Needs And Opportunities

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This workshop comes at a propitious time. Although extensive study of particular nonindigenous species (NIS) began in the 19th century, there was no synthetic science of invasion biology as recently as twenty years ago. Ten years ago, it was a new, largely arcane branch of ecology driven by the academic curiosity of a few ecologists, and its relevance to agricultural, silvicultural, and other real-world concerns was barely recognized. Ecologists did not talk much to weed scientists, Extension entomologists, and similar people dealing with problems on the ground, much less to the managers fighting invasions in the trenches. And people battling invasions like those of rangeland weeds and Russian wheat aphid did not see themselves as allies, in a larger battle, with those struggling against the zebra mussel or the rainbow trout. By five years ago, that was changing fast. Increasing publicity about introduced species problems, with tremendous costs as well as conservation and sometimes human health consequences, plus a natural evolution in the scientific and managerial communities, crystallized a growing science of invasions and began to bring together researchers and managers—this workshop is one result.

The opportunities to ratchet up the battle against invasive NIS are great. People everywhere are recognizing the problem as huge. In the United States alone, the costs are almost certainly in the tens of billions of dollars annually and may exceed $120 billion. Worldwide the costs must be staggering.

Furthermore, there is growing agreement among conservationists that NIS are the second leading cause of extinction and endangerment of species, following only habitat conversion. Often the distinction is fuzzy, because many NIS cause or even constitute habitat conversion, as when zebra mussels carpet an entire soft-bottom surface, or when melaleuca forests replace half a million acres of sawgrass and muhly prairies.

The Executive Order on Invasive Species highlights the problem and raises even further the consciousness of policy makers and the public to invasive NIS. International activity is also growing, signaled by the Convention on Biological Diversity in 1994. The initiation of the Global Invasive Species Programme, the formation of an Invasive Species Specialist Group by the IUCN, and the United Nations workshop in Trondheim, Norway, all reflect this increased concern.

The key factor that separates this issue from other environmental issues, and augurs well for real progress, is that commerce, agriculture, forestry, and conservation and environmental stakeholders are all on the same side. It is not a situation in which an industry wants to increase production and environmentalists want to stop them. Sometimes the same species are causing both production and environmental problems: the leafy spurge, balsam woolly adelgid, and zebra mussel. Usually in the NIS struggle, all sides lose together, they all want pretty much the same thing, and they are beginning to understand that cooperation and coordination can help everybody. One key focus of the Executive Order will be to improve cooperation among agencies, but this is already happening.

So how can this tremendous eagerness to solve the NIS problem help us with databases? Everyone recognizes that data are crucial to understanding the problem and that we cannot begin to solve it until we understand it. So everyone agrees we need databases; that is why there are so many of them. It is also obvious from this workshop and that convened by FICMNEW that there are more databases out there than anyone had realized. What more must be done? Needs are both short term and long term.

Short-Term Needs

Because the whole reason for the interest in invasive NIS is the problems they cause now, short-term needs must take precedence. We have to be able to provide the data that are needed, right now, to help managers in the field. A general urgent short-term need is to have sufficiently comprehensive and accessible data

that it is possible to tell quickly whether a report represents a totally new threat, a range extension of a threat that already exists, or simply just another record of something already known. We need to begin immediately to link and/or integrate some databases and to begin to move toward one-stop shopping.

State and Local Needs. Many people who have to deal on the ground with NIS, in both decision-making and managerial capacities, are not in federal agencies or international programs. In the U.S., many are in state and local agencies. For workers in federal agencies or universities, it is a trivial matter to use databases on the Web; we do this sort of thing all the time, or we have students or colleagues who can help. But many people in state and local agencies are ill-equipped to deal with anything but the most user-friendly database. Often they have marginal hardware and lack facility in dealing with something even as simple as an Access file without a lot of help. Many people dealing with NIS in third-world countries are in even worse shape and are also forced to work in a foreign language.

Even to those of us with a lot of experience with databases on the Web, especially now that we know the great number of NIS databases, it is forbidding to have to call up one after the other to see what is available. This is why we have all gravitated towards the idea of one-stop shopping. If we feel this way, imagine how important it is to someone in a state department of parks or a developing nation's resource ministry. The exact nature of the linkages that achieve one-stop shopping is not too important in the short term, so long as the resulting product is very user-friendly. The important point is that this is an immediate need, and we have to settle on a system and make sure that all relevant databases are linked to it.

Risk Assessment. Another set of short-term needs not too well addressed by many of the existing databases relates to the fact that any user has to prioritize activities. No one has enough money or time to attempt to deal with all NIS; there is a danger of management grinding to a halt if we attempt to exclude, eradicate, and control every alien species. So we have to have some way to rank them in terms of likely impact. Therefore, we need to be able to do some version of a risk assessment on each, even if it is a very cursory one, in order to know where to put our energies. And since a lot of the real use of these databases will be quite local, the assessment has to be based on information related to risks in a local setting. Since NIS often pose very different risks in different settings, this poses a burden on databases, but this variation in risk has to be taken into account or we can waste a lot of effort.

Some existing databases are directly associated with a risk assessment; e.g., the Exotic Forest Pest Information System. A number of existing risk assessment tools are very similar but lack their own database: for example, the National Park Service has a ranking system applicable to both plants and animals at both site and regional levels, and so does the Australian Weed Risk Assessment program. Also, the Aquatic Nuisance Species Task Force and USDA's Animal and Plant Health Inspection Service have developed risk assessment protocols.

To use risk assessments or other sorts of predictive tools, there has to be a fair amount of ecological and other biological information, and many of the databases do not capture this information. We need information on:

- Entry pathway and modes of dispersal.
- Likely types of impacts, at several levels. Some species affect entire ecosystems, directly or indirectly—feral pigs, European boar, and their hybrids, for example. There are effects at the community level, for example on community structure. There are a whole battery of impacts on particular species, like predation, competition, parasitism, disease, herbivory. Hybridization is also a frequent impact. And there are economic and other impacts associated with these ecological impacts.
- Biology: life history, breeding system, natural history.

Some fraction of this information is needed for even a cursory risk assessment. It will be obvious that, for many NIS, much of this information is unavailable, so some databases will be sparsely populated, a point I will return to. But some of it is available, and it is important information.

Prioritization and Decision Making. For prioritization purposes for both managers and decision makers,

a risk assessment is necessary but not sufficient. We have to make a decision based on the results of the risk assessment and information on the costs and likelihood of success of potential management procedures. No matter what the risk is, if there is zero chance that anything we do will help to control the invader, it does not pay to try. Some people say that the jellyfish-like marine animal, *Mnemiopsis leidyi* in the Black Sea and Azov Sea falls in that category. It is also possible that some procedure will probably exert economically or ecologically significant control of the invader, but the cost will be so great that there will be no resources left to fight other invaders. Or there might be a high probability of a major impact on nontarget species—as with many chemicals, for example.

So for a database to be maximally useful in decision making, it has to have available information on effectiveness, costs, and risks of various possible management procedures.

Internationalization. Another short-term need is the internationalization of whatever system we settle on to achieve one-stop shopping. The problems are international, so there is every reason to think that the different countries can learn from one another's experiences. Many of the species that rank as major pests in the Hawaiian islands, for example, crop up repeatedly in lists of the worst pests of small island nations. And the growing volume of travel and trade can only enhance this overlap. We in the U.S. would be missing a bet by not associating our distributed database system with databases of other nations. Some are very advanced technologically. Further, we are not being good global citizens if we do not try to disseminate whatever we know that might help others dealing with similar problems.

Long-Term Needs

Consolidation. As some version of a one-stop system becomes operational, there will be consolidation and evolution of the component databases over a long period. Different entities evolved different kinds of databases partly because they had different missions and needs, and these differences will remain. Furthermore, different entities will be better equipped to do the verification and housekeeping procedures required to keep parts of the database system current and accurate. Nevertheless, it is also true that there is much overlap among some of the databases, both in the kinds of data they intend to capture and the way data are organized. Furthermore, managing a database is an onerous proposition requiring resources. So attractive economies of scale will lead some people to forswear the natural proprietary sense that we all have when we have developed something that works and to consider allowing the job to devolve to someone else.

Regardless of how the system of databases is linked in a one-stop system to begin with, the components will evolve to be more similar at least in form and probably also in content. That is because different databases will be seen to have different advantages; there is more than one way to build a mousetrap, and if someone does part of it better, it will be natural to try to adopt that way of doing that part. Each of us has frustrating stories of trying to use the so-called ultimate database. Obviously these will improve as the people using them also use other databases that are much more user-friendly and want to emulate them. It will then be a still smaller leap simply to merge one or more databases.

Probably there will also be some movement towards consolidation within the system by an evolution towards similar standards for data entry and verification. Another factor leading towards consolidation is the expense and inevitability of upgrades in both software and hardware. Mature databases, like the Natural Heritage Network, have already gone through several generations, and it is expensive yet absolutely necessary to evolve as the technology evolves.

Another long-term need that would begin to be met by partial consolidation of the component databases is the ability to look at many different taxa simultaneously. We must do this for several reasons. One is again prioritization; we have to prioritize across taxa if we are going to use our resources optimally. If insects, weeds, vertebrates, and pathogens all attack some crop or reserve, we cannot focus only on one taxon when deciding what to do.

Synergy. There is another fundamental reason to look at data on many types of organisms at once. Some species facilitate actions of other species, and some groups of species act synergistically to make a greater problem than the sum of the individual

effects. An exotic pathogen can be innocuous or a scourge depending on whether or not an exotic vector is also present. Fig trees were harmless ornamentals for many decades in south Florida until their obligatory pollinator fig wasps were introduced, and then they suddenly became highly invasive. The ornamental shrub, *Lantana camara,* in Hawaii spread much faster once the myna bird was introduced. There are many other ways in which NIS become more problematic when they are together than when they are alone. So a risk assessment for many species is going to have to take account of which other species are present. This kind of data will surely be more easily captured in a consolidated database.

Data Gaps. Another long-term need is that some taxa, even important ones, are not yet well covered. NIS mammals, bacterial pathogens of plants, spiders —the data are not comprehensive or assembled. So there is much basic work to make any database system taxonomically comprehensive, and this will take time.

Systematics. This last need relates to two issues that are long-term projects, but they will have to be solved or the whole enterprise will ultimately be in trouble. First is that at the very time when we need systematists to generate the data in the database system, there is a sharp trend to reduce the training needed to produce systematists. This is also true, to a lesser extent, for the field ecologists needed to populate the database system with all the information that would be needed for a risk assessment and to help develop the various management procedures that should also be present for use in making decisions.

To the extent that systematists and ecologists can hitch their stars to conservation biology and molecular biology, there is an opportunity to help to redress this trend in academia, but certain kinds of ecology and systematics are old-fashioned, yet critical to dealing with NIS, including producing useful databases. Perhaps we should turn the problem around and ask if the burgeoning interest in introduced species can boost the fields of systematics and ecology. After all, we need to increase the knowledge base in both systematics and ecology, and in basic research in general, in order to confront the problem of NIS in every way, not just the production of sufficient databases. Even as we deal with the immediate need to get a usable system on-line quickly, we must recognize that we need to develop more scientific knowledge to deal with this problem effectively. This is probably our biggest challenge—getting a public that wants short-term results on pressing problems to see that long-term progress has no quick fix and requires basic research.

The Challenge

We *can* meet these needs! But it is up to us to capitalize on unparalleled opportunities that now face us. The climate for new and expanded initiatives to deal with NIS is propitious, as is noted above. We all sense this, and the problem is increasingly recognized every day. Obviously the data needs are great, but they are not mysterious or technically impossible. If we agree among ourselves that these *are* the needs we must satisfy to make major headway in the battle against NIS, if we can avoid battling among ourselves over turf and funds, and if the public increasingly recognizes the scope and expense of the problem, we ought to be able to present the case in a unified, understandable way to convince them to give us the wherewithal to do the job.