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Toward a comprehensive information system to assist invasive species management in Hawaii and Pacific Islands

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The need for coordinated regional and global electronic databases to assist prevention, early detection, rapid response, and control of biological invasions is well accepted. The Pacific Basin Information Node (PBIN), a node of the National Biological Information Infrastructure, has been increasingly engaged in the invasive species enterprise since its establishment in 2001. Since this time, PBIN has sought to support frontline efforts at combating invasions, through working with stakeholders in conservation, agriculture, forestry, health, and commerce to support joint information needs. Although initial emphasis has been on Hawaii, cooperative work with other Pacific islands and countries of the Pacific Rim is already underway and planned.

Key words: *Miconia calvescens*, biological surveys, data integration, information services, decision support systems.

The Severity of the Problem for Oceanic Islands

Oceanic island ecosystems in general, and the Hawaiian Islands in particular, are highly susceptible to damages caused by biological invasions. Because of their evolution in relative isolation and in the absence of many forces shaping continental organisms, ecosystems of the Hawaiian Islands are particularly vulnerable to invasion by alien species from continents (D'Antonio and Dudley 1995; Denslow 2003). The islands provide abundant textbook examples of evolution in isolation (Williamson 1981), but more endemic species have been eliminated in Hawaii than anywhere else in the United States and most places in the world (Loope 1998). Although habitat destruction has been an important cause of extinction and endangerment, the introduction of invasive alien species has contributed in a major way in the past and is now the predominant cause of biodiversity loss in Hawaii (Loope et al. 2001). Hawaii's role as a key transportation hub for the Pacific exacerbates the problem. Hawaii's agriculture, economy, health, and quality of life also suffer severely from biological invasions (Holt 1996). Hawaii's problem is by far the most severe of any state. Federally, significant resources are at stake here, with prime national park natural areas and more than one-fourth of endangered species in the United States. The federal Fish and Wildlife Service and National Park Service have major responsibilities and challenges, as do state and local governments. Partly because of the severity of the situation and partly because of the great value of what still remains, Hawaii provides a superb laboratory for addressing problems caused by harmful invasive species. The pervasiveness of this issue for society in Hawaii provides hope that it may be possible to marshal adequate resources and innovative approaches. These islands are little fortresses, surrounded by large expanses of ocean, isolated from each other, from other island groups, and continental land masses. Given rational interagency management based on good science and with the help of informed citizens, it may be possible to effectively address the issue. The issue of harmful invasive species is equally crucial and addressable for other Pacific islands.

The Quest for Solutions

The Pacific Basin Information Node (PBIN) is a regional node of the United States National Biological Information Infrastructure (NBII) (www.nbii.gov). The NBII is evolving as a world wide web–based series of specialized information systems called nodes. This distributed approach allows each node to specialize on a specific topic (e.g., fisheries) or location (e.g., Hawaii and the Pacific) within a national data infrastructure. Each node contributes toward an integrated national whole while providing deeper information content and better targeted applications than possible at a national or global scale. The basic premise for NBII (and hence PBIN) was first articulated in a report prepared by the National Academy of Sciences (NRC 1993). The National Research Council (NRC) report recognized the vast amount of information that was collected across the nation and that the majority of the information does not come from within the federal government; this information was not readily available to potential users. The authors encouraged the U.S. Department of Interior to take the lead in "establishing a national partnership to provide new information and more powerful tools for managing, using, and preserving biological resources." A subsequent report of the President's Committee of Advisors on Science and Technology (PCAST 1998) suggested further definition for the partnership when it encouraged that a "next generation NBII" be established as a series of interconnected nodes that seek a dramatic increase in content as well as in analytic and synthetic capabilities.

Using the recommendations from these reports, PBIN was established as a regional partnership including resource managers, scientists, and other organizations that contribute to biodiversity science or management in the state. PBIN partners include federal (United States Geological Survey, National Park Service, United States Fish and Wildlife Service, United States Department of Agriculture), state (De-

partment of Land and Natural Resources and Hawaii Department of Agriculture), educational (Bishop Museum and University of Hawaii), and nongovernment organizations such as island invasive species committees and The Nature Conservancy. The initial focus has been to become a part of the invasive species enterprise in Hawaii and build basic integrated capabilities to address questions related to species identification and locations—some of the key data needed to combat invasive species.

Hawaii is unfortunate in having the intensity of invasive species problems and the devastation that they have caused, but fortunate in having a track record of strong grassroots partnership efforts at addressing current and future invasions (Holt 1996; Loope and Reeser 2002). These partnership efforts typically involve federal, state, county, and private entities. One such effort, the Hawaiian Ecosystems at Risk (HEAR) project, provided a head start for PBIN in its role of addressing invasive species problems. In early 1994, when the Department of Interior was exploring possible ecosystem initiatives to prevent biodiversity train wrecks, a group of scientists and managers in Hawaii identified the primacy of the need for a clearinghouse for information on invasive species to serve information needs of land managers, partnerships, and the public. This initiative got underway in 1996, with the USGS Pacific Island Ecosystems Research Center and the University of Hawaii as its coordinators. It came to be known as the HEAR project, and became best known for its website, www.hear.org. A recent review of this project by Van Driesche (2002) praised its grassroots, human-centered, enterprise-wide approach: "The purpose of an information sharing network is to support and enhance the conservation community as it exists—not to replace it with some ideal of how it ought to be." HEAR (which is now part of the NBII network) provided the beginnings of the system articulated by NRC and PCAST. It is available through the PBIN and NBII. Others have also been working to develop information to support biodiversity science and management.

In 1992, the state of Hawaii established the Hawaiian Biological Survey (Allison and Miller 2000) based at Bishop Museum in Honolulu, becoming the second (next to Illinois) state with a biological survey. The six-step process included in the survey, results in a georeferenced knowledge base of organisms that is continually updated (Allison 2003). The survey provides several elements useful for combating invasive species in Hawaii: (1) a comprehensive checklist of species for the state, (2) a list of authoritative names to ensure consistent taxonomic usage, (3) the ability to determine whether or not a particular species is known to exist in Hawaii and to document its occurrence, and (4) the basis for quick screening of biological control agents by agricultural authorities.

A third key effort was the establishment of the Hawaii Natural Heritage Program by The Nature Conservancy of Hawaii in 1985. Although its original focus was on rare species, over the years the program has developed a wide range of biodiversity-related spatial data as well as key capabilities in geographical information systems and modeling.

Early Progress and Directions

Because of the early efforts noted above, PBIN has been able to focus on integrating and advancing the various data and services offered or planned by many of the partners and is rapidly approaching an information system that is a key weapon in the arsenal for combating invasive species. During this calendar year, users will be able to access data collected by many of the partners, link to taxonomic services for species identification, and use web-based geographical information systems tools to analyze or map spatial data. The next step is to use these capabilities to develop specific applications for prevention, early detection, eradication, and long-term control of invasive alien species.

There are two prototype projects under development that illustrate the types of applications that can be developed. One is a system to support Hawaii state decisions regarding the importation of birds. This web-based system will provide information to the public on the birds that are approved for importation, allow individuals to apply for permits for birds not addressed, and support the state review of importation requests. When complete, the database will contain information regarding potential invasiveness of parrots and finches based on their impacts in other locales, data on life history characteristics, and maps of potential spread of a particular species should it escape into the wild. If successful, this system may be expanded to include other species as well. The second project is being developed in cooperation with the Brown Tree Snake control efforts. The web-based spatial data system will contain information on location of snake sightings and data collected during an interview process. It will display the data spatially and temporally and offer data analysis capabilities. Ultimately, we hope to automate the data collection process.

The effort to take the invasive species enterprise to a much higher level involves expanding partnerships, both institutionally and geographically. Our hope is that PBIN will play an important role in information gathering and sharing for vastly improved collaboration among biodiversity conservation, agricultural, and public health interests. The system that has evolved to prevent uninhibited dissemination of pests throughout the world has been developed primarily by agriculture (and to a lesser extent public health) interests (Kreith and Golino 2003), and that is the system we must build on. Prevention of spread of organisms to protect biodiversity is an afterthought, albeit a very important afterthought (Campbell 2001). Clearly, all sectors can benefit from collaboration. We believe that such collaboration will be a powerful force in combating invasive species. The three sectors comprise far more potent a force collectively than each acting individually.

To carry this model a step further, PBIN has begun developing partnerships within the international community, including the South Pacific Regional Environment Programme, the Secretariat for the Pacific Community, Global Biodiversity Information Facility, the Global Taxonomy Initiative, and the Invasive Species Specialist Group of the World Conservation Union. The cultural and economic interdependence in the region requires that we collaborate with all Pacific Island and Pacific Rim nations because the constant movement of people and goods is a primary vehicle for the spread of alien species throughout the region. Our best example for how to implement this model internationally involves a plan to prevent the Red Imported Fire Ant and other invasive ants from reaching Pacific island counties and territories (Vanderwoude 2003).

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Spread of the invasive tree *Miconia calvescens*, the brown tree snake, the red imported fire ant, the West Nile virus, and many other invasive species would be devastating to the Pacific Islands. If we collectively manage to avoid becoming much worse off than we are now with pest invasions in Hawaii and the Pacific, it will be because of creative methods of developing pest risk assessments (Daehler and Denslow 2004; Pheloung et al. 1999); heroic efforts at public education; and unprecedented institutional collaboration in physically stopping the establishment and spread of pests through prevention, early detection, rapid response, and control. Experience from New Zealand—the island nation with the most demonstrated commitment to date—can help lead the way (Loope 2004). Cooperation, a strong legal foundation, and up to date information are mandatory if we are to succeed. Information systems developed through collaboration and in a highly integrated fashion can play a key role in supporting these efforts.

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