those questions are.

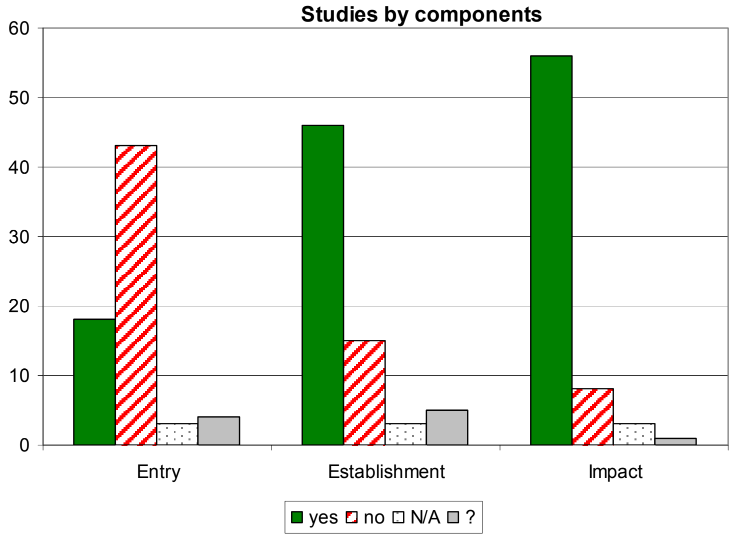

Figure 2. Reviewed studies by included main components.

As for the number of questions in the reviewed studies, 16% had less than 10 questions and 19% had 49 questions, which is the number of questions in the widely applied Australian weed risk assessment model. The mean number of questions was 24 and the median was 22. It has been established that the number of questions in the model does not necessarily affect the outcome. For instance Daehler et al (2004) noted that there is a statistically significant linear relationship between the number of questions and the pest status of the evaluated organisms, but that the fit of the regression is low (R^2=0,08). Yet, in other words, although there is a connection, it only explains a small proportion of the pest status. In other studies (e.g. Dawson et al 2009) no statistical connection has been found. Increasing the number of questions may be warranted, however. In the widely used Australian weed risk assessment model there a relatively many questions in order to reduce the need for further evaluation (Parker et al 2007). Having said that, in different studies it has been noted that often the ranking is not very much affected when the number of questions is reduced (e.g. Daehler and Carino 2000). However, it is perhaps difficult to state *a priori* which are the questions that determine the outcome and which could be dropped. Also, although a few questions could relatively reliably predict harmful pests as such, they often also predict harmless species to be harmful (e.g. Gordon et al 2008). In other words, the sensitivity of the model is good, but its specificity suffers. This property has also been found difficult to predict in other studies (Reichard and Hamilton 1997; Kriványek and Pysek 2006).

The scoring is mostly on a semi-quantitative scale. In other words, numbers are used but they are not absolute measures of the property that is being measured. For instance, probability of spread may be measured on a scale (e.g. 1-5) rather than being measured as an absolute probability. Such a system is faster than a fully quantitative approach, as often the information available is not accurate enough to allow full quantification. On the negative side, the scores and their aggregation are arbitrary, which may not be fully transparent (McKenzie et al 2007). Also letters (e.g. A-E) have been used (Morse et al 2004), but these are converted to numbers when aggregation is conducted. The use of letters is probably more to do with psychology and allowing the evaluators to concentrate on the descriptions of the available choices rather than thinking in terms of numbers. Nonetheless, whether using letters or numbers, it is important that the options have clear verbal descriptions in order to reduce the scope for different interpretations by different evaluators. The clearer the descriptions, the more trustworthy the outcome of the scoring (Ryan 2006).

Many studies use the Likert scale, which typically ranges from 1 (strongly disagree with statement) to 5 (strongly agree). However, for instance McKenzie et al (2007) have chosen a scale from 1 to 4 in order to avoid having a middle value (3) and hence forcing the evaluators to choose whether the property is more or less likely, rather than choosing the mean. Further, it has been argued that for instance having a scale running from 1 to 9 and hence having a lot of choices is unclear, as each alternative is unlikely to be clearly defined. For instance EPPO uses such a scale, and in some studies (e.g. Copp et al 2005) that have used the EPPO criteria, the authors have actually modified the scale to have a lower number of options. Also elsewhere (e.g. MacLeod and Baker 2003) it has been noted that without precise verbal descriptions, using a scale such as 1-9 in a standardised way is impossible. Evaluation on a scale 1-3 (low, medium, high) or 1-5 (very low, low, medium, high, very high) is more likely to yield similar results from different evaluators, hence being more objective. On the other hand, for instance a scale with only three available options may result in little difference to the overall rank of the species, making ranking more difficult.

The overall rank is typically obtained by either multiplying the different component values by each other or summing them up. One property of the multiplicative approach is that the rank approaches zero if any of the individual components does so. For instance, if the probability of entry is zero, then the total score is zero as well. In an additive model it is possible that the total rank is still relatively high, although for instance habitat suitability is very low (Parker et al 2007). Having said that, the majority of the reviewed studies apply additive aggregation (60% of studies), while in only 11% the aggregation is multiplicative. In further 10% there is no aggregation and in 19% the method of aggregation is unclear. There are also studies where the results are aggregated by categories or sections (e.g. Ciotti 2003). In the Australian weed risk assessment (Pheloung et al 1999) the outcome can be separated by whether the impact is on the environment or on agriculture without necessarily having to aggregate these impacts (although the model also results in a combined rank). In South-Australian weed model the assessment is done based on land use, when the relative values of economic, environmental and social impacts need not be considered to such large extent (Virtue 2007).

In aggregation it has to be decided whether each category within the assessment carries a similar weight in determining the final score. Similarly, it has to be decided whether each question carries a similar weight when determining the score for each category or sub-category. If each question contributes directly to the final score, does each question have a similar effect on the final score? In other words, is there some weighting of the relative importance or not, when aggregation is done. In the reviewed studies, roughly 41% does not apply weighting, 44% applies weighting and in the rest of the cases the documentation does not support assessment of whether it is done or not. The weighting is primarily applied such that it is already built into the scoring system: different questions or categories obtain different number of points. In a few cases specific weights are explicitly assigned to categories, making it more transparent.

Discussion and conclusions

Assessment of risks is an uncertain business. The information on which such evaluations are based is always imprecise or inadequate. From the perspective of economic theory, the prioritisation models are not without problems. For instance, the points are not linearly related. Score of 2 may be a better (less harmful) than score of 4, but it is not necessarily twice better. Hence direct aggregation is difficult. For direct aggregation to be theoretically sound, a change in score from, say 1 to 2 should have the same effect on social welfare (or utility) as a change from, say, 4 to 5. In other words, the scores and welfare should be linear functions of each other (Ryan 2006). Moreover, a change of one point in score should have the same effect on welfare regardless of the category in which it occurs. In many models the impact on the total score may differ between the categories, let alone the impact on welfare. Also model-based prioritisation may be based on subjective information, but it can be better controlled. Although the system itself is transparent, it is not transparent how it is used to support decision-making (DEFRA 2006). Perhaps the main problem with ranking is that they do not link acts to probable consequences. In other words, they assume nothing is done about the problem or that doing something has similar cost and implications for all hazards. This is not a weakness in the methodology as such, but rather in its use. If nothing is done to assess the interventions and the consequences of those interventions, allocating resources on basis of the priority lists is misleading. If the policy impacts are accounted for, then priority lists can act as a valuable tool.

These cautions aside, it is clear that ranking and prioritisation is carried out every day. Whether it is based on models or on individual opinions or other aspirations is the key question. Cook and Proctor (2007) found that the list produced by the prioritisation process ended up with a very different distribution of resource use than was currently in force. Resource reallocation is naturally difficult: plant health officials cannot overnight be transformed to animal health officials. Adaptation should, however, occur over time according to the relative risks (Ryan 2006). The current level of resourcing should of course be taken into account. For instance, Horby et al. (2001) note that an organism/disease high in the ranking may already be well resourced, whereas an organism further down may be, relative to its position, very much under-resourced. Hence having an organism high in the ranking does not automatically mean that we should be investing more resources in it than is currently done.

Ranking tools do not provide an absolute hierarchy. Rather, it is a basis for decision-making and for detecting hazards that require attention. Prioritisation does not directly tells how much to spend on each hazard. Rather, it is a way of thinking through the problem analytically in the face of uncertainty in order to achieve a better overall allocation of scarce societal resources. Ryan (2006) summarises the benefits of prioritisation as 1) more efficient resource allocation; 2) transparent basis for decision-making; 3) conceptualisation of the problem; and 4) a quantitative aid to decision-making when there are conflicting objectives that are measured in different units. Finally, as Hiebert and Stubbendieck (1993) point out, the prioritisation tool should be used correctly and by able operators. The numbers themselves have little meaning – the objective is to differentiate the hazards by their level of risk. Prioritisation is also not a static exercise, since the risk presented by the organisms varies in time and space. Hence prioritisation should be regularly updated. All frameworks are designed to support decision-making. They are not decision automats and should never be used as such.

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