Overview on Best Available Technology in Science and Economics in Pre-Import Risk Analysis

Session: Context

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Introduction

Wherever scientists have looked on earth, damages from biological invasions have increased to the environment, human health, and the economy. It has therefore become clear to policy-makers that improved management is needed of vectors of nonindigenous species. The two main categories of vectors of nonindigenous species are: transportation-related vectors, in which species hitchhike in or on vehicles of transport or products; and commerce in living organisms, in which the transport and sale of living organisms is the purpose of the many industries (e.g., pet, horticulture, watergarden, bait, live food, and aquaculture industries (Lodge et al. 2006). Here we consider only commerce in living species.

For commerce in living species, the identity of the species proposed for use in commerce are known, or could be learned easily (compared to the many usually unknown species hitchhiking on transportation-related vectors). Given the identity of a species before it has been imported, the opportunity exists to evaluate carefully what hazards might be posed from importation of the species, and what the probability of those hazards occurring would be under specified conditions and risk management strategies. In this paper, I provide an overview of standard risk assessment and risk management protocols, and suggest in general terms how they might be applied with existing and emerging scientific and economic tools to pre-import risk analysis of living species. Other speakers in the workshop address each tool in more detail.

Estimating probabilities for transitions in the invasion process

Every invasion follows the same sequence of transitions (Fig. 1 left column) (Lodge et al. 2006). The probability of a species surviving each transition (Fig. 1 middle column) is determined by the interaction of human behavior (e.g., where, when, how many of the species are transported and released), biological characteristics of the organism (e.g., environmental tolerances, life history traits), and the characteristics of the receiving environment (Kolar & Lodge 2002). The probability of undesirable outcome for society is the product of all the probabilities in the middle column of Fig. 1. Existing and emerging tools make it possible to estimate each of these probabilities with increasing accuracy.

The probability that release(s) of a species will result in the establishment of a self-sustaining population depends on propagule pressure, and how well the receiving environment matches the requirements of the species. Unfortunately, no models of the probability of establishment as a function of propagule pressure exist that are specific enough to be employed as a risk assessment tool (Drake & Lodge 2006, Drake & Jerde 2009). An increasing number of tools exist, however, that are well suited to estimating the likelihood that a receiving
environment is suitable for establishment (Elith et al. 2006, Herborg et al. 2009), given sufficient propagule pressure. Likewise, an increasing number of modeling approaches exist to estimate the direction and rate of spread of a species from a site of initial establishment. Because species dispersal is increasingly determined by human transport, spread models for both terrestrial and aquatic species increasingly add human transport onto consideration of natural dispersal (Muirhead et al. 2009). The accuracy of such models make them useful as a guide to risk assessment and risk management (Bossenbroek et al. 2007, Bossenbroek et al. 2009). Statistical and machine-learning models based on the traits of species are also useful for estimating all three transitions from establishment to spread to impact. Such models are built with data sets comparing the traits of species known to have made the transition with those of species known to have failed at the transition (Kolar & Lodge 2002, Keller & Drake 2009).

Ultimately the best estimate of the probability of an undesirable impact occurring must be compared to the acceptable level of risk as determined by the relevant individual, industry or agency. Only then can a risk management decision be made.

Risk management and cost:benefit of risk analysis

Risk assessment must also be an iterative process as it also takes into account different scenarios of risk management. Each of the transition probabilities discussed above can be affected by changes in human behavior. Containment protocols, for example, can reduce each probability. Thus, risk should be assessed using the best available tools reviewed above under different plausible risk management regimes.

Once a risk assessment is complete, it may also be desirable to apply a cost:benefit analysis in which the costs of reducing risk to a specified level are weighed against the benefits that will be preserved or created as a result of reducing risk. Even if a cost:benefit analysis is not possible for each species, it may be possible to estimate the cost:benefit for applying risk analysis in general. For example, a recent analysis demonstrated that Australia is reaping economy-wide gains by assessing and managing the risks posed by plants proposed for importation (Keller et al. 2007).
Conclusions/Recommendations

If the tools described above are employed in pre-import decision-making, a great deal of damage to the environment, human health, and the economy could be avoided, and indeed net economic benefits could be realized (Keller et al. 2007, Keller et al. 2009). One approach to creating a decision support framework that employs the tools reviewed above is illustrated in Fig. 2. Questions are in a logical order that also reflects an increasing level of data and sophistication of analysis. Thus where data, technical capacity, or resources are limiting, decisions could be made early in the decision support process, relying perhaps on any documented history of invasiveness in similar environments. As data and capacity increase, more steps and rigor could be added to a decision support process, taking more advantage of the best available technology. Such a decision support tool could be used by industry in a voluntary context or by a government agency in a regulatory context.

Figure 2. A hypothetical decision support framework, illustrating one possible ordering for questions about the risk assessment probabilities from Fig. 1. The order of questions partly reflects an increasing demand of data and capacity needs.

Risk assessment frameworks (e.g., Fig. 2) should be peer-reviewed, quantitative when possible, transparent, and repeatable (NRC 2002). Otherwise, little confidence from industries, government, or citizens is warranted. If such risk assessment frameworks are developed and employed, a net gain in the benefits of trade in living organisms is possible because only harmful organisms can be prohibited while allowing continued trade in benign species.

References cited


