To Introduce or not to Introduce: Trade-offs of Non-indigenous Organisms

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The following item is a summary of an international workshop organized by the Institute of Pacific Islands Forestry in Kauai, Hawaii. This paper details workshop findings and outlines research needs in the controversial issue of exotic species introductions. It is reprinted from the journal Trends in Ecology and Evolution 12: 424-425. November, 1997.

Human-mediated introductions of organisms are continuing at a growing pace in many parts of the world. Organisms now occur in communities and ecosystems that they would not naturally have reached. Whenever an organism is introduced outside its native range, benefits of the organism in its new habitat should be weighed against the generally unexpected costs incurred. This assessment is complicated because both the benefits and risks of introductions are unevenly distributed among ecosystems within and across regions, among sectors of society, and over time. The potential for contradictory impacts of introduced species has led to polarity within the scientific, agricultural, and land management communities as to the circumstances under which benefits of introducing non-indigenous organisms outweigh risks.

In an effort to identify the areas of agreement and difference among scientists whose research involves either development of new introductions or the negative impacts of invasive organisms, the Institute of Pacific Islands Forestry (USDA Forest Service) convened an international workshop from June 9-12, 1997 in Kauai, Hawaii, USA. Twenty-one ecologists, foresters, entomologists, conservation land managers, botanic garden curators, and an environmental lawyer attended the workshop. The products anticipated from this effort include:

1) a scientific paper on the research needed to resolve controversies and provide support for policy decisions, and
2) a document written for policy-makers and regulators that concisely describes issues involved in species introductions, policy needs, and areas of policy that can be and cannot be better informed by research.

To introduce or not to introduce

Benefits of introduced non-indigenous organisms are legion. The utility of lead tree (*Leucaena leucocephala*) in re-foresting eroded lands and as a cattle forage has led Colin Hughes (Oxford Forestry Institute) to explore the introduction of 21 additional Leucaena species. Introduced biological control agents have successfully reduced agricultural and rangeland pests, and botanical garden collections are a valuable tool for both education and conservation. Some non-indigenous organisms appear better able than natives to rapidly revegetate degraded areas; Japanese cherry (*Muntingia calabura*), for example, effectively reclaims mined lands on Christmas

Island in the Indian Ocean (Dennis O'Dowd, USDA Forest Service, Hawaii). Nonetheless, costs often appear to parallel these benefits. In many locations including Hawaii, *L. leucocephala* is now a management concern in ungrazed habitats, where it can prevent growth and succession of native species (Lloyd Loope, USDI National Park Service, Hawaii). Svata Louda (University of Nebraska) presented data documenting the demographic impacts of *Rhinocyllus conicus*, a weevil introduced for biological control purposes, on an unintended target, the native Platte thistle (*Cirsium canescens*). One of the worst invaders in Tahiti, miconia (*Miconia calvescens*), was introduced through a botanical garden (Lloyd Loope, USDI National Park Service, Hawaii). Japanese cherry may be poised to dominate native forests on Christmas Island through its accumulated seedbank (O'Dowd).

The values placed on native biodiversity and natural ecosystem system function relative to improvement to human economies and well-being are difficult to weigh. Peter Vitousek (Stanford University) argued that the impact of non-indigenous organisms on native species and ecosystems around the globe is sufficiently extreme to represent a type of global change — perhaps even more significant than global warming. Several examples of individual species causing ecosystem level changes in soil nutrient content, hydrology, geomorphogy, and fire regime were provided by Carla D'Antonio (University of California, Berkeley), Doria Gordon (The Nature Conservancy, Florida), and Curt Daehler (University of Hawaii). Despite these few examples, Ariel Lugo (USDA Forest Service, Puerto Rico) argued that most species introductions have caused little harm, and that the ecological changes we observe today will be resolved through evolution and succession within the new systems. The creation of new ecosystems may be necessary to increase or restore productivity and ecosystem services within degraded landscapes. Despite the presence of a non-indigenous organism at high densities or biomass, the invaded ecosystems may not always have substantially altered ecosystem processes (Jack Ewel, USDA Forest Service, Hawaii). Although melaleuca (*Melaleuca quinquinervia*) is displacing native species in south Florida wetlands, Marcy LaHart (South Florida Water Management District) pointed out that there is no clear evidence of a concomitant loss of ecosystem services. This lack of evidence limits the development of effective mitigation and control policies.

Cost prediction

If we were able to predict which introduced organisms are likely to cause substantial ecological or economic costs, we would have a basis for policy decisions. Scientists still have varying degrees of confidence in our ability to predict ecological or economic costs associated with introductions, as is reflected in the few policies regarding organism introductions. Even within research and educational institutions like botanical gardens there is no consensus regarding introduction policies or escape precautions (Luis Gomez, Estacion Biologica Las Cruces, Costa Rica; David Lorence, National Tropical Botanical Gardens, Hawaii). Research into prediction of invasiveness and impacts has focused on correlations between organism attributes (taxonomic or ecological), attributes of the recipient environment, and negative impacts (Richard Hobbs, CSIRO, Australia; Bill Lee, Landcare Research, New Zealand; David Richardson, University of Cape Town, South Africa). Lee described the New Zealand Biosecurity Act, the first legislated screening procedures for proposed introductions based on recent predictive models. Similar policies have been proposed in Australia and South Africa; no such policies are under development in the United States. However, the strongest predictor of negative impacts of a non-indigenous organism remains whether it has had negative impacts in other areas to which it has been introduced. Thus, a comprehensive, broadly accessible database of invasive species by latitude and habitat could be used as a basis for preventative policy development. Participants agreed that a policy to exclude "repeat offenders" would substantially reduce the risks associated with proposed introductions.

Alternative strategies for reducing risk

In the absence of strong predictive techniques and legisla-

tion involving introduced species in most countries, alternative strategies for minimizing post-introduction costs are needed. For biological control agents, careful research into the dispersal, host preference, and genetic variation of organisms, and the interaction of these factors with the environment can reduce the risks of both introduction failure and unintentional non-target effects. Peter McEvoy (Oregon State University) demonstrated the use of population matrix models to identify weak links in a biocontrol target's life cycle so that an appropriate control agent can be selected. Keith Hopper (USDA ARS, Delaware) suggested that research on the interspersion of different agricultural land uses may increase the effectiveness of control agents or prevent outbreaks of pests with the need for introductions. Research in these areas might result in the need for fewer biocontrol introductions in the future, thereby decreasing risk. Increased research into and use of indigenous crop, forestry, and horticultural species would provide sustenance and revenues while reducing the need to introduce non-indigenous species. Indigenous plants grown in multi-species stands at different successional states show the best promise for diversifying the types and timing of products produced (Roger Leakey, International Center for Research in Agroforestry, Nairobi).

Outlook

Workshop participants proposed that research focus on both real-time and post hoc measurement of ecological, economic, and social benefits and costs that accrue from introduced organisms. Only through simultaneous and long-term analysis of all three aspects of introductions will we better understand the range of effects and trade-offs involved. Well-developed case studies should provide the data for informed policy decisions (Alan Holt, The Nature Conservancy, Hawaii). Genetically modified organisms (GMOs) have recently received attention in both the scientific and policy arenas (Joy Bergelson, University of Chicago), and policy developed to address GMOs could be more broadly developed to cover all types of introduced organisms. Vitousek noted that most countries have long-established protocols for assessing the risks associated with the use of chemical agents in agriculture, yet introduced organisms, which carry similar risks, are not usually subjected to a similar evaluation prior to importation. Without legislation to minimize ecological and economic risk, we will continue to make introductions for prospects of short-term gain at the expense of long-term ecological and economic harm. It is hoped that the products of this workshop will help to precipitate informed policies regulating introductions of non-native organisms both at national and international levels.

References

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