

The role of prediction in determining the quarantine significance of weeds

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Summary

While many countries maintain lists of weeds whose import is restricted or prohibited, the scientific grounds for inclusion are rarely, if ever, elaborated. This paper reviews the approaches which have been employed to estimate potential impacts of weeds in uninvaded regions. It concludes that while predictions can be used to support existing prohibitions, uncertainty about future conditions (in particular the possibility of climate change) is a sufficient reason to maintain some form of restriction upon the import of plants which are serious weeds elsewhere.

Introduction

Unless quarantine decisions are scientifically based, they may be perceived as barriers to trade. Predictions are implicit in any decision to exclude a species, but there has been little attempt to develop a scientific basis for exclusion. Lists of prohibited or restricted weeds have not been examined systematically in order to determine whether each species poses significant economic and environmental risks. It is apparent, however, that much damage could result if quarantine decisions were based upon erroneous predictions.

Quarantine-related predictions can be tested only in an ad hoc manner, if at all. If entry is prohibited, the underlying prediction cannot be tested unless quarantine is breached (and the weed is able to survive the hazards of early colonization). Similarly, if a species were deemed to pose little threat, the prediction could be tested only if colonization occurred naturally. Authorities are unlikely to grant permission for the introduction of a potentially weedy species, although field introductions to investigate weed potential can be conducted under secure conditions (4).

Methods for predicting weed distributions

Methods based upon climatic parameters have been used to estimate the potential distributions of weeds (5). They vary mainly in the degree to which reference is made to specific biological features. On a gross level, computer models such as CLIMEX and BIOCLIM compare climates of locations or regions with climates known to be suitable for weed growth and persistence (5,6). Another approach has been to relate documented physiological responses to the climatic characteristics of uninvaded regions (3,7,10). The latter method has the advantage that mechanisms for limitation by climatic factors are involved, but it suffers from the time and expense required to determine the physiological behaviour of individual species.

In addition to climatic factors, soil type and land use have important influences upon weediness (5). Relevant data can be

stored in a Geographic Information System (GIS) and overlaid on climatically-based estimates. Unfortunately, all three factors may interact in a non-predictable manner. For example, Wapshere (9) remarked that the Australian method of wheat cultivation so increased the survival and reproductive success of Chondrilla juncea that this weed occurred at high densities in edaphic and climatic conditions which would be regarded as unsuitable in its source regions. While the example may be exceptional, it shows the importance of basing a prediction upon the estimated responses to multiple factors.

Reliability and the use of predictions in decision-making

The reliability of predictions based on climatic parameters depends inter alia upon whether a weed is limited by climatic factors in its source region(s). Limits to physiological responses as well as the occurrence of cryptic climatic adaptation (5) may be best determined in phytotron studies (2), although it can be difficult to predict distribution limits from physiological tolerance limits (1).

Weather patterns are a particularly dynamic feature of the physical environment. These can vary so much between years that atypical seasons may permit a weed to establish and begin to spread in an otherwise inhospitable location. Because models such as CLIMEX and BIOCLIM utilize long-term climatic averages, their predictions do not take into account the potential biological significance of extreme circumstances. The dynamic nature of climate over longer periods is an even greater cause of uncertainty. Global warming and associated changes in rainfall patterns could have major effects (both direct and indirect) upon weeds (5).

Land use can change as primary producers follow market movements. The presence of a weed which imposes additional costs may pre-empt or limit the capacity to take advantage of such changes. Future opportunity costs will be minimized if the assessment of weed potential takes into account likely alterations in land use.

There are two types of error possible when the quarantine status of a weed is determined. The less serious leads to the prohibition of a weed which, in reality, poses little threat. The consequences of this error are that effort is expended for detection and otherwise importable goods will be rejected. A more critical error lies in the non-prohibition of a potentially harmful species. Not only may such a weed be able to establish, but its real importance might not be recognized until eradication is no longer an option. Thus, the greatest certainty is required for estimates describing low potential impact.

A recent study using BIOCLIM showed that Parthenium hysterophorus was not climatically preadapted to any part of New Zealand, largely as a result of cool summers (6). On this basis, a decision could be made to remove Parthenium from the list of prohibited species. However, increases in mean annual temperature of 1.5-3.0°C are predicted over the next 60 years (8), suggesting that conditions will gradually become more favourable for weeds requiring higher temperatures (albeit less favourable for plants with lower temperature optima). While additional factors can be expected to influence the weediness of Parthenium in New Zealand, it is clear that quarantine decisions based upon current environmental conditions may be inappropriate for the future. The

availability of predictions for global warming and the uncertainties about indirect consequences of such warming (5) together suggest that the best course of action would be to continue prohibition of any weed for which the climate is currently too cool. (To date, weeds lacking climatic adaptation because of supraoptimal temperatures have not been identified.)

There is little doubt that predictions can be valuable aids to the management of pests. Nevertheless, it must be accepted that some predictions are going to be wrong, however refined the methods. For quarantine purposes, estimates of risk based upon prevailing conditions may support prohibition of a weed. An apparent lack of adaptation to current conditions is not sufficient grounds for non-prohibition, however, owing to the available evidence for climate change and the strong influence of land use upon weed population dynamics. A high degree of confidence would be required for predictions of future conditions before a weed could be allowed to enter freely. For this reason, the import of species known to be serious weeds elsewhere in the world, when not fully prohibited, should remain restricted.

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