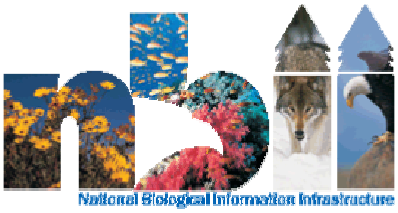
Experts Meeting On Implementation of a Global Invasive Species Information Network

Proceedings of a Workshop

Baltimore, Maryland, USA
6-8 April, 2004



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Edited by

Elizabeth Sellers
Annie Simpson
Jeffrey P. Fisher
Shelaine Curd-Hetrick

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To request paper copies of this document please write to or email:

Annie Simpson (asimpson**AT**usgs.gov) or Elizabeth Sellers (esellers**AT**usgs.gov)
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National Biological Information Infrastructure,
National Program Office – USGS, MS302, 12201 Sunrise Valley Drive – Reston, VA 20192, USA.

Foreword

The Convention on Biological Diversity (CBD) defines invasive alien species (IAS) as those non-native species that threaten ecosystems, habitats or other species[1]. Other groups have defined IAS more broadly, considering an invasive species as a species that is, "non-native (alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health"[2]. Under the broader definition, a global estimate of environmental and socioeconomic damage from IAS (based on an extrapolation from estimates in six major geopolitical units) amounts to 5% of the global economy, or $US1.4 trillion annually.[3] Because of their global significance, IAS are being discussed in nearly every international trade and environmental policy arena in order to develop cooperative solutions to the economic and environmental problems they cause. Sustainable biodiversity, global warming, threatened and endangered species preservation, watershed management, living modified organisms, global plant, animal, and human health—the role of invasive species must be addressed in all of these discussions.

Non-native species were historically transported into new habitats by natural disturbance events such as hurricanes. While disturbed environments remain a fundamental feature that determine whether a non-native species can become established in a new place, the contemporary pathways for the initial introduction of IAS are predominantly unnatural. Today, dominant pathways for the introduction of IAS include the exchange of ships' ballast water, the "hitchhiking" of non-native organisms in cargo or as pathogens, and the intentional release of foreign plants and animals for agriculture and aquaculture. Preventing the transboundary transport and introduction of non-native organisms via such trade vectors has become the responsibility of all States, yet the capacity to manage domestic and transboundary IAS problems varies substantially among States.

One of the limitations facing many geopolitical units addressing IAS problems is the easy access to information on IAS prevention and management relevant to their region. Dozens of databases exist that address aspects of IAS taxonomy and management, but often the information contained within them lacks regional relevance, or is represented in such a fashion that users cannot find the information they need readily in their web searches. Most such databases serve limited audiences and are not interoperable or coordinated with other related information systems. Traditional print-based approaches to sharing information on IAS are even less efficient, more costly, reach only a limited audience, and are not amenable to updating without significant cost. A coordinated approach to linking existing IAS databases around the globe has been suggested as an essential means to confront the growing global problems IAS create[4].

The Global Invasive Species Information Network (GISIN) will address the need recognized by many resource managers, researchers, trade specialists and the broader public for a central portal system that will link *all* existing IAS databases, while retaining the independence of the

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[1] Convention on Biological Diversity, (Article 8(h)). 2003. Secretariat of the Convention on Biological Diversity.
[2] USA Executive Order 13112, as cited in: National Invasive Species Council. 2001. Meeting the Invasive Species Challenge. Available online at http://www.invasivespecies.gov/council/nmp.shtml (Accessed 26 August 2004.)
[3] Pimentel, D., editor. 2002. Biological invasions: economic and environmental costs of alien plant, animal, and microbe species. Boca Raton/London/New York/Washington DC; CRC Press, 369 pp.
[4] Ricciardi, A., W. M. Steiner, R. N. Mack, and D. Simberloff. 2000. Toward a global information system for invasive species. BioScience 50:239-240. Available online at http://sgnis.org/publicat/papers/riccstei.pdf (Accessed 26 August 2004.)

databases that are linked. What is the ultimate goal for the GISIN? Ideally, a one-stop shopping center for IAS information exchange around the globe, speeding the delivery of information on IAS identification, prevention and management into the hands and minds of those who need it faster than IAS are able to establish. What the GISIN is not, is a new model intended as a repository for data. Data repositories already exist and should continue to be populated with new data. In those regions where they do not exist, efforts should continue to build them for ultimate linkage to the GISIN.

The proceedings of this workshop summarize the initial efforts of a broad group of database architects and IAS experts at defining the organizational structure and essential “first steps” for making the GISIN a reality. Papers presented summarized a variety of databases that already exist, how they are populated with new data, and how they could be ultimately linked to the GISIN. Working groups met for two subsequent days with the purpose of clarifying how the GISIN could work, and the best technical means for it to function. More work will be required to ensure that the GISIN is activated soon, and an Interim Steering Committee appointed at this meeting has taken on the selfless task of helping to ensure that the fundamental tasks identified in the workshop for establishing the GISIN will be accomplished in the next two years. The Global Invasive Species Programme, the Secretariat of the Convention on Biological Diversity, and the Global Biodiversity Information Facility have all offered their support in this effort as well. The path ahead is challenging, but the risks of inaction are great. The rewards of such an effort are perhaps the hardest to measure in that they will reflect IAS problems that were thwarted as a result of improved information exchange. It is these rewards that the GISIN hopes to facilitate in the years to come.

Jeffrey P. Fisher, United States Department of State

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(Curd-Hetrick)

Executive Summary

The Global Invasive Species Information Network (GISIN) is the realization of discussions and workshops that have taken place since 2001 to formalize efforts to share invasive alien species (IAS) information in a readily accessible form throughout the globe. These proceedings summarize the outcome of the first meeting to create the structure for the GISIN, convened by the United States Geological Survey-coordinated National Biological Information Infrastructure (NBII).

The purpose of the meeting was to determine how to accomplish the interconnection of existing IAS databases and develop a user-friendly information network that will facilitate decision-making for addressing IAS problems.

The concept for the GISIN arose from a series of seven regional workshops held around the globe, and funded primarily by the United States Department of State, with additional support from the United States Agency for International Development (USAID), the World Conservation Union (IUCN), and the Global Invasive Species Programme (GISP). The sponsors and the conveners of these workshops—GISP, IUCN and CAB-International, recognized a common problem inherent in each of the regions: there was no central location or "portal" to which managers and scientists could turn to efficiently retrieve relevant information on IAS taxonomy, prevention and management, nor a site where they could post their regional information to help increase invasive species awareness and capacity building regionally and around the globe.

A survey conducted in an electronic discussion prior to the meeting analyzed 47 databases to assess what elements are needed for a functional and useful GISIN. The questions were also designed to determine the information needs of the GISIN community in order to refine the Expected Outcomes listed below.

- Creation of an online working group community that will develop a global invasive species information network
- Agreement on common data types for the creation of cross searches for invasive species information at a global level
- Creation and distribution of a proposal funding toolkit, with templates, sample proposals, and detailed lists of possible funding sources for this information network
- Generation and maintenance of a complete annotated link list of online invasive species databases
- Development of a report of the workshop's proceedings and the results of a survey of participants concerning their region's current status of invasive species information

Ultimately, 76 experts from 26 countries[1] participated in this first GISIN meeting. Managers of IAS information, database developers, project managers, and decision makers exchanged ideas about specific infrastructure, content, and standards to achieve IAS database interoperability. Presentations on the Nonindigenous Species Database (NISbase), the IABIN Invasives Information Network (I3N), the Global Biodiversity Information Facility (GBIF), Conabio, Discover Life, and the concept of Web Services, described models

[1] Argentina, Australia, Bangladesh, Brazil, Canada, China, Colombia, Denmark, Finland, Germany, India, Jamaica, Lithuania, Malaysia, Mexico, Morocco, New Zealand, Peru, Philippines, Poland, South Africa, Sri Lanka, Taiwan, United Kingdom, Unites States, Venezuela

for distributed approaches to database integration for consideration by the conference delegates. In such distributed systems, data providers share portions of their information via a central portal through which users query providers' metadata. Other information systems, following a centralized data model, were also discussed for relevancy to the GISIN, including the European Research Network on Aquatic Invasive Species (ERNAIS), NatureServe, the Chinese Species Information System (CSIS), FISHbase, and the Global Invasive Species Database (GISD).

Through discussions in working group sessions interspersed between the presentations, participants agreed that successful development and implementation of the GISIN will depend on concurrent actions on four fronts:

1. From the top down, through development of widely-accepted standards for content and infrastructure;
2. from the bottom up, through the development of GISIN hubs with either a regional or a taxonomic focus, that each obtain funding to advance the Network's development;
3. through the development of centralized information systems that are integrated into the larger system, such as the GISD, which consolidates invasive species information in the form of species profiles and information on management and global distribution; and
4. by expanding existing distributed database information systems (NISbase, I3N, and others) to include more members and more types of shared information.

In addition to the 15 formal and informal presentations and six electronic posters or e-posters[2] presented in Baltimore, attendees divided into breakout groups to discuss and reach a consensus on database infrastructure, content, capacity building, and the GISIN organizational framework. A fifth impromptu breakout group met to discuss the specifics of joining the NISbase consortium and the general status of aquatic invasive species information sharing.

Principal outcomes from each of the five working group sessions are summarized below.

Database Infrastructure Working Group-- It was recognized that the GISIN should respect existing database diversity and individuality and allow multiple portals to be developed as information needs are identified by the users. With this understanding, a three part system was suggested for the overall GISIN architecture: a portal (or portals) for user access with a metadata catalog; a registry containing a database's technical information; and the member databases with full data content. An architectural design document was discussed, to provide a roadmap for creating the system, market the GISIN concept, and generate cost estimates (Appendix I).

Possible GISIN products identified by this working group included:

- Guidelines for future database development;
- Provision of expertise and support for database and portal development
- A schema or schemas and standard for acknowledging data authorship.

Database Content Working Group-- Minimum data fields that databases would need in order to be searchable were discussed by this working group. Consensus was reached that the GISIN should form a platform to share freely available IAS information and that the absolute minimum fields required of

2 CABI compendia, GloBallast, Sri Lanka IAS, Bangladesh IAS, I3N, and NOBANIS.

contributing databases are genus, species, and publisher (source/ authority) information. Additionally, family name was highly recommended, to avoid ambiguity in cases where multiple species share the same scientific name. Six general database types were defined, based on the information that GISIN data providers might serve (providers may serve more than one type):

1. fact sheet or species profile,
2. experts/expertise,
3. observation-based,
4. specimen-based,
5. bibliographic, and
6. projects/research.

Eight possible data fields were suggested for cross-referencing IAS database searches: name, life form or higher taxonomic unit (e.g. tree, mammal, bird etc.), habitat, pathway, origin, and date for that location. Highest priorities were assigned for searches by name and place. However, it was agreed the GISIN should not require data providers to follow any one particular standard, and thereby be as inclusive as possible.

Capacity Building Working Group--Three primary issues were identified as the highest priorities for capacity building among a list of 17 considered:

1. Development of a simple interactive IAS database with common minimum standard fields, formats, and terms.
2. Development and marketing of an information start-up package and model database for new IAS database developers.
3. Development of methods/actions for addressing what is commonly known as the digital divide – the gap that exists between those with and without access to digital technology.

In addition, in order to encourage participation, it was suggested that the GISIN–

- Create an IAS database development manual. (In such a manual, database developers would likely be encouraged to store data in small incremental data fields rather than in one general data field—a much more complicated approach).
- Distribute value-added products that support individuals and organizations addressing IAS issues.
- Create tools such as IAS identification guides and mapping applications.
- Identify and/or endorse existing tools, and support their distribution and access through the network.
- House a virtual library to facilitate access to IAS literature.

GISIN marketing strategies discussed included developing and distributing press releases, surveys, and other promotional and informational material through listservs and embassies.

Aquatic Systems Working Group--
Participants in this working group recognized the value of the existing experiences and achievements in IAS database development, such as the Non-Indigenous Species Database (NISbase) an Extensible Markup Language (XML)-based distributed database system with an Internet portal interface that allows five databases on aquatic non-indigenous to be searched simultaneously. The NISbase system has succeeded by working with each individual database to make it compatible with the larger system, and is an example of a distributed system with data exchange between datasets that define a species as invasive and datasets that do not (referring only to non-native status). The GISIN will facilitate the further development of NISbase and other databases, as practicable and appropriate.

Organizational Framework Working Group--In developing the structure for the GISIN, this working group agreed that all effort should be made to cooperate with existing partner organizations (GISP, GBIF, ISSG, etc.), to form new links with organizations such as the International Plant Protection Convention (IPPC) and the International Maritime Organization (IMO), and to avoid duplication of effort and products. A draft GISIN organizational framework document provided a basis for discussion and tentative agreement on the next steps to be taken to implement the GISIN concept (Appendix K). The group highlighted the need for GISIN to develop partnerships as a key step in the development process, rather than developing a new and separate organization.

Interim Steering Committed Appointed at Close of Meeting

At the recommendation of the Organizational Framework Working Group, participants appointed an interim Steering Committee (iSC)[3] representing a broad spectrum of expertise, and geographic and organizational experience to further develop a program of work for the GISIN over the next two years.

Tasks to be undertaken by the iSC over the next two years will include:

- identifying appropriate affiliations and partnerships for the GISIN (e.g., GISP, ISSG, IPPC, etc.);
- reviewing the structure and governance of the GISIN, and its relationship to related database projects and communities;
- determining the advantages and disadvantages of designing the GISIN to meet the needs of various potential audiences; and
- developing a business plan and initiating fund raising activities to support it.

Since April, a final “Baltimore Declaration” has been distributed and adopted by conference participants, summarizing the intent and mission of the GISIN and the commitment to its realization. An article on the GISIN in the journal BioScience has also been published,[4] and presentations about the GISIN have been made at several international venues by iSC members and other sponsors of the initiative.

[3] http://invasivespecies.nbii.gov/as/interimSC.htm

[4] Simpson, A. 2004. The Global Invasive Species Information Network: what's in it for you? *BioScience* 54(7): 613-614.

The Baltimore Declaration

Technical Workshop on the Implementation of a
Global Invasive Species Information Network (GISIN)
Baltimore, Maryland, USA
6-8 April 2004

We the participants in the aforementioned scientific workshop recognize that:

Invasive alien species (IAS) represent one of the foremost challenges to the integrity of agriculture, natural ecosystems, and biodiversity in the new millennium. IAS cost human societies hundreds of billions of USA dollars per year in control costs and losses to agricultural production, human health, and ecosystem services, far exceeding the combined cost of natural disasters such as floods, wildfires, oil spills, and earthquakes.[1] The threat is global. The increasing movement of people and biological products in global travel and trade render every landscape on earth vulnerable to new infestations.

Freely available information on sources, identities, pathways, and successes and failures of past control efforts provide our best protection against the onslaught of new invaders. This requires building an easily accessible global network for sharing and exchanging data, information, and knowledge (i.e., digital content) about invasive species and their management, among hundreds of governments and research institutions and including thousands of data, information, and knowledge providers and users. Such a network will have to be built on commonly shared ideas and concepts, and will have to provide a platform for the exchange of different viewpoints.

The objectives of the Experts Meeting were as follows:

- Creation of an online working group community that will develop a global invasive species information network,
- Agreement on common data types for the creation of cross searches for invasive species information at a global level,
- Creation and distribution of a proposal funding toolkit, with templates, sample proposals, and detailed lists of possible funding sources for this information network,
- Generation and maintenance of an extensive annotated link list of online invasive species databases,
- Reporting new developments on IAS research and information management throughout the world, and
- Development of a report of the workshop's proceedings and the results of a survey of participants concerning their region's current status of invasive species information

[1] UNEP. December 2003. Press release. *Weather Related natural Disasters in 2003 Cost the World Billions.* Accessed online (30 May 2004)
http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=362&ArticleID=4320&1=en

The Mission of the Global Invasive Species Information Network:

- To provide a platform for sharing invasive species information at a global level, via the Internet and other digital means.
- To offer a central place for the reporting and tracking of new alien species sightings via email listserv.
- To develop and share electronic information management tools to better identify, map, and predict the spread of invasive species at regional and global levels.
- To build the capacity of network members in the development and use of information tools to integrate IAS databases.

Therefore we conclude:

A successful global network for sharing and exchanging technical and scientific IAS information (including information on native species that are invasive elsewhere) among hundreds of diverse participants using several languages will need to be widely distributed and ultimately highly scalable. It will also need to be integrated with existing IAS programs, including those within the framework of the Convention on Biological Diversity (CBD), the International Plant Protection Convention (IPPC), and other relevant international structures.

GISIN "guiding principles" will include the following:

- Require a simple minimum of equipment, software, and computational expertise for participation, so as to include people and institutions with all levels of technical resources.
- Make critical information needed to recognize and manage IAS freely available to the public and discoverable through widely used search technologies, so that IAS information users (such as land and aquatic area managers, farmers, and schools) will find the information they need.
- Adopt widely used technical standards, including World Wide Web technologies, especially XML (Extensible Mark-up Language), RDF (Resource Description Framework), Semantic Web, Web services, and others as feasible and appropriate.
- Agree on and share common vocabularies to describe comparable objects or concepts in different information sources, and in different languages. Work toward consensus on these mutually-useful vocabularies for properties such as taxonomy, geolocation, and recommended practices, in order to develop interoperable information systems.
- Promote these incentives for sharing data:
    - professional recognition for developers of databases,
    - increased linkages to local Websites to increase their availability and use,
    - metadata strategies that help assure that providers of data are properly credited, and
    - tools to make preparation of standardized data and metadata easier and more automatic.

- Seek technical, financial, and logistical collaboration with interconnected projects developing under GISP, IABIN, NBII, IUCN-ISSG,[2] and many other organizations, to establish a network of regional and national IAS hubs that provide a model for a broader GISIN network.
- Focus on the GISIN mission and collaborate with partner organizations to avoid duplication of effort.
- Approach global and regional donor agencies such as WB, GEF, USAID, EU, UNDP, UNEP, TNC, CI,[3] and others, for financial support to successfully implement GISIN activities.
- Seek collaboration with existing efforts and portals, such as the GISP Website and GBIF, to develop several network components based on the Web services approach, including, but not limited to, a centralized portal, an index of the distributed content, and a registry of the distributed content providers and their services.
- Agree, as data providers, to catalog a minimum set of simple but widely applicable data types, and to express them on Websites in standard formats (currently XML-based) readily accessible to the other IAS hubs.
- Contribute content such as fact sheets/profiles, non-native and invasive checklists, experts, observations, specimens, bibliographies, identification/diagnostic information, maps, images, and projects, all of which are to be tagged with a resource identifier and authority (publisher information).

The workshop participants recommend that parties collecting IAS information in agricultural and natural ecosystems collaborate and support the development of full specifications and deployment of a GISIN. To this end, an interim Steering Committee has been selected to develop a program of work over the next two years that will lay the foundation for full implementation of the Network.

[2] GISP = Global Invasive Species Programme; IABIN = Inter-American Biodiversity Information Network; NBII = United States National Biological Information Infrastructure; IUCN-ISSG = Invasive Species Specialist Group of the Species Survival Commission of the World Conservation Union.

[3] WB = World Bank; GEF = Global Environment Facility; USAID = United States Agency for International Development; EU = European Union; UNDP = United Nations Development Programme; UNEP = United Nations Environment Programme; TNC = The Nature Conservancy; CI = Conservation International.

Meeting Process

In preparation for the Experts Meeting on Implementation of a Global Invasive Species Information Network, an online community was created and hosted by the National Biological Information Infrastructure (NBII) at http://my.nbii.gov. The GISIN online community facilitated discussions and document/resource exchange among international IAS information managers, database developers and managers, researchers and other parties interested in the successful creation of a GISIN. The main goals and discussion points for the meeting were derived from those issues raised in online discussions and from the results of online surveys completed by GISIN online community members.

On Tuesday, April 6th, 2004, the meeting commenced with introductions and greetings from the meeting coordinator Annie Simpson (NBII) and Jeffrey Fisher of the United States Department of State (sponsor). Members of the GISIN Planning Team were introduced, as were each of the morning's presenters and their presentations, and a brief description of the agenda was presented to the participants.

Each day of the three-day meeting was broken out into sets of three oral presentations followed by breakout group discussions. Each set of three oral presentations included one example each of a theoretical database, a centralized database, and a distributed database system approach.

On Tuesday and Wednesday afternoon participants reconvened for presentations of summary breakout group reports. Breakout groups were divided into the following topic areas: Developing Databases in Practice (Content), Developing Databases in Theory (Infrastructure), Developing Databases & Capacity Building (Capacity Building), Financial and Organizational Framework (Organizational Framework), and Aquatic Invasive Species (Nonindigenous Species Database Network (NISbase) collaboration). Each breakout group consisted of one or two group leaders who were responsible for directing discussions, and supported by rapporteurs responsible for note-taking and presenting summary reports at the end of each day.

On Thursday morning, participants were introduced to the members of the newly elected six-member interim Steering Committee. Participants briefly described new achievements and tentative collaborative agreements resulting from their attendance at the meeting; and the group initiated the development the document now known as the Baltimore Declaration. The meeting was adjourned at noon on Thursday, April 8th, 2004.

In addition to paper-handouts and materials for oral presentations, electronic posters were displayed on a rotational basis during refreshment, mealtime, and breakout group segments of the meeting (Appendix E).

In May 2004, transcripts of the entire proceedings of the meeting were made available to members of the GISIN online community with accompanying electronic presentations and handout materials. Additional materials including further elaborations on issues raised at the meeting were distributed to the members through the GISIN online community after the meeting. GISIN community members continue to share information and discuss the future of the GISIN through emails and the online forum at http://my.nbii.gov.

Plenary Proceedings

Databasing Invasions: A Review in the Context of the Global Invasive Species Information Network (GISIN)

Elizabeth Sellers, Information International Associates Inc., P.O. Box 4219, Oak Ridge, TN 37831-4219. (703) 648-4385, esellers@usgs.gov[1]

Abstract

Due to significant and costly impacts on agriculture, economy and biodiversity caused by the accidental or intentional introduction and establishment of invasive alien species (IAS), they are recognized as a significant global threat in need of urgent attention. Consequently, the international community has been urged to address the IAS issue as a national and international priority. The burgeoning status of global trade and travel guarantees that all nations will not only experience the direct impact of IAS, but will find them an ominous threat at some point in the near future (if not already).

Among the nations of the Americas, Europe, Asia and Africa, IAS databases, biodiversity clearinghouse mechanisms, networks and international agreements have grown in number and complexity. Regardless of whether they are called Web sites, online databases, clearinghouse mechanisms, hubs, or portals, if they provide IAS-related information through the globally accessible Internet and continue to develop network linkages with other complimentary online information systems, they lend valuable support to the continued development of a Global Invasive Species Information Network (GISIN). Databases represent a potentially valuable yet often inaccessible or unobtainable resource to nations that lack their own. Nations that are developing IAS databases should share their information resources in a cooperative effort towards combating the common threat posed by IAS.

However, the act of sharing information presents several problems in itself. Standards, formats, methods and protocols must be adhered to by dissimilar data products if they are to share or exchange data in an efficient and effective manner. Recent cooperative development efforts among members of the international community and the Convention on Biological Diversity have resulted in the definition of international standards for biodiversity data exchange. Members of the international community have called for the development of a Global Invasive Species Information Network. The success and persistence of this network will depend on the support and participation of capable stakeholders, international standardization and cooperation in data exchange, and continued maintenance and development of the component information sources.

A white paper distributed at the Experts Meeting on Implementation of a Global Invasive Species Information Network described and synthesized invasive species information management activities occurring around the globe during the past decade. It was prepared in the context of the Convention on Biological Diversity's recommendation that the Global Invasive Species Programme (GISP) coordinate the development of the GISIN. The results described in the white paper were summarized in a presentation given at the GISIN experts meeting.

Keywords: invasive alien species, invasive species, invasives, alien species, exotic species, introduced species, non-native, nonnative, database, information system, Web, Internet, online, global invasive species information network, GISIN, IAS, GISP.

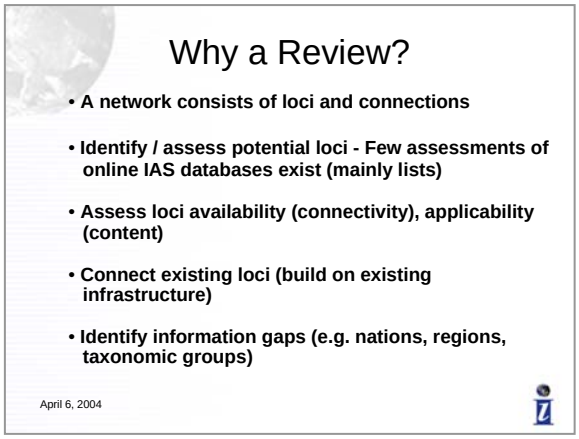
Introduction

Why perform such a review? Why create a list of databases? We're all here to discuss the creation of the Global Invasive Species Information Network. A network consists of loci and links or connections between those loci. Before you can create anything resembling a network you must identify its possible components – find them, and assess them for their content, connectivity, and applicability to the type of network you are trying to create. Comprehensive

[1] Current address: National Biological Information Infrastructure, USGS / 12201 Sunrise Valley Drive, Mailstop 302 / Reston, Virginia 20192.,

assessments of this type do not exist, in part because the loci do not exist online or they exist only in theory. Lists of invasive species on Web sites currently constitute the majority of potential loci at this time.

Funding and time is commonly the most limiting factor in the development of information systems and supporting technology. If the loci already exist, then it is much more efficient to build on and learn from existing achievements and products, rather than recreate them. Information gaps are also often identified during an assessment such as this. Whether those gaps happen to be national, regional, area-specific, species-specific, or specific to individual taxonomic groups, the patterns start to emerge when you review and assess the existing components.



Methodology

The Internet search engine, Google, was the main online research tool used to create the list of information systems. The clustering engine, Vivisimo was also used as an online search tool. Information was gathered from the proceedings of regional meetings (funded by the United States Department of State) along with other national reports, journal articles, and general printed media. Existing lists of databases on Web sites and reported in articles often constituted the basis for Internet searches that resulted in the identification of other related and connected databases. For example, the Web site - Invasivespecies.gov maintains a very comprehensive list of databases including those serving IAS information and part of Sellers' research involved working through this and other lists to find databases relevant to the GISIN community and concept. The database list was developed over roughly a two month period and will continue to expand as new databases are added.

The research was conducted in English, in the United States. An Internet search using Google from a USA location will list USA Web sites first in the results, so there is a bias in the lists that are returned. One must dig deeper into the results to obtain a semblance of international balance.

Results

The results consisted of Hypertext Transfer Markup Language or HTML-based Web pages, database-driven Web pages, databases, distributed database systems, clearing house mechanisms, and information systems. Almost anything containing information about IAS was included in the list. But before being included, each item was tested to determine its character and relevance.

Identification of Loci

The list of online IAS information sources identified during the two month period started at 150 and grew to 160 as a result of contributions received from participants on the first day of the meeting. During the research, 80 online 'general biodiversity' information sources that contain IAS information were also identified. There is a plethora of biodiversity type databases in existence e.g. we want to list every species we have in our nation/region). Most of them do not indicate if a species is invasive somewhere, and so that potentially useful information is lost to those who are managing invasive species.

Loci - Connectivity

We have identified over 150 potential information systems for connecting, some of which are already connected to each other to some degree. The connectivity of these loci is most affected by the format of the database – the way that the data is delivered or served online, and stored in the database itself. Standards recommended by the Convention on Biological Diversity (CBD) are evolving and growing with information management technology and information uses within the popular field of biodiversity information management. In addition to the standards recommended by the CBD, and those being developed for application with biodiversity data (such as DiGIR), there are other standards that must be considered such as those for Internet content delivery.

Research Bias

With respect to the question of applicability, the loci identified during this research definitely exhibited a United States of America (USA) bias. Approximately 50% of the databases identified were originated in the USA and/or focused on species in the USA That bias may be an effect of heightened productivity in the USA or an effect of the research methodology. Almost ever State in the USA supports its own state-focused invasive species list, database, Web page, information system, native plant working group, invasive species working group etc.

The potential effects of the research methodology include those of performing the research in English, from a United States base, and time constraints that prevented the complete examination of the extensive lists of results generated by the Internet search engines (thus potentially limiting the examination to those results appearing first in a Google list). The first fifteen to twenty pages of each Internet search were investigated in most instances. Any investigation beyond this point usually resulted in items that did not match the search criteria (keywords).

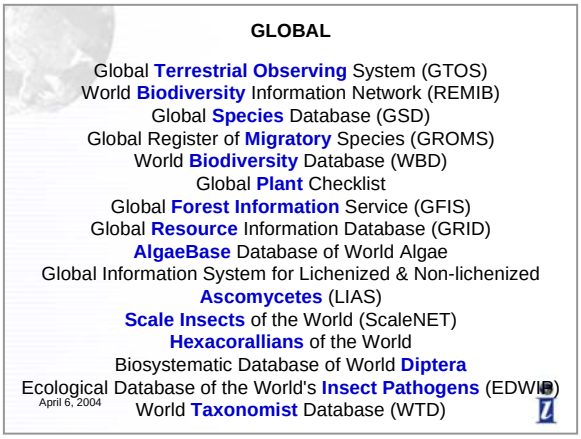
Most of the databases are available in English, if not entirely, then partially. Some database have built in translation options while you can employ translation tools such as that offered by Google to generate an alternate translation of databases served in languages other than your own native language. There were ten additional languages supported by the databases, and included in the top five spoken languages in the world as well as the top five languages used for delivering Web content. Language support is an important consideration with respect to reaching the broadest possible audience with the information served by/through the GISIN. FISHbase demonstrates an exceptional level of language support, currently serving information in fourteen different languages, with a fifteenth translation under development. The project employs SYSTRAN, the translation engine that is behind Google, AltaVista and America Online (AOL) and is leading the way in information translation.

Loci – Description

Approximately 55 of the databases contained information on floral invasive species and 35 had an aquatic invasive species focus. There is a lot of overlap between these databases, because, for example, invasive species can be both floral and aquatic. It is quite difficult to separate these databases into unique groups according to the information they contain, but an attempt was made to provide a rough estimate of the numbers and types of loci that were identified.

Although terrestrial fauna are not well represented by existing IAS databases, they are documented quite extensively in biodiversity databases, but their status as an invasive species is not necessarily indicated. Thus we have identified IAS databases as well as databases that contain IAS information or designate or indicate IAS species among their records.

There are global information systems, biodiversity systems, and comprehensive clearing house mechanisms that serve information on almost everything you could possibly imagine. A very small subset, representing approximately one tenth of the databases from the list of 80 general biodiversity databases, includes systems such as AlgaeBase, Ascomycetes, Scale Insects of the World, Hexacorallians, taxonomic and bibliographic databases. There is a need to include this wealth of information in the knowledge base for invasive species management.

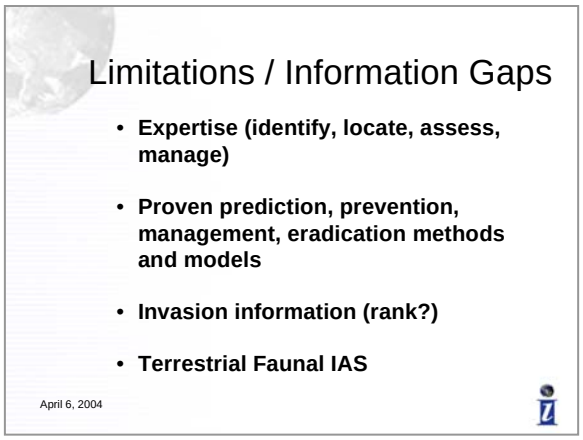


National and regional clearing house mechanisms such as the European Community Clearing House Mechanism and the Regional Biological Invasions Center are already starting to make connections on their own. These and other online sources of IAS information represent the loci we can start to build on, learn from, and facilitate.

Limitations and Information Gaps

Expertise

The lack of expertise is a prominent information gap. Invasive species managers and policy-makers are in need of support and expertise in identifying IAS species, locating them in their region, and assessing their impact(s). Expertise databases and ranking systems for invasive species assessment can fill these gaps.



Mechanisms and Methods

There is a great need for proven prediction and prevention mechanisms, management and eradication methods, and models. Geographic Information Systems (GIS) represent a bleeding edge technology right now, especially in invasion prediction. Managers and policy-makers need to know not just that a species is invasive (for example by a one-word designation in a biodiversity database), but how invasive the species is, how quickly does the species invade and by what mechanism(s)? Can we develop a ranking system – an international ranking and classification system for invasive species? Or at the very least, can we develop national ranking systems and share our experience with other nations? Perhaps a ranking system of one nation could be employed by a neighboring nation with similar ecosystems or experiencing similar threats from IAS. These systems will help nations channel funding and resources to manage high risk species or protect ecosystems that are most threatened.

Infrastructure, policy and regulations

Some discussion that occurred in the online community mentioned that there are some regions and nations that have wildlife regulations and laws that actually interfere with IAS management. How can we develop regulations that address IAS and consequently support the development of

databases, international collaboration, and connectivity?

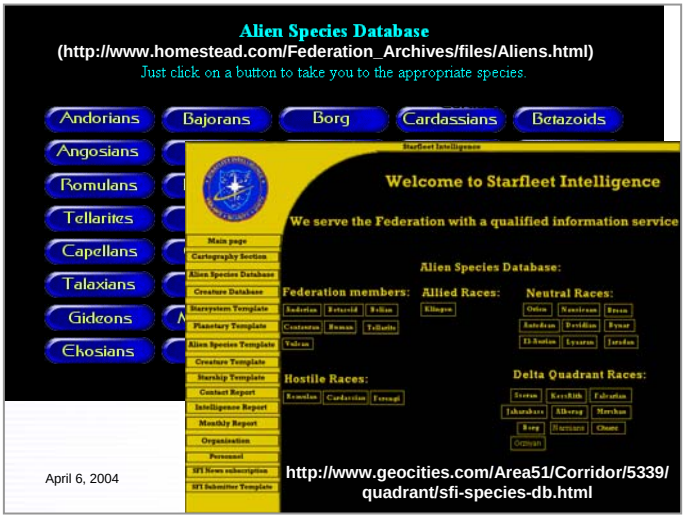
Information standards
Information standards are developing as biodiversity information management and technology develops. We need to identify those that we are going to support.

Technology
Software applications and tools represent a separate group of resources to be identified and assessed for applicability to the GISIN concept. Imagine a comprehensive catalog of software tools or technologies for IAS managers, information managers and database developers. One characteristic of the databases that were reviewed during this project was their lack of information about the technical development and structure of the systems. When visiting an online IAS database, users should be able to find out technical details such as what programming language the database was written in; what software/tools were used to develop and populate the database; and what information collection and delivery protocols were followed.

The search effort of a developer that may be investigating potential loci to connect/collaborate with, can be reduced by providing this information (excepting proprietary and security-related information) through the database's Web site. The inclusion of this technical information about the database on the Web site may actually encourage collaborators to make contact because they can identify commonalities or curiosities in the approach of other database developers. The potential for the connection of new databases to existing systems with very little effort, as opposed to needing a complete redesign, may be increased through this sharing of technical design information.

The greatest limitation to the development of loci is funding. All of these activities require funding to: collect data; pay people to digitize the data; store the data; manage the data; and *continue* to manage the data. Extensive funding is needed to database invasions.

The StarTrek television series involves space exploration where the starship Enterprise *boldly goes where no man has gone before* and encounters new alien species.



The two databases depicted above contain the cultural, social, biological, and taxonomic information for every alien species encountered by the Enterprise crew. If the reproductive ecology of fictitious species such as the Borg, Klingons, Ferengi, and Vulcans is so evident on the Web, then there also should be more comprehensive information on real invasive alien species around our globe in databases of similar, and preferably superior, complexity.

Selected references:

Sellers, E. 2004. Databasing Invasions: A Review in the Context of the Global Invasive Species Information Network (GISIN). Prepared for the Experts Meeting on Implementation of a Global Invasive Species Information Network, Baltimore, Maryland, USA, 6-8 April 2004. Information International Associates Inc., USA. Available online (accessed 21 May 2004): http://invasivespecies.nbii.gov/as/Databasing_Invasions_A_Review_ESellers(IIa).htm [Appendix B].

Sellers, E., Simpson, A., and S. Curd-Hetrick. 2004. - DRAFT - List of Invasive Alien Species (IAS) Online Databases and Databases Containing IAS Information: A preliminary draft document, prepared for the Experts Meeting Towards the Implementation of a Global Invasive Species Information Network (GISIN), Baltimore, Maryland, USA, 6-8 April 2004. Information International Associates Inc., USA. Available online (accessed 21 May): http://invasivespecies.nbii.gov/as/DraftIASDBs.htm [Appendix C].

GISIN Survey Results – Participants' Information Needs

Shelaine Curd-Hetrick, Information International Associates, Inc., P.O. Box 4219, Oak Ridge, TN 37831-4219. (865) 481-0388, shelaine@infointl.com

Abstract

In preparation for the Experts Meeting on Implementation of a Global Invasive Species Information Network (GISIN) held 6-8 April, 2004, three surveys were distributed to members of the GISIN Community – an online electronic discussion and resource access forum. The surveys analyzed respondents' information needs as they related to invasive species databases, data sets, or distributed database systems (DDSs).

Sixty individuals from 26 countries participated in at least one survey. The majority of respondents were developers using IBM-compatible personal computers with Windows operating systems and Internet Explorer 5.x (or later) to meet geographically-focused national initiatives, with Microsoft Access and/or Structured Query Language (SQL) Server as their development software. The majority of initiatives were nationally funded. The represented systems supported a wide variety of export formats, were mostly available in English, and were mainly species-focused (as opposed to specimen-focused).

Hardware and software quality and availability created the greatest technological limitations affecting database development. Future funding was identified as the greatest non-technological limitation. Most respondents reported having a reliable internet connection; however, the connection speeds varied greatly.

When asked what kind of invasive species information should be shared between Invasive Alien Species (IAS) databases, respondents indicated that the highest priority would be taxonomic information, either all inclusive or more specifically Genus, Species, and Family. The most important requirements identified by respondents for data types included species name, biology/ecology and geographic origin. The most important search criterion was scientific name. The type of database search result respondents rated most important is the species profile or fact sheet.

Roughly half of the respondents are involved in database development collaborations and roughly a quarter use the Integrated Taxonomic Information System (ITIS) as a taxonomy, terminology, and data standard. The highest ranked issues in future database development were taxonomy and funding.

These surveys served as a discussion and collaboration tool to allow GISIN Community members to better share IAS information.

Keywords: survey, invasive alien species, invasive species, invasives, alien species, exotic species, introduced species, non-native, nonnative, database, information system, Web, Internet, online, global invasive species information network, GISIN, IAS, DDS, questionnaire, survey.

Introduction

Pre-meeting discussions for the GISIN and resource sharing among professionals in invasive alien species (IAS) science, information management, and database development were facilitated by the creation of an online community hosted by the National Biological Information Infrastructure (NBII) at http://my.nbii.gov/. Members of the GISIN Community also completed surveys to assess their IAS information needs and priorities (Appendix D). The results of these surveys were used to shape the GISIN agenda and identify focus areas for the breakout groups at the meeting.

Methods

Prior to the meeting, a review was conducted to assess the status of current online IAS information systems and database resources (Sellers 2004). The results of this review were used in part to design the questions and topics covered by the surveys. Issues raised by GISIN members in online discussion forums were also considered in the design and focus of the survey questions.

Designed for GISIN Community members, three of the surveys analyzed the content and development of online and offline electronic invasive species databases, data

sets or distributed database systems (DDSs). A fourth survey allowed respondents to evaluate the other three.

- Survey 1--Online Database Survey: questions focused on the respondents' online databases or information systems and their availability to others. This survey consisted of seven questions (Appendix D1).

- Survey 2--Database Content Survey: questions were divided into two sub-sections. The first focused on the specific content of the respondents' database(s), languages, information types, standards, subject, and geographical area focus and could be taken more than once if a respondent represented multiple information systems. The second section was for all respondents (whether or not they represented a specific information system) and asked respondents to identify priority search criteria or desirable characteristics for IAS databases (Appendix D2).

- Survey 3--Database Development and Technology Survey: questions were also divided into two sub-sections. One focused on database import/export format, development software, funding, developer, purpose, technical and non-technical limitations, and whether or not it is available online. The other section asked about respondents' hardware, computer platforms, operating systems, internet browsers, internet access, and to rank in importance the different IAS database types (Appendix D3). Respondents were encouraged to take the first part of this survey more than once if applicable.

- Survey 4--Evaluation of Survey: questions allowed respondents to provide feedback on the effectiveness/applicability, content, or effort involved in completion of, or suggestions for improvement to, any or all of the three surveys (Appendix D4).

Completion of the surveys was entirely voluntary. The only required fields in the survey were those for name of respondent, phone number, and email address. The surveys were conducted in English in a format that included text entry answers, check box selection, ranking, and list selection.

The results were tallied for each question and analyzed using Microsoft Excel. Text answers are cited as they were received, with spelling errors corrected. Since respondents were able to choose more than one option for the check box questions, the data received from these questions are represented in bar graphs showing the number of responses for each choice (i.e., the totals do not indicate the number of respondents, but rather the number of responses).

For ranking questions, respondents were requested to rank every choice and use each rank number only once. Responses that did not rank the options were not included in the analysis (i.e., if all options were ranked highest, then the respondent's answers for that question were not included in the analysis). For analysis purposes on ranking questions, the mode (the rank that was most frequently chosen) and the average scores are shown.

Results

Overall Survey Response

At the time that the surveys were distributed to the GISIN Community, there were approximately 140 members. Sixty respondents from 26 countries (Argentina, Australia, Bangladesh, Brazil, Canada, China, Colombia, Denmark, Finland, Germany, India, Jamaica, Lithuania, Malaysia, Mexico, Morocco, New Zealand, Peru, Philippines, Poland, South Africa, Sri-Lanka, Taiwan, United Kingdom, United States of America - USA, and Venezuela)

participated in at least one of the three surveys. Twenty of these respondents were from the USA. Of the 60 respondents, 40 (representing 24 different countries) completed the Online Database Survey (Survey 1), 58 (representing 25 countries) completed the Database Content Survey (Survey 2), and 56 (representing 24 countries) completed the Database Development and Technology Survey (Survey 3). Twenty-two respondents completed an Evaluation Survey (Survey 4).

Survey 1 - Online Database Survey

Forty individuals from 24 countries completed survey 1 (13 from the USA). Three respondents took the survey more than once, to represent more than one IAS information system with their answers.

Database Availability

Figure 1 shows that 34 of the online databases represented by respondents are publicly available, while 6 support restricted access. Three respondents (in the Other category) indicated that their databases would be publicly available soon.

Database Format

When asked about the format in which their database is served, the majority of respondents indicated that their databases are served using HyperText Markup Language (HTML) (Figure 2). Other formats reported by respondents included ArcIMS maps, Internet Database Connector (IDC),

Figure 1: Availability of IAS databases.

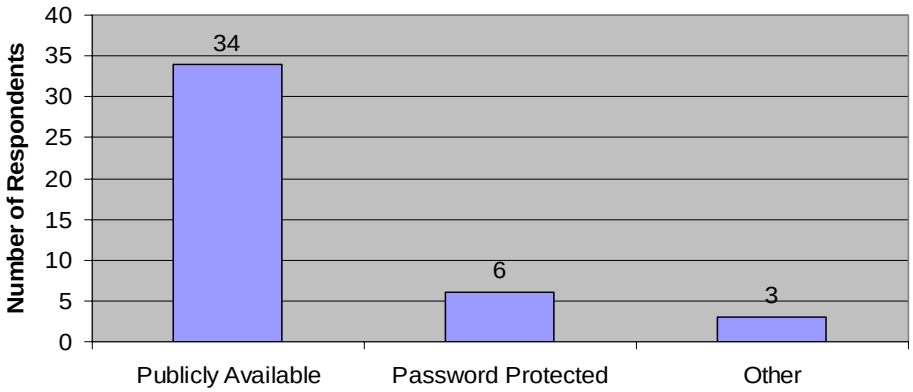
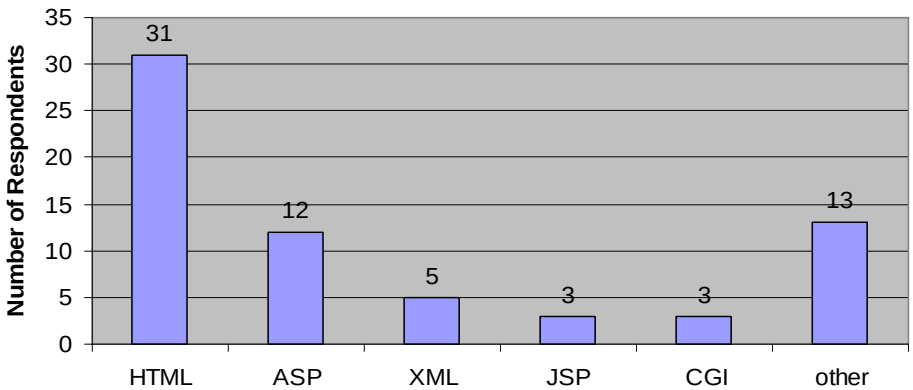


Figure 2: Formats IAS databases are served in.



JavaScript, Hypertext PreProcessor (PHP), and Structured Query Language (SQL) Server. Respondents whose databases are not yet online were undecided as to format.

Survey 2 - Database Content Survey

Fifty-eight respondents representing 25 countries (14 from the USA) completed Survey 2 and one individual took the survey four times to represent different databases. Ten respondents that were not representing a database or a DDS with their answers partially completed Survey 2.

Database Language Support

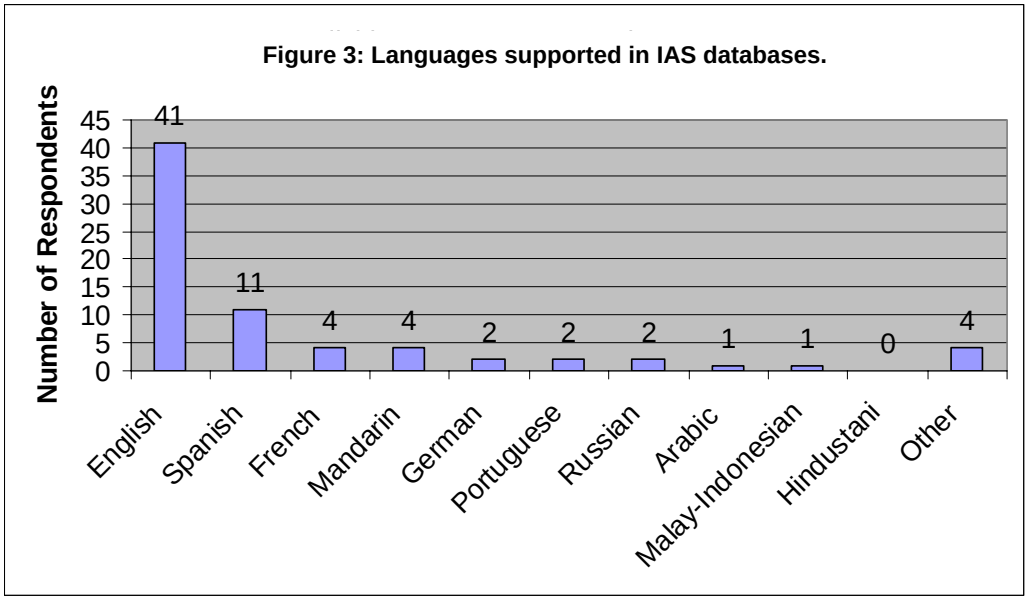
Fourty-one databases represented by respondents are available in English (Figure 3). Other languages supported by the databases included Spanish (11), French (4), Mandarin (4), German (2), Portuguese (2), Russian (2), Arabic (1), Chinese (1), Italian (1), Malay-Indonesian (1), and Polish (1). A comment submitted in the Other category indicated that Systran (a translation service) is used by FishBase for translation support in Chinese, Dutch, German, Italian, Portuguese, Spanish, and Swedish.

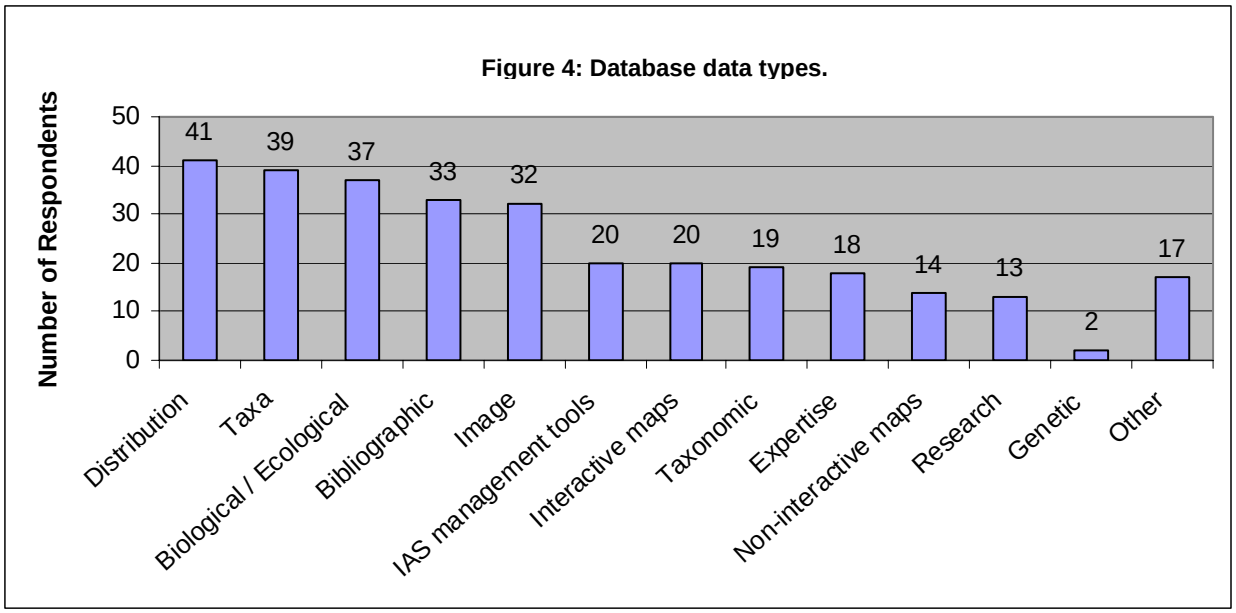
Database Data Types

The respondents were asked to indicate all data types that were contained in the database they were representing. A single dominant information type was not clearly indicated by the results (Figure 4). However, distribution (41), species based taxonomy (39), and biological/ecological data (37) were the three most common database information types. Other information types reported by respondents included bibliographic (33), images (32), IAS management methodology tools (20), interactive maps (20), taxonomic (collection records) (19), expertise (18), non-interactive maps (14), research (13), and genetic information (2).

Data types submitted in the Other category included web links, identification aids, glossaries, modeling results, management tools, introduction pathways, impacts (economic, biodiversity, human health), history as an invasive species elsewhere, common names, data about the species, abundance and habitats in its native area, growth form (for plants), diet (for animals), mode of reproduction, introduction date, landscape information, and threat assessment tools.

Figure 3: Languages supported in IAS databases.



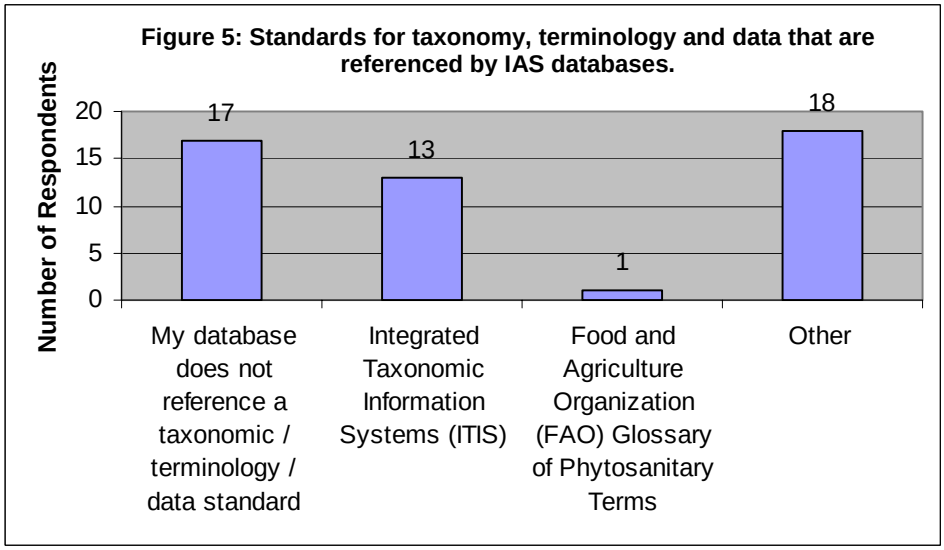


Standards for Taxonomy, Terminology, and Data

Respondents were asked to indicate which taxonomic/terminology/data standard (if any) is referenced by their database. The responses can be divided into three main groups: those using the Integrated Taxonomic Information System (ITIS) (13), not using a standard (17), or those using a standard not listed in the survey (18) (Figure 5). One respondent uses the Food and Agriculture Organization (FAO) Glossary of Phytosanitary Terms.

Responses in the Other category included:

- CABI,
- CABI Index Fungorum,
- CAB Thesaurus,
- International Committee on Taxonomy Virus database (ICTV),
- Germplasm Resources Information Network (GRIN),
- International Legume Database and Information System (ILDIS),
- National Geospatial Intelligence Agency (NIMA, USA),
- National Center for Biotechnology Information (NCBI, USA),



- Missouri Botanical Garden vascular plant nomenclatural database (TROPICOS, USA),
- Biodiversity Information System (SIB, in Colombia),
- Dr. W. Eschmeyer's Pisces (California Academy of Sciences, USA),
- Ecological Metadata Language (EML),
- ZOOCODE (http://www.zin.ru/projects/zooint/index.html).
- German plant taxonomic standard list,
- Species2000,
- Bishop Museum (Hawaii, USA),
- Dublin Core,
- London-Insects standards, and
- natural history museum standards in general.

One respondent indicated that they were developing a cross-walk between ITIS and the current standard they are using.

Database Subject or Focus

The majority of databases represented by respondents (23) focused on aquatic and terrestrial species and twenty-one address both flora and fauna (Figure 6). Some respondents' databases are focused more specifically on diseases (11), flora (11), invertebrates (6), aquatic species (4), terrestrial species (3), arthropods (1), or fauna (1).

Other database subjects or foci described by respondents included fungi (that do not specifically cause disease); native species; flowering plants; plants of disturbed habitats; insects/fire; *Parthenium* spp.; invasive species that are threats to Hawaii, the Pacific, and USA agriculture; native and invasive species of China; and taxa of importance to agriculture, rangelands, forestry, animal health, and aquaculture.

Database Geographic Focus

The geographic focus of the respondents' databases is mainly National (24), with the rest being evenly distributed among Local (an area within one part of a country or political unit) (16), Regional (includes more than one country or political unit) (14), and Global (13) (Figure 7). Responses in the Other category included statewide, China, Nordic, Baltic, north western Russia, Poland, Germany, Greenland, Faroe Islands, Pacific, and Pacific rim. One respondent commented that databases may be designed to be useful for local invasive management and can be re-scaled to apply to larger areas.

Figure 6: Subjects or foci of IAS databases.

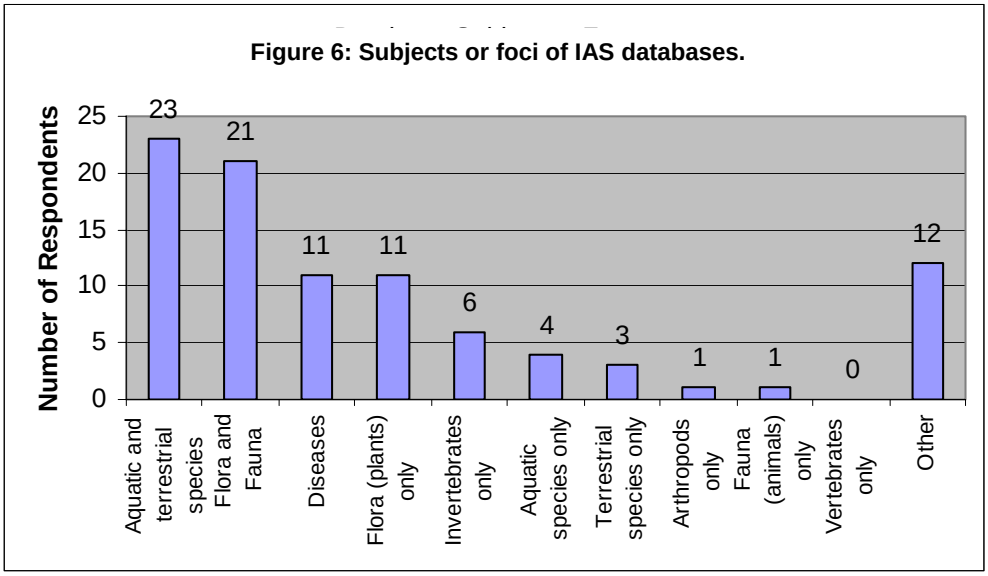
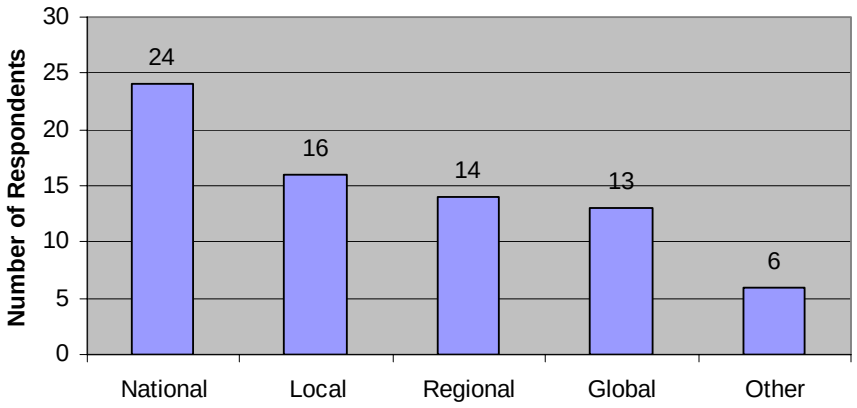


Figure 7: Geographic focus of IAS databases.



Important Database Search Criteria
Respondents indicated that the most important database search criteria was scientific name, followed by geographic area, genus, keyword search, invasion pathway/method, common name, and taxonomic unit (Table 1).

Rank IAS database search criteria (1=most important, 7=least important)		
Search Criteria	**Mode**	**Average**
Scientific Name	1	1.29
Geographic Area	3	2.78
Genus	3	3.45
Keyword Search	4	4.02
Invasion Pathway/Method	4	4.1
Common Name	4	4.22
Taxonomic Unit	4.5	4.42

Table 1: A ranking of IAS database search criteria.

Responses in the Other category included control method; date of introduction; exact location data; diagnostic characters; vegetation type; organism type; designation as weed, pest, or fungus; geographic origin; pollination and dispersal type; life cycle length; economic impact; legal situation; habitat invaded; hosts/habitat threatens; impact; population status; habitat (marine/freshwater); rating or ranking of threats by region; spatial restriction; status as an invader; invasiveness with respect to climate; hosts; agricultural versus environmental; and various combinations of these.

Important Database Search Result Type
Respondents indicated that the most important database search result type was fact sheets/species profiles, followed by species occurrence reports, distribution maps, management and control information, bibliographic information and references, and current and past research (Table 2).

Rank IAS database search results (1=most important, 6=least important)		
Search Results	**Mode**	**Average**
Fact Sheets / Species Profiles	1	2
Species Occurrence Reports	2	2.74
Distribution Maps	2	2.81
Management and Control Information	3	3.06
Bibliographic Information and References	4	3.79
Current and Past Research	4.5	4.12

Table 2: A ranking of IAS database search result types.

Responses in the Other category included local classification of species as invasive or their invasiveness, abstracts, country of

occurrence, host/prey records, hosts/habitats impacted, images, life form, experts, pathways, species that could be confused (misidentified) with IAS, and specimen voucher acquisition number.

IAS Database Taxonomic Categories
Respondents clearly indicated that Genus (27), Species (25), and Family (24) should be required as taxonomic categories in an IAS database (Figure 8). However, twenty-four respondents also indicated that All taxonomic categories (Kingdom through Species) should be required. Fewer respondents indicated a preference for Phylum/Division (6), Order (6), Kingdom (5), and Class (3) to be required categories.

Responses in the Other category included strains/biotypes, subspecies, race, and form. Respondents also commented that the type of taxonomic category that *must* be included depends heavily on what is being studied. For instance, in insects, Tribe may need to be a mandatory field. Respondents with information systems still in the development stage indicated that they had not yet decided which taxonomic categories to include.

IAS Database Data Types
Respondents were also asked to indicate all data types that should be included in an IAS database. Among the responses given, no individual data type was indicated as being notably more important than another (Figure 9). Biology and Ecology (43), and Geographic origin (43) received the highest number of responses.

However, the additional options for selection in the survey question were selected on progressively lower frequencies with Related Geographic Information System (GIS) Data Layers being selected by the lowest number of respondents. Other data types that respondents recommended were status, invasiveness, population trends, control methods, images, taxonomic information, experts listing, references, and information such as predator and prey relationships.

Respondents also commented that it is important to include information on when a record is entered, when it is updated and by whom, and references.

Figure 8: Recommendations for taxonomic categories required in IAS databases.

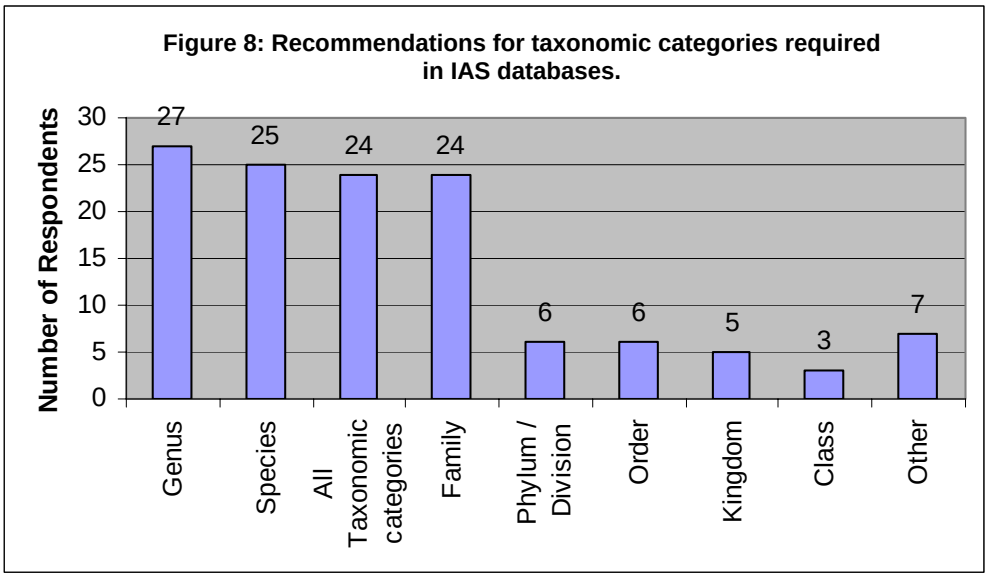
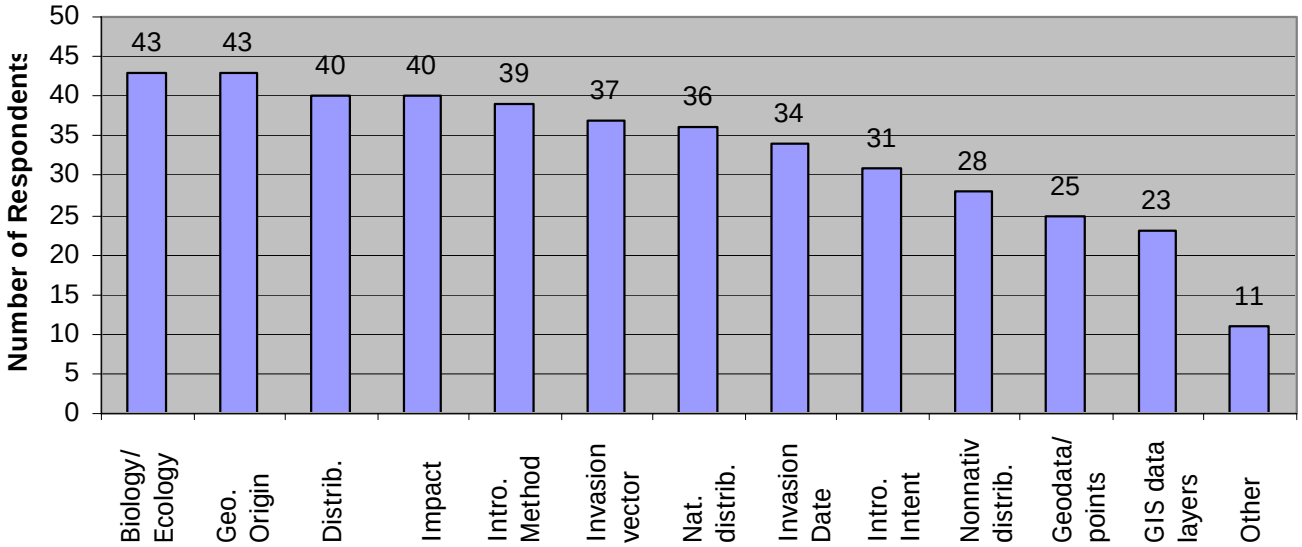


Figure 9: Recommendations for data types required in IAS databases.

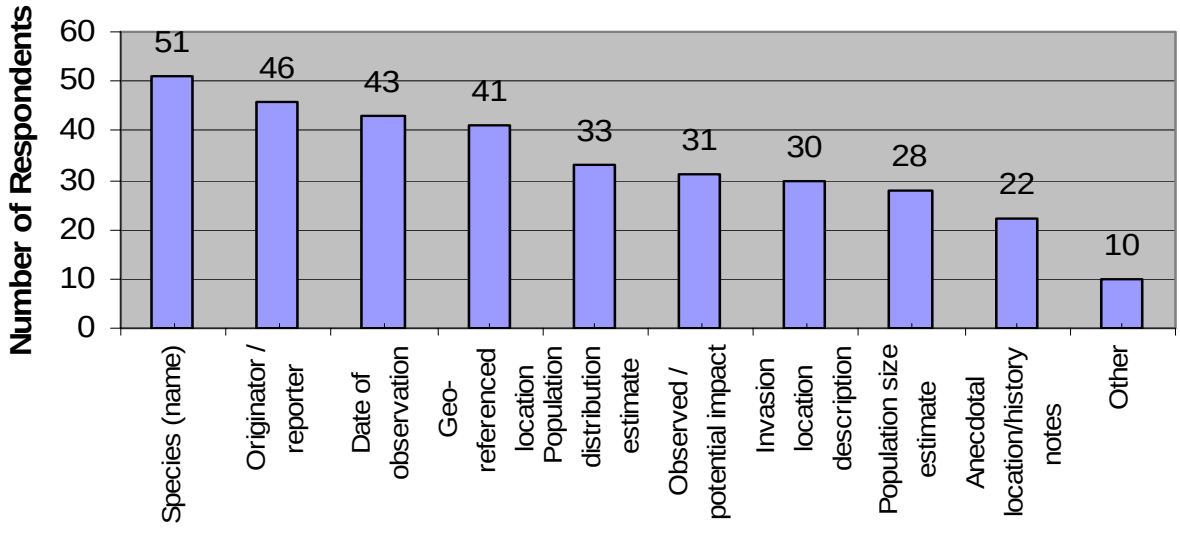


IAS Occurrence Report Data Fields

Respondents were also asked to identify the type of data fields that should be required in an IAS species occurrence report. Responses to this question indicated that all of the data fields described in the question should be included in species occurrence reports (Figure 10).

The Species (name) field received was the data type selected most by respondents (51). The Anecdotal Location/History Notes field was the date type selected least by respondents (22).

Figure 10: Recommendations for data types required in IAS occurrence reports.



Respondents also submitted other data types that should be included in a species occurrence report including status, invasiveness, experts/contact persons, responsible party for management/ control/monitoring, elevation range, bio-status, reference, vegetation type, and purpose of introduction. Respondents commented that it is important to include information on when a record is entered, when it is updated, and who updated the record (including references), as well as the results of any attempt to control or manage an invasive species (since this information would assist in tracking the success and subsequent monitoring of the population).

Database Development Issues

The most important issues affecting future development of information systems and the GISIN, as ranked by respondents were: agreement on standardization (standards) of database field formats, identification and procurement of funding, agreement on taxonomy/taxonomic authority, agreement on standardization of a core group of required IAS data types to be included in databases, and data ownership and copyright issues (Table 3).

Future Development Issues of DDSs & GISIN (1=most important, 5=least important)		
Issues	**Mode**	**Average**
Agreement on standardization (standards) of database field formats	1	1.97
Identification and procurement of funding	2	2.09
Agreement on taxonomy / taxonomic authority	4	2.65
Agreement on standardization of a core group of required IAS data types to be include in databases	4	3.56
Data ownership and copyright issues	5	4.5

Table 3: A ranking of GISIN development issues.

Respondents suggested other issues that affect future development such as obtaining software and compatibility of software, sustainability, access to data, data import/export, technical support for national/regional databases that may participate in the GISIN, maximizing access and GISIN participation, and native species distributions. A respondent commented that while it is not particularly important to agree on taxonomy, agreement on taxonomic authority (including standards, and developing the ability to cross-walk from one nomenclature to another while documenting this cross-walk) is imperative to successful data sharing among multiple databases/agencies.

Survey 3 - Database Development and Technology Survey

Fifty-six individuals from 24 countries completed Survey 3 (20 from the USA). One individual took the survey four times to represent four different databases, and 11 individuals answered half of the survey.

Database Availability

Thirty-three respondents indicated that the database they represented is currently available online (Figure 11). Eleven databases are available on CD-ROM (Compact Disk - Read Only Memory), 7 are privately held, and 5 may be exported as electronic files. Responses in the Other category described databases available on DVD (Digital Versatile Disc), downloadable from the Web, or that are not currently available.

Data Extraction Formats

For collaboration purposes, the respondents were asked to indicate the format in which data can be extracted from their database (Figure 12). The majority of respondents (26) indicated that data can be extracted from the databases using HTML. Eighteen respondents indicated a Relational Database, followed by Extensible Markup Language (XML) (14), spreadsheet or flat file (14), Comma Separated Value (CSV)

files (11), Active Server Pages (ASP) (10), Rich Text Format (RTF) (7), Common Gateway Interface (CGI) (4), and Java Server Pages (JSP) (3).

Respondents also reported using other formats including Darwin Core (DwC)/ Distributed Generic Information Retrieval (DiGIR), an Oracle dump file, TXT, IDC, and ESRI shape file GIS format. Those who have not reached this development phase indicated that they had not yet decided on a data extraction format. A comment received on this question indicated that ASP, CGI, and JSP are not relevant output formats since they are technologies that enable scripting of web servers and can be used to generate "output formats."

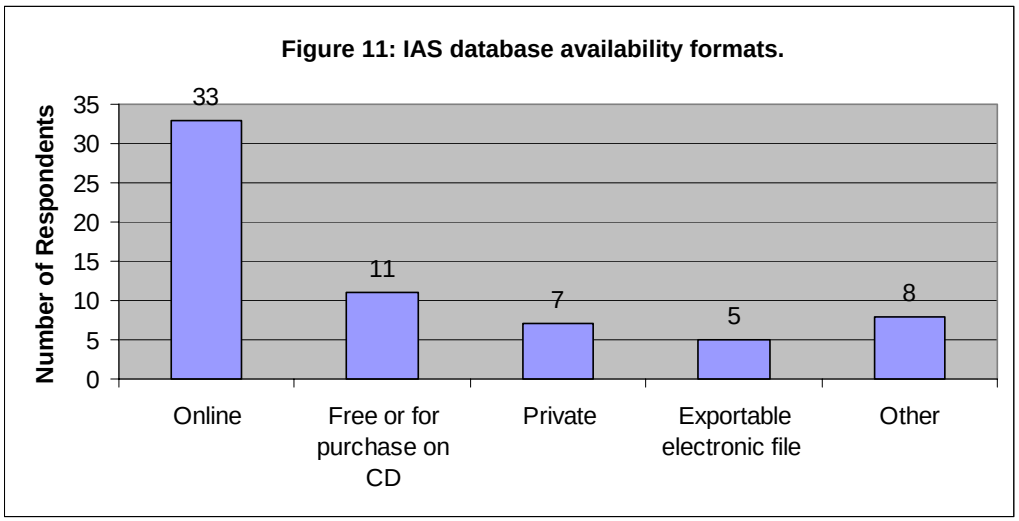


Figure 11: IAS database availability formats.

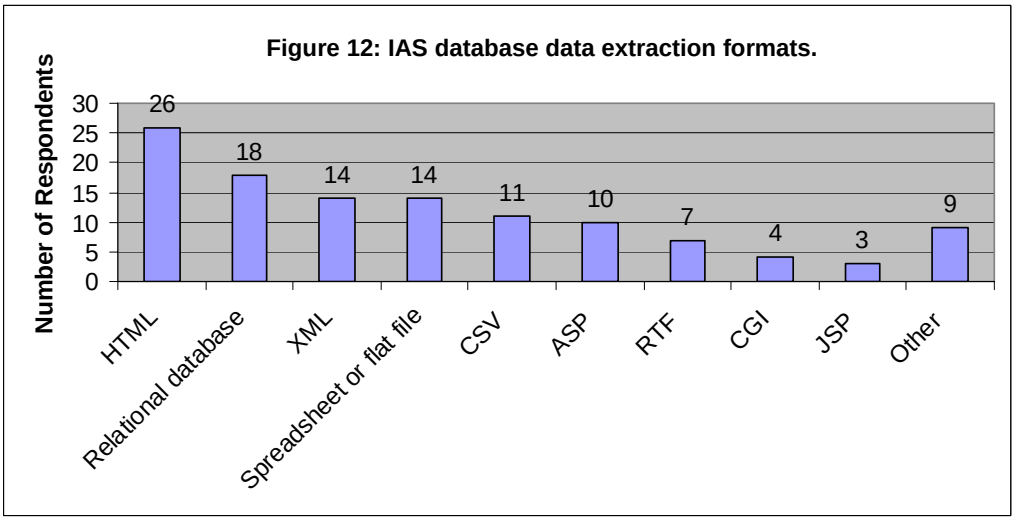


Figure 12: IAS database data extraction formats.

Database Development Software
Twenty-three respondents use Microsoft Access as their database development software; 13 use both MS Access and SQL Server, nine use SQL alone, five use Oracle, and three use Filemaker Pro (Figure 13). Fifteen responses in the Other category described MS Excel, MS Visual Basic, Avenue, PowerBuilder, Visual Objects, Java, MySQL, PostgreSQL, Robohelp, Paradox, and custom designed software.

Database Funding
Development of most of the respondents' databases was funded with National government funds (24), followed by respondents' organizations (17) (Figure 14). Development of other databases was also funded by non-profit organizations (9), employers (8), state governments (8), private organizations (4), personal funds (1), educational institution (1). In the Other category respondents described donations, and international (cross-border) funding sources from government organizations.

Figure 13: IAS database development software used by GISIN

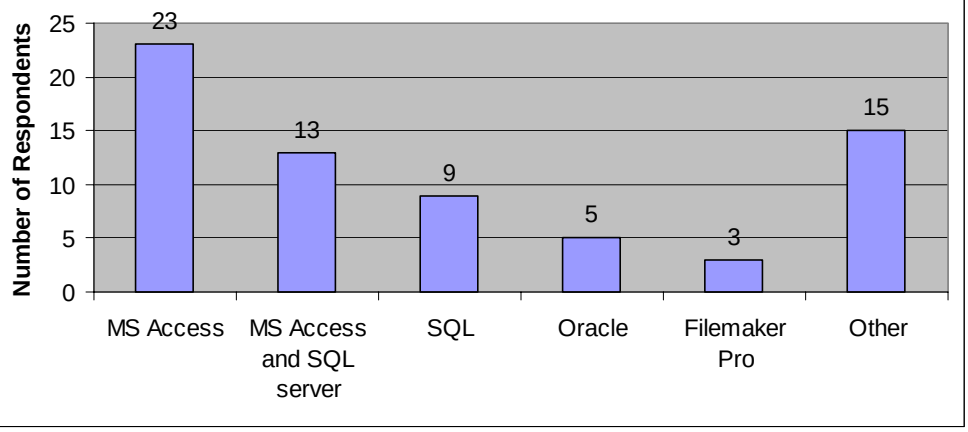
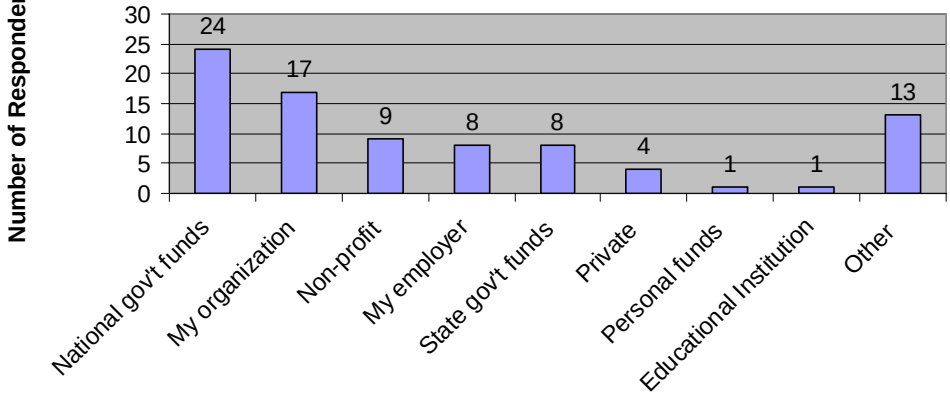


Figure 14: IAS database development funding sources of GISIN members.



Database Development Personnel
The majority of respondents developed their own database (28) (Figure 15). Thirteen used a private contractor; 12 worked with partner organizations; others employed individuals (10) or individual contracting organizations (4) to develop a database; or used the skills of students (5), or interns (2).

Responses in the Other category either indicated that the respondent was alone in the development of the database, worked with colleagues and experts within organizations, or used open source products.

Database Need Fulfillment
Twenty-three of the respondents' databases were developed to fulfill a need on a national level, 14 regional, 14 global, and 9 local (Figure 16). In addition, four of the databases were developed to fulfill a private research need and one was developed for an educational purpose.

Responses in the Other category indicated that databases were developed to fulfill sponsor or employer expectations.

Figure 15: Types of IAS database developers.

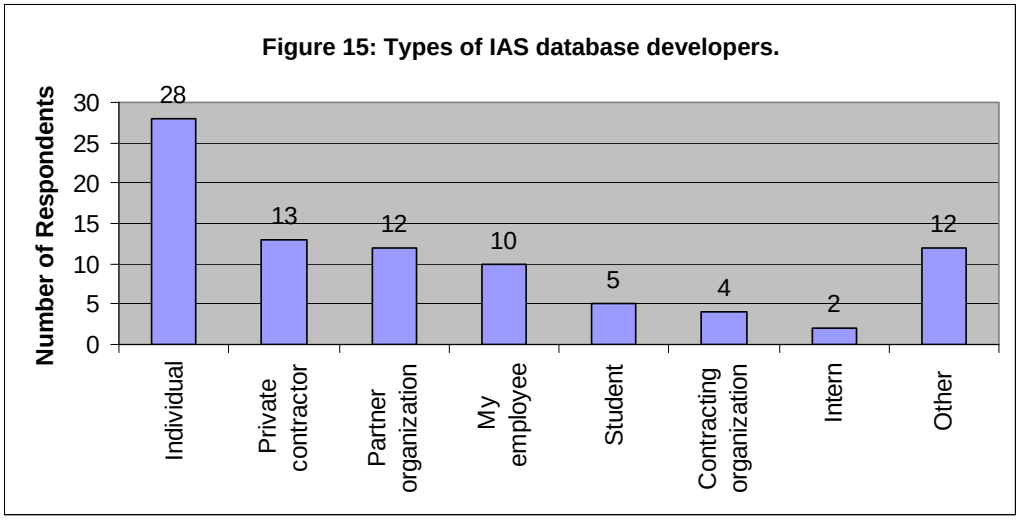
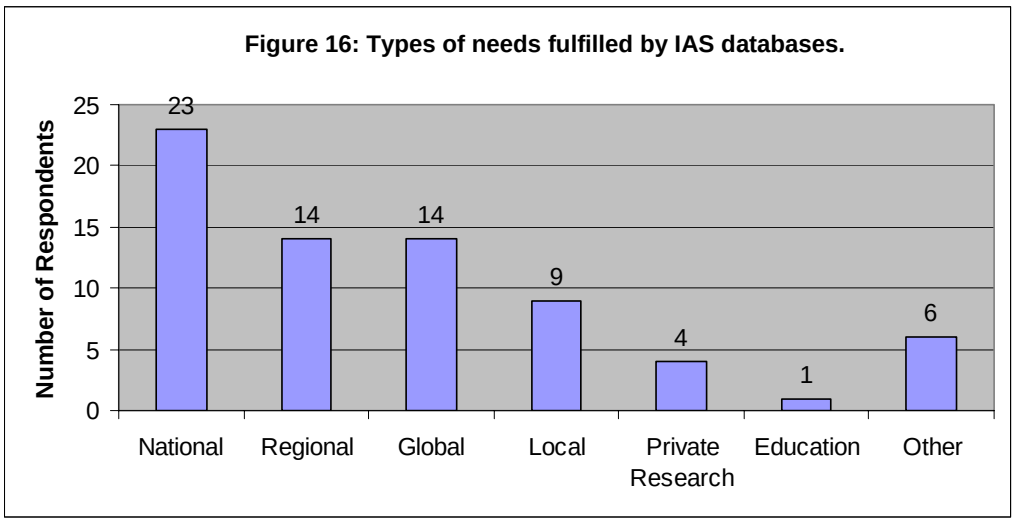


Figure 16: Types of needs fulfilled by IAS databases.



Collaboration
Forty-nine percent of those who responded to Survey 3 are currently collaborating with another database (Figure 17).

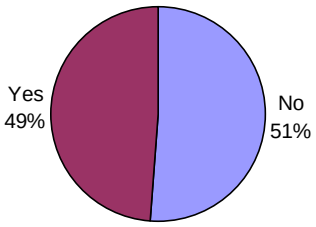


Figure 17: Percentage IAS database collaboration among GISIN members.

Technological Database Development Limitations
Software and technology hardware quality and availability were ranked as the most limiting factors to database development, followed by internet connection speed and internet connection availability (Table 4). Other technology limitations included a lack of knowledge regarding appropriate technology, the technology itself, and limitations of users. Two respondents indicated that none of these were limitations for their database development and collaboration.

Technological Limitations (1=most limiting, 4=least limiting)		
Limitation	**Mode**	**Average**
Software quality and availability	1	1.86
Technological hardware quality and availability	2	1.96
Internet connection speed	4	2.93
Internet connection availability	4	3.29

Table 4: A ranking of technological limitations to IAS database development.

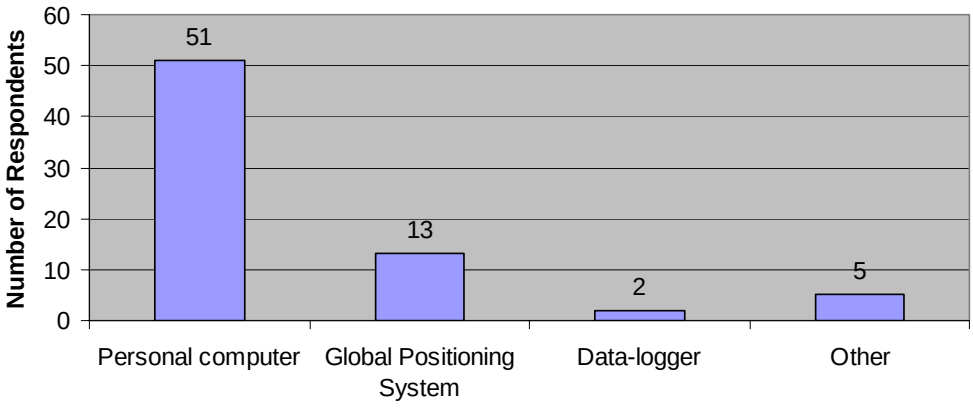
Non-Technological Database Development Limitations
The highest ranked non-technical limitation was funding, followed by programming expertise, database design expertise, IAS expertise, and data ownership/copyright (Table 5). Additional non-technical limitations given by respondents were the high security related to IAS and quarantine interceptions (i.e., because dissemination of information could result in trade barriers), and the lack of the following: time, widely-accepted formats, reinvention of existing solutions, acceptance in organizations/ governments, institutional capacity, expertise, and national political commitment. One respondent commented that this ranking was not very meaningful, because the limitations listed were dependent on each other and that with additional funding all other limitations would evaporate.

Non-technological Limitations (1=most limiting, 5=least limiting)		
Limitation	**Mode**	**Average**
Funding	1	1.7
Programming Expertise	2	2.52
Database Design Expertise	2	2.88
IAS Expertise	4	3.61
Data Ownership and Copyright	5	4.33

Table 5: A ranking of non-technological limitations to database development.

Database Development Hardware
Fifty-one respondents use a personal computer (Figure 18). Respondents also use global positioning systems (GPS) and Data-loggers. Responses in the Other category included Linux or other server, public computer, Palm Pilot, or digital camera.

Figure 18: Computer hardware used by GISIN members.

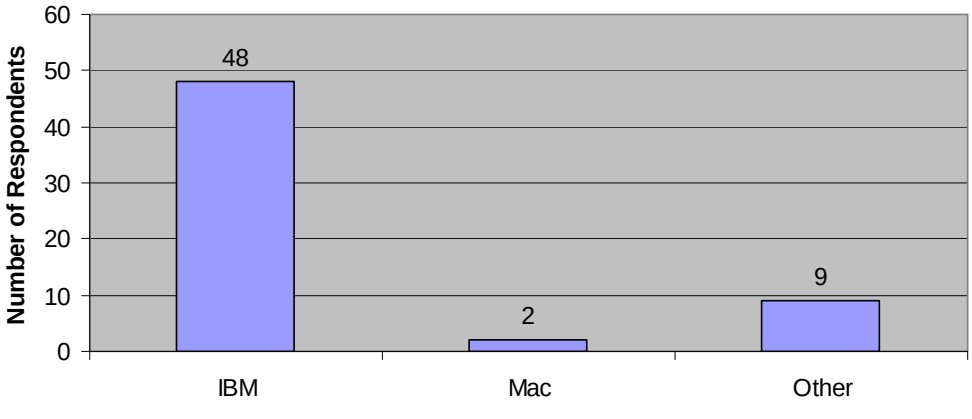


Database Development Platforms
The most popular computer platforms were IBM compatibles, used by 48 respondents (Figure 19). Only 2 respondents indicated the use of the Macintosh platform. Computer platforms submitted in the Other category included SUN, Palm, and Solaris.

Database Development Operating Systems
Most respondents use Windows operating systems (OS) with the majority (33) using Windows XP.

Other Windows operating systems included Windows 2000 (23), NT (13), 98 (11), and ME (3) (Figure 20). Two respondents use the Macintosh OS. Seven and four respondents use LINUX and UNIX respectively. The three responses in the Other category indicated that they use the Palm OS, Windows 2003 server, or that they were unsure of their operating system.

Figure 19: Computer platforms used by GISIN members.



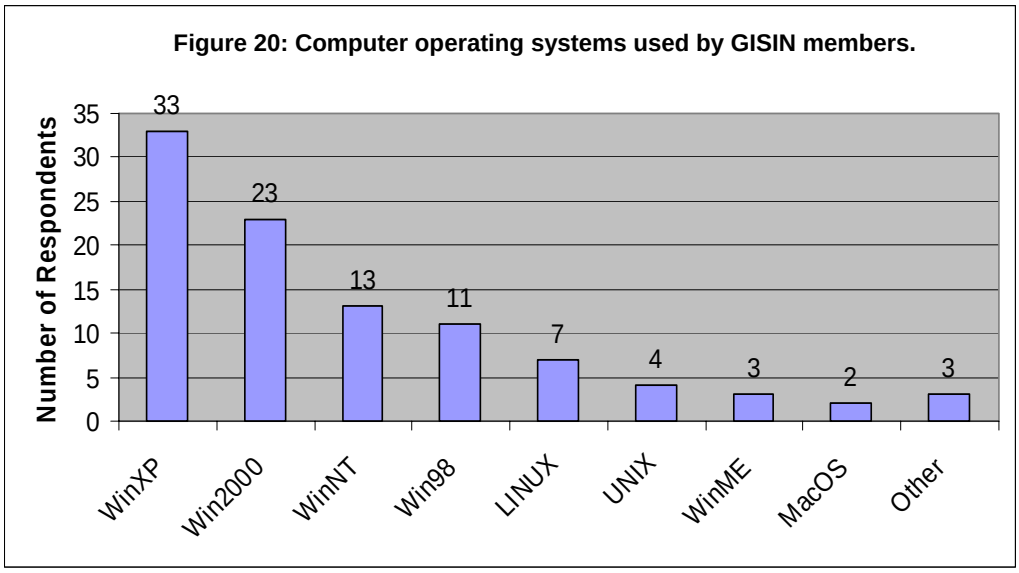


Figure 20: Computer operating systems used by GISIN members.

Internet Browser Applications

Microsoft Internet Explorer (IE) (version 5.x or later) is the most commonly used Internet browser application, with 48 respondents choosing that option (Figure 21). Four respondents reported using earlier versions of IE, giving a total of 52 respondents who browse the internet using IE. Eleven respondents use either Netscape Navigator (8) or Netscape Communicator (3).

Five respondents indicated in the Other category that they use Mozilla or the Mozilla-based FireFox applications. One respondent indicated that since eleven countries are involved in their project that several different browser applications are used. One respondent commented that they were not sure why this is relevant, because "all web-base applications/data should be accessible to anyone with any level of technology access".

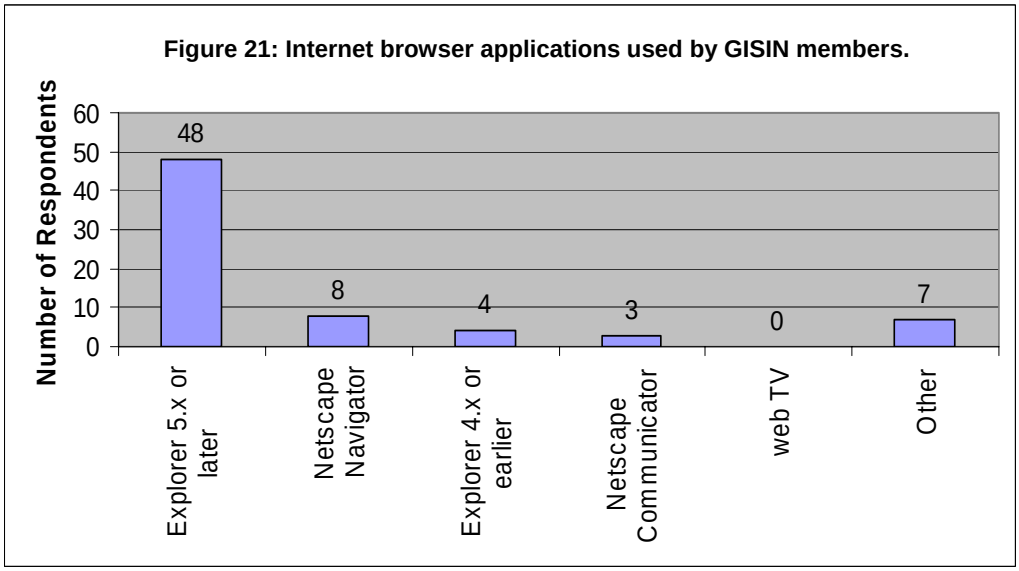


Figure 21: Internet browser applications used by GISIN members.

Internet Access and Reliability
Fifty-four respondents indicated that they have reliable Internet access (Figure 22). Two respondents in the Other category noted that the audience for their data may have a lower level of Internet access or bandwidth capability.

Internet Connection Speed
Twenty-eight respondents have a T1 or T3 (T-carrier digital transmission line) internet connection (Figure 23). The remaining 42 respondents have varying internet connectivity types, including Digital Subscriber Line (DSL), cable modem, or dial-up modem (56 Kilobits per second or 28Kbps). In the Other category respondents reported use of half of a T1 line, a modem via satellite, or commented that there may be various connection speeds for users.

Figure 22: GISIN members' Internet access and reliability.

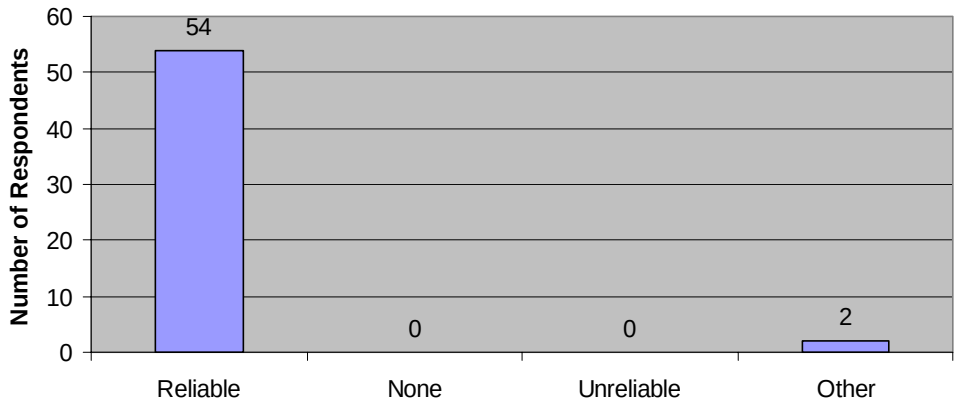
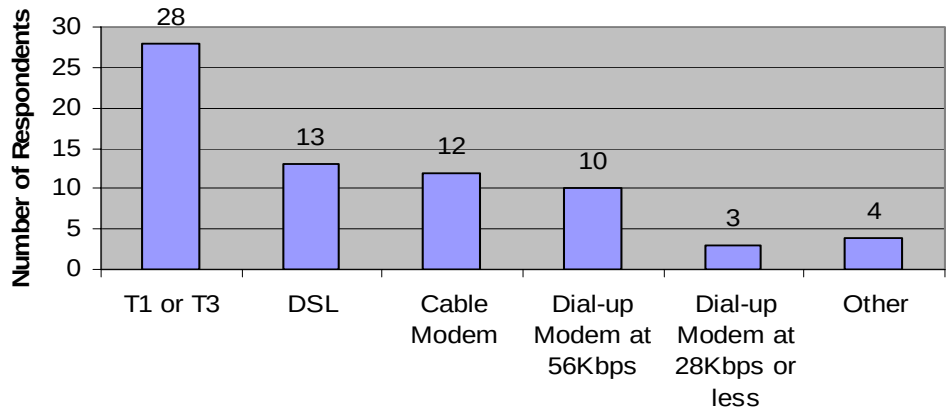


Figure 23: GISIN members' Internet connection speeds.



Important Database Types
Respondents ranked database types with respect to their importance to the GISIN (Table 6). The highest ranked database type was species/taxonomic followed by distributed database systems, geospatial, expertise, images/graphics, bibliographic, and IAS research.

Respondents commented that databases that include both native and non-native complete flora/fauna inventories and species profiles are important since a species that is alien in one place is native in another.

Database Types in Relation to GISIN (1=most important, 7=least important)		
Database Types	**Mode**	**Average**
IAS Species / Taxonomic	1	2.02
IAS Databases in DDSs	1	3.91
IAS Geospatial	2	3.75
IAS Expertise	3	4.45
IAS Image / Graphics	4	4.66
IAS Bibliographic	5	4.52
IAS research	6	4.64

Table 6: A ranking of database types with respect to their importance to the GISIN.

Survey 4 - Evaluation of Surveys
Sixteen respondents evaluated all of the surveys, three evaluated the Online Database Survey, four evaluated the Database Content Survey, and four evaluated the Database Development and Technology Survey.

Survey Applicability
Respondents indicated that the surveys addressed IAS database and GISIN-related issues, including data and database-related issues/goals of the Global Invasive Species Collaborative Forum adequately, well, or very well (Figure 24). No respondents chose the *not at all*, *inadequately*, or *extremely well* options.

Survey Length
Thirteen respondents indicated that the length of the surveys was just right overall while three respondents reported that the surveys were too long (Figure 25).

Future Discussion Topics
Nineteen of the 22 individual respondents that completed this survey made suggestions for future surveys, including:

- Who are the expected users or target audiences for GISIN?;

Figure 24: Evaluation of GISIN survey applicability by GISIN members.

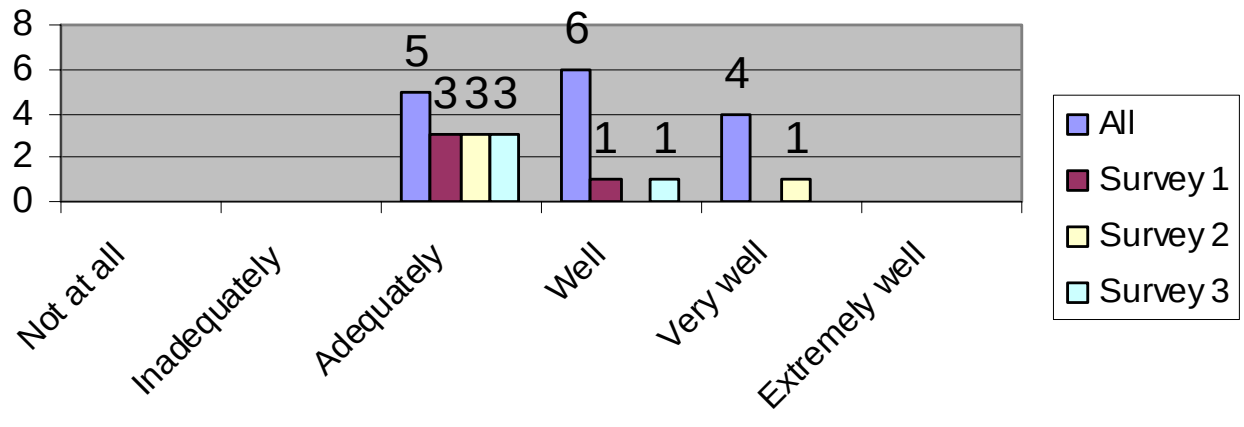
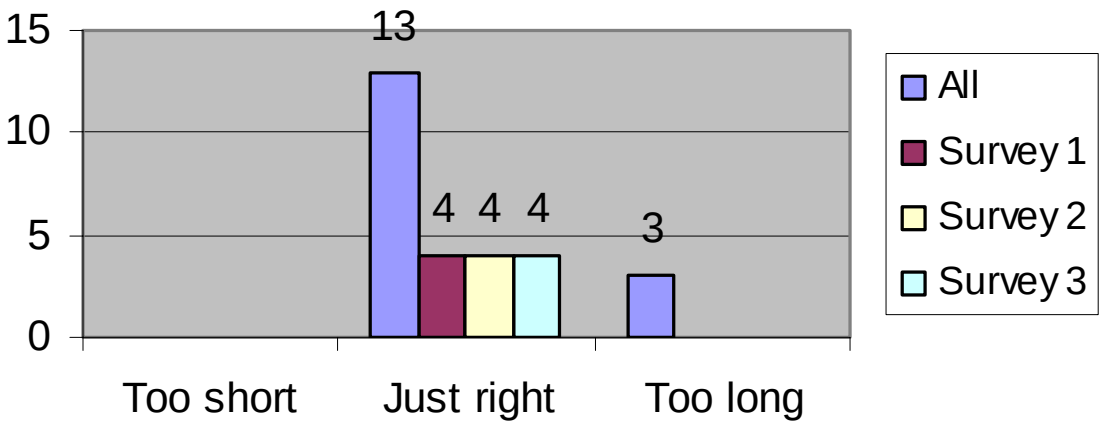


Figure 25: Evaluation of GISIN survey lengths by GISIN members.



- Legal issues;
- Security of IAS and quarantine interception data and the potential for misunderstandings resulting in trade barriers, e.g., specimen details of previously eradicated IAS or single IAS specimens intercepted in ports;
- Can countries ever agree to share IAS interception databases? For example, country A may impose phytosanitary measures on imports from country B based on interception records from country C;
- Questions regarding actual standards;
- Details on technical expertise (knowledge of XML, web services, dynamic web pages);
- Who is using the currently available database software?;
- Meta-data for distribution maps;
- Languages used in databases;
- Funding source identification;
- Data modeling.

DISCUSSION

The GISIN Community surveys were used in part to develop the agenda and establish appropriate breakout groups for the GISIN meeting.

The first step in this process was to determine a baseline of information beginning with compatible technology and infrastructure. In this day of high-speed internet and ever developing tools, applications, and enhancements, it was not surprising that obtaining a stable internet connection speed or internet connection availability were not considered limitations for the respondents to this survey. However, this is not to diminish the fact that different speed and connectivity rates do exist among the GISIN community and can cause difficulties at times. In addition, the majority of respondents had compatible infrastructure: most respondents are using

IBM-compatible personal computers with Microsoft operating systems and Internet Explorer 5x or higher as their browser application. While this may not seem important for examining database content and development, since different browsers react differently to code and often function differently in production of web interfaces (as well as usability), for collaboration purposes, it is a useful piece of information.

Most of the databases represented are publicly available, serve their data in HTML, and are available in English (which is not surprising, because these surveys were conducted in English). However, it is interesting that although Hindustani is one of the top 5 spoken languages in the world (CIA 2004; Global Reach 2004), none of the respondents' databases have data or datasets available in that language. This begs the question, "Are IAS databases written in Hindustani?" and assuming they are, "How do we facilitate collaboration and translate this information?"

Many of the databases represented received sponsorship from a national entity and therefore were nationally focused. In addition, most of the respondents were the actual developers of the databases. It is hoped this will facilitate collaboration, since the developers are intimately involved in the knowledge and working of the databases. Almost half of the respondents indicated current on-going collaboration, and after this meeting it is expected that number has increased.

The IAS databases represented focused on species, offered national coverage, and included information on distribution, taxonomic structure, and biological and ecological information. The surveys did not delve into the details of database structures or the individual definitions of fields that need to be compatible in order to achieve data exchange. This may be the topic of a future survey.

Although roughly a third of respondents indicated that they are using ITIS as a taxonomic standard, it was shocking to discover that more than a third do not reference *any* taxonomic standard. Taxonomies may vary between countries and sometimes between regions within one country, which can cause confusion and misinformation.

For successful collaboration and exchange of information, the ability to cross-walk between GISIN standards is imperative. This was recognized by respondents, who agreed that one of the top future development issues is 'standards.' Agreement and voluntary compliance with taxonomic standards, nomenclature, and well documented cross-walks are needed to assure the success of GISIN. Data cannot be exchanged in a meaningful way unless the relationship between the fields of different information systems is understood and clearly documented.

Respondents indicated that the most important search criterion was "scientific name" and the most important search results "fact sheets / species profiles." Instead of being specifically focused on serving one or two data types, these results indicate that the databases are including as much information as they can in the species records. Fact Sheets are seen as the all inclusive report on a species that by definition should include a summary of all known/available information on that species.

It is interesting that interactive maps were more commonly included in the information systems than were non-interactive maps, which indicates a high level of GIS development. However, the information types "research" and "expertise" were towards the bottom of the list in spite of being labeled as "existing resources that should be built upon" by the CBD. Genetic information is also under-represented, but it is interesting that it is represented at all, given the fact that geneticists are very rarely

involved in invasive species science. Genetics is definitely becoming increasingly important to invasive species. There is a common fear that genetically modified species may become super-invaders, and at the other end of the spectrum, the same technology may create highly specific biological control agents to combat invasions. And from a taxonomic point of view, global consensus about species identifications may be reached through advances in genetic sequencing – the use of unique genetic IDs for species may eliminate the whole name problem.

Any future survey on IAS information management should also include a question requesting respondents to prioritize and add to a list of generic IAS fact sheet field names and their definitions. Composite fact sheets cannot be created unless the data entry fields in contributing information systems are populated with agreed-upon information that would be included in a fact sheet. Respondents were not provided with an opportunity to fully define a fact sheet, species profile or occurrence report. However, a sample species fact sheet or profile could be developed based on the ranking of survey questions and the information provided by respondents in the *Other* categories. Many organizations are beginning to create information fact sheets such as "Plant Invaders of the Mid-Atlantic Natural Areas," published by the United States National Park Service and United States Fish and Wildlife Service at http://www.nps.gov/plants/alien/pubs/midatlantic/index.htm (NPS 2004). In this example, an important field is native alternatives, since many of the invasive species listed in this publication are garden ornamentals that the public are hesitant to remove without replanting something else in its place.

A term used in the surveys that needs definition is "expertise." The non-technical limitation results suggest that (after solving funding issues) programming and database design with biological/ecological interest/skills/experience would be valued more than IAS experts. The need for a true collaboration effort across fields that traditionally have not joined is again reiterated (IT and IAS science). The world of genetics and medicine has learned from each other and their efforts to store and share information. Cross-cutting issues like IAS can only be successfully dealt with through strong collaboration and inter-disciplinary science.

When respondents ranked database types in importance to GISIN, this ties in again with the point that ‘research’ is ranked lower than just plan ‘information’ about a species. A database type that was ranked highly was 'geospatial,' and 'distribution' is highest among current database information types.

Although this survey and the GISIN meeting focus on IAS data, databases, and DDS, we need to remember that what is invasive in one place is native somewhere. Sharing detailed fact sheet information about species where they are native may be very helpful toward possible management techniques where they are invasive. This approach to invasive species control can only be achieved through extensive collaboration among nations.

CONCLUSION

Extensive similarity in infrastructure and technology exists among the participants of this survey. Issues that must be addressed in order to achieve successful collaboration among IAS information systems are identification of funding sources, establishment of common standards, and agreement on, or cross-walking of, clear taxonomic information. Strong collaboration across disciplines is required to achieve global success in invasive species information management.

To increase the usability of an IAS database, emphasis should be placed on the identification of species, information and

references about the species, and metadata regarding who, when, and where data is recorded. Comprehensive fact sheets or species profiles were considered the best format in which to deliver information on invasive species. However, to have this information shared, a standard structure or content-set of a "fact sheet," will also need to be established.

In completing the surveys, respondents were asked to consider the details and considerations involved in the development of IAS databases and the implementation of a GISIN. The survey results helped to identify some of the needs and priorities of the IAS information management community. Both the survey developers and respondents learned from the experience and have gathered valuable ideas for developing IAS information systems and planning the future program of work for the GISIN.

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Acknowledgement

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Web Services: Who, What, Why, Where, and When?

Robert A. Morris, Professor of Computer Science, University of Massachusetts/Boston, Computer Science Department, 100 Morrissey Blvd, Boston, MA 02466 USA.

Abstract

Database designers cannot know in advance how their data will be used, or what information a user or an application will need to combine with query responses, much less where that information will come from. The Web Services architecture addresses these and other questions that usually do not arise in centralized databases and so supports more robust and extensible systems than monolithic, centralized data repositories. Using current open source or proprietary tools, most of the work of deploying Web Services comes down to reusing the interfaces that already exist between databases and Web browsers, and designing controlled vocabularies to represent the content. Since a controlled vocabulary is desirable in virtually any data sharing architecture, the technical appeal of Web Services is very high. In some environments (e.g. Microsoft.net), the technical burden on the organization deploying the service is very low.

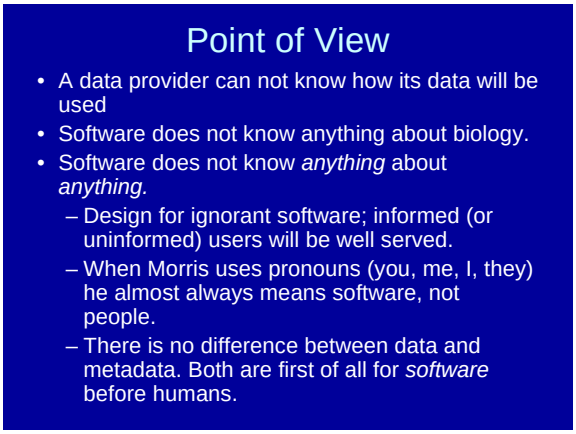
This is a non-technical overview of the answers to the questions of the title as applied to the Web Service architecture, along with how the architecture itself dynamically addresses those same questions for distributed data sources. The huge existing base of Web Service tools and standards offers an appealing way to position GISIN to concentrate more on content and end-user applications than on infrastructure. Its natural fit to a model of open data adds further appeal. This paper briefly outlines what would be necessary for GISIN to be based on the Web Services technologies, and what parts of the GISIN enterprise are *not* in this realm and would have to be accomplished no matter what distributed database environment is implemented.

Introduction

The most important thing for a data provider to understand is that it is impossible to know or predict who is going to use the data and how they are going to use it. The second most important concept to be grasped is the fact that software does not know anything about anything. All software is ignorant, but both informed and uninformed users are nevertheless often well served by such software. A third issue is that it is very difficult to take something that was originally designed for human consumption or interpretation, and put a machine interface on it. It is however very easy to do this in the reverse.

… it is impossible to know or predict who is going to use the data and how they are going to use it.

Finally note that from the informatics point of view, there isn't any difference between data and metadata. They are all treated in the same way.



The aim of this report is not to provide a technical discussion of Web Services. Instead it provides an idea of what the GISIN participants might need to be concerned about including, what they will get out of using Web Services, and how hard it may be to ask data managers to use Web Services.

What is a Web Service?

A web service is any facility on the Web that can answer a question or provide some sort

of result from the activity of a computer somewhere on the Internet. But when referenced with capitalized name it is a Web Service whose query is wrapped up in a software envelope that uses a standard language or Simple Object Access Protocol (SOAP), and which conforms to certain other standards about how the service behaves.

What

- What is a web service?
  - Any facility on the web that can answer a query or provide the result of a computer activity.
- What is a **W**eb **S**ervice?
  - A web service in which the query is wrapped in an envelope using a standard envelope language (SOAP)
  - A method of registering Web Services
  - A method of querying registries for registered Web Services. This method is itself a Web Service!

Web Service protocols also offer a method of registering services in a registry, which is thus a sort of database of databases. The registry itself functions as a Web Service.

A web service is any facility on the Web that can answer a question or provide some sort of result from the activity of a computer somewhere on the Internet.

A Web Services Scenario

Consider the scenario in which a researcher asks: "Find the potential plant invaders of the State of Karnataka." The steps to be taken in addressing this include: 1) identifying where Karnataka is (it's a State in India); and 2) establishing potential criteria for 'invasion' (e.g. what are the invasive species in adjacent states?).

Representing Step 2 to a computer is quite difficult. The establishment of criteria for *invasion* is a subject of a lot of research in the domain of the Semantic Web and ontology in relation to invasive species. Jim Quinn (University of California / Davis) has recently received funding to work with Jim Hendler (University of Maryland), one of the inventors of the Semantic Web, to address the question of what it might mean to ask a database for criteria for *invasion*.

Once the criteria for *invasion* have been identified, one must determine what data meet those criteria. So to complete Step 3 one might ask: "Find all of the GISIN databases whose geographic coverage intersects States that are adjacent to Karnataka." The data obtained in Steps 1 and 3 may not be represented by GISIN databases, but rather usually comes from another service such as a Digital Gazetteer (DG).

A scenario and some subscenarios

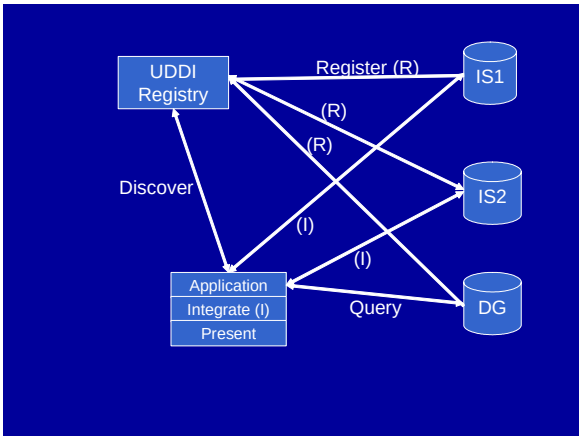
- Find the potential plant invaders of the state of Karnataka
  - Find out where Karnataka is
  - Establish potential criteria for invasion (e.g. "species is in an adjacent state")
  - Find all GISIN databases whose geographic coverage intersects states adjacent to Karnataka
  - Query all
  - Integrate data (e.g. resolve taxonomic names into taxonomic concepts and compare)
  - Present answer

When databases have been identified, they must be queried and compared. In the case of taxonomic names, in the event that two or more databases treat names differently, the names must be resolved into taxonomic concepts because there is no guarantee that because two databases refer to the same scientific name they are referring to the same species. The Global Biodiversity Information Facility (GBIF) and a few large projects in the United States have recently begun to address this particular issue.

Web Services Architecture

The Web Services Architecture diagram below represents the situation where an

application with a user interface (perhaps on a browser or plug-in) is trying to solve a scenario like the Karnataka question. In Web Services, databases register themselves in the Uniform Description, Discovery, and Integration (UDDI) registry (arrows between IS1, IS2, and DG in the Web Services Architecture diagram below). The registry, a database of databases, is populated with enough information to permit applications to discover what kinds of information are contained within each of the databases cataloged by the registry.



The DG would for example register the fact that it is a database that contains information about the geographic footprints of the State of Karnataka. The IS1 and IS2 may register that they contain metadata about basic species in/about India. These databases may not describe what the metadata is, but where to find it. At this point the Application has to perform what's referred to as *discovery*. It has to ask the UDDI registry: "Where are the things that solve my needs?" This is a two step process. The first step is the discovery of the DG data, which the application queries for metadata. The second step is discovery of the actual invasive species data, which the Application also has to query. Once these two steps have been completed, the information has to be combined because in this case, it came from two different sources. That step is called *integration* or you may hear it referred to as *federation of databases*.

It's very important to understand that *integration* or *federation* is not really part of Web Services. The process succeeds or fails on the quality of the information that is contained in the envelope and Web Services has nothing to do with the quality of the results. Web Services are as good at transporting garbage as they are at transporting good quality information.

The last step is to present the results. This may involve delivery to someone viewing a Web browser, or to a software application that is going to perform further operations with the resulting data.

This scenario represents the type of distributed model that Web Services are designed for. Web Services are simply protocols for those parts of the information retrieval process that are represented by the arrows (i.e., registration, discovery, and query). There are other examples of software systems that address the same functions, such as the Distributed Generic Information Retrieval (DiGIR) protocols that have been adopted by GBIF. These systems were stabilized sooner than Web Services so in some cases digital architects chose to implement the simpler DiGIR system over the more powerful Web Services whose infrastructure was incomplete. GBIF has however committed to and begun working on developing Web Services interfaces.

Biologists should not be deterred by the seemingly abstract or technical nature of Web Services. Web Services are meant to be interoperable in that they should not be dependent on the hardware or Web servers that are in the chain of communications. Apache is the manufacturer of the most widely used Web servers on the Web. Microsoft.net has a very similar story in that its Web Services are functionally the same and usually interoperable with the java-based Web Services that Apache has been standardizing.

The envelope language is SOAP. There is also something called the *protocol language*. In the case of Web Services this protocol language is the Web Services Description Language (WSDL), which addresses processes that are not about the envelope or the content of the envelope, but rather the many behind-the-scenes things that occur in the system.

The WSDL is also able to perform the query function – although it need not express what kinds of queries can be made to a Web Services server. This is one of the ways in which Web Services is slightly more powerful than DiGIR. DiGIR is designed to have queries expressed in a specific way (a small extension of Structured Query Language (SQL)). That characteristic simplified the design of DiGIR substantially. Working with this framework does not involve much work on the part of the information manager.

How

- Envelope language is SOAP
- Protocol language is WSDL
  - (analogy: how mail is sorted and delivered based on the envelope and other things independent of the content)
  - WSDL expresses what kinds of queries can be made to the server, where and how to ask and how the content will be returned.
- Content is typically, but not necessarily XML
- Little work for maintainers:
  - Server side: Apache Axis handles all envelope construction, management and delivery of query to middleware, which can be identical to the middleware required for non WS solutions, such as server side support for CGI, JSP, or Javascript.
  - Client side, Apache Web Services Invocation Framework manages all extraction of content from envelope and delivery to the application

If you wish, you might think of it as the *post office*. There's a system called Axis (developed by Apache) that manages the *post office*. One interesting thing about Axis is that the hard work that must be performed by people deploying a Web Service is neither more nor less than the same hard work that must be done if you're using some other mechanism to allow access to your databases. The components on the server side are literally the same as what we call *middle-ware*, which you would use for any other mechanism so there is not much more work involved. On the client side, there is something called *Web Services and Location Framework* that has a similar ability.

…there is a very large base of existing software support for Web Services and they are easy to install.

Why should anyone be interested in Web Services? Firstly there is a very large base of existing software support for Web Services and they are easy to install. Another very important characteristic of Web Services is that they are agnostic with respect to how the information moves. Web Services are not restricted to HyperText Transfer Protocol (HTTP), which is used with browsers. In fact information can even be transported by email.

Accommodating users that do not have permanent connections to the Internet is among the limitations to information exchange being discussed during this meeting. An application based on Web Services infrastructure can be developed to look the same to users without permanent Internet connectivity as it does to those with high speed permanent Internet connectivity except that behind the scenes, an email is sent to the Web Services server and then the answer is returned in the same way. The answer may arrive two days later, rather than 90 seconds later, but there is no difference in the delivery process. Queries could even be made to a compact disc on your own machine.

Why

- Huge base of existing standards-based software support on both server and client side.
- Web Services are transport agnostic: http is not a required transport method, e.g. email, tcp/ip, JMS, …all do fine.
- Routing is supported.
- Scalability, especially for discovery
  - (True of any registry mechanism)
- Reduces federation issues entirely to the content.
  - Biologists: you can run but you can't hide!

Complex routing is supported in that the information does not necessarily need to be obtained directly from the database server. Web Services has a highly scaleable setup, which is especially important in addressing the question of finding out where the information is located and this is more or less true of any registry mechanisms.

Several projects are currently implementing Web Services or include activities related to it. The Science Environment for Ecological Knowledge (SEEK) project is a very large four or five year project, originating at the University of Kansas and involving the inventors of DiGIR. Jim Quinn and Jim Hendler are the Principal Investigators for the Spatial Image Retrieval Engine (SPIRE) project.

In Europe, the Task Group on Access to Biological Collection Data (ABCD) is developing more sophisticated access to collection data than that provided by the Darwin Core schema. The Taxonomic Data Working Group (TDWG) is developing a standard that GBIF will be examining for descriptive data. This standard is concerned with how you describe data. So for example, it makes no attempt to say what a taxon is or what a character is, but rather how you can make shared vocabularies that users, machines especially, can compare to one another.

Some cool projects

- SEEK; James Beach (KU), Matt Jones (NCEAS), Bertram Ludaescher (SDSC)
  - Ecological knowledge management; semantic web; Ecology Metadata Language (EML); predictive distribution modeling; deducing taxonomic concepts (vs. names)
- SPIRE; Jim Quinn (UC Davis), Jim Hendler (UMD)
  - Semantic web; developing a framework for integrating public information on invasive species, biodiversity, vegetation, watershed analysis, and projecting future impacts of growth
- BioCase ABCD; Walter Berendsohn
  - Access to Biological Collections Data (Darwin Core on steroids…)
- TDWG Structure of Descriptive Data (SDD)
  - XML Schema that provides a standardized mechanism for specifying controlled vocabularies about taxa, characters, and identification keys.

Online Alien Species Database: Experience of Regional Cooperation in the Baltic Sea Area

Sergej Olenin, Chief Scientist, Coastal Research and Planning Institute, Klaipeda University, H. Manto 84, Klaipeda, 5808 Lithuania

Abstract

Well-established international co-operation is a prerequisite of any regional initiative, especially in the field of environmental protection. Invasion of alien species is a global problem, which by definition requires international interaction. This paper presents an overview of the successful regional cooperation in the Baltic Sea area, which comprises nine countries with different cultural and political traditions.

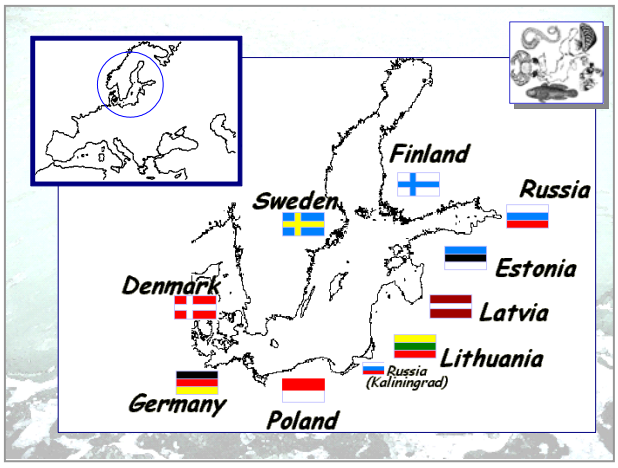
In 1994, the Baltic Marine Biologists (BMB), a scientific non-government organization, established a new Working Group on Non-indigenous Estuarine and Marine Organisms (WG NEMO). In 1997 the BMB WG NEMO created the first version of the online Alien Species Directory. In 2000, with support from the Helsinki Commission (HELCOM), the intergovernmental commission for the protection of the Baltic Sea environment, a new concept of the online database was developed. Now, the online Baltic Sea Alien Species Database is an interactive tool, which includes several information retrieving options. The next step includes development of schemas for continuous updating and fast dissemination of information. The Baltic Database is seen as a regional node in a future global information system on invasive species. The experience of the Baltic international co-operation may be applied in the implementation of GISIN tasks.

Introduction

The Baltic Sea Alien Species Database (http://www.ku.lt/nemo/mainnemo.htm) contains information from the Baltic Sea region, which consists of nine countries with very different historical and political infrastructural backgrounds. The Baltic Sea is a well-studied area and aquatic invasive species were incorporated as a component of the political environmental policy agenda in the mid 1990s. Prior to the 1990s, aquatic invasive species were not recognized as a problem.

Initially, the geographic focus of the project was restricted to the Baltic Sea, but now it goes beyond this and serves as a regional node in the global information system on biological invasions (i.e. GISIN).

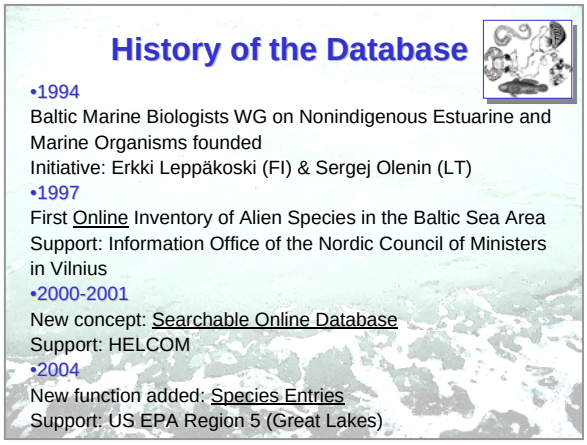
Just over ten years ago, regional cooperation on this issue was established through a research network. It was very quickly decided that a database was needed to meet the goals of providing: a qualified reference system on aquatic alien species for the Baltic Sea area; up to date information on alien species biology, introduction vectors, spread, and environmental and economic impact; and to encourage the exchange of data among different geographical regions. Initially, the geographic focus of the project was restricted to the Baltic Sea, but now it goes beyond this and serves as a regional node in the global information system on biological invasions (i.e. GISIN).



Database Principles

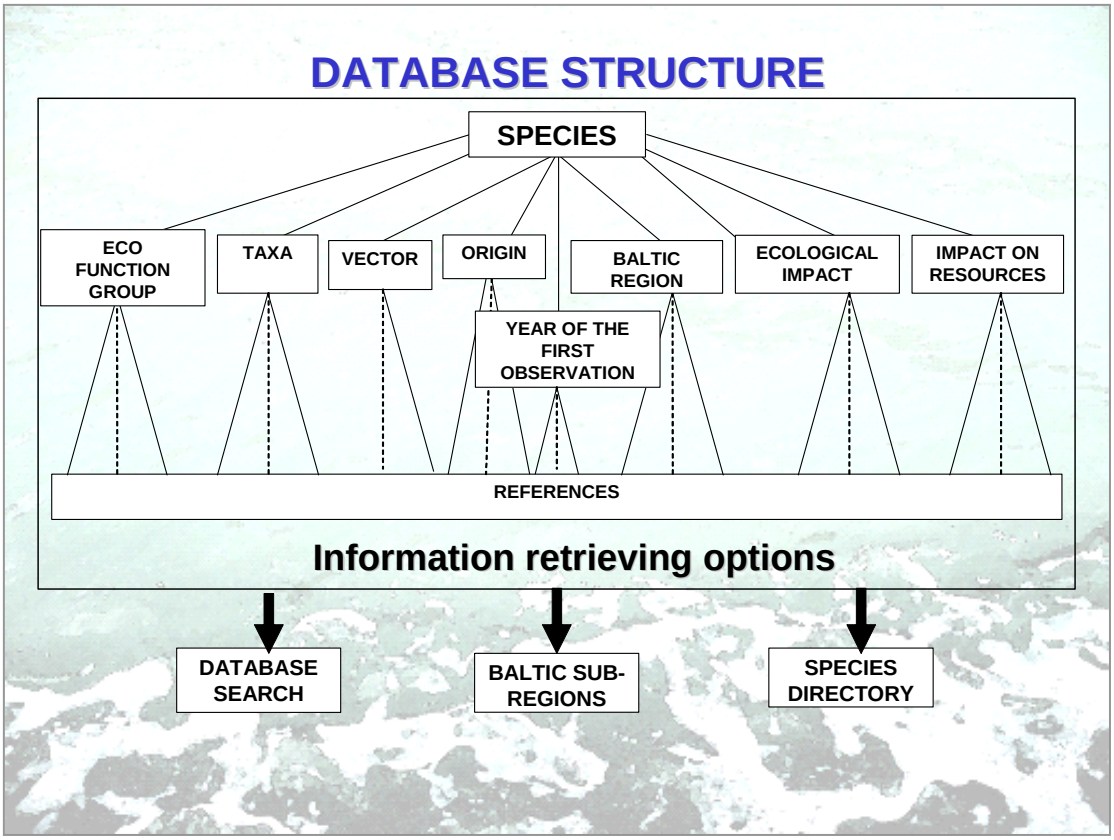
The database is built on the principles of scientific background and information quality to meet the needs of four different kinds of users. It was developed to accommodate potential users from governments, management agencies, shipping and port industries, and scientists and students (academia). The database developers later learned that it was being used by many other types of users that were not necessarily from the Baltic Sea region. Queries have originated from users as far away as New Zealand, Australia, and Canada.

Flexibility is also important. Addition of new regions, species, and impacts etc. to the database should be easy. Other principles upon which the database was built include user-friendliness, support of multiple search options and cross-linking, and of course timely updates. This last principle is largely dependent on the availability of experts.



Database History and Structure

In 1994, the BMB decided to establish a new working group on alien species in the Baltic Sea. In 1997, the first online inventory of alien species appeared on the Web. It included a list of species and some additional information such as year of introduction. Three years later, a new concept was developed – a searchable database on aquatic alien species in Europe.

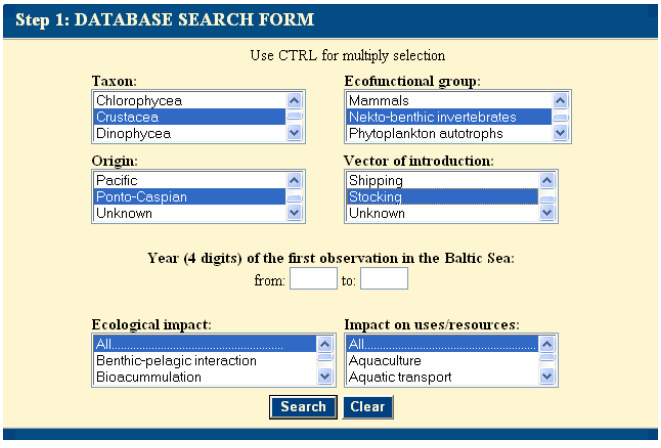


Just a few weeks prior to the April 2004 GISIN meeting a *species entry* option was added. The database's development is however hindered by a lack of funding, and this is a topic that needs to be discussed at this meeting.

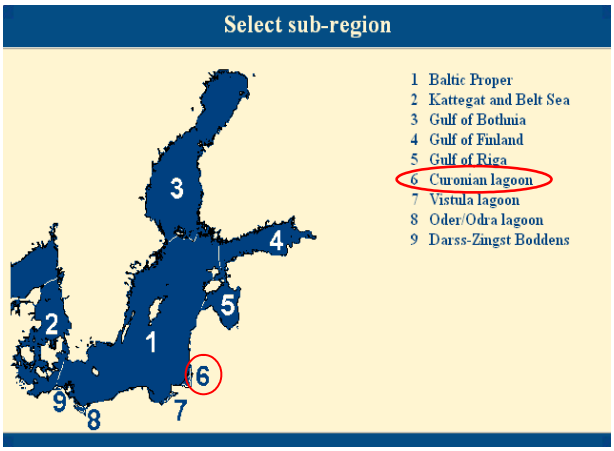
The core component of the database structure is *species*. All of the information in the database is related directly to *species*. There are three information retrieval options– database search, Baltic sub-regions, and a species directory.

The database search allows you to construct your own query. For example, you may be interested in species recorded in the Ponto-Caspian region in a specific year. These search criteria can be submitted using the database search form and a list of species matching those criteria are returned in the results.

You can click on any particular species to view and print out all of the information available for that species, including references. Alternatively, users can access the data through the species directory and click on the species listed there to view available information for each species.



A third option is to search for information by Baltic sub-region. If a user is interested in any particular sub-region they can choose one to view all of the information for species that occur in that area. Information is also available on the environment and invasion history of the area including salinity, temperature regime, and other things that are important for modeling and data analysis.



The references component of the database allows you to search over 300 references in all of the languages of the Baltic Sea region (Finnish, Swedish, Estonian, Latvian etc.). International readers in general cannot read all of these languages so one of the goals of this regional database is to translate and make all of the information available for international users.

The database management system is MySQL. The database resides on a server running the Linux operating system and Apache, and is physically located at the Klaipeda University computer center. PHPMyAdmin is the database administration tool. The database itself is very small. There is no special software involved in its development except for the Internet server that reports to the PHPMyAdmin tool for publishing data.

Further development of the Baltic Sea Alien Species Database

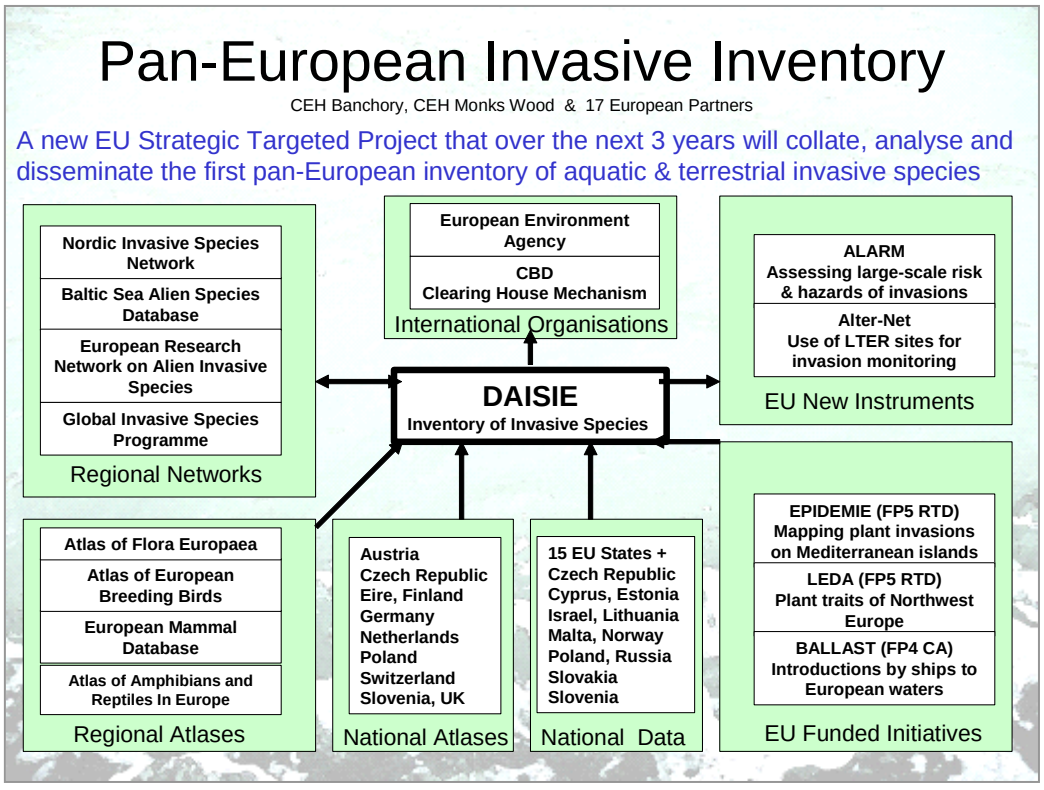
- Increase predictive value of the Database by introducing new searchable features
  - Baltic sub-regions (salinity and temperature ranges, habitat availability, native flora and fauna richness, available invasion corridors)
  - Species traits (salinity, temperature, oxygen tolerance, breeding season, fertility, etc.)
- Creation of new and revision of old individual species entries and sub-region descriptions
- Linkage with the HELCOM biological monitoring and abnormal event early warning systems

Future Database Development

The development team would like to increase the predictive value of the database. It is currently used for vector analysis and to analyze the origins of alien species. A description of all of the Baltic sub-regions in terms of salinity and temperature will allow data to be easily retrieved for species that for example, occur in specific salinity and temperature ranges. Information for invasion corridors and species traits including salinity tolerance, temperature tolerance, and oxygen tolerance will also be added to the database.

The international biological monitoring system in the Baltic Sea region is quite well developed. One of the future tasks will be to link this system to the Baltic Sea Alien Species database so that if someone finds something unusual or different, they can report it and information for that species can be added into the database quickly.

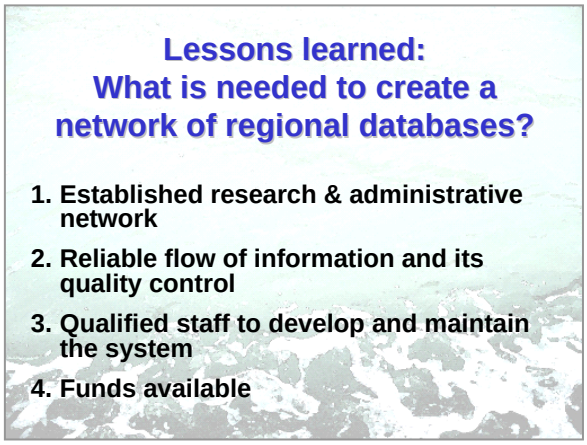
A new project (the Nordic Baltic Network on Invasive Species - NOBANIS) recently launched by the Nordic Council of Ministers, is included in plans for regional and pan-European cooperation. The Global Environment Facility (GEF) Baltic Sea regional project, which includes an invasive species element, has promised to support some of the database's development. The European Union strategic research project DAISIE also aims to *Deliver Alien Invasive Species Inventories for Europe*. It is important for this project to cooperate with the GISIN and to be made aware of the outcomes of this workshop.



Lessons Learned
During the ten years of database development, the team learned that it is very important to establish a research and administrative network that allows researchers around a particular area to get to know each other and communicate regularly. Researchers should meet periodically like the members of the Baltic Sea Working Group, which is convened every 3 to 5 months.

[Database] maintenance requires committed personnel and resources for the long term.

It is also very important to maintain a reliable flow of information and a level of quality control. The Baltic Sea Alien Species Database developers give preference to peer-reviewed papers because they represent relatively reliable information. But they are often also obliged to use data from environmental reports and other sources that may not be as reliable, so there must be a filter in place. The retention of qualified staff to develop and maintain the system should also be a priority.



The Baltic Sea system was developed as a project product, but there must be someone tasked with maintaining the database on a daily basis because there is a lot of new information being gathered that must be quickly processed and incorporated into the database. This lesson, that maintenance requires committed personnel and resources for the long term, is applicable to all regions developing databases on invasive species.

NISbase: A Distributed Database System for Non-indigenous Species Information

Brian Steves[1], Shawn Dalton[2], Pam Fuller[2], and Greg Ruiz[1]

Abstract

During the past decade, many non-indigenous species (NIS) database workshops have been held around the world to discuss NIS data sharing. If you've attended one of these workshops recently, it is likely you have heard terms like "XML" and "distributed databases" touted as a promising way to share our NIS information with each other. With this in mind, NISbase has been developed as a relatively simple Extensible Markup Language (XML)-based distributed database system for NIS information.

Designed by the Smithsonian Environmental Research Center (SERC) and the United States Geological Survey (USGS) and built around existing non-indigenous species databases, NISbase enables end-users to search multiple data providers for information concerning NIS (existing species summaries and collections records) from a single interface.

NISbase currently includes five data providers from the United States and Australia with an emphasis on marine and aquatic NIS. The technical expertise required for participating in NISbase as a data provider has been intentionally kept to a minimum to allow for greater participation. The search portal is also easily implemented, allowing for the potential creation of various regional and thematic NISbase portals.

[1] Marine Invasions Research Laboratory, Smithsonian Environmental Research Center, 647 Contees Wharf Rd, P.O. Box 28, Edgewater, MD, USA, 21037
[2] Nonindigenous Aquatic Species Program, United States Geological Survey, Center for Aquatic Resources Studies, 7920 NW 71st Street, Gainesville, FL, USA, 32653

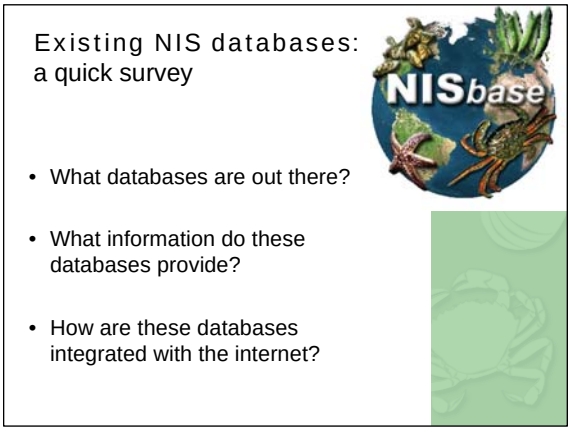
Introduction

The NISbase or Nonindigenous Species database (http://www.nisbase.org) is a distributed database system (DDS) that approaches the idea of Web Services at a very low technical level. It is built on existing nonindigenous species databases.

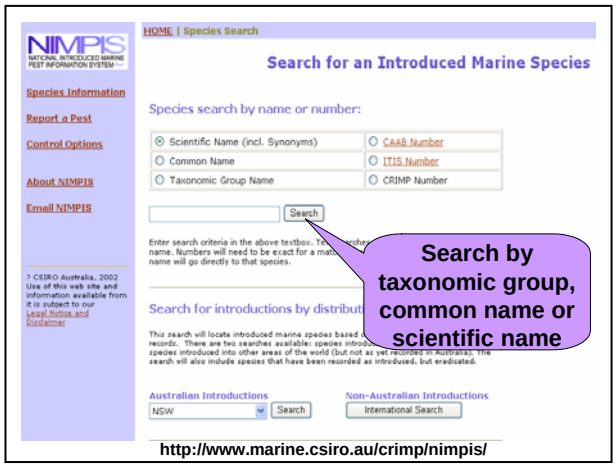
The project began with the Smithsonian's National Exotic Marine Estuarine Species Information System (NEMESIS) (http://invasions.si.edu/nemesis/index.html). This system is served on the Web and includes a search form that allows users to search for information by taxonomic group, common name, or part of a scientific name. The results are displayed in a HyperText Markup Language (HTML) table that usually contains a list of species and links to species summary pages.

The technical expertise required for participating in NISbase as a data provider has been intentionally kept to a minimum to allow for greater participation.

Once an alliance between USGS' Nonindigenous Aquatic Species (NAS) database (http://nas.er.usgs.gov/queries/default.asp) and the Smithsonian's NEMESIS database was established, other international online databases were sought that provide the same types of information and use a similar approach/structure to that of the NEMESIS.



An examination of other databases such as the Australian National Introduced Marine Pest Information System (NIMPIS) (http://www.marine.csiro.au/crimp/nimpis/), led to the conclusion that the structure used for NEMESIS and the NAS database is quite common.



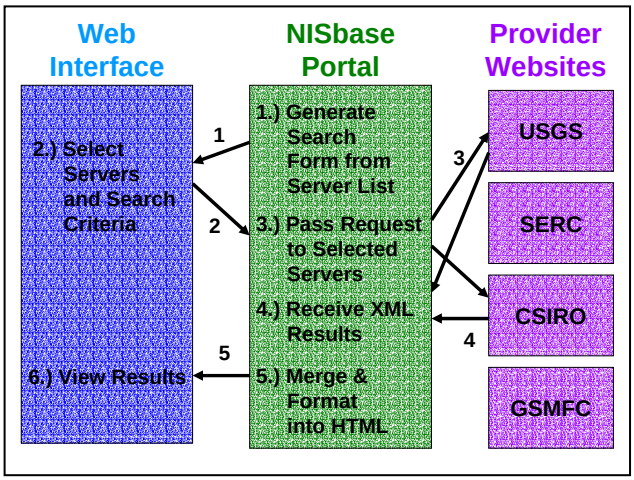
http://www.marine.csiro.au/crimp/nimpis/

The question of how these similar information systems, NEMESIS and NIMPIS, could be made interoperable (linked as a distributed system) was then addressed. A single form was designed to search the same parameters in multiple databases and display the combined results in a single HTML table. This simple approach is analogous with that of travel booking Web sites like Expedia or Orbitz, where customers can compare and select flights from multiple airline companies through a single access point. The more time-consuming alternative of accessing each airline company's Web site separately and repeating the same search for prices, availability etc. would provide the same results that are displayed by a single search on Expedia.

Thus for efficiency's sake, a DDS appeared to be the best approach for NIS information as well. The data that would be searched would include species lists, fact sheets, and some collection records. Given the popularity of XML at the time, it was chosen as the programming language for implementing a DDS. The advantage of using XML is that it makes implementation of a DDS simple, and it doesn't require extensive funding or the services of a full time java programmer, for example.

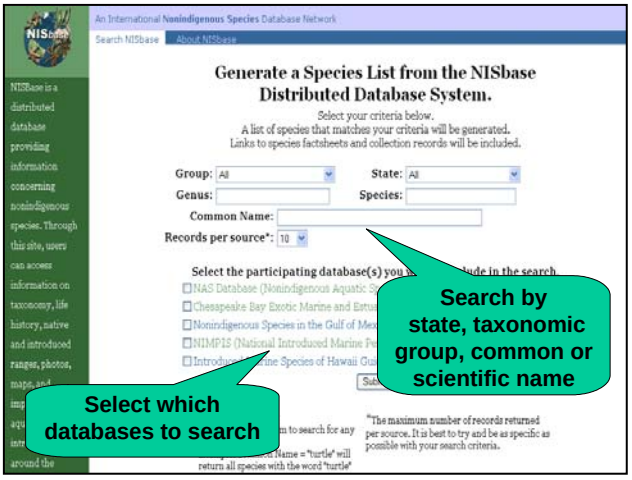
XML can be used as an object to perform data-binding and automatic XML-output functions can be used on some of the higher end databases. XML can also be treated as text and used as a very basic method of generating an HTML table from a database. The search form passes parameters to a scripting page, which generates a query statement to the database. A connection is made to the database, a record set matching the search criteria is retrieved, and for each record a row in the table is populated with the corresponding values. The operator then disconnects from the database. Thus, if an existing database currently operates by adding simple XML tags to their data table (i.e. rather than generating an HTML table) and places the data within those tags, then XML is created. The only additional information needed is the knowledge of how to create a table in HTML.

NISbase has three tiers of operation. The first tier is the Web Interface, which is the user interface. The second tier is the portal software, which does most of the work, and the third tier is the various data providers that are accepting the queries and providing the data.



The portal generates a search form from a list of servers. That list of servers is in an XML file with a list of data sources as well as some basic metadata relating to them. For example, the metadata may describe the USGS' database; a uniform resource locator for the search page; a link to the USGS logo; that it's a freshwater database for animals all over the USA; and that it contains fact sheets, citation records, images, and maps.

On the NISbase search page, that XML for the servers is transformed into an HTML table with check-boxes that allow users to select which database they wish to search. Links are provided for accessing each individual database, and their metadata is displayed if the mouse is hovered over their names. The user submits search criteria that the Web page passes to the portal, which in turn passes them to the selected databases. The online data providers return the results as XML.



Each taxa record returned by a database contains a scientific name, taxonomic group, and in some cases a URL to a species collection. In the portal, this information is gathered from the various providers, merged, and converted into an HTML table. The user can then view the results and follow any associated links through the interface. The information returned for a species can also include things like Google images and appropriate links to the Integrated Taxonomic Information System (ITIS).

If species summaries could be standardized and put into an XML format, we could integrate one mega-fact sheet from multiple sources so that users would not have to follow links to access the information.

So what is next for NISbase? The team wants to add more searchable queries to the database, much like those that the Baltic Sea Alien Species Database currently has, allowing searches by habitat, vector, or source region. They'd also like to see a standard developed for species summaries (species profiles). If species summaries could be standardized and put into an XML format, we could integrate one mega-fact sheet from multiple sources so that users would not have to follow links to access the information. It would all be merged and displayed on one species summary page.

NISbase is also adding more data providers to the current group of five and investigating the possibility of becoming a Web Service so that new collaborators (databases) would not have to use the portal page. The parameters could be passed directly from the interface to the database and the XML could be retrieved and used in unlimited ways. And finally, the Distributed Generic Information Retrieval (DiGIR) protocol may soon be implemented in NISbase.

DiGIR is currently being developed using the Darwin Core standard for museum collections. With NISbase, and as the case may be with the GISIN, there are ways to modify the protocols that are being used for museum records so that they are applicable to nonindigenous species records. The Darwin Core can be extended, or a new schema can be created. NISbase is working

on a DiGIR-like structure, customized for nonindigenous species by adding relevant fields (e.g. introduction status, population status, and pathway). Additional information about the system is available online at http://www.NISbase.org.

European Research Network on Aquatic Invasive Species (ERNAIS)

Vadim E. Panov [1] and Stephan Gollasch [2]

Abstract

The importance of international cooperation on the invasive species issue on both the regional (Pan-European) and sub-regional levels is well recognized by the European scientific community. The European Strategy on Invasive Alien Species, adopted under the Bern Convention in December 2003, aims to promote the development and implementation of coordinated measures and cooperative efforts throughout Europe to prevent or minimize adverse impacts of invasive alien species (IAS), including regional and sub-regional cooperation in exchange of information.

European cooperation relevant to aquatic species invasions resulted in the establishment in 2001 of the European Research Network on Aquatic Invasive Species (ERNAIS),[13] which currently includes more than 100 experts (scientists, managers, and administrators) from 27 countries. The searchable online ERNAIS experts database is available online at http://www.zin.ru/projects/invasions/gaas/ernaisdb.asp. Facilitation of international cooperation in research, scientific information exchange, and management of aquatic invasive species in Europe and worldwide is a main objective of ERNAIS.

The future ERNAIS priority objectives include facilitation of development of the subregional thematic networks/information hubs (Nordic/Baltic, Mediterranean, Ponto-Caspian etc.) and, in long-term perspective, integration into the Global Invasive Species Information Network (GISIN) via development of the European Information Network on invasive alien species, based on subregional information hubs.

[1] Coordinator, Regional Biological Invasions Centre Information System, Zoological Institute of the Russian Academy of Sciences, Universitetskaya Nab.1, 199034 St.Petersburg, Russia
[2] (Presenter) Senior Scientist, GoConsult, Bahrenfelder Str. 73 a, Hamburg, 22765 Germany

[13] http://www.zin.ru/rbic/projects/ernais/

Introduction

The European Research Network on Aquatic and Invasive Species (ERNAIS) (http://www.zin.ru/projects/invasions/gaas/ernaisdb.asp) is mainly a database of scientists.

History of ERNAIS

1999 - first discussion on the idea of ERNAIS, 16th BMB meeting in Klaipeda, Lithuania.

2001 - SIL WGAIS and BMB WG NEMO initiated a broad discussion of the ERNAIS concept, sending electronic "call for cooperation" to the known European experts. Finally virtual network was created: ERNAIS web site was open, listing around 50 experts by the end of 2001.

2002 - searchable on-line ERNAIS experts database was created, which included information on 101 experts from 27 countries by the end of 2003.

In 2002, the ERNAIS was first recognized by EC (see EC Report 2 to CBD 2002. Thematic Report on Alien Invasive Species).

In late 2003, role of ERNAIS in European cooperation on invasive alien species has been recognized by the European Strategy on Invasive Alien Species, adopted under the Bern Convention on Dec. 1, 2003.

Starting in 1999, the initiative was stimulated by the Baltic Marine Biologist initiative referred to in the report on the Baltic Sea Alien Species Database. When the Baltic Database on introduced species became available, the question was asked, "Who should be approached in the event that a new invader is identified?" So a database was created of all European experts that agreed to be responsible for certain invaders or invasion vectors. ERNAIS has since received the honor of being recognized by the European Commission.

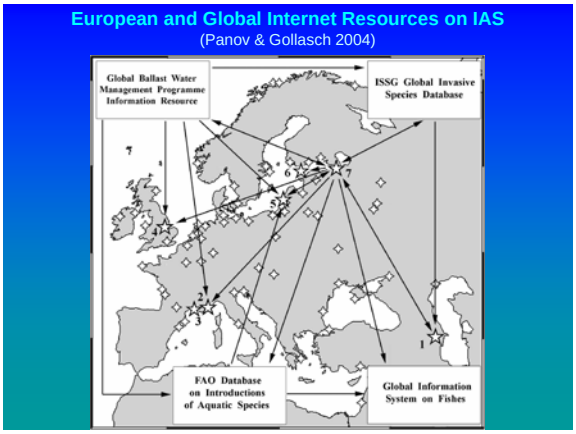
Structure and Content

ERNAIS is hosted by the Regional Biological Invasions Center (RBIC) in Russia. The RBIC also draws on the resources of several other data providers including the World Conservation Union Species Survival Commission Invasive Species Specialist Group's (IUCN-SSC ISSG) Global Invasive Species Database (http://www.issg.org/database/welcome/); the Global Ballast (GloBallast) Water Management Program Information Resource

(http://globallast.imo.org/index.asp?page=search_library.asp) that refers to the International Maritime Organization (IMO) initiative on ballast water; the Food and Agriculture Organization (FAO) Database on Introductions of Aquatic Species (DIAS) (http://www.fao.org/figis/servlet/static?dom=root&xml=Introsp/introsp_s.xml); and the Global Information System on Fishes (FISHbase) (http://www.fishbase.org).

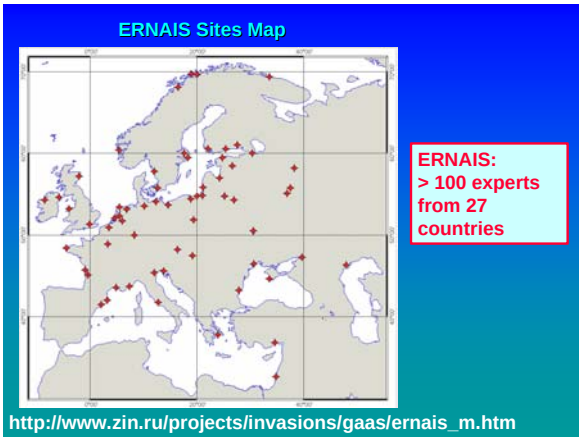
… the project has gathered information for 101 experts in ERNAIS from 27 European countries.

So far, the project has gathered information for 101 experts in ERNAIS from 27 European countries. The overall objective of ERNAIS is to facilitate cooperation and research, exchange of scientific data, and management to avoid the overlap of research initiatives and the duplication of effort in order to spend research money more efficiently.



The ERNAIS seeks to create a network to exchange information on port and ballast water studies, but is not focused only on ballast water and shipping vectors. However, shipping is recognized by the project as an extraordinary vector for species invasions world-wide that is becoming more and more prominent.

The ERNAIS Sites Map illustrates the various origins of the registered scientists that create a truly European-wide coverage in expertise. Scientists are registered in places as far south as Turkey, Israel, the Black Sea, the Caspian Sea, and from the North and Baltic Seas. In addition to containing information on researchers, the system also includes data on regional inventories of invaders, selected invaders in the area, and Geographic Information System (GIS) data or distribution information of certain invaders where available. To query the database, users can select year and region criteria.



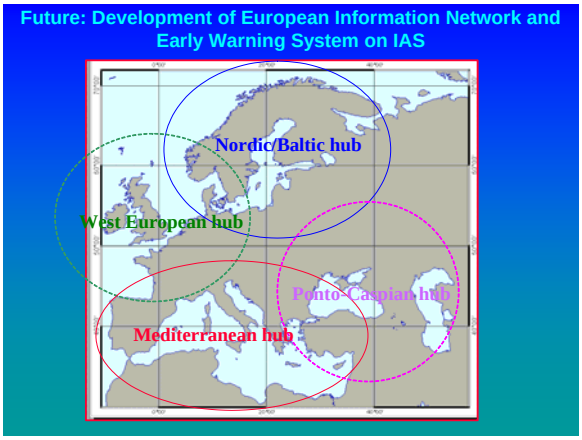
ERNAIS and GISIN

In the future the ERNAIS will facilitate development of subregional thematic networks and information hubs. The long term overall objective is to integrate ERNAIS into the GISIN network via the development, for example, of a European information network on exotic species, based on subregional information. The idea of this initiative is to identify regional information hubs, which may present quite a challenge in Europe in comparison to other continents. There are several seas in Europe. Each of these seas and the nations surrounding them are unique in their own way.

An information hub is needed for the Baltic region, and the Baltic database in Klaipeda, Lithuania should be considered for this position. An information hub representing

the Mediterranean Sea is available in the form of the International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM) Atlas of Biological Invaders (http://www.ciesm.org/atlas/).

Additional information hubs may be established in the Ponto-Caspian region, the Northwestern European countries around the North Sea, and the Irish Sea region. The ERNAIS team is happy to offer their expertise to help fulfill the need for experts in the IAS information field.



FishBase: A Global Information System on Fishes

Christine Casal, Research Associate, WorldFish Center, WorldFish Center – Philippine Office, Khush Hall, IRRI College, Los Banos, Laguna 4031, Philippines.

Abstract

This global information system includes specific references to non-native and invasive species of fresh water and marine finfish species. Information on the date and pathways of introductions, as well as notes on impact, are provided (where available).

FishBase was conceived in 1987 and developed at the WorldFish Center in collaboration with the Food and Agriculture Organization (FAO) of the United Nations and many other partners, and with support from the European Commission (EC). At first distributed on compact disc, it was Web enabled in 1996.

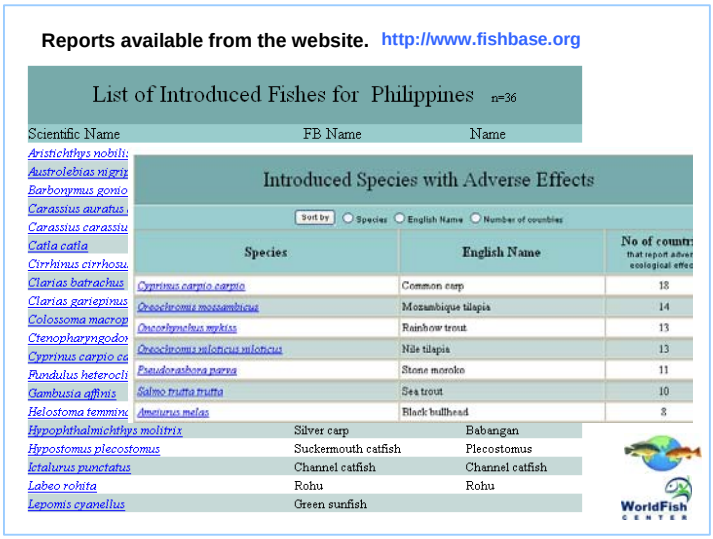
The creation of species profiles for all fish, 28,500+ species, is among the plans for future development, and they will include information related to species invasiveness.

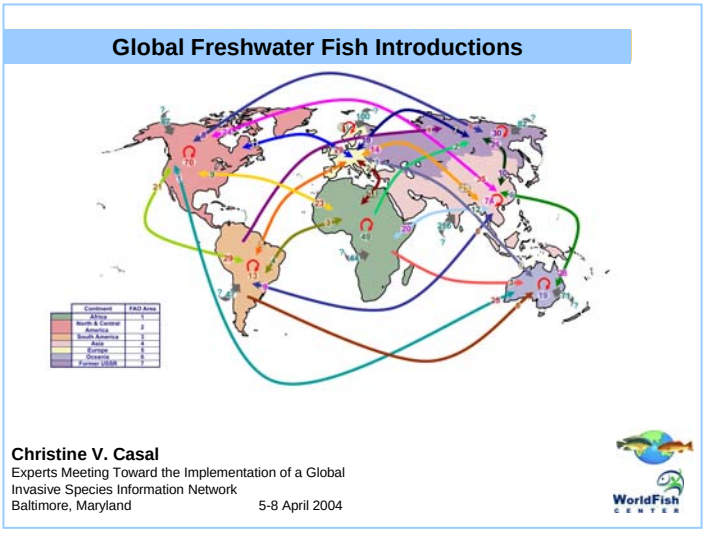
Present

Finfish introductions are documented in FishBase (http://www.fishbase.org), a global information system on finfish. This database includes information on marine and freshwater introductions, invasive as well as non-invasive species, origin and destination of the fish, date and reason for the introduction, and establishment and impact (when data are available).

Reports printed on demand from the FishBase Web site include the list of introduced species by country and a list of species with reported adverse impacts. A global introduction matrix is also available that shows the magnitude of introductions from and to different FAO areas or geographic regions. Information is available in reports showing the number of introduction records and species involved.

Reports available from the website. http://www.fishbase.org





Future

Future development of FishBase includes expansion of the system to include species profiles of all fish species (28,500+ to date). A modified species profile will be provided to include taxonomic information as well as information related to species invasiveness such as habitat, global distribution, temperature and salinity ranges, and species-specific diagnostics for identification, general biological information, reproduction or parental care, productivity, and food requirements. Information such as 'countries where species have been introduced' and references to related databases can be automatically retrieved from FishBase for all species (invasive, newly introduced, and species that are being considered for introduction).

The Global Biodiversity Information Facility and GISIN

Hannu Saarenmaa, Deputy Director for Informatics, Global Biodiversity Information Facility Secretariat, Universitetsparken 15, Copenhagen, 2100 Denmark

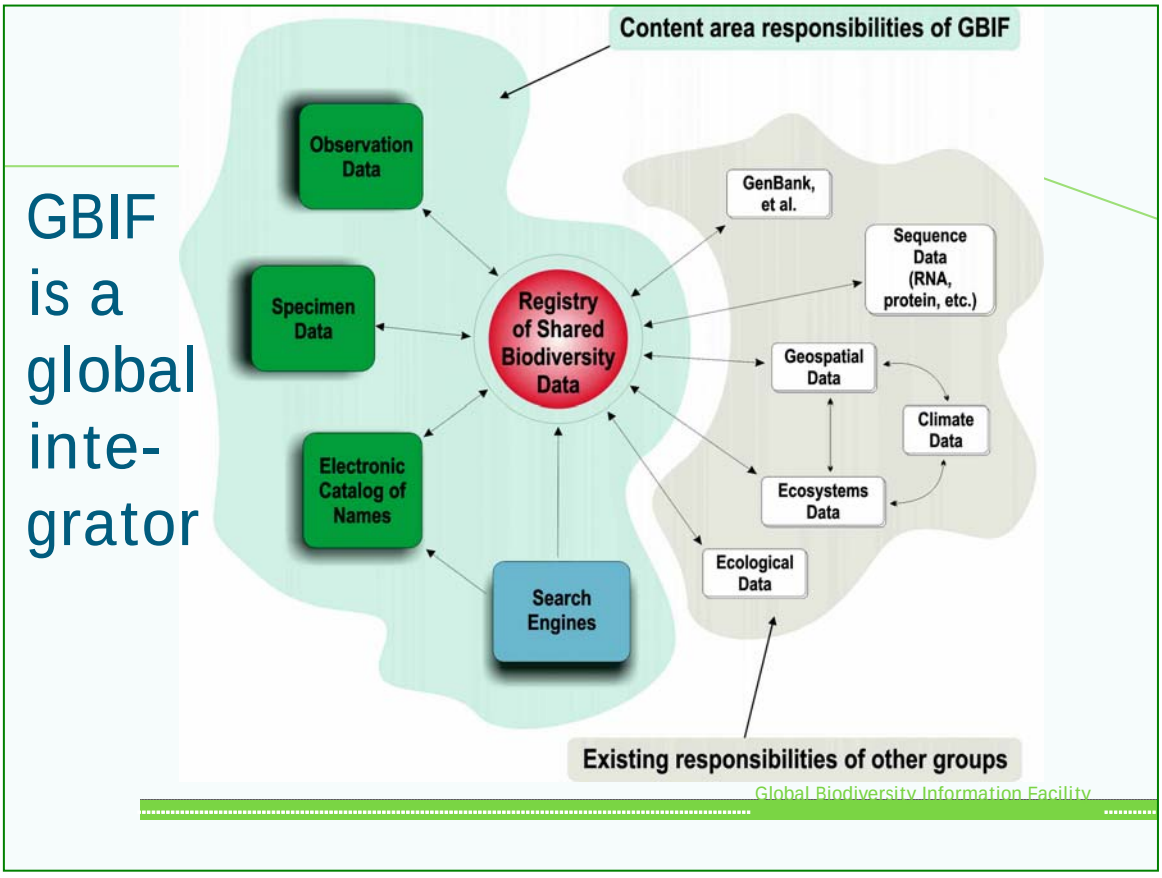
Abstract

The Global Biodiversity Information Facility (GBIF) provides an information infrastructure for biodiversity data. This infrastructure has components such as portals, providers, and a registry. The providers currently only provide "primary biodiversity data" in the Darwin Core format. The Darwin Core is good for expressing things like "a species has been found in a certain place at a certain time". In future other formats and types of data will be included.

All these types of data and protocols are defined in the registry. The providers advertise their data and services there, with entries like "I provide type A data with protocol B." The registry is open for anybody to register their provider, any portal, and search engine to discover the right providers.

Now how does that fit with GISIN? If we look at the data types required (diagnostics, distribution, basic biology, dispersal, impacts, biotic associations, modes of dispersal, control methods, bibliographies, and expert contact information), we realize that distribution is the only one that can be implemented according to the existing Darwin Core today. Diagnostics can soon be covered with Structured Descriptive Data (SDD). For others we need to select/write a data exchange format and protocol, and data provider application.

Technically speaking, GBIF could include all these information/provider types in its registry. This would be like a global phone book of available invasive alien species (IAS) data and information. However, as we are not only talking about biodiversity data but pest control etc., it might be more appropriate that another registry similar to GBIF's is established for IAS. The registries, if made using compatible standardized approaches like Universal Description, Discovery, and Integration (UDDI),



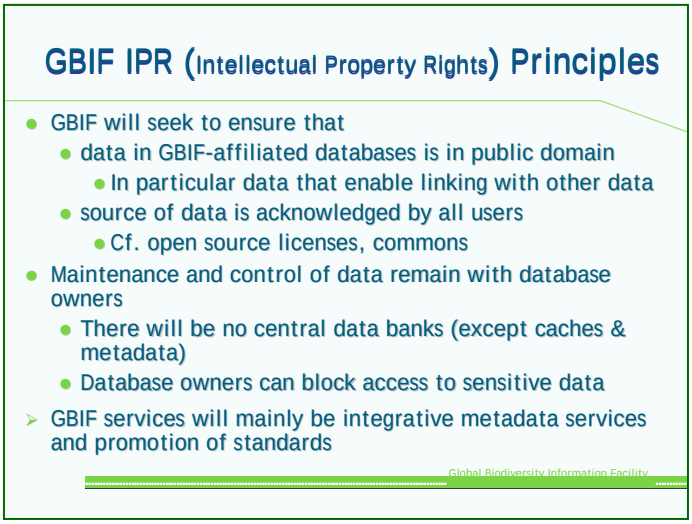
can share their information where needed, like data on distribution and diagnostics. So, one hesitates to include all these information types in GBIF, but GBIF does provide a model for an infrastructure that works and the linkages/data flows between GBIF and GISIN should be strong.

Introduction

The Global Biodiversity Information Facility (GBIF) (http://www.gbif.org) is an international organization with the mission of establishing a distributed information infrastructure for sharing primary biodiversity data or more specifically species and specimen level data, observations, and names etc. The development team also plans to link these data to other levels of information. GBIF's infrastructure primarily serves specimen and observation data, but hopes to incorporate other information types such as genetic, geospatial, and ecosystem data.

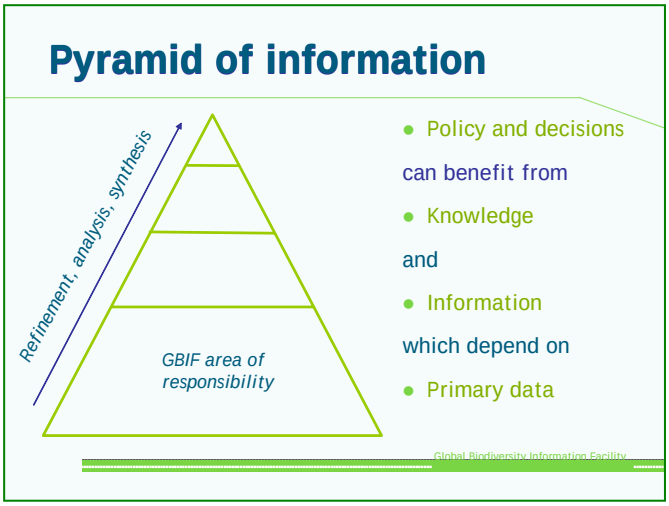
All of these pieces of data must be put in the right place. This placement is achieved through an approach resembling that of an open market place, or a phone book (a directory of shared biodiversity data called the registry) which uses Web Services terminology. GBIF concentrates on the creation and maintenance of this registry while other groups, institutions, initiatives, organizations, and networks work on other components that can then be linked to the GBIF information.

GBIF is very clear on one thing: free and open access to biodiversity information must be assured. The information that is shared through GBIF is publicly available but there are some very important intellectual property rights (IPR) principles that those who wish to share data must understand. GBIF has created the necessary agreements for contributors to sign before they share their data openly through the facility.



Information Types

The relationship between primary data and other types of data can be illustrated in a pyramid. Primary data, which is really observation data for certain species found in a certain place at a certain time, is represented by the base of this pyramid. From this basic information, more refined, aggregated forms of information important for decision makers, such as species home pages and integrated pest management systems, are created.



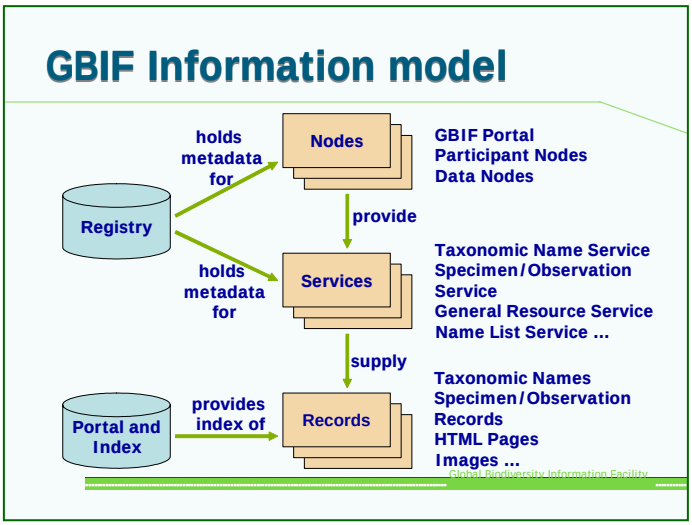
GBIF's activities are currently occurring at the base of the pyramid. Other initiatives like the Clearing House Mechanism might occur at the top level of the pyramid, while

GISIN, having species summary pages and related information, would have a major focus in the middle level. Although GBIF is currently focused on specimen and observation data, scientific names and concepts, it plans to serve species-level aggregated information once a sufficient baseline has been developed with the primary data. GBIF also needs to work on the integration of digital images and literature into the system. At this time, the GBIF team is working mainly on metadata that describes who is providing the information and how.

By recent estimates there are 200 to 300 million digital records of primary biodiversity data existing in the world and among GBIF participants (about 30 or 40 countries). How many of these records are available online today?

Primary data is quite interesting. There are various estimates of the number of specimens in museums and collections worldwide, which are really the foundation for primary data. The estimates range from between one and three billion specimens. Field observations are also important by providing evidence that the species was found in a certain place at a certain time. Recent estimates state there are 200 to 300 million digital records of primary biodiversity data existing in the world among GBIF participants (about 30 or 40 countries). How many of these records are available online today? GBIF has mobilized 18 million records in 47 data providers to date. These integrated and mobilized records shared through GBIF represent just ten percent of the total, but this percentage is quickly growing.

GBIF integrates this data through participants that have agreed to set up nodes. These nodes are gateways to data. They are really the ones that provide the services.



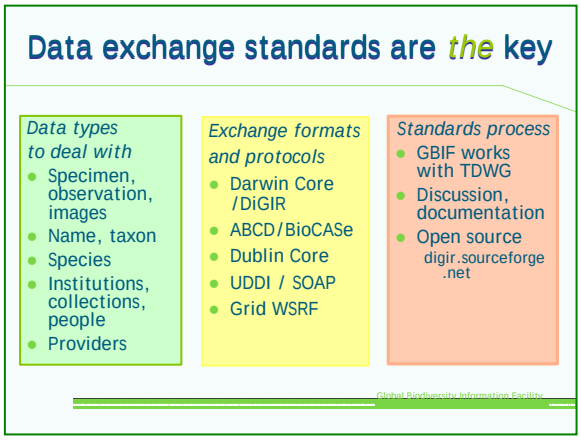
One of these services involves providing access to the 18 million primary biodiversity data records. GBIF has a registry that keeps track of the nodes and their services, and the portal operates as an index that caches and keeps track of the records that all of the providers are servicing. Integration can only occur successfully through an organized structure such as this.

Standards and Protocols

Information exchange standards are the key to a successful organizational infrastructure. Several different types of standards are needed to manage and serve the data through GBIF. The Darwin Core and the Access to Biological Collection Data's (ABCD) standard are two standards that GBIF uses for specimen observation data. The Distributed Generic Information Retrieval (DiGIR) protocol and the more sophisticated Biological Collection Access Service for Europe (BioCASE) protocol define the methods for transporting the data. Data exchange standards such as the Dublin Core keep track of information sources.

GBIF works with the Taxonomic Databases Working Group (TDWG) instead of having its own standards committee, which would be a duplication of effort. GISIN should consider this idea.

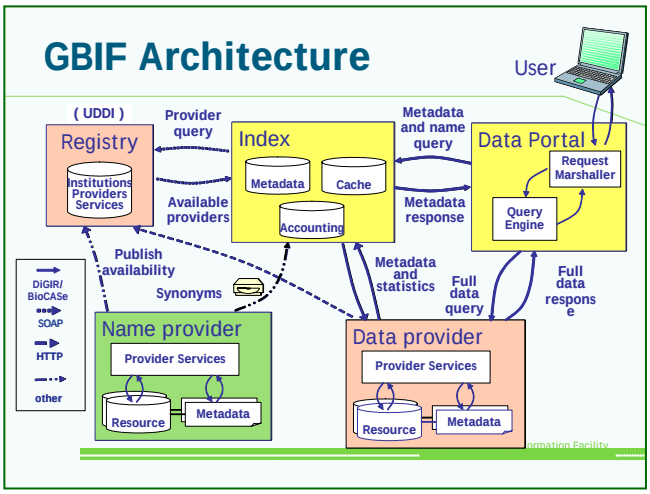
The UDDI Simple Object Access Protocol (SOAP) manages GBIF's registry of institutions, collections, people, and providers. GBIF is also considering the Grid Web Services Resource Framework (WSRF) technology, but it may be several years before it can be applied to the GBIF model.



GBIF also works with the Taxonomic Databases Working Group (TDWG) to create all of these standards. It is very important to have an open standards process where the whole community has ownership. GBIF works with TDWG instead of having its own standards committee, which would be a duplication of effort. GISIN should consider this idea because it will need to agree on standards, on how they are created, and on the processes by which they are created.

GBIF Architecture

GBIF is building a distributed network of databases using a Web Services approach. GBIF did this by starting with the basic Internet and agreeing on Extensible Markup Language (XML)-based messaging (how data is moved from one place to another using the DiGIR protocol); how these services are described using the Web Services description language; how they have been published and discovered using certain standards; and finally how they have been integrated into a portal.

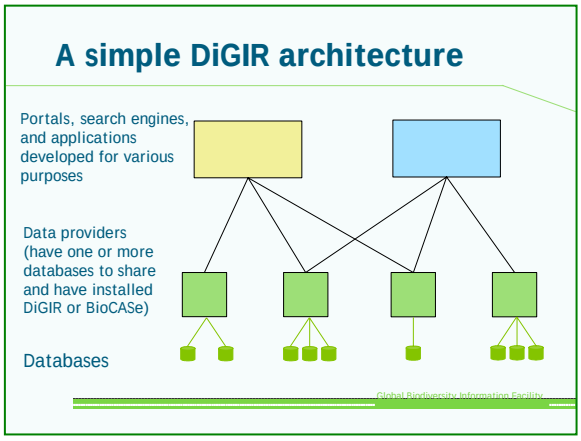


DiGIR is the carrier of GBIF data today, even though the ABCD standard and BioCASE have also been mentioned here. DiGIR is a very simple, yet specialized protocol that is very good at enabling the search and retrieval of structured data.

The protocol allows portal search engines and applications to communicate with data providers. The data providers can link their databases into a provider application, which maps the heterogeneous database structure into a common format and then communicates that with the users.

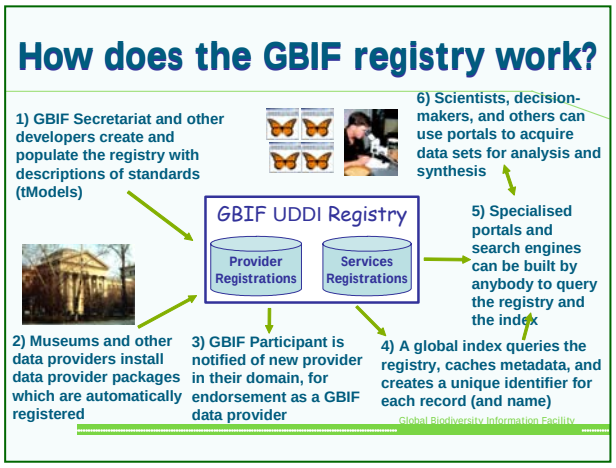
GBIF is however, a bigger and more complicated enterprise, and GBIF doesn't always know who the data providers are. The DiGIR architecture is suitable for one small network, but additional support is needed to develop a network on a global scale. GBIF has the providers, databases, and portals that a small network has, but a registry is a fundamental requirement of its larger network. With a registry, the portal

can be more than just a query engine. It can have its own memory and indexing page, which makes the network easier to use because with multiple data providers (e.g. 160 databases like those in the IAS databases list) there are often times when they are not all online, or online when somebody wants to access their data. So an index or a registry is needed.



Registry

The GBIF registry is populated automatically when new providers are installed. It is based on the UDDI technology and contains a basic directory that lists the institutions, what their services are, and what standards each of their services follows.



The registry can also have additional categories and identifiers for thematic networks, such as those for mammals and aquatic species information. *Invasive species* could be an additional identifier. The registry has open interfaces to portals so anyone can build their portal based on this registry.

The GBIF Secretariat develops the registry, then data providers such as those at museums are populated through the provider registration process. Anybody can register with GBIF, so there needs to be a certain degree of quality control employed at this point. When a new provider is registered, a GBIF participant is asked to make a recommendation for indexing it. If the new provider is not considered to be offering professional biodiversity data, they can be registered with GBIF but not indexed, and consequently their data will not be directly available for others to access through GBIF.

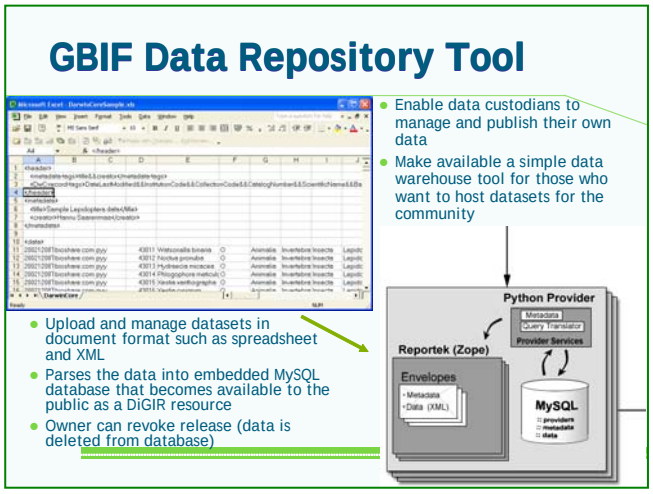
Acceptance of GBIF's data sharing agreement is an important part of the registration process. Registrations are not accepted without an acceptance of the data sharing agreement. There is also a simpler data use agreement that must be accepted by end users in order to download the data.

Data Provider Software

GBIF currently has two DiGIR providers with different implementations and software bases. The classic one comes from the DiGIR project. GBIF has created a *turnkey* package for easy installation so that the DiGIR software can be installed in approximately ten minutes. Mapping a database to the Darwin Core Exchange standard takes slightly more time, but a well-organized database can be mapped in one hour or less. This *turnkey* DiGIR package installs just like any Windows software application.

GBIF also provides another tool called the Data Repository. It allows individuals to upload things like spreadsheets into a Web server where they are automatically parsed and the data goes into a hidden MySQL database, which is then used by another

provider that is searching for information. This tool can provide a data warehouse for individual data providers on one shared Web server. The files are displayed in GBIF's custom folder structure just as they would appear on a file server.



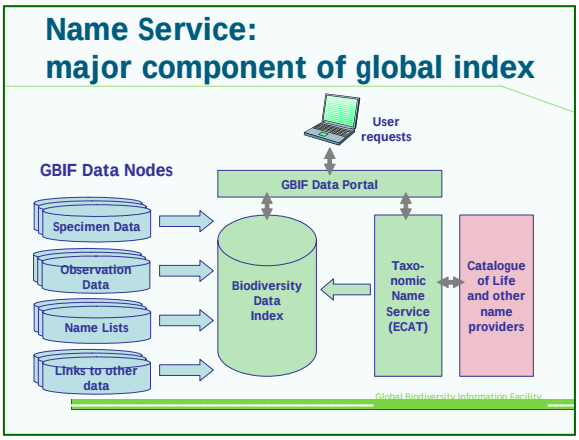
Data Portals

Anybody can write a portal to access GBIF's distributed information resources. Portals integrate all of this distributed data but a portal is not required in order to share data. Most thematic networks and countries want to have their own portals. GBIF has its own multilingual portal, opened just two months ago, that allows users to search/browse data by name, country etc., and to download data. The portal maintains a cache of key data (about 12 of these 47 Darwin Core elements are cached centrally). The software code for the portal will be available in the future.

… when people share their data, they don't have to use the latest scientific name; they can use any name that they happen to have in their database.

GBIF Name Service

An important component of the code is the name service that maps taxonomic names from the Integrated Taxonomic Information System and the catalog-wide partnership against the observation data so that when people share their data they don't have to use the latest scientific name; they can use any name that they happen to have in their database. When users query the data through the portal the information on a species will be retrieved for them, regardless of the name that they queried. This is a simple type of synonym resolution that does not take taxonomic concepts or homonyms into account, but it is quite effective.



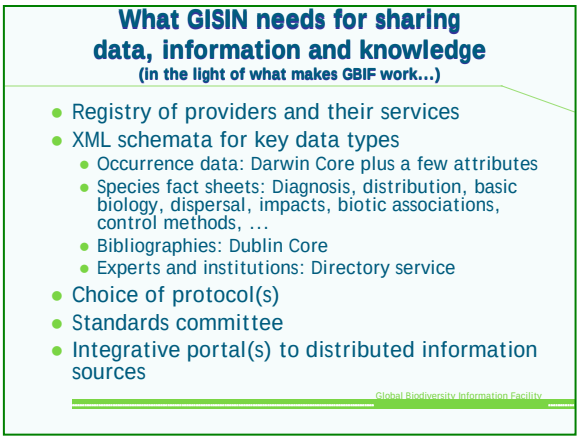
GBIF and GISIN

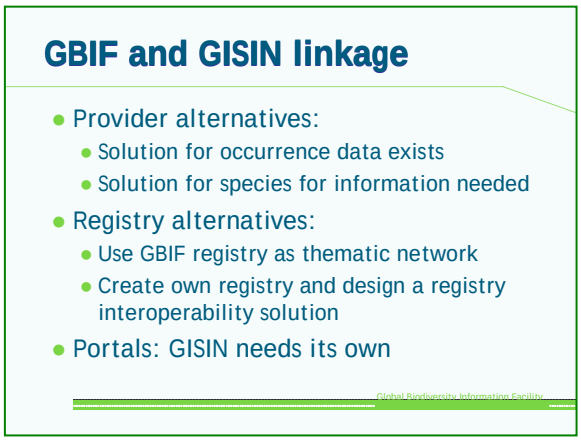
How is the structure of the GBIF network relevant to GISIN? GISIN, or any large network, would need a registry of providers and their services, and an XML schema for exchange of key data types.

There is already a solution for occurrence data – the Darwin Core – but GISIN may need to add something to the Core that is specific to invasive species. Species fact sheets need an XML schema and other information could include bibliographic data and expert directories. Then a data exchange protocol for transporting these data should be selected. GISIN will need to have a standards committee, or like GBIF, an arrangement with TDWG. At least one integrated portal would be needed to provide access to the distributed data sources; possibly many portals. The development of a complex system would

also require an architecture document describing the system traits.
With respect to providers, the solution for handling occurrence data already exists. We need a solution however for species information pages. GBIF's sleeping program (yet to be activated), *Species Bank* is aimed at identifying a solution for this. This program may be activated in 2005 but there are many other groups that are thinking of working on this issue and GISIN could help pioneer this area.

Rather than creating its own registry, GISIN may decide to use the GBIF registry and be identified as a thematic network for GISIN providers serving invasive species information. If GISIN chooses to create its own registry, then GBIF and GISIN will need to ensure interoperability between the registries and agree on methods of sharing information, given the amount of commonality between the two systems. The National Biological Information Infrastructure has a UDDI registry installation that could do this.





The GBIF portal may not necessarily be the right solution for GISIN. There is clearly a need for at least one IAS portal, and perhaps many. Regardless of GISIN's architectural design, it will follow the basic three part organization that GBIF uses, i.e. portal – registry – provider information. GBIF and GISIN have agreed to work together to develop the GISIN architecture.

Discover Life -- Translating Across Standards

John Pickering, Discover Life, University of Georgia, 717A Biological Sciences Boulevard, Athens, GA 20602-2602 USA

Abstract

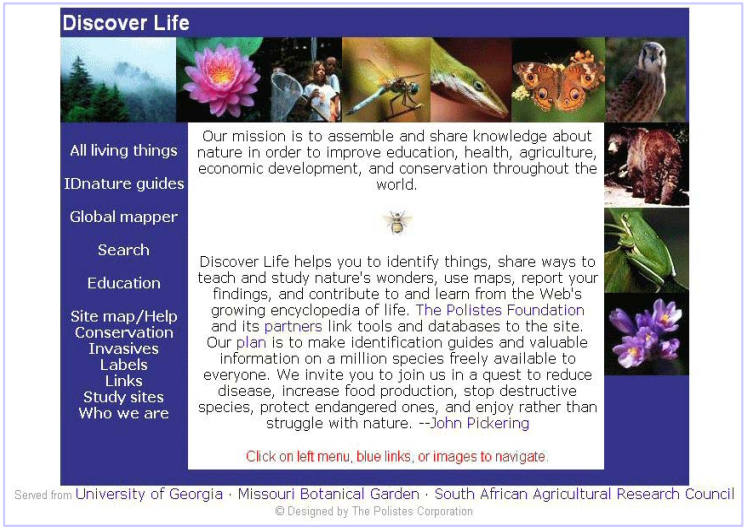
Discover Life, at http://www.discoverlife.org, provides Web tools to assemble, process, and share text and images on invasive and other species. These tools help users to identify, report, database, and map information using most Internet browsers. They are designed to integrate data from numerous sources, require minimal training or technical knowledge to use, and are available to everyone with Web access for free. The philosophy behind their success is that it is much easier to build translators to share data than it is for everyone to adopt one or more new data standards.

With the exception of the Transmission Control Protocol/Internet Protocol (TCP/IP) and other low-level protocols, it is unlikely that new standards will meet all the specific needs of the global invasive species community. Furthermore, because of the high costs of moving from legacy systems, rewriting functions, and retraining personnel, it may be more efficient to integrate existing systems and data structures than to adopt new ones. Discover Life's tools allow users to import data using Web forms and software packages that export HyperText Markup Language (HTML), Extensible Markup Language (XML), RFC822 headers, or flat text files. They support Microsoft Excel, Microsoft Access, and Structured Query Language databases.

This paper will describe how to add, share, and query data with (1) Discover Life's IDnature guides and checklists, (2) its Global Mapper developed in partnership with Topozone.com, (3) a reporting system that supports customized species data entry forms, and (4) a Web-based data manager that uses globally unique identifiers to label specimens and track records. For details please see http://www.discoverlife.org/pa/or/polistes/fe.

Introduction

The Discover Life project at http://www.discoverlife.org began in 1998 with the goal of enabling over 2000 volunteers in the Great Smokey Mountains National Park (United States of America (USA)) to be able to contribute information about species. It became clear however, that for many reasons, the public was unable to help or contribute this type of information. One of the main reasons for this was that the public could not identify most of the species that they found. So Discover Life concentrated on providing identification tools via the online Discover Life system.



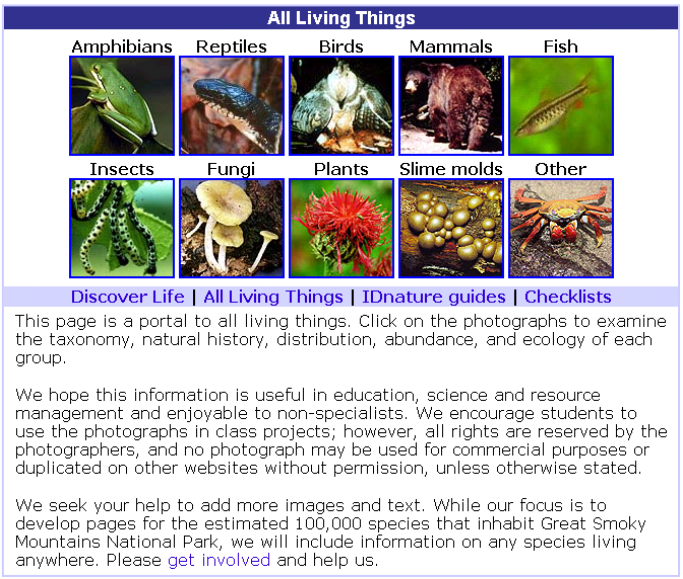
The second main reason why the public could not contribute was that they were unable to put their information into a database. They had no way of reporting their observations electronically. Thus, in addition to the identification tools, the team began to develop online reporting systems with a focus on mapping.

It is much easier to build translators to share data than it is for everyone to adopt one or more new data standards.

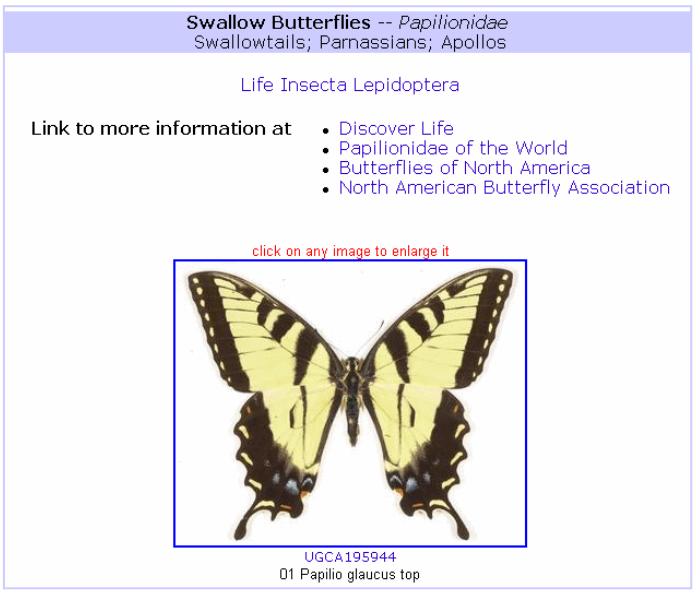
The mission of Discover Life is to assemble and share knowledge about nature in order to improve education, health, agriculture, economic development, and conservation throughout the world. It will do this via the Web with funding and support from many sources, including the National Biological Information Infrastructure's (NBII) contribution to build identification tools. In addition to the six Sun servers at the University of Georgia, because of a gift from Sun Microsystems Inc., we now have a mirror site served by the Missouri Botanical Gardens at http://usmo3.discoverlife.org.

Along with the Smithsonian Institution and other institutions, Discover Life plans to build an encyclopedia of life. Their goal is to provide identification guides and serve information on one million species within ten years. If different groups and individuals agree to work together and use the tools Discover Life now provides, it is possible to integrate the data and create such an encyclopedia sooner than this, possibly within five years. GISIN for example, could work on the invasive species information, while other groups work on other datasets.

The Discover Life system consists of several major components. The *All Living Things* component is somewhat like the table of contents of an encyclopedia.



It allows users to drill down to species information by clicking on images and descriptive links. For example, users that know what information they want and are familiar with a taxonomic group or species could select *Insects* → *Kinds of Insects* → *Lepidoptera (butterflies and moths)* → *Families (of Lepidoptera*), and so on until they reached a species.



Species Pages

When a specific species is selected (by clicking on a species name) a species page is displayed. Species pages are constructed from images and other information gathered from multiple (clearly identified) external Web resources and displayed in a single Web page for each species. For example, the *Papilio glaucus* species page includes images from a database in Georgia along with information sourced from the United States Geological Survey, Butterflies of North America, and others. This is accomplished through use of a proxy server that knows the Universal Resource Locators (URLs) of the information sources and gathers, repackages, retrieves, and displays the information in real time. Information from other sites is not stored on Discover Life, but is retrieved from the linked sites each time a user clicks on a link.

IDnature Guides

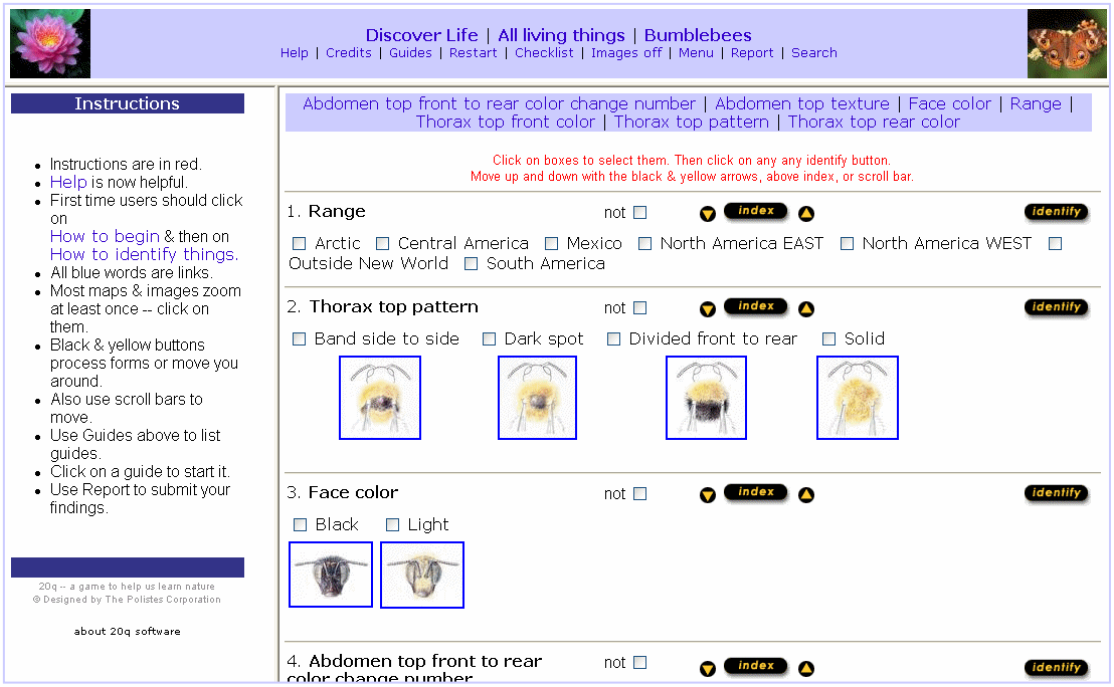
The *IDnature guides* on the Discover Life system provide text, line drawings, and photographs in Web forms to help users identify species. There are 50 IDnature guides currently under development on plants, invertebrates, insects, mollusks, and other groups. While our initial focus was on North American species, there are now numerous guides being developed for many other parts of the world.

IDnature guides provide a menu of various tools, instructions for using the guide, and questions about the species being identified. The structure of the guides is different from a dichotomous key. Choices are not necessarily dichotomous. There can be multiple states for each character under consideration. Furthermore, unlike conventional paper keys, the questions in the guides can be answered in any order. If they are unsure of a character, users can even skip answering the question and proceed to another question. *Identify* buttons allow the user to submit each new answer to the identification process, which narrows down the resulting list of possible species remaining. Questions in the guides are also presented in such a way as to allow the user to eliminate characteristics by choosing the *Not* option, indicating that the species does *not* have a specific characteristic.

The *Simplify* function allows users to tailor the guide as they work through it. Clicking the *Simplify* button removes any criteria that are no longer relevant with respect to the answers already given and the geographic location where the user is. As the list of possible species is narrowed down to just a few or a single species, a reporting option is displayed allowing users to submit observations and information on the species they have identified.

Reporting System

Once the guide has identified the possible species, the user can view the species page and verify whether it matches what they described. They can then submit a report on the species including information about the observer/submitter (name, email address, location etc.). Through an agreement with www.Topozone.com, the locations of these observers and observations can be mapped (detailed maps are currently available only for the USA). The gazetteer mechanism behind this mapping function contains over



seven million points – two million in the USA and five million elsewhere. For example, on an aerial image of the White House (supplied by Topozone), a user could specify that they observed an insect on a particular tree in the image and automatically obtain the latitude and longitude for that tree from the image. Species observation reports are stored in a database and can be monitored for quality through development of a type of observation quality profile, similar to a consumer's credit report that is based on the individual's behavior over time.

The gazetteer mechanism behind this mapping function contains over seven million points – two million in the USA and five million elsewhere.

The Discover Life project is just beginning to implement quality control measures on publicly submitted observation records. Using volunteers, a training program has been set up to test for variance in species identification accuracy. Quality scores will be developed based on variances between observers. As large amounts of data or observation records are submitted, data quality ratings or scores will be created for reporters by comparing their observations with museum records and reports from other individuals. These ratings constitute the quality profile or credibility report.

The *IDnature guide* system has been tested by secondary school students supplied with a known specimen that they must identify using an *IDnature guide*. The students' identifications are compared with the known identification for the specimen. Guides are improved to help eliminate mistakes based on the success rate of accurate identifications.

Citizens can report observations of invasive species such as the Hemlock Wooly Adelgid by using an IDnature guide to identify it and the reporting system to submit their observations.

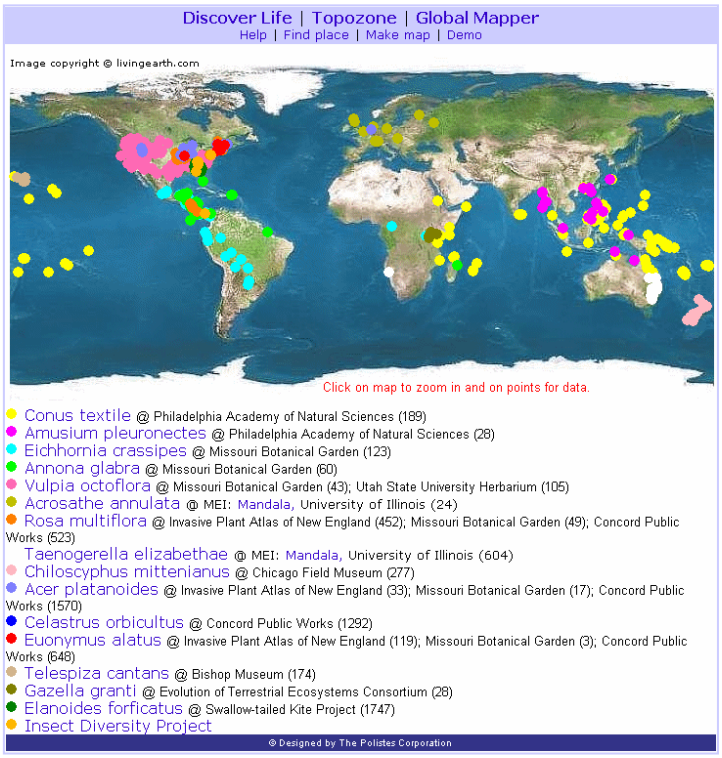
This will be a very useful tool for early detection of invasive species. Citizens can report observations such as the Hemlock Wooly Adelgid by using an IDnature guide to identify it and the reporting system to submit their observations. At the technical level, the distinction between native and introduced species records is integrated into the *IDnature guides* by importing the data in the form of American Standard Code for Information Interchange (ASCII) text files, converting it into Extensible Markup Language (XML), and hashing it into an indexed file. An attached flag is then used to indicate whether the species is introduced or native allowing users to select from *Introduced* and *Native* checkboxes in the IDnature guide form.

Global Mapper

The *Global Mapper* constitutes another major component of the Discover Life system. This tool allows users to zoom in on groups of points and select individual points that indicate observation records for different species, each a different color. If the mouse is hovered over a point, or if the user clicks on a point (rather than an empty space on the map), information about the observation record is displayed. Users can also create their own map of species observations using this tool and insert the URL for it into their own Web site or use it for other reference purposes.

Additional tools available through the Discover Life system include a database, IDnature guide building tools, data import tools, and an image processing tool.

The *Global Mapper* does not currently contain any satellite images for countries other than the United States. But if a user selected a country other than the United States, the tool can provide National Imagery and Mapping Agency (NIMA) data at a one to one million scale for the entire planet. Topozone is willing to host other people's maps. For example, for Jane Goodall, a high quality image of Gombe National Park in Tanzania is available. Unfortunately, the remainder of Africa so far only yields course-grain maps.



Additional tools available through Discover Life include a database, IDnature guide building tools, data import tools, and an image processing tool. The image processing tool allows users to edit and annotate images for their Web sites, IDnature guides, and species pages without having to own an image processing software application of their own.

The system is set up so that browsers assigned to and running on separate servers can be processing multiple images at the same time. In a four hour period, a person might process one or two thousand images and place them on the Web in IDnature guides. Import tools allow users to import large data sets such as Microsoft Excel spreadsheets, or a Microsoft Access database of observation records, and plot the data in the Global Mapper, or integrate it into an IDnature guide or Checklist in just 30 minutes.

Conclusion

The Discover Life team believes that as a community they can serve information for one million species online with identification tools in five years. To do so, they will need help from the NBII, the Smithsonian Institution, Missouri Botanical Garden, The Field Museum, the Instituto Nacional de Biodiversidad (INBio), and all of the members of the GISIN, to name but a few. Discover Life has developed the technology and capacity to serve information for one million species online with identification tools, images, maps, text, and associated specimen databases. The combination of expertise and resources from around the world must now come together so that we can provide a very powerful benefit of serving real-time species information for everyone.

Web-accessible Information on Invasive Species in the Americas: A Multinational Invasives Information Network

Andrea Grosse[1], Sergio Zalba[2], and Silvia Ziller[3]

Abstract

Decision-makers and managers benefit from ready access to invasive species information from all countries. In the Americas, information from published and unpublished accounts and databases on invasive species is scattered in locations and formats not easily accessible even to local users.

The Invasives Information Network (I3N) pilot project of the Inter-American Biodiversity Information Network (IABIN), sponsored by the United States Department of State (DOS) and the United States Geological Survey (USGS), created a distributed network of catalogs of invasive species lists, experts, projects, and datasets. Software tools were developed by the National Biological Information Infrastructure to assist with the cataloging and distributed searching.

The pilot project was completed successfully in 11 countries, with many unexpected benefits. The I3N is composed of in-country information providers working towards the use of common standards. Each provider's invasive species information is controlled by the provider but is documented and posted on the Web in a standard format. The public can search the records for free from a single entry-point. Several new countries are starting to create I3N catalogs.

[1] Project Manager, International Biological Informatics Initiatives, National Biological Information Infrastructure, National Program Office - USGS, 12201 Sunrise Valley Drive, MS 302, Reston, VA 20192 USA
[2] Professor, Universidad Nacional del Sur, San Juan 670, Bahia Blanca, Buenos Aires, 8000 Argentina
[3] President, Horus Institute / Coordinator, The Nature Conservancy do Brasil, Rua Dr. Manoel Pedro, 495/906, Cabral, Curitiba, PR, 80035-030, Brazil

Introduction

'I3N' stands for *IABIN Invasives Information Network* (http://www.iabin-us.org/projects/i3n/i3n_project.html). 'IABIN' is the *Inter-American Biodiversity Information Network* – an internet based forum for technical scientific cooperation throughout the Americas. In 2004 we were granted six million dollars from the Global Environment Facility (GEF), which in combination with cofinancing will add up to 30 million dollars for developing IABIN as a whole. The I3N will be one of six thematic networks within IABIN.

The pilot project for I3N was sponsored by the DOS and the USGS, and it was successfully completed in 11 countries (colored in red above). The countries that are depicted in shades of green are interested in, or have started the process of participating in the I3N.

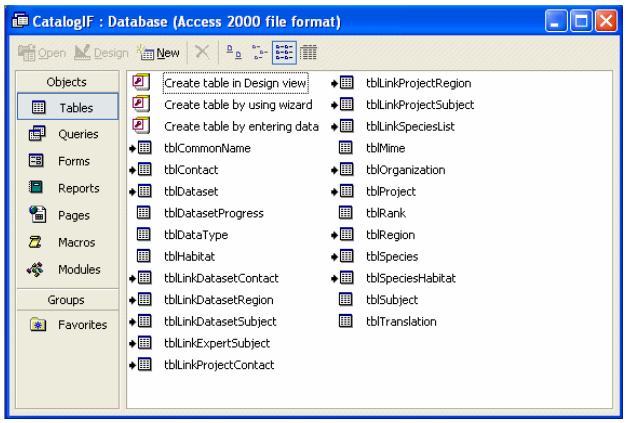
The objectives … were to develop four standard catalogs of information in each country – … experts, projects, datasets, and species lists.

The objectives of the project were to develop four standard catalogs of information in each country – a catalog each of experts, projects, datasets, and species lists. These catalogs are Web accessible, but distributed so that each information provider has complete control over their own catalogs. The catalogs are integrated through one single online entry point and

can be queried using a single search mechanism.

I3N Cataloger

The I3N Cataloger tool was developed to assist those that did not want to deal with the technology involved in creating their own catalogs. It allows biologists to create catalogs (databases) and make them available in a standard format.



This tool supports three languages – Spanish, Portuguese, and English. It was developed using Microsoft Access 2000 and automatically generates Extensible Markup Language (XML) from the cataloged data. A new version has recently been released and is freely available for download from the I3N Web site at http://www.iabin-us.org/projects/i3n/i3n_project.html. Documentation for I3N is also available on the Web site along with data for each participating country, and access to the I3N List Serve.

Benefits and Achievements

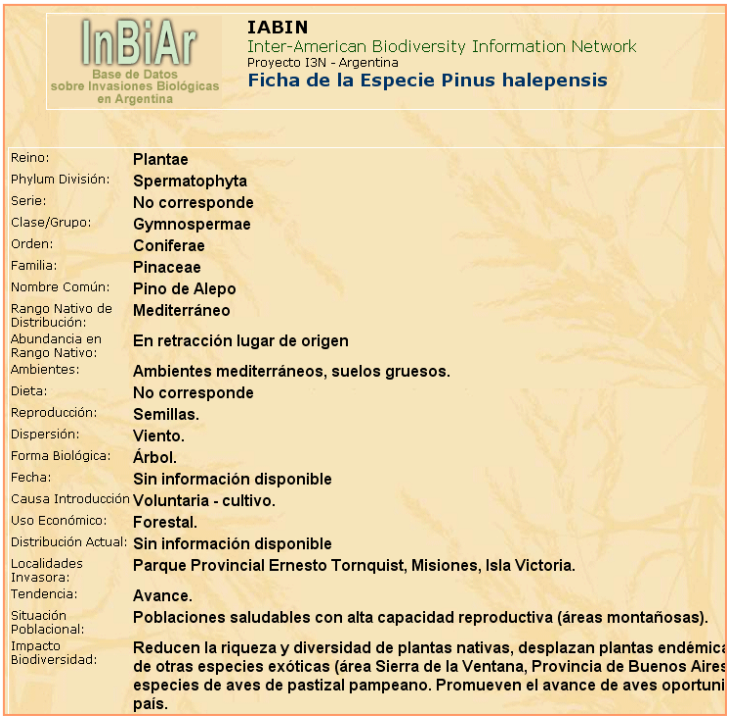
With very little funding, the countries participating in I3N have made great achievements. For example, one country was able to create their very first national registry of invasive species and specialists. The Bahamas developed a National Invasive Species Strategy using I3N data and acknowledging the contributions of the I3N. El Salvador has created a compact disc containing species fact sheets and other information.

… one country was able to create their very first national registry of invasive species and specialists.

Many challenges were overcome during the implementation of I3N. Some of the products have not yet been standardized, largely due to lack of human or infrastructural capacity, software bugs in the I3N Cataloger, a lack of existing information, and other political and social issues. For example, in one country the exchange of data among different federal agencies requires payment. The I3N lead in that country was not able to pay for all of the data, so the data are not yet complete.

I3N Argentina (InBiAr)

In 2002 the development of a system was initiated to compile and organize information about invasive species in a database known as InBiAr, which stands for *Invasiones Biológicas En Argentina* (a national database on biological invasion).


InBiAr
Base de Datos sobre Invasiones Biológicas en Argentina

IABIN
Inter-American Biodiversity Information Network
Proyecto I3N - Argentina
Ficha de la Especie Pinus halepensis

Reino:	Plantae
Phylum División:	Spermatophyta
Serie:	No corresponde
Clase/Grupo:	Gymnospermae
Orden:	Coniferae
Familia:	Pinaceae
Nombre Común:	Pino de Alepo
Rango Nativo de Distribución:	Mediterráneo
Abundancia en Rango Nativo:	En retracción lugar de origen
Ambientes:	Ambientes mediterráneos, suelos gruesos.
Dieta:	No corresponde
Reproducción:	Semillas.
Dispersión:	Viento.
Forma Biológica:	Árbol.
Fecha:	Sin información disponible
Causa Introducción	Voluntaria - cultivo.
Uso Económico:	Forestal.
Distribución Actual:	Sin información disponible
Localidades Invasora:	Parque Provincial Ernesto Tornquist, Misiones, Isla Victoria.
Tendencia:	Avance.
Situación Poblacional:	Poblaciones saludables con alta capacidad reproductiva (áreas montañosas).
Impacto Biodiversidad:	Reducen la riqueza y diversidad de plantas nativas, desplazan plantas endémica de otras especies exóticas (área Sierra de la Ventana, Provincia de Buenos Aires especies de aves de pastizal pampeano. Promueven el avance de aves oportuni país.

This project constituted the Argentine component of the I3N initiative. A more detailed understanding of the seriousness and scope of the problem of invasive species in Argentina needs to be developed and shared with other countries. The final aim of the project was to promote the rational management of biological invasions. One year later, the first national catalog of invasive species, researchers, and projects was created as a result of the initiative.

Database Development Challenges for InBiAr

One of the first challenges experienced during the implementation of the InBiAr recording system was that of defining an invasive species. As a general principle, the project adopted the definition proposed by The World Conservation Union (IUCN) – *Alien species which become established in natural or semi-natural ecosystems or habitats, are agents of change, and threaten native biological diversity*. The development team later chose to exclude *impact* as a criterion due to the lack of studies providing objective evaluations of the occurrence of impacts from invasive species. Therefore, the presence of a non-native species in a natural or semi-natural area justified its inclusion in the database.

A species was defined as *exotic* when its distribution range did not include Argentina prior to European colonization. Those species with uncertain previous distribution ranges whose status as natives or exotics was doubtful (cryptogenic species) were also included in the database. Natural habitats were defined in keeping with the IUCN definition as those where human-induced disturbance is minimal or that, having been disturbed, retain significant native elements. Those species considered weeds, pests, or pathogens but that had not yet demonstrated the capacity to colonize natural environments were excluded from the database (i.e., those that impact only agricultural or managed ecosystems).

Information for the database was gathered by making requests to experts via email with a response success rate of approximately ten percent (10%). Preliminary lists of species were also submitted to participants at scientific meetings, and suggestions were solicited and received through the database Web site. The resulting information has been included in the Web site of the Universidad Nacional del Sur online at http://www.uns.edu.ar/inbiar.

The InBiAr Web site received 2300 visitors in one year, with 52% originating in Argentina, and the remaining 48% originating in nine other countries.

The Web site is freely accessible and provides general information on biological invasions, information about IABIN and I3N, a description of the criteria adopted by the project, links to other sites, and the three searchable catalogs. The Web site received 2300 visitors in one year, with 52% originating in Argentina, and the remaining 48% originating in nine other countries.

The species database includes 28 fields that can be grouped under the following six information categories:

Category 1 – Taxonomic identification including scientific name, kingdom, phylum or division, series, class, order, family, and common name;

Category 2 – Information about the species in its original range including geographic distribution, abundance, and environments where it lives;

Category 3 – Biological characteristics including diet, reproduction, dispersal, and biological form;

Category 4 – Characteristics of the invasion process itself including the estimated date and the reason for introduction, present economic uses of the species in the country, distribution range in Argentina, localities where it behaves as an invasive, present tendencies, and population status – discriminating among a population with a few individuals reproducing only sporadically, self-sustaining populations, and true invaders (those that are spreading widely in natural environments);

Category 5 – Information about the effects of the invasion and management strategies including impacts (on biodiversity, economic activities, and human health), and information about control actions that have been initiated or planned;

Category 6 – Bibliography and other observations on the species.

Most of the information on invasive species in Argentina was not published and had to be collected through interviews with researchers.

Another of the main challenges in the development of the database was the lack of accessible information. Most of the information on invasive species in Argentina was not published and had to be collected through interviews with researchers. Some fields in the database contain almost no information at all. For instance, many exotic species of insects have been recognized as pests, but there is no available information about their possible occurrence in natural environments or if they affect native species. The development team is also experiencing funding problems and difficulties in sustaining the project.

InBiAr Future Development

Future plans for the project include incorporating a recording and updating system for information related to the distribution of invasive species in Argentina. This may be accomplished by linking the InBiAr database with a geographic information system (GIS). Before that can be done the development team must decide on the most appropriate geographic scale or resolution for the data, considering the utility of the database, baseline availability, and updating costs. Written and graphic descriptions will continue to be added to the database, and the development team will also continue to strengthen international links including the strong relationship that currently exists with Brazil.

Brazilian Invasive Alien Species Database

In order to help illustrate the problems associated with biological invaders to the people of Brazil, a database of information on the geographic distribution of alien species in Brazil needed to be developed. However, the development team wanted to organize the existing information and start to collect additional information, but did not want to invest the time normally associated with the development of a new database.

Database Design -- Collaborating with InBiAr

Michael Browne, the manager of the Global Invasive Species Database online at http://www.issg.org/database/welcome/, provided some advice on how to create a database and recommended some contacts in France that were involved in the development of a plant database. But Brazil needed a database to cover all groups of alien species. At this time, the InBiAr database was launched on the Internet.

The development team contacted Sergio Zalba (InBiAr) and asked him if they could use the InBiAr database structure to build the Brazilian database. Fortunately, he was

willing to share the database structure with Brazil. The Brazilian invasive alien species database benefited from the results of the I3N project through the sharing of this database structure, but it was not initiated as part of the I3N project. The two database development teams agreed to share ideas and cooperate in the continued development and improvement of their databases so that the two would continue to maintain the same structure.

In 2003, the Ministry of Environment in Brazil provided funding to extend the database and continue to gather information for an additional year, covering five groups: terrestrial species, marine, freshwater, health, and production. Five organizations are in charge of the groups, and the preexisting database will be used by all as the standard. The Horus Institute / The Nature Conservancy team will gather this information by interviewing people throughout Brazil. Fields added to the original database structure include information on species location, contacts, projects, and references. A feasible controlled vocabulary is based on that of the Global Invasive Species Database. Future work on the database structure includes exploration of the spatial aspect associated with the species information fields, and development of a separate table for images.

…Brazil is not only a sink, but also a source for invasive species identified elsewhere in the world… [so] the database … contains information on Brazilian species that are invasive in other parts of the world.

Database Content

The Brazilian Invasive Alien Species database currently contains 140 species. The *Location* fields were expanded to include space for recording geographic positioning information, which is usually difficult to obtain. Despite the absence of geographic coordinates for some records, references on location, municipality, and the State in Brazil are available. Ecosystem type descriptions can be accessed via links, and a look-up table allows users to select from the Brazilian vegetation classification system. Information about the data source or provider is also included in the same table. The development team is also building an ArcView shape file that will be linked to the ecosystem type descriptions. This shape file will be used as a decision making tool, and provide support for the creation of regulations on the use, eradication, and control of alien species.

The Brazilian Invasive Alien Species database and InBiAr are offering the database structure to other Latin American countries, and to any other countries that are beginning the process of creating a database for invasive alien species.

A basic assessment of invasive species introduction sources in Brazil shows the same tendencies often observed in other countries. The horticultural industry is the main source, contributing up to 32% of introductions in Brazil, followed by agriculture (for food), forage, forestry, soil stabilization, and 13% of introductions are through involuntary events. In consideration of the fact that Brazil is not only a sink, but also a source for invasive species identified elsewhere in the world, a new table was added to the database that contains information on Brazilian species that are invasive in other parts of the world.

Future Development

Funding is needed for the creation of an interface so that the database can be served on the Internet, and for the translation of the species fact sheets that are linked to the species listed in the

database (currently in Portuguese). There is a need to create a register of consultants and collaborators that would have direct access to the database and be able to modify some of the information. For quality control, an additional group of people to assess the reliability of new data from often unknown sources is also needed.

Creating the register and the Quality Assurance/Quality Control group would cost approximately $15,000. In a second phase of development, the data will be displayed in a GIS application in cooperation with Argentina.

Information Management for Invasive Alien Species in China

Yan XIE, Director, Interdisciplinary Research Promoting Center, Institute of Zoology, Chinese Academy of Sciences, 25 Beisihuan Xilu, Beijing, 100080 China

Abstract

China is the world's third largest country and one of the richest in terms of biodiversity. A wide range of habitats and environmental conditions makes China especially vulnerable to the establishment of invasive species of foreign origin. Alien species occur in each of China's 34 provinces, municipalities, and autonomous regions.

This paper will show the distribution patterns of invasive alien species (IAS) based on distributions, taxonomy, biology, and other features of 128 of the most serious IAS in China. They will be used to show the IAS problem in each of these units and their higher divisions. The paper will review information management status of relevant sectors and the Chinese Academy of Sciences (CAS).

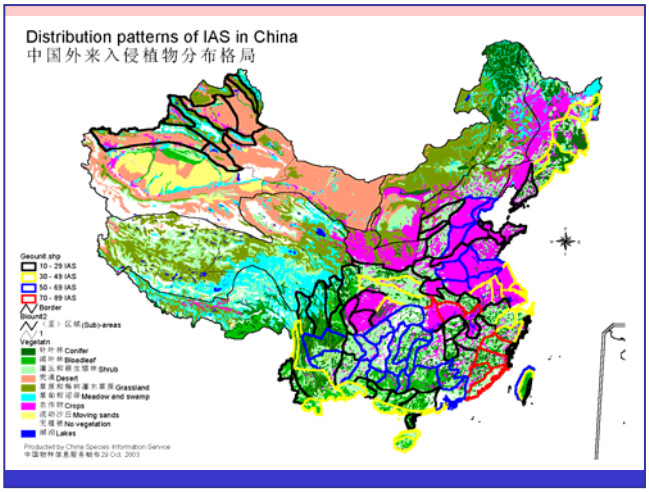
Three key recommendations on improving information management for IAS in China will be presented. The first one is that it is important to manage IAS information together with native species. The second is that using biogeographical divisions will help with understanding the status and impact of IAS. The third is that the Internet is the most powerful data sharing mechanism.

Keywords: China, IAS, Distribution, Information, Management, CSIS

Introduction

Research by the Chinese Academy of Sciences has described the distribution patterns of 90 known invasive alien plant species, representing 31 families in China. It has shown that many areas in southern China have been affected by alien species. Several regional or national alien invasive species information systems are available online in Chinese, including the Exotic Plants Information System of China at http://weed.njau.edu.cn/exowort/exoweeds.htm, the China Invasive Species Network at http://www.bioinvasion.org.cn:9090/xu716/index.jsp, and the China Species Information Service (CSIS) hosted on the Conserving China's Biodiversity Web site at http://www.chinabiodiversity.com/indexe.shtm.

These sites allow users to search for information such as species lists, transmission patterns, quarantine methodologies, biology, and experts. The Conserving China's Biodiversity Web site is managed by the Protected Areas Task Force/China Council for International Cooperation on Environment and Development, and the Institute of Zoology, CAS in China. It serves invasive species research information online in English and Chinese, along with a searchable database that returns species fact sheets, taxonomic data, distribution maps, and bibliographic information.

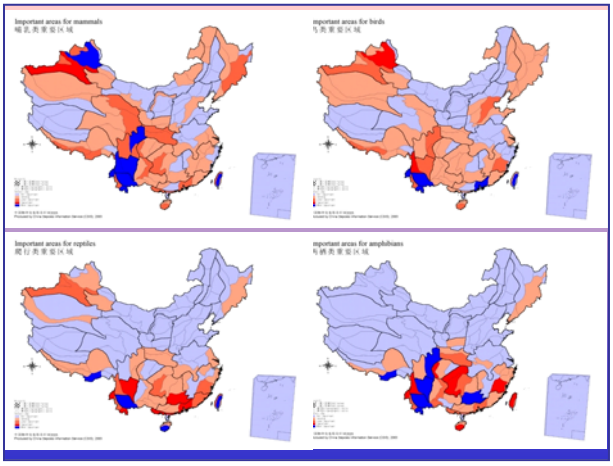


The CSIS is focusing on improving information management in China in four main ways: 1) working with biogeography units, 2) linking with native species information systems, 3) linking with protected area systems, and 4) developing criteria for defining and selecting invasive species for inclusion in the database.

Working with Biogeographic Divisions

China is divided into 124 biogeographic units based on characters such as altitude,

landform, climate, and vegetation classification. Each of these units has an aspect of uniqueness in geography, ecosystem, or landscape. Species composition similarity analyses were performed based on native species of mammals and higher plants within these units. The results of the analyses showed that the species were clustered into higher levels of geographic division.

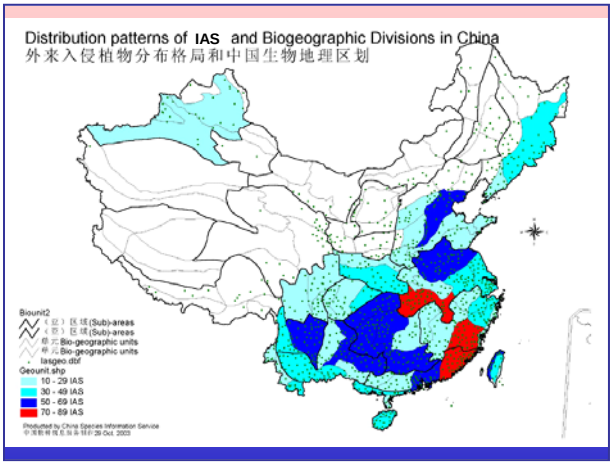


A native species importance index was developed from these analyses using China's biogeographic units and native species information. Species with limited distribution were ranked higher in importance than other species. The sum of the importance of native species found in each unit then became a native species importance index for each unit. These units, ranked according to the species importance index, were then mapped to indicate key areas for mammals, birds, reptiles, amphibians, and fish.

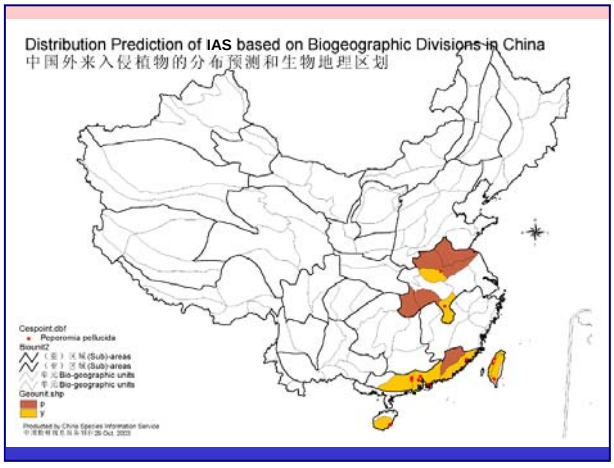
…range maps for areas of high occurrence potential for IAS were extrapolated using observational data from a few localities.

A similar methodology could be employed in the management of alien invasive species. Biogeography information was combined with invasive species information to produce a map based on the number of invasive alien species (IAS) occurring in each unit.

A comparison of native and invasive alien species shows that some units that are important with respect to local biodiversity have high numbers of IAS, while some units that are not important with respect to biodiversity also have high numbers of IAS.



This biogeographical information can also be used to predict the future distribution of IAS. Many of the observation records used in this study represent a single point or dot. But if a single observation occurs in one of the units, it can be predicted that the whole area of the unit could have been invaded by that species. At the very least, there is a high potential for that species to spread within that unit.

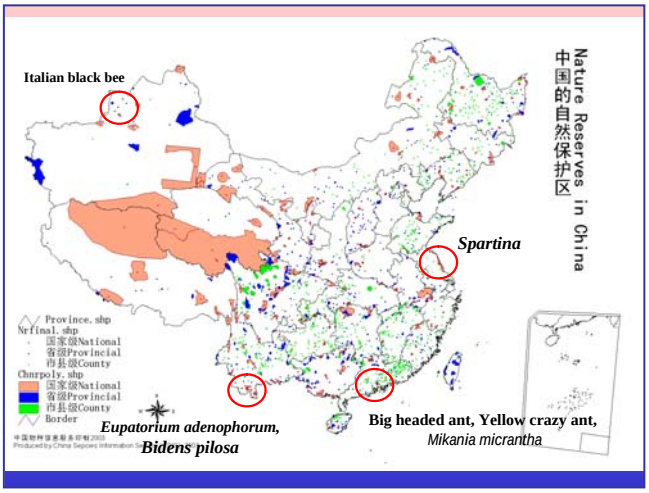


Taking this predictive application to a higher division level (covering a larger area), range maps for areas of high occurrence potential for IAS were extrapolated using observational data from a few localities.

Nature reserves represent a very good network that could be developed for managing IAS because they are already protected and have staff currently carrying out surveys, monitoring, and control activities.

Working with Nature Reserves

The nature reserve system in China is quite extensive with approximately 15% of the land under protection. Some of the nature reserves have reported problems with IAS. A list of potential IAS threats can be developed for each nature reserve using the biogeographic divisions that were identified and ranked according to their IAS richness. Nature reserves represent a very good network that could be developed for managing IAS because they are already protected and have staff currently carrying out surveys, monitoring, and control activities.



The analyses show that key biodiversity areas are under-protected in China. A combination of these areas that are important with respect to native biodiversity, and the nature reserves that may be threatened or impacted by an IAS, can be used to identify areas where monitoring and inventory efforts should be increased.

An invasion risk assessment needs to be developed in order to determine what species should be included or defined as being invasive. Several invasive species ranking systems exist throughout the world. A risk assessment protocol for China could be modeled on one or more of these international examples. The ranking system could be used to answer questions such as, "Which species can be introduced without risk?" Any risk assessment that is developed should be simple and easy to work with and applicable to all taxonomic groups. It should be useful for evaluating the progress of introductions, for monitoring local IAS management efforts, for early detection, for choosing targets for monitoring, and for promoting management and awareness of the IAS problem.

If biogeographical information is already available for native species at the global level, then it only needs to be connected with the same information for IAS to develop a global IAS impact assessment that allows the identification of key areas for monitoring, management, and early detection.

The information presented here applies to biogeographical divisions within China. The same process may be applied on a global scale through the use of the World Wildlife Fund's eco-regional divisions. These eco-regional divisions closely follow the biogeographical divisions within China that are described here. There are several global mapping systems that could be employed including the CSIS, the Protected Area System, or global protected area

mapping by the World Commission for Protected Areas (WCPA). If biogeographical information is already available for native species at the global level, then it only needs to be connected with the same information for IAS to develop a global IAS impact assessment that allows the identification of key areas for monitoring, management, and early detection.

The CSIS provides information on IAS in Chinese and English on the Web. Species fact sheets on native species can be located by searching on scientific name, locality, and province. The Red List of 10,000 species in China is accessible through this site.

The system also allows users to provide feedback and submit additional information for inclusion on the site. The information on native species that is contained in this system can be connected with similar information on IAS, the Protected Area System, and Nature Reserve information. The CSIS will cooperate with the GISIN in continuing to develop these information resources for all users.

NatureServe Explorer

Terri Killeffer, Botanical Research Associate, NatureServe, and Rachael Muir, Biologist, United States Geological Survey, 1101 Wilson Boulevard, 15th Floor, Arlington, VA 22209

Abstract

NatureServe is a non-profit conservation organization representing an international network of natural heritage programs operating in 50 USA States, Canada, Latin America and the Caribbean (74 programs with some 800 scientists). Over the last 30 years, the network has documented detailed information on a half-million occurrences of at-risk species and communities.

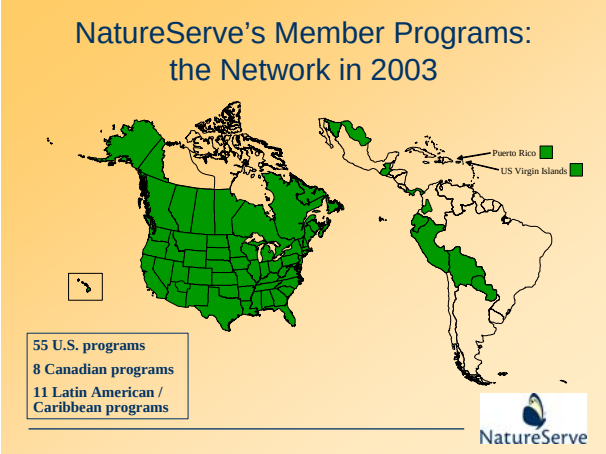
Biotics 4, a geographic information system software tool for managing biodiversity information, is designed to ensure that data collected in each member program can be aggregated, analyzed, and exchanged between the member programs and the central database. Much of this information is delivered through the website, NatureServe Explorer at http://www.natureserve.org/explorer/ with the intent to enhance research capabilities and provide more searchable data in the future. A rigorous set of biological inventory and data management standards are applied which serves as a common language for our network. The network utilizes many sources for data: natural heritage scientists as well as scientists at universities, conservation organizations, museums, botanical gardens, and state and federal agencies.

Historically, NatureServe's principal focus was species of concern. Fields have been recently added to Biotics 4, expanding the invasive species information for plants by including data developed using a peer-reviewed Invasive Species Assessment Protocol that evaluates non-native plant species for their impact on biodiversity. The network has the capacity for additional information regarding invasive alien species and is available to participate in the Global Invasive Species Information Network.

Introduction

The non-profit organization NatureServe has 74 natural heritage member programs and conservation data centers located throughout the United States, Canada, and Latin America. The program members collect and manage data about plants, animals, and ecological communities. NatureServe employs ecologists, botanists, zoologists, and data specialists to fulfill its mission of connecting science with technology.

The first natural heritage program was established in 1974, in South Carolina, USA, by The Nature Conservancy (TNC). At that time, NatureServe was the data management and data collection component of TNC. They captured and collected data on rare species and ecological communities to help TNC prioritize land acquisitions. Eventually separating from TNC in 1994 (and first known as the Association for Biodiversity Information), NatureServe has continued to develop the now 30 year old network, which today reaches across most of the Western Hemisphere. The programs are housed at state or provincial agencies (78%); some are affiliated with universities, while fewer than five are still operated by the TNC.

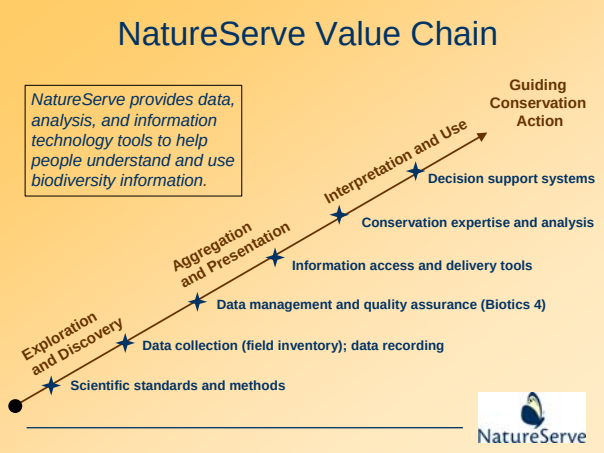


The program members collect information mainly on rare species, but not exclusively. NatureServe has collected general information such as distribution, life history, and taxonomy on invasive species in the past, but is beginning to collect even more

data on them since they are a major threat to rare species and communities.

Key NatureServe Activities
Key activities of the organization include development of scientific standards for inventory and biodiversity management, creating comprehensive and current databases for at-risk species with biodiversity information accessible to the public and to clients, and providing information to guide research decision making. NatureServe's products are developed through a hierarchical process.

First the standards and methodologies are developed, and then the data is collected and recorded. Software is provided to member programs to help them maintain the consistency of the data collections; and finally, the information is delivered to the general public and other clients in order to guide conservation action.

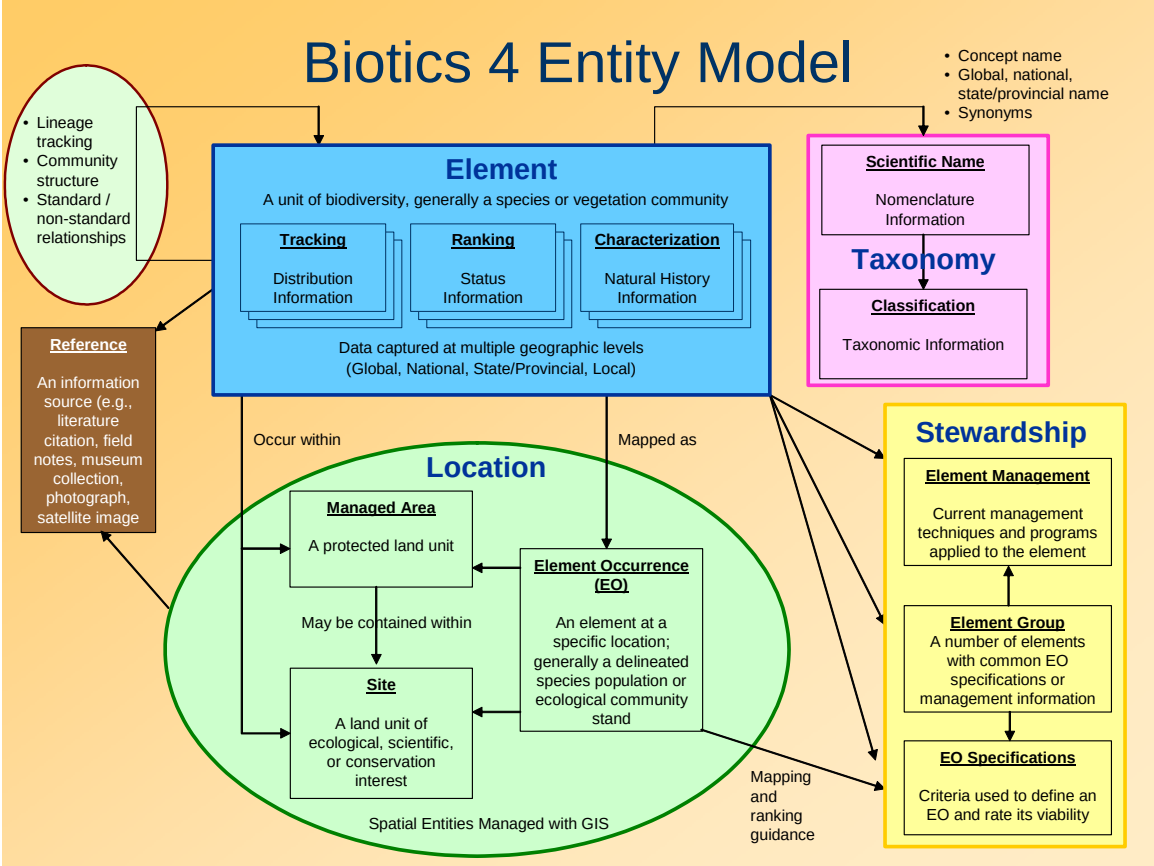


The organization maintains its scientific standards by sending all new employees to a biannual Core Heritage training course. Through this course, employees obtain background information on the organization, the methodology used to record data, and the type of information that NatureServe holds.

NatureServe Products – Biotics 4
NatureServe's biodiversity data management system, Biotics 4, is a desktop geographic information management system that manages and analyzes biodiversity information at the species and ecosystem level, and contains general information on a state, national, and global scale. The system's main strength lies in its data management flexibility. Although NatureServe provides the software and the methods for data collection and storage, the application's flexibility allows local users to insert additional fields according to their individual needs. The system also supports better management of taxonomic complexities including synonymy and concept changes. The system also has the capability to cross-walk between data sets during our annual exchange of data with each individual member program.

The information that is collected on elements or biodiversity units (e.g. species, ecological communities) includes distribution, status, natural history, taxonomy, management information, location, and other information types. This information is captured on global, national, sub-national, and local levels. By maintaining a taxonomic standard centrally, local members can continue to use their preferred taxonomic treatments (which may differ from the taxonomic standard due to a taxonomic combination or split resulting in a new concept but the member program does not agree with the newest treatment) without losing the connectivity of the data to that organism or entity during the cross-walking process.

Currently, all of the information collected by NatureServe at the local level is only for rare species and communities. On the national level, NatureServe began evaluating non-native plants in 2004, using a new methodology: *An Invasive Species Assessment Protocol: Evaluating Non-Native Species for Their Impact on Biodiversity* (Morse, et al., NatureServe 2004).

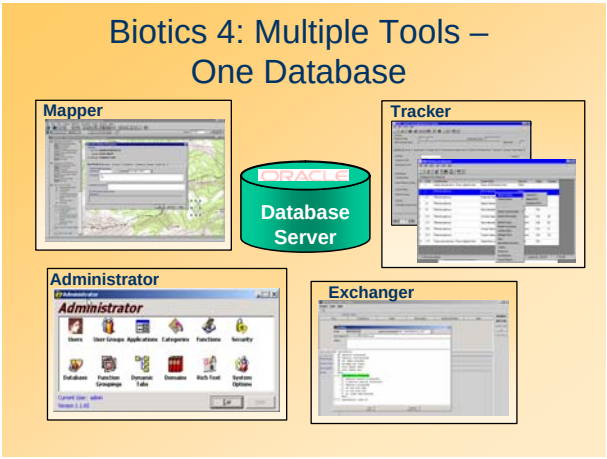


NatureServe is also pursuing the addition of non-native species or invasive species information to the system, which will allow them to be tracked at the local level and find overlaps between invasive and rare species occurrence observations.

Biotics 4 Components

Existing taxonomic standards were incorporated into the Biotics 4 model during its development. The model shares some of the same sources as the Integrated Taxonomic Information System (ITIS) and the metadata is from the Federal Geographic Data Center (FGDC). NatureServe also cooperated with the National Biological Information Infrastructure (NBII) and the Global Biodiversity Information Facility (GBIF) in the development of the model.

The Biotics 4 application consists of four main components – the *Mapper*, *Tracker*, *Administrator*, and *Exchanger*. The Mapper is the GIS component and tracks locational information as a polygon. The Tracker component contains general global information on a species or specific locational information per site occurrence.



The Administrator performs administrative tasks including defining security and access control such as the *View only* option. Information is transferred between all of the other member programs annually through the Exchanger tool. The Exchanger compares fields related to taxonomy and author, and performs any necessary cross-walking using an XML exchange format.

To assist in the cross-walk . . . NatureServe established fields in addition to Scientific Name and Author which are Concept Reference Citation and Name Used in Concept Reference.

Cross-Walking Solutions

Some problems identified during the development of the information exchange process included the need for universal identifiers and the appropriate handling of taxonomic definitions. In other systems, when a code is generated from a species name, the code usually changes with the species name. This affects the cross-walking process significantly in that the code must be tracked through each change cycle. NatureServe overcame this problem by generating a code for each species from the database rather than from the species name. Alternate keys were also included so that unique information or records could be located based on fields other than the code field.

To assist in the cross-walk with comparing our standard taxonomic treatment to other treatments, NatureServe established fields in addition to *Scientific Name* and *Author* which are *Concept Reference Citation* and *Name Used in Concept Reference*. These additional fields give a reference to a specific circumscription of the element (a circumscription is a definition of the element's boundaries which define its concept). Sometimes a species may have the same scientific name and author but the circumscription may be different as the result of a combination or split of material into or out of it. Every element is assigned a unique combination of these two additional attributes. This allows clear record-matching when different names are used for the same concept, and differentiation of records when the same name is used for different concepts. When this system is used in conjunction with synonyms, it eases the cross-walking process.

For example, John Kartesz is NatureServe's expert for botanical records. *Nanozostera japonica* is the name that Kartesz accepts for dwarf eelgrass in his new draft 2004 treatment. But the concept or entity that he's referring to is actually *Zostera japonica* as described in the Flora of North America. To put it another way, the concept being described is *Z. japonica*, but the name that Kartesz uses to refer to that concept or entity is *N. japonica*. In the Biotics 4 database, the Scientific Name field will show NatureServe's standard, which is *N. japonica*. This is the Concept Name. Then *John Kartesz* is included as a Concept Reference for that name. After this Concept Name and Concept Reference combination, a second combination is included that describes the Concept Name *Z. japonica* with its Concept Reference *Flora of North America*.

NatureServe's Invasive Species Data Resources

In the past, NatureServe has focused on collecting data on rare species, but the organization is gradually shifting this focus to one that includes collection of information on non-native species. The non-native species information that has been collected so far includes non-native versus native status, general distribution, taxonomy, life history, and management. Information on specific groups is provided through non-species specific *Element Groups* such as the *Shrub Honeysuckles* group developed for the United States, which contains

information on controlling shrub honeysuckles, related references, and global range comments.

Invasive Species Impact Ranks (I-Ranks) have been added to the Biotics 4 system. The rank is derived from *An Invasive Species Assessment Protocol: Evaluating Non-Native Species for Their Impact on Biodiversity* that has been developed by NatureServe in cooperation with TNC and the National Park Service (NPS) (Morse *et al.* 2004). The rank assesses the impacts on biodiversity of non-native species that have escaped into natural ecosystems. The protocol consists of 20 questions that deal with four different sections covering ecological impacts, current distribution, distribution trend, and management.

NatureServe is seeking assistance from the GISIN community to help answer questions in these categories such as: Does it hybridize with a native species?; Does it completely destroy or kill all of the canopy layers?; Is the species range expanding – where is it now, where is it going?; How hard is it to control – does it take ten years or two? NatureServe plans to include a protocol on its Web site online at http://www.natureserve.org/getData/plantData.jsp, along with other information sourced from Biotics 4.

The Web site provides access to the searchable *Explorer* database that contains information on management, conservation status, distribution maps, life history, county and watershed level data, and images. Precise occurrence locations are excluded from the database to protect sensitive species. In addition to being able to search for information by community name, conservation status, location, and a rare species rank. In the future, users will be able to search for information based on I-Ranks (high, medium, low, insignificant, or unknown).

www.natureserve.org/explorer

The online Explorer tool provides data that is updated approximately three times per year. However, funding has been allocated to develop a portal that will support querying of the database on a real-time basis. As a complement to Explorer, the online InfoNatura tool provides similar information for species in the Latin American region.

Future Plans

In order to contribute to the GISIN and continue the development of Biotics 5, NatureServe is considering a move towards a server-based geographic information system (GIS) to provide easier access for member programs and others (mobile clients) using the data. A modular delivery approach is also being considered for Biotics 4, where components of the application would be delivered to clients according to their specific information needs. For example, clients wishing to track invasive species would receive the *Invasive Species* module rather than the whole package.

NatureServe plans to facilitate Internet data publishing, versioning, and validation, and support geodatabase environments and streamlined metadata creation. NatureServe also plans to improve interstate and interagency collaboration to form new national partnerships, and continue its involvement in international partnerships with organizations such as the Inter-American Biodiversity Information Network

(IABIN) and the Global Biodiversity Information Facility (GBIF).

Maintaining a taxonomic standard centrally allows network members to continue to use their own taxonomic treatments or standards without jeopardizing the information cross-walking process.

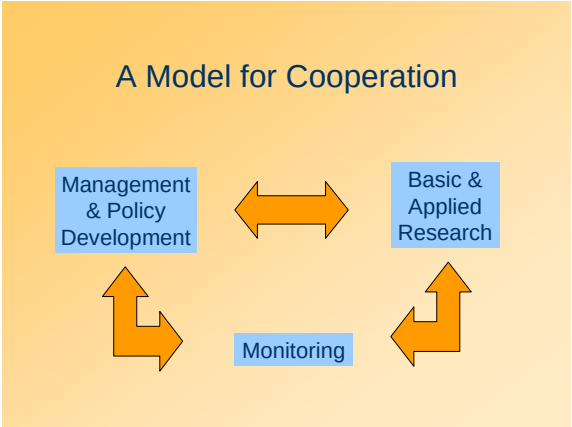
Recommendations

Standards must be developed to support a core methodology for data collection and management. NatureServe took this concept a step further by imbedding standards into its core software while also allowing the flexibility for users to add fields according to their local information needs. Maintaining a taxonomic standard centrally allows network members to continue to use their own taxonomic treatments or standards without jeopardizing the information cross-walking process.

Always be sure to accurately credit an information source, which promotes good will among network providers and members.

Training courses and conferences also play an important part in keeping network members apprised of new developments. NatureServe recognizes the importance of providing support to the users and members of a network. Personnel are available to provide online help, network access assistance, and expert advice and support. NatureServe has also established discussion groups, online help, and consulting services to help support its members.

When working with information at multiple scales, the data should meet local user needs as well as contribute to the greater good of the entire network. Data captured at its finest scale can be added to or built on, while fine-scaled data is often difficult to extract from data collected at a broader scale. Information should also be accessible to users at the decision making level, which is often the local level where early detection, eradication, and rapid response measures are being implemented.



Always be sure to accurately credit an information source, which promotes good will among network providers and members. Identify data custodians with defined roles and responsibilities in maintaining quality control measures that will also ensure a degree of trust for the quality of the information you are providing. Maintain awareness of sensitive data issues, which can vary locally, nationally, and by species.

Set clear priorities and consider starting with limited scope projects that are able to show progress and results in a short time, and may consequently be more successful at obtaining funding for project initiation and extension.

NatureServe hopes that their information on non-native species will be a valued resource that will guide research, public education, control, and management.

Selected References

Morse, L.E., J.M. Randall, N. Benton, R. Hiebert, and S. Lu. 2004. An Invasive Species Assessment Protocol: Non-Native Plants for Their Impact on Biodiversity. Version 1. NatureServe, Arlington, Virginia, USA. Accessed 19 July 2004 online at http://www.natureserve.org/getData/plantData.jsp

An IAS Database in the Colombian Biodiversity Framework

Ángela M. Suárez-Mayorga, Chief Data Administrator, Biodiversity Information System, Alexander von Humboldt Biodiversity Research Institute, Cra. 13 No. 28-01 Piso 7, Bogota, D.C., 1321 Colombia

Abstract

The Colombian Invasive Species Database (CISD) is one of the databases integrated to the Biodiversity Information System of Colombia (SIB, after its name in Spanish). SIB is a distributed system conceived as a national alliance to efficiently manage the information about the biodiversity of the country. Like other integrated databases, CISD is actually working under a robust database structure known as "biological records" where every unit recorded is tied to five reference components: spatial, temporal, classification, conceptual, and source. Each component (except the temporal one) is supported by a reference dataset, provided–or recommended– by the system and administered by the coordinator team.

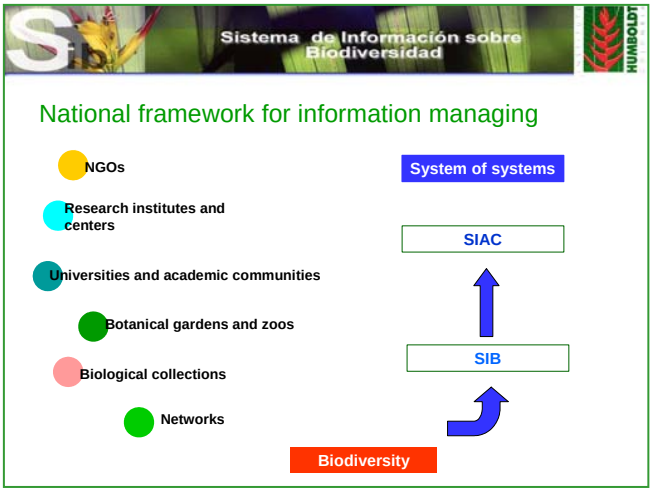
Using that structure allows everyone to manage information about any biological entity (from species to ecosystem), even simultaneously, as long as three conditions are met: 1) entities, methods, and attributes of interest are defined, 2) almost all the contents come from controlled languages, i.e. authority files, and 3) relationships among entities and between them and their references are established. The invasive alien species (IAS) working group of Instituto Humboldt and the coordinating team of SIB are responsible for fulfilling those requirements. The information structured that way will be ready to be shared in Extensible Markup Language (XML) format, so interoperability of CISD with other databases, systems or networks (the Inter-American Biodiversity Information Network or the Global Biodiversity Information Facility, for example) is assured.

Introduction

Colombia is a country that is considered to be mega-diverse. With a scientific tradition of more than 200 years, starting from the first botanical expedition in 1765, the country has a well established (but not necessarily well funded), active, working academic and scientific community that is generating significant amounts of information about many topics, including biodiversity. Colombia has more species of frogs and birds than any other country in the world. It hosts a large number of species of plants, freshwater fishes, butterflies, and reptiles.

Colombia has more species of frogs and birds than any other country in the world.

Taking the model of Noss (1990) as the model for biodiversity, most of the work that has been completed has focused on the composition of the country's biodiversity rather than on structure or function.

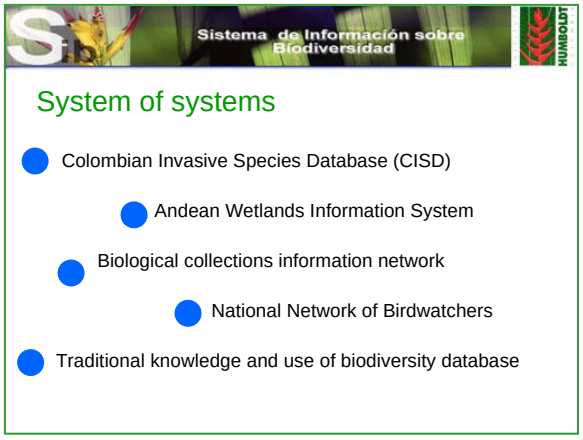


In terms of the Convention on Biological Data (CBD), Colombia continues to focus scientific work mainly on quantifying or qualifying biodiversity, and very little on conservation and use studies. However, as Colombia has a high cultural diversity, these

issues must be considered in the management of the information.
In that context, the Alexander von Humboldt Biodiversity Research Institute started the implementation of an information system in 2001 that is now the Biodiversity Information System (SIB, the acronym for Sistema de Información sobre Biodiversidad) of Colombia. Following the publication of the 17th Article of the CBD and the national biodiversity policies, and according to different national biodiversity strategies, the system was developed as a component of the Environmental Information System for Colombia (SIAC). But SIAC is currently under construction. This system is mainly supported by the Global Environment Facility (GEF) World Bank Andes project. The Humboldt Institute is the focal point of IABIN and the Clearing House Mechanism (CHM), and intends to be a data provider to the Global Biodiversity Information Facility (GBIF). The SIB assumes the responsibility of coordinating the interaction among them.

The Institute is developing a system of systems to coordinate all of those who generate, use, or are interested in biodiversity. Three types of users have been identified – those that are involved in the system (e.g. manage, use, or generate information); those that are interested in the system (at the level of decision-makers); and the general public. The system consists of datasets, data managers, databases, structure, networks, and nodes of information that could be regional or thematic.

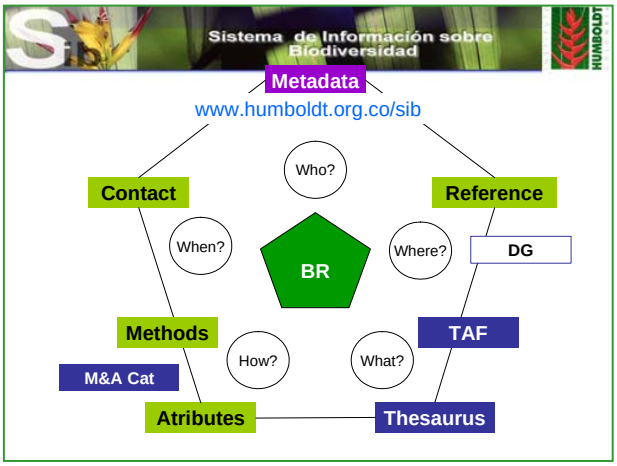
Examples of the networks and databases in this system include the Biological Collections Information Network and the Colombian Invasive Species Database (CISD). The CISD is not part of a thematic or regional network inside Colombia. The database is intended to be part of the regional network of the Inter-American Biodiversity Information Network (IABIN), for example – the Invasives Information Network (I3N), and that is what the Institute is working toward.



Modeling Database Development
The CISD represents the first attempt to organize the information available for identifying and studying invasive species in Colombia – whether they are alien or not. Information is also being collected about native species that could become invasive. The database is focusing on obtaining and uploading information from secondary sources, and organizing it according to the guidelines established by the SIB.

…for each unit or biological record (BR) (e.g. genes, communities, species, ecosystem etc.), five questions are answered: what, when, where, who and how?

The SIB has developed a model for biological records where for each unit or biological record (BR) (e.g. genes, communities, species, ecosystem etc.), five questions are answered: what, when, where, who and how? Every unit that is recorded is tied to those references and every reference is supported by a reference database that is provided or recommended by the system, and made available online.



Examples of these reference databases include taxonomic authority files (TAF) supporting descriptions of organisms, thesauri that support ecosystem or process descriptions, and digital gazetteers that contain location information about the data. The Institute had to build new taxonomic authority files because of the high degree of undescribed biodiversity in Colombia, and the need to provide taxonomic information in Spanish. The SIB does not have the capacity to develop a digital gazetteer, but it does have an online digital directory of the gazetteers that are currently available. An online methods and attributes catalog was also built by the Institute as part of this project.

Every biological record in the model refers to a reference or a contact, or both. In terms of a database of invasive species, the 'What' question is answered with species name, taxonomic category, or common name. 'Where' is answered with names of places, coordinates (if available), and other biogeographical information. 'Who' concerns information about the data source including geography, project, person, or organization. The question of 'When' is satisfied by the inclusion of dates and times while 'How' involves information such as descriptions of invasion patterns, impacts, or biological and ecological conditions.

The CISD is not currently online, but the Institute is continuing to develop the SIB search engine and portal where information on people, organizations, projects, documents, news, taxonomic information, and metadata can be located by keyword online in Spanish at http://www.humboldt.org.co/chmcolombia/servicios/jsp/buscadorsib2/. Metadata catalogs are available for each data set to describe the data provider and content. However, the data itself is not yet available.

Conclusion

There is still more work to be done. An infrastructure needs to be built to make the data available online. To insure the success of the project, capacity building must be a priority and a trusting relationship must be developed between the Institute and data providers. Financial support and the availability of skilled people that are interested in working on this project are also key factors that will effect the continued development of the system. The Institute also welcomes and encourages comments and recommendations. The SIB will continue to be developed as a national alliance among people and institutions, with the goal of facilitating data and information management, and efficiently supporting research, education, and decision making processes related to knowledge, conservation, and sustainable use of Colombian biodiversity.

Selected References:

Noss, R. F. 1990. Indicators for monitoring biodiversity : a hierarchical approach. Conservation Biology 4(4):355-364.

CONABIO: National Commission for the Knowledge and Use of Biodiversity, Invasive Species Programme, Mexico.

Patricia Koleff, Director of Analyses and Priorities, Conabio, Av. Liga Periferico Sur 4903 Col. Parques del Pedregal, Mexico City 14010 Mexico.

Abstract

Conabio's national biodiversity information system is based on specimen data. It is hosted on the Conabio Web site http://www.conabio.gob.mx and contains species profiles for native species. It hopes to provide the same information for invasive species including original distribution, natural range, information about habitat, and predictive information about potential distributions.

Conabio demonstrates the use of information gathered from museum collections and other organizations to carry out risk assessments, give advice to authorities and the public, and act upon the threats posed by introduced species.

Introduction

The national biodiversity information system of Mexico (SNIB, for its name in Spanish, Sistema Nacional de Información sobre Biodiversidad) is mainly based on specimen data. It is hosted on the Conabio Web site http://www.conabio.gob.mx that also contains information about the invasive species program and links to species and expertise lists. Multiple institutions provide their data through Conabio's Web site. The data is available to users that are party to Conabio's data use agreements.

Conabio has convened invasive species workshops, contacted institutes, and initiated projects gathering information about invasive species in Mexico. They are building an information system that contains 2500 taxa. At least 700 of these taxa are exotic, alien, and invasive in Mexico. They include *translocated* species, defined as species that did not formerly exist in an ecological or biogeographical region, and by their introduction might become invasive. Conabio maintains a list of over 3000 translocated species.

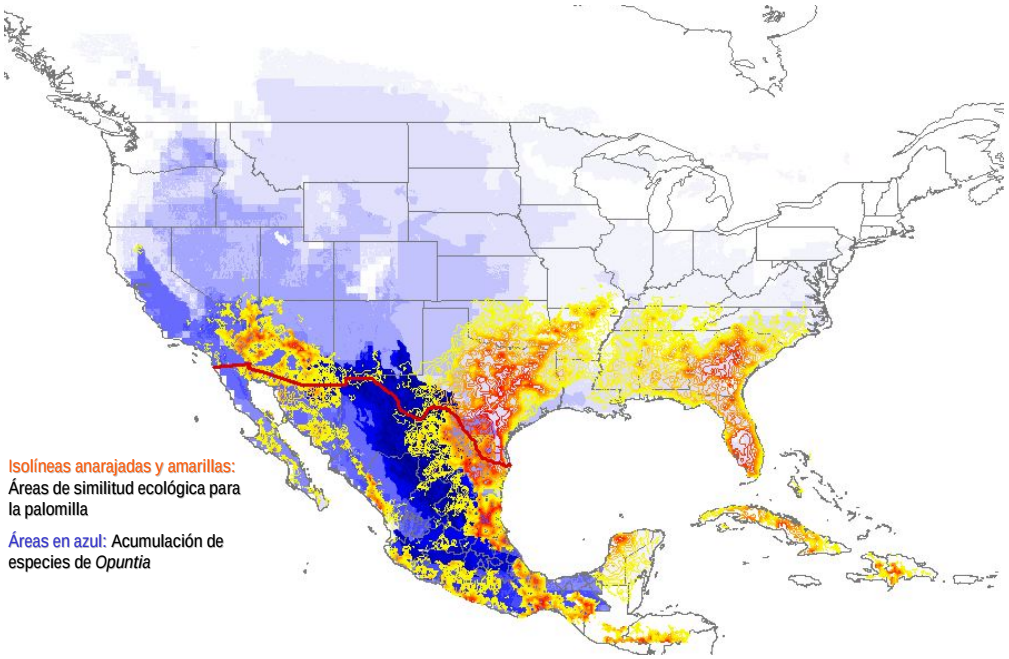
Conabio is trying to include all of the biological information and distribution data on individual groups of species, and has also been working on risk analysis.

Conabio's risk analyses have caught the attention of Mexico's authorities and governments.

Consider the cactus moth (*Cactoblastis cactorum*) that is native to northern Argentina and Brazil. This moth is the most successful example of the biological control of pests. It was imported into Australia to control prickly pear cactus (*Opuntia* spp.). But the cactus moth was introduced from Australia into the Caribbean, and now threatens to invade the southern United States and Mexico (where there is a large number of endemic *Opuntia* species). In Mexico*, Opuntia* is also a very important agricultural product. Therefore, it is important to educate the authorities about the significant threat posed by the cactus moth, because if it were to reach Mexico, the species would find perfect habitat, climate, and food supply.

Conabio's risk analyses have caught the attention of Mexico's authorities and governments. Authorities have funded workshops on assessing the invasiveness of the cactus moth. An educational poster was developed to teach the public how to identify the cactus moth.

Áreas potenciales de sobreposición entre *Opuntia spp* y la palomilla, *Cactoblastis cactorum,* en Norte América



The risk analysis methodology used by Conabio is also being applied to plant genetics – particularly for assessing introductions of transgenic crop species.

Taking specimen label data from diverse Mexican and USA Herbaria, and combining it with georeferenced data, Conabio used Floramap to determinate the main climatic attributes of the cactus moth's habitat to develop a map of areas of high cactus moth invasion potential. They then correlated these areas with the richest areas of *Opuntia* in Mexico to identify priority areas for monitoring.

Plans for introducing a bee species from California for honey production in Mexico were diverted by Conabio's risk assessment that indicated that introducing the bee would pose too great a threat to the numerous endemic bee species.

Conabio was able to identify high risk and low risk locations for bee introduction and provided recommendations for alternative locations where the bee could be introduced without threatening the endemic bee population.

The risk analysis methodology used by Conabio is also being applied to plant genetics, particularly for assessing introductions of transgenic crop species. Mexico's related wild cultivars must be protected from invasion by new genetically modified crop species. Conabio is collecting the information needed to carry out the necessary assessments in Mexico.

Conabio's database provides species profiles for native species and hopes to provide the same for invasive species, including original distribution, natural range, information about preferred habitat, and

predictions for potential distributions. Approximately 200 requests for information have been received by the Conabio databases.

Conabio has demonstrated the importance of using existing information from museum collections and other organizations to assess risk, give advice to authorities and the public, and act upon the threats posed by introduced species.

The Global Invasive Species Programme: Achievements and changes in the past year

Silvia Ziller, Member, GISP Board of Directors / TNC South America Conservation Region Scientific Assistant/President, Horus Institute, Rua Dr. Manoel Pedro, 495/906, Cabral, Curitiba, PR, 80035-030, Brazil

Raising Awareness
An important emphasis of the Global Invasive Species Programme (GISP) is to raise awareness about invasive alien species (IAS) in countries where the issue is failing to be recognized. For example, Brazil hosted a South American workshop in 2001 with GISP that resulted in an increased consciousness at the governmental level, so that there is now a national policy in Brazil on biodiversity with several recommendations about the IAS issue, and a national survey on IAS has been initiated.

As the GISIN moves forward in IAS information management, it is important not to forget to address the problems with the digital divide, language barriers, and different levels of awareness; the GISP may be able to help out in this respect.

As the GISIN moves forward in IAS information management, it is important not to forget to address the problems with the digital divide, language barriers, and different levels of awareness. The GISP may be able to help in this respect. They are now elaborating a detailed program of work related to the CBD's designation of the GISP as the International Thematic Focal Point on IAS under the Clearing House Mechanism. The CBD also directed GISP to identify standards and protocols for implementation of a Global Invasive Species Information Network (GISIN). It is obvious that the GISP and GISIN will need to work closely together, order to avoid duplication of efforts.

The GISP secretariat was officially launched in South Africa earlier this year. There is also a new Chairman of the Board, Dr. Mark Lonsdale, a leading authority on biocontrol as it relates to IAS who is an invasive species science manager at the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia.

Web Site Redesign
The GISP Web site has been totally redesigned, and is now considered part of the Clearing House Mechanism. The reports from the six regional IAS workshops held around the globe can be accessed there, at http://www.gisp.org.

There is a global interactive map on the site currently being populated with country-level invasive species information and links to Web sites and databases, as well as a downloadable documents library in several languages, and a news archive.

Publications
The latest GISP publication is the ‘Africa Invaded’ booklet which was on display at the GISIN and is also available for download on the GISP Web site. A similar approach is underway for South East Asia and South America, and GISIN participants

have been invited to contribute to these works.

GISP future plans

In addition to these developments, there will soon be chat rooms incorporated into the GISP Web site and an online management course is being created in cooperation with the ISSG. The course will be modular and adaptable to different regions of the world.

The GISP is also producing a series of best practices manuals focusing on different aspects of IAS management, prevention, control, island issues, and marine species, to be made widely available in different languages. GISP is constantly expanding partnerships through its facilitation working group that functions on national and regional levels to promote forums supporting the invasive species issue.

And finally, the May 2004 GISP newsletter will highlight the GISIN workshop, its accomplishments, and future plans in invasive species information management. GISP looks forward to working with the GISIN to facilitate broader access to IAS information around the world.[14]

[14] The second GISP newsletter (featuring the GISIN) may be accessed online in English, French, and Spanish at: http://www.gisp.org/newsletter/index.asp

Breakout Group Reports

Database Infrastructure

Group Leader: Hannu Saarenmaa (GBIF)[1]
Rapporteur: Jennifer Forman Orth (UMass-Boston)[2]

Introduction
The Database Infrastructure breakout group discussed the practical and technological issues associated with implementing a GISIN, and presented possible solutions to questions about the actual physical structure and components of the network.

Report
The first issue tackled by this breakout group was whether the GISIN should consist of a single Web site or portal. The group agreed that the one-portal idea supported the most simplistic and possibly best approach to serving information on the Internet. A single portal could provide the kind of easy, single-search access to a vast array of information that users often demand. However, the group recognized that many databases relevant to the GISIN have already been developed, and that a lot of heterogeneity exists among these databases. Rather than make existing databases conform to the requirements of a single-search portal, the group suggested that the GISIN should respect the individuality of databases and allow multiple portals to be developed as information needs are identified by the broader community of users. It is often important for organizations to develop their own portals and databases in order for them to obtain recognition and funding. The GISIN must develop a method to indicate data sources for data that are passed from one place to another (e.g. among portals, among users etc.).

It is often important for organizations to develop their own portals and databases in order for them to obtain recognition and funding.

The breakout group developed a list of products that the GISIN should generate in order to support networking and data exchange among databases or data providers. These products included:

- developing guidelines or standards for future database development;
- providing expertise and support for database and portal development (sourced from the GISIN members that are experienced in such tasks); and
- developing tools and materials such as
  - machine interfaces,
  - a schema,
  - a standard for acknowledging data authorship,
  - a definition of intellectual property rights,
  - a standard for referencing taxonomic naming authorities, and
  - a method for cross-referencing taxonomic names.

In addition, the group highlighted the importance of dating records. Records should be tagged with a creation date and the dates of any subsequent modifications. If any authorities or sources are referenced by or listed for database records, those entities should also be tagged with a date. The question of which languages should be supported in translation services was also briefly discussed.

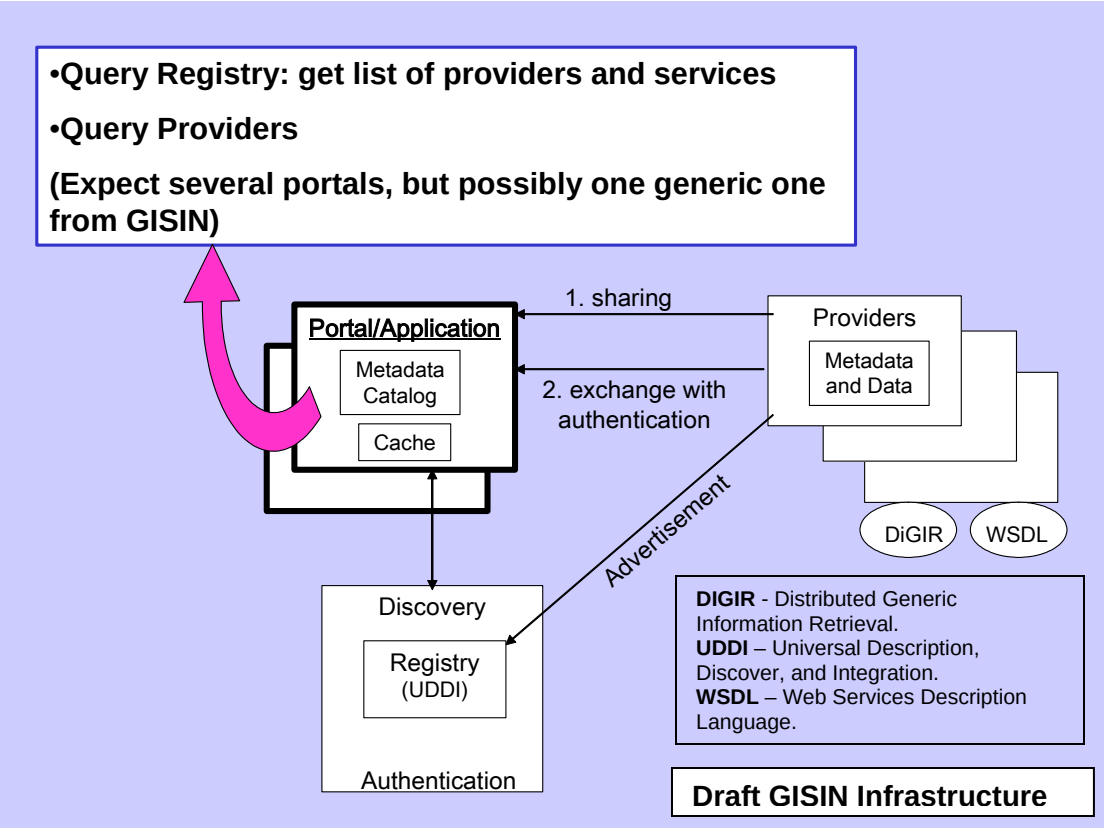
[1] Global Biodiversity Information Facility
[2] University of Massachusetts at Boston

GISIN Infrastructure
The group developed a possible infrastructure diagram for the GISIN that represented information providers, the discovery process, the portal or application where users may query the information, and the relationships that exist between these three components. Providers would advertise their services and content through registry entries that are then discovered by portals.

Users can then access/search the content of each provider via the portal. In order to achieve this type of structured information sharing, the breakout group recognized that methods and tools need to be identified or developed for information exchange, authentication, metadata creation, populating the registry (discovery), and for serving the information (e.g. through a portal/application).

Information Exchange
A commitment needs to be made to building tools for serving both structured and unstructured data. The group suggested building a tool that would facilitate the exchange of unstructured information in a structured way. They recommended investigating small tools that can convert documents (unstructured data) into Extensible Markup Language (XML) (structured data) so that they can be read by portals, and described an example for handling unstructured information that may be contained in legacy documents.

Using the example of a fact sheet developed in 1999 in Portable Document Format (PDF), the group suggested that a method could be developed to extract species names and geographic locations from that fact sheet, so that the fact sheet's information is searchable/discoverable.



Discovery
A registry provides the best method for database discovery. The group committed to creating a tool or toolkit that database developers/owners/managers could use to generate a Universal Description, Discovery, and Integration (UDDI) record or registry entry for their database. Once a database is entered in the registry, it can be discovered by portals.

… the GISIN should seek to be recognized as a network of providers that adhere to a high standard of quality with respect to database content.

Authentication
The question of whether the GISIN should employ some level of quality control was also discussed by the breakout group and by the larger body of participants at the meeting. A consensus was not reached on whether the GISIN should allow/deny registration in the network based on whether a provider meets certain measures of data quality, what those measures of data quality might be, or how they would be derived. Data providers will follow standards such as the Distributed Generic Information Retrieval (DiGIR) and Web Services Description Language (WSDL) protocols for managing their content and metadata.

The GISIN meeting participants generally agreed that the GISIN should seek to be recognized as a network of providers that adhere to a high standard of quality with respect to database content. Therefore, the issue of whether to require specific data quality standards, and if so, which ones, will be determined at a future date.

GISIN Architecture
The most likely scenario is that the GISIN will consist of several portals, but it is suggested that a generic GISIN portal be developed initially. The breakout group recommended development of a registry containing a database's technical information, and a metadata catalog containing the regular database content metadata. The registry would be hosted in a central location, while the metadata catalogs would be hosted by the portal. However, other portals would cache some of the data from the databases that they are querying to some degree.

In order to provide accountability and quality assurance for those tasked with designing the GISIN, an architectural design document was discussed. For developers within and outside of the GISIN, this document would provide a roadmap for creating the system and a blueprint for developing related programs. The document would also be used to market the GISIN concept and to generate cost estimates. The GISIN would be developed in several phases that provide the outline for the GISIN architectural design document. A draft architectural design document was developed and submitted to the group for review by Jim Quinn during the meeting (Quinn 2004) (Appendix I).

The first phase of development would be the analysis and modeling phase during which programming needs, and use cases are identified and defined. A design approach would be selected during this phase (waterfall or cascade design approach, versus a spiral design approach), and a model would be developed for integrating the GISIN with existing and related initiatives.

The second phase, or design phase, will involve defining the components and functions of the GISIN program. The group intends to start this phase with development of an informational model (standards), some of which may be defined by recommendations from the Developing Database Content breakout group. Tools, coding, and a user interface for the network

would be developed during the third or construction phase.

In the final implementation phase a security policy would be developed and user accounts would be implemented. Service levels such as availability and response times would also be defined during this phase. Support tools or a help desk, software applications, and toolkits for portal or database developers should be distributed during implementation and followed up with training and trouble-shooting support.

This breakout group hopes to begin assigning tasks and direction to initiate programming of the GISIN in the near future.

Selected References:

Quinn, J. 2004. DRAFT Technical Framework for a Global Invasive Species Information Network (GISIN). Workshop on the Global Invasive Species Information Network, 6-8 April, 2004. Baltimore, MD, USA. University of California, Davis. jfquinn@ucdavis.edu. (Appendix I)

Database Content

Group Leaders: Vishwas Chavan (NCL)[1], Robert Meese (UC-Davis)[2]
Rapporteur: Catherine Crosier (USGS)[3]

Introduction
The Content breakout group was tasked with discussing the practical issues associated with connecting (electronically linking) databases. Specific issues included identification of the types of databases and data that could be provided through the GISIN, commonalities or common data fields among databases, and possible obstacles and solutions associated with connecting databases.

Report
The topics discussed by the Developing Database Content breakout group initially paralleled those discussed in the Capacity Building breakout group. Both groups considered the question of which data fields should be recommended for inclusion in a standard IAS database, or in the database of a typical GISIN data provider.

After consulting with the Infrastructure breakout group, the Content breakout group acknowledged that the data fields they identified would not only define the important information types for invasive alien species (IAS) databases, but would also affect the connectivity and searchability of different databases. So the group concentrated on separating out the absolute minimum data fields that databases would need in order to be searchable.

The GISIN may in fact adopt the role of defining and issuing a unique identifier for each GISIN data provider.

First, six possible database types were defined based on the information that GISIN data providers might serve:

1) fact sheet or species profiles,
2) experts/expertise,
3) observation-based,
4) specimen-based,
5) bibliographic, and
6) projects/research.

If these databases were to be registered as part of the GISIN, they should be asked to provide a comprehensive description of the data types they serve, which may involve defining their database as falling into one or more of these six database types. It was recommended that additional information be included in the GISIN registry pertaining to the geographic scope of each database.

…all data must have a source or authority for it to have any value.

The only globally required registry entry recommended by the breakout group was a unique resource identifier that would provide a link between the data and the source database or publisher information. Although online information sources are often referenced according to their uniform resource locator (URL), it was agreed that the transient nature of URLs effectively excluded them from being used as unique identifiers for the purposes of the GISIN. The GISIN may in fact adopt the role of defining and issuing a unique identifier for each GISIN data provider.

[1] National Chemical Laboratory
[2] University of California at Davis
[3] United States Geological Survey

Eight possible data search fields were selected from a list that the Capacity Building breakout group had developed, including *name*, *life form* or *higher taxonomic unit* (e.g. tree, bush, mammal, bird etc.), *habitat*, *pathway*, *origin*, and *date* for that location. *Scientific name* (genus and species), and a *date* field were chosen as the minimum data search fields. The *date* field could be used to define any date such as a century or a specific month/day/year. Additionally, *family name* was highly recommended to avoid ambiguity in cases where more than one species share the same scientific name. There was also consensus that all data must have a source or *authority* for it to have any value.

Scientific name (genus and species), and a date field were chosen as the minimum data search fields.

Discussions about the minimum set of data search fields also included consideration for a *biostatus* field in which the native or alien status of a species would be indicated. However, due to the fact that this information is often unavailable, and seldom included in databases that contain both native and alien species, it was decided that although highly desirable, it would not be included as a minimum data search field.

Fact sheet or species profile type databases would be encouraged to provide data for the minimum set of data search fields.

Observation and specimen-based databases should provide this same minimum set of data search fields, plus an additional *family* field and a *location* field that could contain coordinates or text (or both).

A database of experts should provide the expert's *name* and/or *organization*, *contact information*, and an *expertise definition* based on category fields such as taxonomic groups, specific control methods, and geographic region of expertise.

Concerning data field standards, it was recommended that a nomenclature /taxonomic standard such as the Integrated Taxonomic Information System (ITIS), or the more global catalog of Life (with Species 2000), be followed by GISIN data providers. Where available, species codes, such as the ITIS Taxonomic Serial Numbers, should be made part of the database to help to make taxonomic data most easily accessible. Legacy databases or those that follow other taxonomic standards will not be excluded from the GISIN.

For databases containing bibliographic reference data, the Dublin Core standard that has been adopted by the publishing community was recommended.

The Ecological Metadata Language (EML) standard developed by the National Center for Ecological Analysis and Synthesis (NCEAS) was suggested as a standard that could be followed by research/project databases.

The goal of selecting a minimum set of database search fields was to define a set of data fields that all GISIN data providers or IAS databases would be likely to have in common with each other. The GISIN does not seek to exclude data providers that have additional fields, nor those that lack specific fields (for example, a field for family name).

The goal of selecting a minimum set of database search fields was to define a set of data fields that all GISIN data providers or IAS databases would be likely to have in common with each other. The GISIN does

not seek to exclude data providers that have additional fields, nor those that lack specific fields (for example, a field for family name). In order for multiple databases to be searched via a single efficient query mechanism, the most basic and yet most inclusive search would have to incorporate the genus and/or species name of an organism. A search performed using these two data fields would result in the examination of the largest possible number of GISIN data providers.

The GISIN considers a standards-based approach to database development and information sharing to be the best method for achieving interoperability. In recommending standards for data management, the GISIN does not require that all data providers involved in the network follow any one particular standard, nor does GISIN endorse any one particular standard. The GISIN is concerned with encouraging the interoperability of online databases by identifying information that will help databases achieve interoperability.

Developing Databases and Capacity Building

Group Leaders: Soetikno Sastroutomo (CABI)[1], Silvia Ziller (Horus/TNC)[2]
Rapporteur: Philip Thomas (HEAR)[3]

Introduction
The Developing Databases and Capacity Building breakout group was tasked with identifying priorities related to capacity building and outreach. Participants just beginning to collect invasive species information were encouraged to participate in this breakout group. Suggested common minimum standard database fields were drafted and passed to the Content breakout group for consideration.

Report
The Developing Databases and Capacity Building breakout group began their discussions by identifying 17 priorities that should be addressed with respect to GISIN's role in capacity building within the invasive alien species (IAS) community. The group then narrowed the list down to three issues. The text of some of the original seventeen priority issues was incorporated into the final three and a subcommittee further refined the three issues/tasks to:

1) Development of a simple interactive IAS database with common minimum standard fields, formats, and terms.

2) Development of an information start-up package and model database for new IAS database developers.

3) Developing methods/actions for addressing what is commonly known as the *digital divide* – the gap that exists between those with access to digital technology and related services and those with limited or no access.

The discussions of this breakout group initially paralleled those of the Developing Database Content breakout group, as they sought to identify which data fields to recommend for inclusion in IAS databases. They delivered the list of data fields they had identified to the Developing Database Content breakout group, and moved on to discuss the second priority.

Silvia Ziller offered to translate her organization's database into English and Spanish (it is currently served in Portuguese) and supply it to those that would like to use it to develop their own IAS databases. The GISIN should develop and provide a database development manual containing instructions about what information should be recorded in an IAS database, and how it could be structured. For example, the manual should include instructions for storing data in small incremental data fields or groups such as economic impacts, environmental impacts, and health impacts rather than in one general impacts data field. Combining information stored in separate fields is relatively easy, while separating information stored in a general field is much more difficult. In a globally shared network, it makes sense to provide the flexibility for separating out specific pieces of information like this.

Combining information stored in separate fields is relatively easy, while separating information stored in a general field is much more difficult.

The GISIN community needs to develop a marketing strategy for advertising the GISIN concept, and some initial value added

[1] CAB International
[2] Horus Institute / The Nature Conservancy
[3] Hawaiian Ecosystems at Risk

products in support of addressing the global IAS issue. A survey could be conducted to identify potential GISIN participants, including groups that have not yet been involved in discussion of the GISIN concept. Many groups do not know that the GISIN concept exists or that it is being implemented.

A conscious effort must be made to advertise the GISIN movement and to encourage others to get involved. For example, the Convention on Biological Diversity (CBD) Focal Points that have not yet reported on invasive alien species in their area need to be aware that there are others throughout the global community that are still working on this global issue. In addition, once products have been developed they will also need to be marketed to those outside of the GISIN community. One suggested method for doing this is the development of press releases that can be sent to list serves and distributed through other mechanisms so that the information reaches those with and without Internet access.

Value-added GISIN products are needed that support individuals and organizations addressing the IAS issue, whether or not they are actively involved in the network. Some governments are not even aware of the invasive species issue. If an individual or organization had access to a list of IAS in their area, or access to information that would help them to develop such a list, they could then use that information as supporting evidence for getting their government and national public involved in combating IAS. GISIN needs to develop these types of products through its members and contributors.

In addition to developing tools such as IAS identification guides, GISIN could also identify and/or endorse existing tools, and support their distribution or provide access to them through the network. A virtual library might facilitate access to literature through the Internet, compact discs, and printed resources – especially for literature that may be otherwise difficult to obtain.

…species observations are often not reported due to their potential for initiating trade barriers. How should this information be handled by the GISIN?

Members of the GISIN community should also identify barriers to information dissemination and exchange, and suggest solutions for overcoming them. For example, species observations are often not reported due to their potential for initiating trade barriers. How should this information be handled by the GISIN?

In summary, the actions that were identified by the group include:

- Develop marketing strategies to advertise the GISIN concept/activities and to warn of the threat of IAS.
- Develop and distribute press releases and other promotional material through list serves and embassies, for example.
- Conduct a survey to identify potential GISIN participants, including groups that have not yet been involved in discussion of the GISIN concept.
- Develop an information start-up package and model database for new IAS database developers. The Argentina/Brazil database structures may form the basis for this.
- Develop an IAS database development manual with instruction on what types of data to collect for IAS, and how to arrange that data in an IAS database – particularly with respect to achieving interoperability with other data providers in the GISIN network.

- Develop an interface for posting the database on the internet so it is easily accessible at least to decision-makers, scientists, and interested public.

- Develop value-added products that support individuals and organizations that are addressing the IAS issue, whether they are actively involved in the network or not – such as IAS lists or regional IAS groupings.

- Develop tools such as IAS identification guides and mapping applications.

- Identify and/or endorse existing tools, and support their distribution or provide access to them through the network.

- Develop a virtual library to facilitate access to literature through the Internet, CDs, and printed resources – especially for literature that may be otherwise difficult to obtain.

- Identify barriers to information dissemination and exchange, and suggest solutions for overcoming them.

Aquatic IAS & NISbase Collaboration

Group Leaders: Pam Fuller (USGS)[1], Brian Steves (SERC)[2]
Rapporteur: Rachel Muir (NatureServe/USGS)

Introduction - NIS*base* Collaboration
The Non-Indigenous Species Database or NIS*base* is an Extensible Markup Language (XML)-based distributed database system that was developed by Greg Ruiz and Brian Steves (SERC), and Pam Fuller and Shawn Dalton (USGS). Five databases on aquatic (marine) non-indigenous species may be searched simultaneously through this Internet portal.

The GISIN recognizes and will facilitate the existing experiences and achievements in invasive alien species (IAS) database development such as those of the NIS*base* development team. The addition of new databases and datasets to the NIS*base* system will support the GISIN's goal of coordinating and serving IAS information through the Internet, and provides a valuable opportunity to learn and improve technology, and methods for IAS information management.

Twelve individuals representing databases, information systems, and organizations concerned with aquatic organisms and aquatic IAS gathered in an informal breakout group to explore the possibility of collaborating with the NIS*base* system. Prior to the GISIN meeting, Brian Steves provided technical details about the functionality and application of the current *NISbase* distributed database system in a document entitled "*NISbase* (Non-Indigenous Species Database Portal): Information for Developers" (Steves 2004) (Appendix J). This document was posted on the GISIN online Community and paper copies were distributed to the group participants during the discussion.

Common Data Fields and Database Compatibility with *NISbase*
Database characteristics that would make other databases compatible with the *NISbase* system are described in Mr. Steves' report, and include content such as fact sheets, bibliographies, collection records, expertise, and georeferenced data. It was generally agreed that georeferencing for aquatic systems presents a greater challenge than that experienced by researchers and information managers working within terrestrial systems. Many different and unconventional approaches to georeferencing were described by members of the group. It is clear that the development of a georeference standard approach will be a task to be completed in the long term.

…georeferencing for aquatic systems presents a greater challenge than that experienced by researchers and information managers working within terrestrial systems.

A Georeferencing Standard
Until a georeferencing standard is developed, interim methods need to be identified for making existing georeference classification systems compatible. The group identified two such classification systems – those that are geopolitically referenced, and those that are biological or ecological in character.

Defining Invasive Species Data for Information Exchange
The problem of defining an invasive species and methods for doing so are subjects of extended debate within research and conservation communities. Discussions on the appropriate method for cataloguing invasive species in a database to facilitate

[1] United States Geological Survey
[2] Smithsonian Environmental Research Center

information exchange with other datasets that may or may not define a species as invasive, were particularly germane to the focus of this group.

Databases for aquatic organisms such as fishes are comparatively exhaustive in comparison to those for other taxa.

Databases for aquatic organisms such as fishes are comparatively exhaustive in comparison to those for other taxa. Such exhaustive databases often include native, non-native and invasive species without indicating these separations. Species that are considered invasive may be native or non-native, while all non-native species may not be or become invasive. Indeed, the ability for a non-native species to exhibit invasive characteristics is as much dependent on the controlling factors in the receiving environment as it is on the biological characteristics of the species. In short, a non-native species in one environment may become invasive whereas that same species introduced into a different environment may not become a problem.

The question was raised as to how datasets should be managed in terms of whether they contained invasive species or non-invasive species data. One possible solution suggested by the group was to develop a method by which records for invasive species could be tagged or separated, and extracted from records for native and non-native species. There are a variety of methods for defining the invasiveness of a species including risk-based systems, systems such as that used by FISHbase, and decision support systems.

A uniform or standard approach for assessing invasiveness does not currently exist and is unlikely to be developed at this time, and may not be a desirable development. *NISbase* is not currently trying to address this issue, but each database or dataset should include the criteria used to define invasiveness for its species data/records, if applicable. A tool suggested for development was a query system to locate the term 'invasiveness' (or any of the term's equivalents) in database records, compile the information, and examine each database's criteria to see if they meet the user's criteria.

It would be best if metadata were supplied by portals as well as by the original data source. If they deliver only those data that are relevant to the search or particular focus of the access point, information contained within a record may be filtered out by the access point. However, this does not mean that the data was lost or deleted from the original data source, and it should be accessible to the user through the portal.

A portal normally includes a built in policy about how it handles the records it acquires from different sources. Although a data source might choose to accept this policy, the actual records will not be changed. While another access point to the same data may agree with a different policy (such as one that corrects things like the formatting of page numbers in bibliographic references). There's nothing in the architectural design of a portal that prevents you from guaranteeing a certain level of service. This is a policy question that the operators of the portal and/or access point should define.

The breakout group concluded discussions with a call for contributions to the NIS*base* system. Participants exchanged a list of names and contact information for technical representatives so that these representatives could contact NIS*base* (or *vice versa*) and discuss the practicalities of collaboration. NIS*base* system has succeeded by working with each individual database to make it compatible with the larger system. This task of integrating the

database and collaborating with its representatives is relatively simple and can take as little as four hours. The addition of new databases to NIS*base* was recognized as an achievable short-term goal that supports the development of a GISIN. The NBII is providing funding toward the addition of new databases to NISbase and to its general development.

Selected References:

Steves, B. P. 2004. NIS*base* (Non-Indigenous Species Database Portal): Information for Developers. Smithsonian Environmental Research Center. stevesb@si.edu (Appendix J).

Organizational Framework

Group Leaders: Keng-Yeang Lum (ASEANET)[1], Lucie Rogo (CBD)[2]
Rapporteurs: Richard Smith (BioNET-INTERNATIONAL), Shelaine Curd-Hetrick (NBII)[3]

Introduction
The Organizational Framework breakout group was tasked with identifying priorities and the next steps that the invasive alien species (IAS) community must take in order to continue the implementation of the GISIN. A draft GISIN Framework document (Appendix K) was discussed, as was future funding sources and possible organizational affiliations. This group initiated the selection of the six-member interim Steering Committee (iSC) for the GISIN.

Report – Mission and Vision
The mission, vision and goals of the GISIN, as they were outlined in Section 1.1 of the draft GISIN Framework document, were discussed. The GISIN mission was defined as follows:

"Facilitate the electronic assembly and sharing of knowledge on invasive alien species to reduce the spread of IAS worldwide."

The group revised the goals of the GISIN to read as follows:

- *To provide a platform for sharing invasive species information at a global level by internet and digital means;*
- *To offer a central place for the reporting and tracking of new alien species sightings via email listserv;*
- *To develop and share information management tools to better identify, map, and predict the spread of invasive species at regional and global levels;*
- *To build the capacity of network members in the development of invasive species information tools; and*
- *To identify and prioritize critical gaps in integrating IAS databases.*

GISIN Affiliation(s)
With respect to the structure and possible affiliations of the GISIN (sections 2.0 and 2.6 of the draft document), the group raised and discussed the following questions:

- Where will the central hub of GISIN be located?
- Do we need to develop the GISIN within the context of the CBD[2] or other policy or strategic frameworks?
- Should GISIN be affiliated with organizations such as GISP[4], IUCN[5], or GBIF[6], and what are the consequences of doing so or not doing so?
- Can GISIN move forward without formalizing affiliations, and what are the disadvantages of doing so?
- Who is going to use the GISIN?

GISIN's mission: Facilitate the electronic assembly and sharing of knowledge on invasive alien species to reduce the spread of IAS worldwide.

In developing the GISIN, all effort should be made to cooperate with existing organizations, and to avoid duplication of effort and products. The group highlighted the need for GISIN to develop partnerships as a key step in the development process, rather than developing a new and separate organization. They recognized that there are both advantages and disadvantages to

[1] Association of South East Asian Nations (ASEAN) LOOP of BioNET International
[2] Convention on Biological Diversity
[3] National Biological Information Infrastructure
[4] Global Invasive Species Programme
[5] The World Conservation Union
[6] Global Biodiversity Information Facility

affiliating with the GISP and with the CBD, and also with choosing to be independent. They also recognized the fact that the affiliations of the GISIN could affect funding and organizational structure.

The breakout group put forward a draft list of international/global organizations for possible affiliation and partnerships:

- Global Invasive Species Program (GISP)
- Global Biodiversity Information Facility (GBIF)
- International Plant Protection Convention (IPPC)
- Convention on Biological Diversity (CBD)
- World Conservation Union (IUCN) Species Survival Commission (SSC) Invasive Species Specialist Group (ISSG)
- International Office of Epizootics (OIE)
- BioNET-INTERNATIONAL
- International Maritime Organization (IMO)
- CAB International
- The Nature Conservancy (TNC)
- World Trade Organization (WTO)

The GISIN's intended audience should be clearly identified so that the GISIN can meet the needs of key user types in biodiversity, quarantine, agriculture, food, health, plant protection, and other fields.

The GISIN's intended audience should be clearly identified so that the GISIN can meet the needs of key user types in biodiversity, quarantine, agriculture, food, health, plant protection, and other fields. The users are going to define the product and how support is obtained for creating that product. It is important for the GISIN to develop products, and product targets or goals within the first one to two years, which can be used to demonstrate the value of the concept. An example is the short-term goal of connecting a specific number of databases within one or two years. However, medium and long-term goals are an important component of the GISIN work plan. GISIN goals include the identification of IAS information gaps, and defining priorities for filling those gaps.

Information Availability

Whether or not the information provided by the GISIN should be *freely available to all*, was discussed by the group in some detail. The group agreed that the idea falls within the scope of the GISIN concept, but raised the question of how sensitive data such as that affecting trade and quarantine activities should be handled within the GISIN framework. Should GISIN address the World Trade Organization's Sanitary and Phytosanitary Regulations and design its content services accordingly? There was no conclusion on this issue, but it's an important question that must be considered in the GISIN design. Another is whether *freely available information to all* refers to information provided without financial cost, or without requiring user authentication (e.g. no password protection).

Governance

Section 2.2 Governance of the draft GISIN Framework document recommended that a 12-member interim Executive Committee (EC) be established to fulfill the governance requirements of the first GISIN membership meeting. Duties for the EC were also outlined in this section of the document. The EC was renamed *interim Steering Committee (iSC)* to make the governing group more open and more inclusive. In keeping with the text of the draft document, the group agreed that the iSC should contain members with expertise at the strategy and policy level in order to steer the GISIN and be capable of securing support. The iSC should also be able to draw on available expertise to provide the short-term direction and products that are needed to

demonstrate the viability of the GISIN concept.

The breakout group asked Annie Simpson (NBII), Jeff Fisher (DOS)[7], and Lucie Rogo (CBD Secretariat) to nominate six of the twelve iSC members by the end of this first meeting of the GISIN membership. Participants at the meeting were called upon to indicate their interest and availability, and a broad regional and non-government organizational representation was sought. The group recommended that the initial six member iSC should also be tasked with selecting an additional six members that would complete the 12 member iSC.

Short Term Goals and Products

The breakout group recommended short-term tasks that should be undertaken by the iSC as follows:

- Address the issue of the affiliation(s) of the GISIN.
- Review the structure and governance of the GISIN, and present proposals for consideration by the wider community that include or highlight pilot projects that demonstrate current GISIN-type activities and progress.
- Identify advantages/disadvantages of designing GISIN to meet the needs of various potential audiences.
- Develop and agree on a business plan, and initiate fund raising activities.

The breakout group requested clarification on the main goal identified by the GISIN membership (linking databases together) because a clear definition is vital to meeting that goal. They asked the membership to consider what was really meant by *linking databases* and raised the question of whether *linking databases* in the context of the GISIN meant making databases accessible through several searchable portals, or through a single portal. The group generally agreed that some short-term objectives should be identified before this first meeting of the GISIN membership was adjourned. However they felt that they were not qualified to identify such objectives. They asked the other breakout groups to come up with some goals for the GISIN that could be completed within two years. (See the Developing Databases and Capacity Building breakout group report.)

In addition to goals, some basic products that should be developed by the GISIN were identified. The main goal of linking databases could be initiated through the creation of a searchable master directory of the 160 databases identified in the list of online IAS databases that was distributed at the meeting. Development of this product may be initiated and hosted by the NBII.

The members of the GISIN were tasked with reviewing the online IAS databases list and providing further feedback for improving it. Based on the metadata that was supplied for the databases on the list, feedback from the GISIN members indicated that there were some databases that were missing from the list, and some that should not have been included. However, some databases do not provide metadata, or do not provide metadata that would be useful to the GISIN. So the breakout group recommended that a standard list of questions or pre-defined metadata fields be developed by the GISIN and recorded for each of the databases identified in the online IAS databases list.

The breakout group gave their support for developing a list of minimum (recommended) requirements for including databases in the GISIN. This list should also allow databases to report their georeferenced data/records (if available) when they request inclusion in the GISIN.

[7] United States Department of State

GISIN Twelve Month Action Plan Review
The list of 13 Action items in Section 5.0 of the draft GISIN Framework document (Appendix K) was considered in the context of whether they could be addressed within the next 12 months. Responses and recommendations provided by the group are listed with each of the Action items listed below:

1. Select a planning team, location, and dates for the next GISIN meeting.
   Response: This is a decision for the iSC.

2. Prepare a draft proposal document for submission to possible funding agencies for the hub.
   Response: The group recognized that funding for the GISIN should be approached from the bottom up and from the top down. They suggested that the funding models employed by GBIF and the Inter-American Biodiversity Information Network (IABIN) should be considered as examples that could be followed by the GISIN. The group also reported that the National Invasive Species Council (NISC) is coordinating an effort to potentially include an Invasive Species Crosscut Budget (FY06) initiative regarding a coordinated U.S. effort to address the GISIN effort.

3. Develop a GISIN Web site;
4. Publish and maintain a complete catalog of online invasive species databases; and
5. Establish a listserv for GISIN members.
   Response: With respect to Action items 3 through 5, the group reported that communication currently exists in some context (e.g. the GISIN online community) and should be maintained. The NBII will catalog and maintain the list of databases on the Web at GISIN's temporary address- http://invasivespecies.nbii.gov/as/gisin.htm. However the group recommended that future communication mechanisms such as a listserv should follow a simple open format.

6. Agree on a procedure to solicit assistance from the GISIN member organizations for letters of support.
   Response: Combine this Action item with the 13th Action item.

7. Create and distribute the funding toolkit and possibly a legal framework toolkit, via compact disc and on the Web.
   Response: GBIF and IABIN provide examples of funding models that could be followed by the GISIN. The funding toolkit should be defined for both a top-down and bottom-up approach. Top-down funding would support a GISIN secretariat and continuation of the organization (if GISIN is to be an organization), while bottom-up funding should be available for database developers and information collectors/managers. Funds will not be readily available until organizational affiliations are defined. Defining legal issues is not a goal of the GISIN, and a legal framework toolkit was not endorsed.

8. Prepare a draft report of April's GISIN implementation meeting to circulate among the IAS community; and
9. Submit to the U.S. Department of State the final report on the April meeting.
   Response: Tasks 8 and 9 will be fulfilled in the publication of the proceedings from this meeting. A summary report of the GISIN meeting was created and distributed in May 2004 (Sellers *et al.* 2004).

10. Publish on the Web the requirements for inclusion in the GISIN's IAS database consortium for cross search;
11. Convene the GISIN Executive Committee, electronically or face-to-face; and
12. Create the GISIN Mid-term Work Plan.

Response: Tasks 10, 11, and 12 are to be completed by the iSC with the understanding of a logical sequence of events.

13. Prepare and submit a final GISIN hub proposal
    Response: The term *hub* was rejected. The iSC will suggest a procedure to solicit assistance from the GISIN partner organizations and exploit synergies.

Selected References:

Sellers, E. 2004. - DRAFT - List of Invasive Alien Species (IAS) Online Databases and Databases Containing IAS Information: A preliminary draft document, prepared for the Experts Meeting Towards the Implementation of a Global Invasive Species Information Network (GISIN), Baltimore, Maryland, USA, 6-8 April 2004. Information International Associates Inc., USA. Accessed 21 May 2004 online at http://invasivespecies.nbii.gov/as/DraftIASDBs.htm (Appendix C).

Sellers, E., Muir, R., and A. Simpson. 2004. Summary Report on the Experts Meeting on Implementation of a Global Invasive Species Information Network (GISIN). 6-8 April, 2004, Baltimore, Maryland, USA. National Biological Information Infrastructure and The Nature Conservancy, Virginia, USA. May 21, 2004. Accessed 21 May 2004 online at http://invasivespecies.nbii.gov/as/GISINsummary(MuirSellersSimpson)_2.pdf

Simpson, A. 2004. GISIN draft Framework Document for the Experts Meeting on Implementation of a Global Invasive Species Information Network (GISIN): prepared by Annie Simpson for discussion during the Financial and Organizational Framework Breakout Group at the Experts Meeting on Implementation of a Global Invasive Species Information Network, Baltimore, Maryland, USA, 6-8 April 2004. National Biological Information Infrastructure, USA. Accessed 21 May 2004 online at http://invasivespecies.nbii.gov/as/OrgFrameworkGISIN.htm (Appendix K).

Selection of an Interim Steering Committee

The draft GISIN Framework document recommended that an interim Executive Committee (EC) be established to fulfill the governance requirements of the first GISIN membership meeting (Simpson 2004) (Appendix K). The Financial and Organizational Framework breakout group agreed to rename the EC to *interim Steering Committee (iSC)* to make this governing group seem more open and more inclusive.

Short term tasks to be undertaken by the iSC:

- Develop and agree on a business plan, and initiate fund raising activities.
- Address the issue of the affiliation(s) of the GISIN.
- Review the structure and governance of the GISIN, and present proposals for consideration by the wider community that include or highlight pilot projects that demonstrate current GISIN-type activities and progress.
- Identify advantages/disadvantages of designing GISIN to meet the needs of various potential audiences.

The document also recommended a 12-member EC for the GISIN, so the breakout group asked Annie Simpson (NBII), Jeff Fisher (DOS), and Lucie Rogo (CBD Secretariat) to nominate six of the twelve iSC members by the end of the meeting. Participants at the meeting were called upon to indicate their interest and availability, and to nominate meeting participants for the six positions. The breakout group also recommended that the initial six member iSC should be tasked with selecting an additional six members that would complete a 12 member iSC.

The six members of the iSC were selected based on criteria outlined in the draft Organizational Framework document, which recommended selection of members that would provide broad representation from a variety of regions, government and non-government organizations, areas of expertise, and interests; and with the ability to identify six additional members.

The six elected members of the GISIN interim Steering Committee selected and approved at the meeting are:

Malika Bounfour (Morocco)
Dr. Bounfour is an Entomologist and Plant Health Specialist with the Ministry of Agriculture in Rabat, Morocco. She is also a member of the national board of NAFRINET, the North African loop of BioNET-International.

Hannu Saarenmaa (Denmark)
Dr. Saarenmaa is the Deputy Director for Informatics at the Global Biodiversity Information Facility (GBIF) Secretariat in Copenhagen, Denmark.

Soetikno Sastroutomo (Malaysia)
Dr. Sastroutomo is a Senior Project Officer of CAB International's Southeast Asia Regional Center (Selangor, Malaysia) and Technical Secretary of ASEANET, the ASEAN LOOP of BioNET-International and APHCN (ASEAN Plant Health Cooperation Network).

Annie Simpson (USA)
Ms. Simpson is the Invasive Species Theme Coordinator for the Invasive Species Information Node of the National Biological Information Infrastructure in Virginia, USA. She is also the U.S. lead for the Inter-American Biodiversity Information Network (IABIN) Invasives Information Network (I3N) project.

Yan Xie (China)
Dr. Xie is Director of the Interdisciplinary Research Promoting Center, Institute of Zoology, Chinese Academy of Sciences (Beijing, China). She is also Manager of the Chinese Species Information System (CSIS).

Silvia Ziller (Brazil)
Dr. Ziller is President of the Horus Institute and The Nature Conservancy (TNC) Brazil Invasive Species Program Coordinator (Curitiba, Brazil). She is also a GISP Board Member, member of ISSG, and fellow of Ashoka Innovators for the Public.

Appendix A

Acronyms and Abbreviations

AAAS	American Association of the Advancement of Science
ABCD	Access to Biological Collection Data
ABI	Association for Biodiversity Information, (now known as NatureServe).
AIRD	Aquatic Invasions Research Directory
AIS	Alien Invasive Species
AKEPMP	Alaska Exotic Plant Mapping Project
ALARM	Assessing LArge-scale environmental Risks with tested Methods
AOL	America Online
ANSI	American National Standards Institute
ANSTF	Aquatic Nuisance Species Task Force
APHCN	ASEAN Plant Health Cooperation Network
APHIS	Animal and Plant Health Inspection Service
APIRS	Aquatic Plant Information Retrieval System
APIS	Aquatic Plant Information System Online
APRS	Alien Plants Ranking System
APWG	Alien Plant Working Group
ArcGIS	(A Software Application) Geographic Information System. A scalable system of software for geographic data for organizations. Developed by ESRI.
ArcIMS	(A Software Application) Internet Mapping Solution. Provides the foundation for distributing high-end GIS and mapping services via the Internet. Developed by ESRI.
ArcInfo	(A Software Application) The most comprehensive GIS in the ArcGIS software family. Developed by ESRI.
ArcView	(A Software Application) The world's most popular desktop GIS and mapping software. Developed by ESRI.
ARL	Association of Research Libraries
ARS	Agricultural Research Service
ASCII	American Standard Code for Information Interchange
ASEAN	Association of Southeast Asian Nations
ASEANET	The ASEAN LOOP (Network) of BioNET-INTERNATIONAL
ASP	Active Server Pages
BALLAST	Balanced Loading Via Automated Stability & Trim
BDP	Biological Data Profile
BioCASE	Biological Collection Access Service for Europe
BMB	Baltic Marine Biologists
BR	Biological Record
BRD	Biological Resources Discipline (USGS)
BRGB	Biodiversity Research Group of Bangladesh
CAB	Center for Agriculture and Biosciences
CABI	CAB International. (Formally known as the Center for Agriculture and Biosciences International)
CAS	Chemical Abstracts Service; Chinese Academy of Sciences
CBD	Convention on Biological Diversity
CBI	Center for Biological Informatics (USGS)
CD	Compact Disc
CD-ROM	Compact Disc Read Only Memory
CGI	Common Gateway Interface
CHM	Clearing House Mechanism
CIA	Central Intelligence Agency (USA)
CIESM	International Commission for the Scientific Exploration of the Mediterranean Sea
CIPM	Center for Invasive Plant Management
CISD	Colombian Invasive Species Database
CITES	Convention on International Trade in Endangered Species
CMI	Conservation Management Institute
CONABIO	Comisión Nacional para el Conocimiento y Uso de la Biodiversidad
CRC	Cooperative Research Centers (Australia)
CRIMP	Center for Research on Introduced Marine Pests (Australia)

CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
CSIS	China Species Information Service
CSV	Comma Seperated Value (output file format)
DAISIE	Delivering Alien Invasive Species Inventories for Europe
DCMI	Dublin Core Metadata Initiative
DDS	Distributed Database System
DG	Digital Gazetteer
DIAS	Database on Introductions of Aquatic Species
DiGIR	Distributed Generic Information Retrieval protocol
DIR	Database of IPM (Integrated Pest Management) Resources
DOD	Department of Defense (USA)
DOI	United States Department of the Interior
DOS	United States Department of State
DSL	Digital Subscriber Line
DVD	Digital Versatile Disc (formerly known as Digital Video Disc)
DwC	Darwin Core
EC	Executive Committee; European Commission
EC-CHM	European Community Biodiversity Clearing House Mechanism
ED/RA	Early detection and rapid assessment
ED/RR	Early detection and rapid response
EFPISNA	Exotic Forest Pest Information System for North America
EML	Ecological Metadata Language
EO	Element Occurrence (NatureServe)
EOS	Earth Observatory System
EPICENTER	Exotic Plant Information Center
EPIDEMIE	Exotic Plant Invasions: Deleterious Effects on Mediterranean Island Ecosystems
ERNAIS	European Research Network on Aquatic Invasive Species
EROS	Earth Resources Observation Systems Data Center
ESRI	Environmental Systems Research Institute
ETI	Expert Center for Taxonomic Identification
EUNIS	European Nature Information System
FAO	Food and Agriculture Organization of the United Nations
FGDC	Federal Geographic Data Committee (USA)
FICMNEW	Federal Interagency Committee for the Management of Noxious and Exotic Weeds
FNA	Flora of North America
FS	Forest Service (USA)
GBF	Global Biodiversity Forum
GBIF	Global Biodiversity Information Facility
GCW	Global Compendium of Weeds
GEF	Global Environment Facility
GIS	Geographic Information System; Geospatial Information System
GISD	Global Invasive Species Database
GISIN	Global Invasive Species Information Network
GISP	Global Invasive Species Programme
GloBallast	Global Ballast Water Management Programme
GPS	Global Positioning System
GRIN	Germplasm Resources Information Network
GSMFC	Gulf States Marine Fisheries Commission
GTI	Global Taxonomy Initiative
HEAR	Hawaiian Ecosystems at Risk
HELCOM	Helsinki Commission
HNIS	Harmful Non-Indigenous Species
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
I3N	IABIN Invasives Information Network
IABIN	Inter-American Biodiversity Information Network
IAS	Invasive Alien Species
IBI	Institute for Biological Invasions
ICTV	International Committee on Taxonomy Virus database
ID	Identification; Identifier; identity

IDC	Internet Database Connector
IE	Internet Explorer (Microsoft)
IETF	Internet Engineering Task Force
IIa	Information International Associates, Inc.
ILDIS	International Legume Database and Information Service
IMO	International Maritime Organization
IMS	Internet Map Service; Information Management System
InBiAr	Invasiones Biologicas En Argentina
INBio	Instituto Nacional de Biodiversidad (Costa Rica)
IPANE	Invasive Plant Atlas of New England
IPCAN	Invasive Plants of Canada
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention (a USA treaty)
IPR	Intellectual Property Rights
I-Ranks	Invasive Species Impact Ranks (NatureServe)
iSC	interim Steering Committee
ISIN	Invasive Species Information Node (NBII)
ISO	International Standardization Organization
ISSG	Invasive Species Specialist Group (New Zealand)
IT	Information Technology
ITIS	Integrated Taxonomic Information System. (Formally known as the “Inter-agency Taxonomic Information System”)
IUCN	World Conservation Union. (Formally known as the “International Union for Conservation of Nature and Natural Resources”)
IUCN-SSC ISSG	World Conservation Union Species Survival Commission Invasive Species Specialist Group
JNCC	Joint Nature Conservation Committee
JSP	Java Server Pages
LEDA	Life-history traits of the Northwest European Flora database
LTER	Long Term Research Center
MS	Microsoft
MySQL	An open source database that uses Structure Query Language (SQL)
NABIN	North American Biodiversity Information Network
NAFRINET	North Africa LOOP of BioNET-INTERNATIONAL
NAISD	National Alien and Invasive Species Database (Canada)
NANIAD	North American Non-Indigenous Arthropod Database
NANSC	National Aquatic Nuisance Species Clearing House (USA)
NAPIS	National Agricultural Pest Information System (USA)
NAS	Non-indigenous Aquatic Species database
NASA	National Aeronautics and Space Administration (USA)
NAWMA	North American Weed Management Association
NBCI	National Biological Control Institute (USA)
NBIC	National Ballast Information Clearinghouse (USA)
NBII	National Biological Information Infrastructure (USA)
NCBI	National Center for Biotechnology Information
NCEAS	National Center for Ecological Analysis and Synthesis (USA)
NEMESIS	National Exotic Marine and Estuarine Species Information System (USA)
NFWF	National Fish and Wildlife Foundation (USA)
NGO	Non-Governmental Organization
NIISS	National Institute of Invasive Species Science (USA)
NIMA	National Imagery and Mapping Agency
NIMPIS	National Introduced Marine Pest Information System (Australia)
NIPS	Non-native Invasive Plant Species
NIS	Non-Indigenous Species
NISbase	Non-Indigenous Species Database
NISC	National Invasive Species Council (USA)
NISO	National Information Standards Organization (USA)
NNIS	Non-Native Invasive Species; Nordic Network on Introduced Species
NOAA	National Oceanographic and Atmospheric Administration (USA)
NOBANIS	Nordic Baltic Network on Invasive Species
NPS	National Park Service (USA)

NSDI	National Spatial Data Infrastructure (USA)
NSF	National Science Foundation (USA)
OES	Bureau of Oceans and International Environmental Scientific Affairs (USA)
OS	Operating System
PDF	Portable Document Format (electronic file format)
PHP	Hypertext PreProcessor
PHPMyAdmin	A tool written in PHP intended to handle the administration of MySQL
PI	Principal investigator
PMIS	(noxious and nuisance) Plant Management Information Sytem
PPQ	Plant Protection and Quarantine
RBIC	Regional Biological Invasions Center
REMIB	Red Mundial de Información sobre Biodiversidad (World Information Network on Biodiversity)
ROBO	Releases of Beneficial Organisms
RTF	Rich Text Format (electronic file format)
SacNET	South Asian Network for Taxonomic Capacity Building of BioNET-INTERNATIONAL
SAFRINET	The SADC (Southern African Development Community) network of BioNET-INTERNATIONAL)
SAIN	Southern Appalachian Information Node (of theNBII)
SCOPE	Scientific Committee on Problems of the Environment
SDD	Structured Descriptive Data
SEEK	Science Environment for Ecological Knowledge
SERC	Smithsonian Environmental Research Center
SGML	Standard Generalized Markup Language
SIAC	Sistema de Información Ambiental de Colombia (Environmental Information System of Colombia)
SIB	Sistema de Información sobre Biodiversidad (Colombian Biodiversity Information System)
SNIB	Sistema Nacional de Información sobre Biodiversidad
SOAP	Simple Object Application Protocol
SPIRE	Spatial Image Retrieval Engine
SQL	Structured Query Language.
SSC	Species Survival Commission
UC Davis	University of California at Davis
UDDI	Universal Description, Discovery and Integration protocol
TAF	Taxonomic Authority Files
TCP/IP	Transmission Control Protocol/Internet Protocol
TDWG	Taxonomic Data Working Group
TNC	The Nature Conservancy
TXT	Text (electronic file format)
UDDI	Universal Description, Discovery, and Integration
UN	United Nations
URL	Uniform Resource Locator
US	United States
USA	United States of America
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USNFWF	United States National Fish and Wildlife Foundation
USNPS	United States National Park Service
W3C	World Wide Web Consortium
WCMC	World Conservation Monitoring Center
WCPA	World Commission for Protected Areas (of the IUCN)
WCU	World Conservation Union
WeedRIC	Weed Research and Information Center
WG NEMO	Working Group on Nonindigenous Estuarine and Marine Organisms.
WHDDB	Whirling Disease Data Base
WHO	World Health Organization
WSDL	Web Service Definition Language.
WSRF	Web Services Resource Framework

WWF	World Wildlife Fund; World Wildlife Federation
WWW	World Wide Web
XML	Extensible Markup Language

Appendix B

Databasing Invasions: A Review in the Context of the Global Invasive Species Information Network (GISIN)

Elizabeth Sellers, Information International Associates Inc., P.O. Box 4219, Oak Ridge, TN 37831-4219., (703) 648-4385, esellers**AT**usgs.gov.

Abstract

Due to significant and costly impacts on agriculture, economy and biodiversity caused by the accidental or intentional introduction and establishment of invasive alien species (IAS), IAS have been recognized as a significant global threat in need of urgent attention. Consequently, the international community has been urged to address the IAS issue as a national and international priority. Although some nations may have so far escaped the effects of IAS, the burgeoning status of global trade and travel guarantees that all nations will not only be threatened, but will experience the direct impact of IAS at some point in the near future.

Developed nations with established infrastructure, clearly defined biodiversity-management policies and regulations, decision-supporting data, information systems and technology have already demonstrated their capacity to detect and prevent potential invasions, combat established invasive species, and restore affected communities and ecosystems. A significant factor affecting the success of these activities is the existence, availability, and accessibility of IAS data, databases, and information systems. Databases represent a potentially valuable yet often inaccessible or unobtainable resource to nations that lack their own. Nations that are developing IAS databases should share their information resources in a cooperative effort towards combating the common threat posed by IAS.

However, the act of sharing information presents several problems in itself. Standards, formats, methods and protocols must be adhered to by dissimilar data products if they are to share or exchange data in an efficient and effective manner. The Internet and its associated formats and protocols for information management and exchange, represents a valuable tool for facilitating global IAS-data exchange. Recent cooperative development efforts among members of the international community and the Convention on Biological Diversity have resulted in the definition of international standards for biodiversity data exchange. Members of the international community have called for the development of a Global Invasive Species Information Network. The success and persistence of this network will depend on the support and participation of capable stakeholders, international standardization and cooperation in data exchange, and continued maintenance and development of the component information sources.

Among the nations of the Americas, Europe, Asia and Africa, IAS databases, biodiversity clearinghouse mechanisms, networks and international agreements have grown in number and complexity. Regardless of whether they are called Web sites, online databases, clearinghouse mechanisms, hubs, or portals, if they provide IAS-related information through the globally accessible Internet and continue to develop network linkages with other complimentary online information systems, they lend valuable support to the continued development of a Global Invasive Species Information Network.

This report describes and synthesizes invasive species information management activities occurring around the globe during the past decade. It is prepared in the context of the Convention on Biological Diversity's recommendation that the Global Invasive Species Programme (GISP) coordinate the development of the Global Invasive Species Information Network (GISIN). In this context, the proceedings of seven regional workshops coordinated by GISP are highlighted.

Keywords: invasive alien species, invasive species, invasives, alien species, exotic species, introduced species, non-native, nonnative, database, information system, Web, Internet, online, global invasive species information network, GISIN, IAS.

Appendix B Table of Contents

Introduction

This report was delivered to participants in the Experts Meeting on Implementation of a Global Invasive Species Information Network (GISIN), 6-8 April, 2004. The National Biological Information Infrastructure (NBII) of the United States Geological Survey (USGS), with support from the United States Department of State (USDOS), invited participation from countries involved in ongoing efforts under the Clearinghouse Mechanism of the Convention on Biological Diversity (CBD), the GISP, the Invasive Species Specialist Group (ISSG), the Global Taxonomy Initiative (GTI), the Global Biodiversity Information Facility (GBIF), and others, to further develop regional information hubs around the globe and achieve invasive species information management in an interoperable manner.

The meeting was held in Baltimore, Maryland, United States of America (USA) and attended by over 70 international experts (representing 26 nations) working within the invasive species information management field. The goal of the meeting was to synchronize the global efforts to manage invasive species information and define the steps that need to be taken in the implementation of a Global Invasive Species Information Network or GISIN. Prior to the meeting, an online electronic discussion and resource access forum – the GISIN Community – was created and hosted online by the National Biological Information Infrastructure (NBII). Topics relevant to the goals of the GISIN were covered in pre-meeting discussions, and documents, presentations, case studies and future recommendations for the development of the GISIN were submitted and examined by a broader online community of more than 150 international experts.

Research for this report was conducted online (using the Internet) and offline (using published hard-copy literature resources). The engines used to complete the Internet-based research were www.google.com© and the http://vivisimo.com® Clustering Engine. An accompanying document, DRAFT Online IAS Databases List, constitutes the research results, and includes over 150 online information systems and databases that contain IAS data, along with a brief description and a Universal Resource Locator (URL) address for each one. Each database, information system or Web site is numbered. These numbers are referenced throughout this report e.g. '(#1)'.

For the purposes of this report, the terms 'invasive alien species' and 'IAS' refer to "alien species whose establishment and spread threaten ecosystems, habitats or species with economic or environmental harm" (McNeely, p. 48, 2000). The term 'database' is used interchangeably with 'information system' throughout this review.

A separate draft list of over 80 general non-IAS focused online databases, information systems and Web pages including those containing biodiversity, taxonomic, bibliographic, graphic, geographic (maps), research, expertise and other related biological/ecological information, was also collected during this research. These databases will be reviewed for IAS content, and cataloged along with the list of IAS databases in support of a status assessment of international IAS resources. Both lists will be posted on the Web and maintained and updated by the NBII as one contribution to the GISIN. The lists will be made accessible through http://www.invasivespecies.net/gisin.htm. They are currently available in draft form at http://invasivespecies.nbii.gov/as/gisin.htm.

Standards for Biodiversity Data Exchange

Standards including metadata schemas, formats, and protocols for information management have been developed and followed by various groups for many years, as a simple response to the need to organize and provide access to data in a standardized way. Librarians, herbarium and museum/specimen collection managers, catalogers and database

developers are some of the diverse types of information managers that are involved in developing, implementing, endorsing and in some cases, enforcing the accepted standard, format, or protocol sanctioned for use with their specific type of data. A new justification for strict adherence to standards in information management is the increase in global data exchange and the increased need to standardize the management and exchange of biodiversity data. Global trade and travel continue to increase, all but eliminating borders, and subsequently increasing the need for efficient data exchange between very disparate users and often for very different purposes despite a common need for data. The need for efficient exchange of biodiversity information in combating IAS is no different, and the exchange of information requires a standardized approach if the information is to retain its 'recyclability' and application to the IAS issue and other as yet unidentified potential applications.

In response to calls for the development of information systems to support decision-making and IAS management, monitoring and control efforts, numerous recommendations for information management, exchange and overall database/information system design have been presented (Green, 1994; WCMC, 1996; Reynolds & Busby, 1996; Jasieniuk *et al.*, 1999; Ricciardi *et al.*, 2000; McNeely, 2000; McNeely *et al.*, 2001, Schmitz & Simberloff, 2001). At the 6th meeting of the Conference of the Parties to the CBC (COP6), the CBD recommend specific formats, protocols and standards to improve exchange and management of global biodiversity information and charged GISP with the task of implementing them within the Global Invasive Species Information Network (GISIN) (CBD-COP, 2002). The formats, standards and protocols recommended by the CBD are:

- **Formats**: Dublin Core Metadata Initiative; Federal Geographic Data Committee (FGDC) (later ISO 19115); Federal Geographic Data Committee Biological Data Profile; BIB-1; XML (eXtensible Markup Language) as a description language; and HTML (HyperText Markup Language) [version] 3.1 as a presentation language.
- **Standards**: ISO (International Organization for Standardization) 19115 spatial metadata; ISO 23950 interoperability; ISO 2788 Thesauri; ISO 3166 country codes; ISO 635 language codes; Internet Engineering Task Force (IETF) Request For Comments (RFC) – various; Open GIS (Geographic Information System) Consortium; World Wide Web Consortium (W3C); and GBIF.
- **Protocols**: z39.50; http (HyperText Transfer Protocol); ftp (File Transfer Protocol); and TCP/IP (Transmission Control Protocol/Internet Protocol).

Formats and Protocols Described

The ISO Standards are presented in detail by the ISO on the Web (ISO, n.d.). The Formats and Protocols recommended at the COP6 are briefly described in the following paragraphs.

The Dublin Core Metadata Initiative (DCMI) is an organization that promotes the adoption of interoperable metadata standards and develops specialized metadata vocabularies for describing resources, enabling more intelligent information discovery systems (DCMI, n.d.). The DCMI seeks to make location of resources using the Internet, easier. It develops metadata standards for cross-domain discovery, defines frameworks for the interoperation of metadata sets, and facilitates the development of community- or disciplinary-specific metadata sets (DCMI, n.d.).

The Federal Geographic Data Committee (FGDC) is a committee that is composed of representatives from the U.S. Executive Office of the President, Cabinet-level and independent agencies. The FGDC is developing the U.S. National Spatial Data Infrastructure (NSDI) in cooperation with organizations from State, local and tribal governments, the academic community, and

the private sector. This Infrastructure defines policies, standards, and procedures for cooperative production and sharing of geographic data (FGDC & USGS, 1999). The Biological Data Profile (BDP), developed through a cooperative effort between the FGDC and the USGS Biological Resources Discipline, supports the biological data collection and processing with the objective of providing a set of common terminology and definitions for biological data documentation. The BDP creates extended elements and a profile of the FGDC Content Standard for Digital Geospatial Metadata (FGDC & USGS, 1999).

An Attribute Set is used to define standard identifiers for referring to searchable and retrievable fields within databases. BIB-1 is a Bibliographic Attribute Set of the Z39.50 Information Retrieval Protocol that is primarily applicable to bibliographic searches (CAS, 2004). In order to expand the capabilities of the BIB-1 Attribute Set to support searching of data other than that of a bibliographic nature, the Chemical Abstracts Service (CAS), a division of the American Chemical Society (ACS), developed the Scientific and Technical Attribute and Element Set (STAS). The STAS, a superset of the BIB-1 Attribute Set, uses the Z39.50 Protocol to improve interoperability among consumers and providers of scientific, technical, and related information (CAS, 2004). "Since many scientific and technical databases also contain bibliographic data, the bib-1 Attribute Set supports access to a subset of their data and services. However, prior to the development of STAS, there was no standard way to refer to a large number of the non-bibliographic searchable and retrievable fields within scientific and technical databases." (CAS, 2004).

The Z39.50 Information Retrieval protocol is defined under the National Information Standards Organization (NISO) Information Retrieval: Application Service Definition & Protocol Specification Standard (NISO, 2003). This protocol "addresses communication between information retrieval applications at the client and server." (NISO, p. i, 2003).

Extensible Markup Language (XML) is a 'flexible text format' that was derived from Standard Generalized Markup Language (SGML). XML was originally designed to meet the challenges of large-scale electronic publishing (W3C, 2003). The language is now being increasingly applied in data-exchange operations involving a diverse variety of data on the Internet (W3C, 2003).

HyperText Markup Language (HTML) is used to create hypertext documents that are portable from one platform to another. "HTML documents are SGML documents with general semantics that are appropriate for representing information from a wide range of applications" (W3C[1,2], n.d.). The specification for HTML version 3.0 was released in March of 1995 and was superceded by HTML 3.2 in January of 1997 (W3C[1], n.d.; Raggett *et al.*, 1998). The 3.1 version of HTML never truly existed – at least not by that versioning definition. HTML version 3.2 was technically the format recommended by the CBD-COP. However, HTML version 4.0, an SGML application conforming to International Standard ISO 8879 – Standard Generalized Markup Language, became a Recommendation of the W3C in 1998 (Raggett *et al.*, 1998; W3C, 1999). The most recent specification, defining the first HTML version 4.01 Recommendation, was released by the W3C in 1999 (W3C, 1999).

Having already been recognized as accepted formats, standards and protocols with respect to existing applications of information management other than IAS, many of the CBD-COP's recommendations were implemented by stakeholders involved in developing various online biodiversity information systems even prior to their articulation in the COP6 Report.

Formats and Protocols Implemented in IAS Information Management Products

The CBD-COP6 further elaborated on these recommendations with respect to the

establishment of the GISIN, and also recommended the development of invasive species regional hubs that would build on existing networks and include new initiatives and projects (CBD-COP6, 2002). In 1996, the World Conservation Monitoring Centre (WCMC) described the primary role of a hub as facilitating "information generation by stakeholders" (WCMC, p. 33, 1996). However, in the context of the CBD and the IAS threat, this definition has evolved to include the facilitation of information exchange between stakeholders.

Global Biodiversity Information Facility's Information Management Products

Seeking to "*contribute to economic growth, ecological sustainability, social outcomes and scientific research by increasing the utility, availability and completeness of primary scientific biodiversity information available on the Internet*", the GBIF employs the Distributed Generic Information Retrieval (DiGIR) client/server protocol for retrieving information from specimen-based databases participating in the NBII United States Node to GBIF (GBIF, n.d.). In order to participate in this portal, databases must support metadata schema including the Darwin Core Metadata Schema, the Access to Biological Collection Data (ABCD) Schema and the BDP of the FGCD Content Standard for Digital Geospatial Metadata. The NBII GBIF Web site also references the Integrated Taxonomic Information System (ITIS), which has also been endorsed by the CBD-COP; the Universal Description, Discovery and Integration (UDDI) protocol; and other standards and formats listed by the NBII and the Taxonomic Database Working Group (TDWG) Subgroup on Biological Data Collection (GBIF, n.d.).

DiGIR, Species Analyst, and Darwin Core Information Management Products

The DiGIR protocol is based on HTTP, XML and UDDI (SourceForge.net, n.d.) and is being actively developed as part of the Species Analyst research project (Speciesanalyst.net, 2003). This project, based at the University of Kansas Natural History Museum, is developing standards and software tools for accessing natural history collections and observation databases (Speciesanalyst.net, 2003). The Species Analyst is capable of accessing multiple databases residing on remote and separate servers, including databases that were compiled with incompatible software (Kaiser 1999 cited in Ricciardi *et al.,* 2000; IABIN[2, 3], 2002). It was originally based on the Z39.50 Information Retrieval Protocol (Kaiser 1999 cited in Ricciardi *et al.,* 2000). However, the DiGIR protocol, considered to be a replacement for Z39.50, is being "actively developed and will gradually replace the Z39.50 infrastructure over time" (Speciesanalyst.net, 2003).

The Darwin Core profile, also being developed under the Species Analyst project, "was originally intended for use with the Z39.50 protocol". However, this profile may also be applied to defining searches and XML content generated by databases served using HTTP (Speciesanalyst.net, 2003). It describes the minimum set of standards for search and retrieval (Speciesanalyst.net, 2003). The Species Analyst creates a "Virtual Museum" through integration of data from dozens of institutions, dramatically increasing research efficiency. This network links Internet users to multiple databases and allows them to retrieve data through access portals ([2]IABIN, 2002). Through a new initiative, supported by the USDOS, the Species Analyst will be applied to the problem of invasive species ([2]IABIN, 2002).

International Data Management Issues: Standards, Language, Bandwidth

When considering the concept of international data exchange via the Internet, several issues arise that are not necessarily related to or addressed by the adoption of formats, standards or protocols for information exchange. Given that IAS data exists, the accessibility of the data is the strongest factor affecting its availability to the diverse population of potential users, and its

applicability to their IAS information needs. When serving information internationally, via the Internet, consideration must be given not only to technological standards such as what programming language or information management protocols to use, but also to the accommodation of variable-bandwidth users, backwards compatibility with Internet browser applications and database or data management software, semantics and language. These issues represent the less tangible limitations that are often experienced by those seeking access to information resources.

While tangible technology-related limitations can be overcome to some degree through financial and capacity-building support from collaborators; less tangible limitations may be addressed at the origin or during development of the information resource. Taking language as an example, the top five spoken languages in the world are 1) Mandarin [Chinese], 2) English, 3) Hindu-stani, 4) Spanish and 5) Portuguese (Global Reach, 2004). In comparison the top 5 languages in which Web content is currently described include 1) English, 2) Japanese, 3) German, 4) Chinese and 5) French (Global Reach, 2004). In view of these statistics, the question arises as to whether a standard group of languages, such as the latter group, should be selected for translating Web-based IAS information in order to make the data accessible to the widest possible range of users?

Almost all of the databases located during the research conducted for this report, were entirely or at least partially available in English, and the vast majority originated in the U.S., or focused on or contained IAS information specific to the North American continent. Considering that the research was carried out in English, at a U.S.-based Internet location, it is possible that the apparent English/U.S. bias in the resulting list of databases is also a reflection of the research methodology. In order to avoid excessive search-method bias, efforts were made to locate and translate non-English IAS information resources whenever possible, using Internet tools such as Google's™ language translation service. Each of the five most commonly spoken languages in the world and those listed for Web content description are represented in the research results, with the exceptions of Hindu-stani and Japanese. Additional languages supported by the online databases identified in the research included Polish, Estonian, Finnish, Danish and Swedish.

FishBase and Language Management

A system that is pioneering the translation of biodiversity data, including IAS information, is FishBase (#198) – a Global Information System on Fishes. This database supports no less than 14 languages (English, Spanish, Portuguese, French, German, Italian, Dutch, Swedish, Chinese, Arabic, Russian, Japanese, Hindi and Greek). This was achieved in part, through utilization of the Systran™ Web service, which is the engine that supports the translation routines of Google™, AOL™ - America Online, Inc., and AltaVista™ (C. Casal, Personal Communication, 2004). The problem presented by context-dependent or context-sensitive translation is being addressed through collaborative efforts among Dr. Bernd Ueberschär and Dr. Rainer Froese (both of the Institute of Marine Research, University of Kiel, Germany), the FishBase team and Systran™ – Information and Translation Technologies (C. Casal, Personal Communication, 2004).

International IAS Information Progress and Products

While standards and protocols are being developed, agreed upon and implemented, another important initial step in setting up sources of information exchange involves the assessment of the status of IAS-related activities and information resources currently existing throughout the world (Ricciardi *et al.*, 2000). This review has been written and arranged in the context of seven workshops that were held in different regions around the globe, to assess the threats to biodiversity and national economic development posed by IAS (Addendum 2; USDOS, USDOI & USAID,

2003). In addition to the information obtained at these meetings, the following discussion provides an assessment of the status of IAS-related online databases and information systems that are being developed throughout the world.

The Nordic/Baltic Region and Europe

The Nordic/Baltic Region

Baltic Sea countries including the Russian Federation, Norway and Iceland, and representatives from the European Union met at the 2001 Nordic/Baltic regional workshop. At this workshop recommendations were made for the establishment of a Baltic/Nordic Alien Species Task Force and development of a regional catalog of alien species databases, to be hosted on the Internet by GISP (MEE *et al.*, n.d.; and 2002). This was considered to be a first step in the development of a regional information network on alien species, a part of the global invasive species information network (MEE *et al*., p. 8, 2002). The Nordic/Baltic workshop was followed-up by a workshop in Tallinn, Estonia, held in May 2002. Representatives from nine countries surrounding the Baltic Sea as well as North America discussed the establishment of an IAS database network and developed a plan for a regional invasive alien species information network and inventory/monitoring system at the Estonian workshop (USDOS, USDOI & USAID, 2003).

Databases presented at the Estonian meeting included the Baltic Sea Alien Species Database (#14) that was established by the Baltic Marine Biologists Working Group on Non-indigenous Estuarine and Marine Organisms (NEMO). This database is linked to the Regional Biological Invasions Center information system (RBIC) (#8). It is intended to operate as a regional node in the GISIN (CBD, 2002). The RBIC has operated as a web portal, providing access to the global, regional, sub-regional and national Internet resources on biological invasions since 2001 (V. Panov, Personal Communication, 2004). It currently serves as a regional pan-European clearinghouse on invasive alien species, and as a regional information hub of the GISIN (V. Panov, Personal Communication, 2004). RBIC hosts the RBIC Illustrated Database of Aquatic Invasive Species of Europe, GIS INVADER (GIS on Aquatic Alien Species of the Baltic Sea), an experts database of the European Research Network on Aquatic Invasive Species (ERNAIS), and the Alien Species of North-West Russia information system (under development).

The RBIC network is further expanded through a linkage with GISP's Global Invasive Species Database (# 1) (GISD), which is in turn, linked to the Caspian Sea Biodiversity Database (#25). The GISD includes the 100 of the World's Worst Invasive Alien Species (#2) database (Waage, 1999). It was developed by the Invasive Species Specialist Group (ISSG) (IUCN/SSC-ISSG, 2001; Panov & Gollasch, p. 117, 2004).

A German database on biological and ecological traits of native and alien plant species, BIOLFLOR (#18), was also presented at the Estonian meeting. Germany reported a large number of databases, but no central national database covering all ecosystems. They have however developed an internet accessible database, NeoFlora (#19) which covers alien vascular plant species. (MEE *et al.*, p. 4, 2002). The Alien Species Polish Database (#15), with reference to the involvement of GISP, ISSG and the IUCN in addressing the IAS issue, proposes a linkage with the Nordic Baltic Network of/for Invasive Species (NOBANIS) (#9), which is also hosted by the RBIC. The Nordic Council of Ministers (Norway, Sweden, Denmark, Finland and Iceland) established a working group which produced a joint report, *Introduced Species in the Nordic Countries* (2001). This report included 17 case studies on IAS problems in shared marine, terrestrial and limnic environments and is available from the recently established Nordic Network on Introduced Species (NNIS) (#10). The NNIS provides information on introduced species in the Nordic

countries and links to other related sites (CBD, 2002).

Constituting another linked participant in the NNIS, Denmark has compiled a list of 1200 introduced species on the Danish Forest and Nature Agency's Web site (#13) (MEE *et al.*, 2002). The Estonian Alien Species Database (#11) provides information on alien animals and plants, including some aquatic species, in Estonia. Finland did not report having a national IAS-specific database but IAS data is contained within LUMONET (#16), a biodiversity information system maintained by the Finnish Environment Institute (SYKE) that functions as the Finnish CHM of the CBD (MEE *et al.*, 2002). Latvia does not have a national IAS-database. It does however have individual species-specific databases that could be networked through a mechanism such as the NNIS. Lithuania has prioritized the gathering of information for databases, and has developed a specific data format for data-gathering institutions to follow. Rounding out the IAS-database related activities of the Nordic/Baltic region, Swedish EnviroNet's Environmental Catalogue (#17) contains a section of information on environmental threats that includes the introduction and spread of alien organisms in Sweden (MEE *et al.*, 2002).

Europe

Cooperation with the Baltic Sea nations involves four Member States of the European Union (Germany, Denmark, Sweden and Finland) (CBD, 2002). Development of the European Research Network on Aquatic Invasive Species (ERNAIS) was initiated in 2001. The goal of this program is the development of an international network of European databases on Aquatic Invasive/Alien Species that links existing databases in Europe and worldwide (CBD, Appendix 2 p. 6, 2002). As mentioned earlier, the ERNAIS is hosted by the RBIC (#8). The 1979 Convention on the Conservation of European Wildlife and Natural Resources (Bern Convention), to which 38 European states are party, requires Parties "to strictly control the introduction of invasive species" (CBD, p. 5, 2002). This Convention's initiative for European Strategy on Invasive Alien Species, which began in 2000, assessed the constraints faced by many European countries in their IAS efforts, including the "shortage and inaccessibility of scientific information on IAS" (CBD, p. 5, 2002). Methods and tasks outlined by this convention for European nations to undertake in combating IAS issues, include the development of information systems, networks and other information resources (Genovesi & Shine, 2002).

European database and information system development efforts focus mainly on addressing the threat of aquatic IAS. In their 2004 article on aquatic alien species in Europe, Panov and Gollasch found that information on these species is available in national, regional and global databases and information systems. They highlighted the following sources for European aquatic invasive species information:

- Food and Agriculture Organization's Database on Introductions of Aquatic Species (DIAS) (#131);
- Global Information System on Fishes (FishBase) (#198);
- Global Ballast Water Management Programme (GloBallast) (#177);
- Directory of Non-native Marine Species in British Waters (#23);
- Chinese Mitten Crab Home Page (#24);
- Biological Records Center (BRC) Web site (#25);
- Marine Alien Species of Estonia Web site (#29);
- *Caulerpa taxifolia* in the Mediterranean Web site (#27);
- CIESM Atlas of Exotic Species [in the Mediterranean Sea] (#30);
- Caspian Sea Biodiversity Database (CSBD) (#25);
- Baltic Sea Alien Species Database (#14); and the
- Regional Biological Invasions Center Information System (RBIC) (#8).

Not all of these European sources focus specifically on IAS in the European region alone, nor are they all hosted online by

European organizations. However, the European Community Biodiversity Clearing-House Mechanism (EC-CHM) representing the regional CHM of the CBD attempts to address information gaps. It links to national CHMs, European organizations and networks relevant to biodiversity issues, and the GBIF. The EC-CHM also incorporates databases on nature, hunting, tourism, forestry, agriculture, land cover, fisheries and climate change. There are currently 19 linked nature conservation databases, including the EU Wildlife Trade Reference Database, LIFE databases and the World Conservation Monitoring Centre's protected area database included in the EC-CHM (CBD, p. 30, 2002). The European Nature Information System (EUNIS) a "species module" of the EC-CHM., Focused initially on protected and rare species data for Europe, the EUNIS was recently linked with FishBase (#198), the Atlas Florae Europaeae (#208) database and the Euromed+Plantbase project. The CBD (2002) reports that the EUNIS currently provides very little specific coverage of introduced species in Europe but that the CIESM Atlas of Exotic Species in the Mediterranean Sea database (#27), a digital atlas for exotic species of fish and some shellfish (crustaceans and mollusks), represents the one EUNIS project that addresses introduced species.

The Americas (including Canada, United States, Mexico, Mesoamerica and South America)

Impact in the United States

Almost every U.S. State hosts its own online IAS list, database or information system. This plethora of information resources, now almost certainly exhibiting data overlap and repeated effort, should be networked for national gain and eventually linked with international collaborators, providing a global advantage in addressing the IAS threat. Government and non-government organizations are indeed now taking steps towards development of a coordinated national network of these systems.

As part of a 1998 workshop on databases for nonindigenous plants held in the United States, Jacono and Boydstun (1998) reviewed 17 invasive species databases, some available online, and found that half of them addressed nonindigenous plants exclusively while the remainder included both native and alien plants. At the time, Jacono and Boydstun (1998) indicated that IAS vertebrates and biocontrol agents were more commonly addressed by databases. In 1999, Gregg examined 34 databases, including those reviewed in the 1998 workshop. He found that of those 34 databases, 28 were available online, 21 focused "primarily or exclusively on nonindigenous species" and 14 did not specifically focus on nonindigenous species, but did provide useful data (Ridgway *et al.*, 1999). In contrast, Ricciardi *et al.* (2000) highlighted the fact that support for database development in the U.S. is often derived from affected industries, namely agriculture, when they reported that most U.S. online databases were "devoted to nonindigenous terrestrial plants, particularly agricultural pests". They also found that online databases representing information for marine invasive species affecting the U.S., were also limited in number.

In January of 2001, in response to an Invasive Species Executive Order 13112 issued by then President Bill Clinton, the U.S. National Invasive Species Council (NISC), developed the 'National Management Plan on Invasive Species'. Among other things, the Executive Order directed the NISC to, "identify recommendations for international cooperation" and to "facilitate a coordinated information network on invasive species" (Schmitz & Simberloff, p. 58, 2001). Despite Schmitz and Simberloff's (2001) suggestion that the council lacked "the infrastructure, support, resources, and mechanisms to synchronize the thousands of prevention, management, and research programs that existed" (p. 62), several major U.S. IAS information systems have been developed by private, non-government and government organizations, lending support to the tasks of the NISC.

United States Government IAS Information Systems

Some of the State IAS databases identified during the research for this review included the CalWeed Database (#92) and Cal-IPC List (#93) for the state of California, the Invasive Plant Atlas of New England (IPANE) (#85), the Alaska Exotic Plant Mapping Project (AKEPMP) (#99), and the Minnesota Weed Biocontrol Project (#101).

Numerous databases addressing invasive plant species and pests of plants in the U.S. contributed by the APHIS include the North American Non-Indigenous Arthropod Database (NANIAD) (#66), the Federal Noxious Weeds Database (#78), the APHIS Regulated Pest List (#79), the National Agricultural Pest Information System (NAPIS) (#80), Identified Plant Pests Regulated by APHIS (#81), the Federal and State Noxious Weeds in GRIN database (#82), Team Leafy Spurge (#83), and the Crop Profiles (#204) and PLANTS (#205) databases. The USDA's Agricultural Research Service (ARS) also contributes the Release of Beneficial Organisms in the United States and Territories (ROBO) (#188) database. Information systems hosted by the NPS and FS include an image database - Invasive and Exotic Species of North America (#152) image database, and the Alien Plant Invaders of Natural Areas in the U.S. (#104) database. In 2000, the FS also reported, "taking the lead role to complete jointly with Mexico and Canada, and APHIS, a worldwide listing of foreign insect and disease organisms that pose a threat to North America" (Thomas & Tkacz, 2000). The status of this listing is as yet unknown.

United States coastal and island States, such as Florida, California and Hawaii that are threatened by marine aquatic invasive species as well as freshwater aquatic and terrestrial invasive species appear to have led the way in developing IAS databases. Ample evidence of this can be seen in Appendix C, numbers 66-151. Their databases were developed with an initial state-specific focus which then began to broaden as common IAS threats were identified among bordering states or (in the case of Mexico) countries containing or sharing similar ecosystems with the original focus state.

The Hawaiian Ecosystems at Risk Project

The USGS' Hawaiian Ecosystems at Risk (HEAR) project (#75), initiated prior to creation of the NISC in 1996, constitutes important first steps in fulfilling the need for a recognized IAS CHM that provides IAS-related information for addressing IAS issues throughout Hawaii, and the Pacific (Thomas & Loope, 2004). The HEAR information system consists of a series of databases including the Harmful Nonindigenous Species database, a Species-of-Concern Tracking database, a Cultivated Plants database, an Alien Plant Control and Herbicide Use Log, a Threats to Native Species database, and an Alien and Native Forest Bird-Tracking database (Van Driesche, 2002). In 1998, HEAR was complimented by the addition of the Pacific Island Ecosystems at Risk (PIER) invasive species information system for United States territories in the Pacific (Van Driesche, 2002; Thomas & Loope, 2004).

NISbase, NEMESIS, Smithsonian Environmental Research Center (SERC) and the U.S. Geological Survey (USGS)

The Nonindigenous Species Database Network (NISbase) (#66), a distributed database portal developed by SERC and the USGS, provides access to multiple invasive species databases including the USGS' Nonindigenous Aquatic Species Database (NAS) (#142); the Chesapeake Bay Exotic Marine and Estuarine Species Information System (#66) (a component of the National Exotic Marine Estuarine Species Information System or NEMESIS - #133); the Non-Native Species in the Gulf of Mexico Region (#61) Web site, Australia's National Introduced Marine Pest Information System (NIMPIS) (#38), and the Introduced Marine Species of Hawaii Guidebook (#73) (part of the HEAR project). The development of this linked

network of aquatic IAS databases represents substantial improvement over Ricciardi *et al.*'s (2000) earlier findings of, "few online databases for marine invaders" (p. 240). These efforts to link national and international IAS databases, represent the implementation of a distributed database network for international information access and exchange, and serve as a demonstration project under the Global Invasive Species Program (GISP) (Fofonoff *et al.*, 2003).

Not to be confused with NISbase, SERC's National Marine and Estuarine Invasion Database (NIS) (#135), is part of the National Ballast Water Information Clearinghouse (NBIC) (#134). The NIS has a predominantly aquatic alien species focus and provides information on marine, estuarine (tidal and freshwater) alien species in U.S. waters (SERC[1,2], n.d.). SERC's Aquatic Invasions Research Database (#176) (AIRD) is another component of the NBIC. It was created by SERC in collaboration with GISP and others, and contains information on people, research, technology, policy and management issues relating to aquatic invasions (SERC[3], n.d.) .

The National Biological Information Infrastructure (NBII) and the U.S. Geological Survey

The USGS has collaborated with numerous national and international organizations in projects designed to meet IAS-information needs. In a cooperative effort with the National Aeronautics and Space Administration's (NASA) Office of Earth Science (EOS), the USGS is working to develop a National Invasive Species Forecasting System (#110), "for the early detection, remediation, management, and control of invasive species on Department of Interior and adjacent lands" (NASA & USGS, 2003).

Based at the USGS, the NBII's Invasive Species Information Node (ISIN) acts as the "data arm of the newly-formed National Institute of Invasive Species Science (NIISS), a virtual institute of data-sharing partners" (NBII, p. 2, 2003). Information resources hosted by the ISIN include the mirror Web site of the Global Invasive Species Database (#1) through a partnership with the Invasive Species Specialist Group (ISSG). The ISIN also provides links to IAS-related projects and products of other partners and nodes within the NBII such as the Discover Life Global Mapper (#57) and CRISIS Maps – Weed Map and Data Center (#94) hosted through the California Information Node (CAIN) of NBII.

The NBII also contributes the U.S. Node of the GBIF, described earlier in this report. This node partners with the ITIS, the Inter-American Biodiversity Information Network (IABIN) and the North American Biodiversity Information Network (NABIN); and cooperates with the Global Taxonomy Initiative (GTI) of the CBD (GBIF, n.d.).

The Invasives Information Network (I3N) of the Inter-American Biodiversity Information Network (IABIN)

In 2001, IABIN sponsored a pilot project to exchange information on invasive species. Eleven organizations – one each in Argentina, Brazil, Bahamas, Chile, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, and Paraguay – participated in the IABIN Invasive Species Information Network (I3N) pilot project (#6) (IABIN[1, 2], 2004). I3N is now operational and additional countries are joining the network.

The objective for each nation participating in the I3N is to implement common standards to post their invasive species records on the Web, where they can be searched from a single entry-point. Each organization locates, inventories, and documents local information on projects, data, and experts, and lists invasive species. Studies on IAS effects on natural areas are few, and the "difficulties in identifying species, and [a] lack of taxonomists and other scientists specializing in invasive species" are among the challenges reported by the I3N nations (USGS, p. 8, 2002).

IABIN freely distributes a tool for cataloging existing information – the I3N Cataloguer. This

tool was developed to assist with the inventories. It provides data entry forms for the creation of records, and it outputs these records in a format useful to other users once they are posted on the Web ([1]IABIN, 2002; IABIN[2], 2004). The XML tags added by the I3N Cataloguer are based on the Dublin Core Metadata Standard (IABIN[2], 2004).

Canada

Canada's National Forest Service contributes a National Alien and Invasive Species Database (NAISD) (#48) which provides information on exotic pests threatening Canadian forests and trade of Canadian forest products. The Canadian Botanical Conservation Network (CBCN) (#47) and the IPCAN Invasive Plants of Canada system (#46) provide access to invasive plant information for Canada. Information on the nation's invasive flora and fauna is provided by the Canadian Wildlife Federation through the Invasive Species of Canada database (#52).

Sharing borders with the United States, Canada and Mexico have an obvious vested interest in cooperating on the IAS issue. Invasive species affecting Canada are often included in U.S. IAS databases as a matter of course – invasive species seldom confine themselves to national borders. The NBII's Non-Native Mammals of the U.S. and Canada (#51) database and the Center for Invasive Plant Management's CIPM Noxious Weeds database (#102) illustrate this national information overlap where (in the case of the Noxious Weeds database), a database developed and hosted at the U.S.'s Montana State University, includes information on weedy species known to be distributed throughout the United States and Canada.

Mexico

Mexico's Non-Native Species in the Gulf of Mexico Region (#46) project is the result of a partnership initiated by IABIN, with the Comisión Nacional para el Conocimiento y uso de la Biodiversidad (CONABIO) invasive species program to implement an invasive species information system for Mexico. CONABIO has developed the Biótica (#62) database which describes aquatic invasive species in Mexico and contains information on invasive plant/weed species, fish, amphibians and reptiles, birds and mammals. GulfBase's Resource Database for Gulf of Mexico Research provides an Invasive Species Web page that describes research and activities in the region and lists other related sources of information.

Mesoamerica and South America

In general Mesoamerican nations report a "noticeable lack of information at different levels regarding taxonomy, distribution ranges, biology, ecology relationships, and impacts of invasive species on the environment, the economy and society" (IUCN, p. 8, 2001). The lack of technical and institutional capacity and mechanisms for collaboration in South America was highlighted at the regional meeting in Brasilia, Brazil, as the main constraint facing IAS management among nations representing the region (USDOS, 2003).

Participants in the Mesoamerican regional workshop collaborated in the production of a 'draft regional IAS resource directory' and identified the steps to be taken in tackling IAS threats in the region – including 'expansion and improved use of technical data sources (regional databases, expertise and information networks) (Brasilia Declaration, 2001; GISP, 2001). IABIN's I3N project and its collaborative efforts with other organizations such as CONABIO, appear to have initiated the first productive steps towards addressing these issues and developing an invasive species network for the Americas and the global community.

Africa

Southern Africa

The lack of coordinated IAS databases and access to other regional and international databases reported by delegates at the South Africa regional meeting, will be addressed by the *African Risk Assessment Programme* (ARA) which is scheduled to run 2004-2006 (MacDonald *et al.*, 2003; UNEP[1,2], 2003). Through this program existing IAS databases in Africa will be identified, converted to a standard format, reviewed for information quality, translated into the national languages, and linked together into a consolidated network (UNEP[2], p. 63, 2003). Concomitantly, an inventory of the distribution and extent of invasions by selected alien plant invaders and accompanying databases will be created under the *Assessment and mitigation of the impacts of selected woody alien plant invaders (Prosopis spp., Acacia spp.), in agriculture, forestry and rangelands of Africa* project (2004-2008) (UNEP[1, 2], 2003).

Activities planned within the Information Management component of this project include the development of a database of information that will specifically address the impacts of woody invasive plants (UNEP[2], 2003). The SA (South African) Alien Invasive Plants database (#58) can be accessed through and online Gateway - the *Multi-level Decision Support for Strategic Cooperative Approach to Alien Plant Management in South Africa – Gateway to Knowledge on Alien Invasive Plants.* The gateway (based in South Africa and hosted online by the CSIR), is developing sites that will provide access to global information about invasive alien plant species issues, activities and initiatives, including information for 'Oceana and Islands anywhere' (Austral-Pacific), North America, South America, Europe, Asia and Antarctica.

In 1996, the Southern African Biodiversity Network (SABONET) Project was initiated in order to network botanists in southern Africa and provide, "baseline information for the documentation of the flora of the southern African region" (Siebert & Smith, p. 1, 2004). A project plans to develop a regional botanical diversity network that will produce resources for implementation in national and regional conservation initiatives (Siebert & Smith, 2004). In support of this plan, the ten participating southern African countries, (Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe) are developing National Plant Checklists and SABONET is sponsoring the computerization of herbarium specimens into a database in support of these checklist development efforts (Arnold & Siebert, 2002 cited in Siebert & Smith, 2004). Other products of the Project include, "documentation of Centres of Plant Diversity and Endemism and the implementation of Threatened Plants Programmes" (Siebert & Smith, p. 2, 2004). Although not designed to address IAS specifically, the products of the SABONET Project represent important taxonomic resources that will undoubtedly be employed by others that are addressing the IAS issue in South Africa.

As a result of a meeting held in November of 2002, the SADC network of BioNET-INTERNATIONAL (SAFRINET) and the Agricultural Research Council (ARC) of South Africa started a regional information hub for Southern Africa with support from the NBII and the USDOS. This hub was developed as a contribution to the GISIN and in support of local capacity building for South Africa (BioNET-INTERNATIONAL, 2002). The SAFRINET Web site has set up Web pages in preparation for providing information about pollinating species, alien invasive species, soil micro-organisms, biological control and quarantine.

West Africa

The final regional workshop on prevention and management of invasive alien species was held in West Africa, March 9-11, 2004. Proceedings from this workshop were understandably unavailable for inclusion in this review. However, in an online news article for

Tuesday, March 9th 2004, Home Page Ghana reported the calls from several participants at the meeting for increased awareness of the IAS issue, development of early warning systems, and development of a national and international legal framework for IAS management. Delegates also recognized the need for a regional IAS information management system for the region (J. Fisher, USDOS, Personal Community, 2004).

South and Southeast Asia

Nations participating in the South and Southeast Asia regional workshop in 2002 reported few research activities, resources, regulatory frameworks, expertise and existing data/knowledge resources on IAS. Consequently, very few IAS-specific database developments have occurred in the region. However, the American Embassy in Kathmandu's Regional Environment Office (REO) of the Regional Environmental Hub is cooperating with its, "counterpart Hub in Bangkok" to help the GISP extend a Cooperative Governments Initiative on Invasive Species in South and Southeast Asia (American Embassy – Kathmandu, n.d.). And the Association of Southeast Asian Nations (ASEAN) Regional Centre for Biodiversity Conservation or ARCBC describes itself as, "The Gateway to Biodiversity Information in Southeast Asia" and provides access to various biodiversity databases through the Biodiversity Information Sharing Service (BISS) – "The most comprehensive on-line database for species and protected areas in South East Asia" (ASEAN, n.d.).

Databases available through ARCBC include a World Roster of ASEAN Biodiversity Specialists, an Organizations database, a Training Resources database, and a group of newly added databases includes ASEAN's 100 Most Precious Plants database, the Checklist of Climbing Palms in Southeast Asia and Checklist of Medicinal Plants in Southeast Asia, and Guidelines for Maximizing Biodiversity on Gold Courses. Visitors to the site can also search for biodiversity information by Country (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam) and by Species. The ARCBC also provides a Biodiversity Web Ring facility to allow ease in navigation among biodiversity Web sites (ARCBC Biodiversity Web Ring, n.d.) and "maintains a database referral system which links national and international institutions and agencies holding information relevant to biodiversity conservation, to the ARCBC and National Biodiversity Reference Unit (NBRU) database networks, and…with the ASEAN web network where appropriate" (ASEAN, n.d.). The ARCBC of course is not focused specifically on the IAS problem, some of the national systems hosted by the ARCBC, do however contain sections that address IAS. And through its efforts in biodiversity conservation information gathering and networking, the ARCBC provides a valuable resource for decision-makers combating IAS in the south and southeast Asian region.

Species conservation achievements and highlights identified in the IUCN's Regional Biological Diversity Programme (RBP), Asia Strategy Document (2002-2005) include the establishment of linkages with the Commonwealth Agricultural Bureau International (CABI) and the Invasive Species Specialist Group (ISSG) of the IUCN and future focus areas and plans for preparing "National IAS Action Plans" and developing early warning systems and response protocols for combating IAS (IUCN, n.d.).

In India, a proposal by the National Chemical Laboratory has recently been funded to create a National IAS Information Infrastructure, for the generation of a baseline set of information on invasive species. An integral part of the system will include tools for identification, alerts, mapping, trend analysis, and management (V. Chavan, Personal Communication, 2004).

China

In their comprehensive review published in 2000, XIE *et al.* analyzed the invasive species issue in China, a nation absent from the

ARCBC list of countries. They examined the history and methods of introduction, species composition, and highlighted needs and actions that should be taken to combat IAS in China. The development of databases and information systems and the strengthening of international cooperation were among the recommendations they presented (XIE *et al.,* 2000). The Web site *Invasive Species in China* (#32), hosted by the Institute of Zoology, Chinese Academy of Sciences, provides IAS-related information and articles.

The U.S./China Invasive Species Modeling and Monitoring project, a partnership between the USGS and the Chinese State Bureau of Surveying and Mapping, under the Earth Resources Observation Systems (EROS) Data Center International Program, "involves the estimation of the native invaded distribution of selected invasive plants in the U.S. and China, and prediction of their potential future distribution using ecological modeling, remote sensing, and GIS." (USGS, n.d.).

The Austral-Pacific Region

Nations in the Austral-Pacific region include many island ecosystems, which are often described as exhibiting the greatest vulnerability and therefore experience the greatest threat from IAS. In fact, the GISP identified islands as a 'special case warranting cooperative initiatives' and the Convention on Biological Diversity (CBD) also recognized the very urgent need to deal with invasive alien species issues in isolated and vulnerable ecosystems (IUCN-ISSG, 2001). Many island nations have limited capacity for combating the IAS problem, and will benefit from cooperation with other larger island nations such as Australia and New Zealand and U.S. States such as Hawaii.

Australia

One of the earliest success stories of an alien species invasion and successful management efforts is Australia's saga of Cactoblastis moth (*Cactoblastis cactorum*), which was intentionally introduced as a biological control agent for the invasive prickly pear cactus (*Opuntia* spp.) in the 1920s. As this example illustrates, Australia has a long history of employing IAS information resources to address an IAS threat. Their knowledge base is now evolving into an online knowledge-base. Australian online invasive species databases identified during this research include the Global Compendium of Weeds (#3), the *Exotic Species Database* (#35), the Western Australian Department of Agriculture's state-specific Weed Watcher (#36), and PlantNet (#37).

Gaining particular momentum in recent years, the threat posed by aquatic IAS in Australia is being addressed by databases such as the Western Australian Department of Fisheries' Introduced Marine Invaders database (#39); and the Centre for Research on Introduced Marine Pests' (CRIMP) National Introduced Marine Pests Information System (NIMPIS) (#38).

The Australian counterpart to the U.S.-based NEMESIS, the NIMPIS was created by the CSIRO's Center for Research on Introduced Marine Pests (CRIMP) and designed alongside NEMESIS. As a consequence of this parallel design, the NIMPIS shares a nearly identical information structure, terminology and classification scheme to that of the NEMESIS (Fofonoff *et al*., 2003). This NIMPIS system was developed after the black striped mussel (*Mytilopsis sallei*) invaded three marinas in Darwin in 1998 and was then rapidly eradicated by the Northern Territory government in April of 1999 (Sliwa, 2002). Because no information about the black striped mussel was available at the time, authorities used information about a related species, the zebra mussel (*Dreissena polymorpha*), that had invaded other nations, to plan eradication efforts for the Black Striped mussel.

Recognizing the risk associated with relying on overseas information sources, the Standing Committee on Conservation (SCC) and the Standing Committee on Fisheries and Aquaculture (SCFA) National Taskforce on the

Prevention and Management of Marine Pest Incursions, recommended the development of a national information system to provide Australia's marine managers ready access to information to support responses to introduced marine pest discoveries (Sliwa, 2002). Thus NIMPIS was developed.

When data is collected to address a specific need, some would argue that the data therefore has only one specific application (Ricciardi *et al.*, 2000). However, the successful eradication of one IAS based on the information available on another related IAS presents a strong argument for the continued support of the GISIN. Ideally, each nation would benefit greatly from managing its own IAS database(s), but in the absence of such resources, it is the cooperation of other nations in data exchange that will fulfill this need in the interim.

New Zealand

New Zealand, home of the Invasive Species Specialist Group (ISSG) headquarters, and the Global Invasive Species Database (#1) (GISD), also stands to contribute significantly to the IAS knowledge-base for the Austral-pacific region. New Zealand is reported as being one of the "few countries in the world with databases of its entire flora, both cultivated and wild, including the important stage of naturalization" (Moeed, p. 54, 2003). "In less than 150 years, the size of the national flora of New Zealand has increased more than tenfold through the importation and establishment of alien plant species." (Moeed, p. 55, 2002). With the exception of the Stowaways - Invasive Invertebrates in Natural Ecosystems Web site (#40); and the Invasive Mammals bibliographic database (#164), which currently addresses five mammalian species of concern in New Zealand, few databases specifically addressing IAS in New Zealand were identified for this report.

Palau and the Solomon Islands

In other national reports supplied at the Austral-Pacific regional workshop, Palau reported a cooperative initiative between the Bureau of Agriculture (BOA), the Bureau of Lands and Surveys (BLS), the Palau Community College – Agriculture Department (PCC-Agriculture), and the Office of Palau Automated Land and Resource Information System (PALARIS) resulting in surveys and maps of the grass, *Imperata cylindrica* in the State of Airai (Shine *et al.*, 2003). The mapped data is used by control teams to track the progress of control efforts and to identify any continued or potential spread of the grass. In the future, more species and sites will be surveyed and mapped for monitoring. No plans to operate this project or provide the data through the Internet were indicated, but these efforts provide promise for the use of technology and information management in a small nation with limited resources (Shine *et al.*, 2003). In a separate national report presented by the Solomon Islands, the South Pacific Regional Environmental Program (SPREP), was briefly mentioned as having received very little attention by member countries, including the Solomon Islands (Wairiu & Wagatora, 2003). Thus highlighting the need for capacity building assistance exhibited by many island nations.

Conclusion

The Internet is by no means the solution to all information management problems. And computers will certainly never be directly credited with eliminating an alien species from an ecosystem. But… the almost instant and limitless connectivity potential of the Internet and the information management and computational power of computers and information systems, constitute integral components of the future IAS manager's tool kit. The Internet provides fast, efficient storage, analysis and rapid dissemination of biological data.

The publication of information in book or journal form is often delayed, and many nations to whom this information is of value may not have the library systems and/or financial resources necessary to access it (Green, 1993; Ricciardi *et al.*, 2000). The use of an electronic information network and the

conversion of backlogs of unpublished or inaccessible data, languishing in the collections of researchers and institutions, present a tremendous opportunity to 'recycle' that data (Green, 1994). In a resource-limited environment where a strategy of *information conservation* and efficient data-application must be adopted in order to use the information to the greatest benefit, contributions to networked databases make economic and scientific sense (Green, 1993).

"A coordinated global approach is necessary to detect and manage the large-scale movement of invaders" (Ricciardi et al., p. 240, 2000) and "the justification for making the effort to build or contribute to biodiversity data-bases is that the entries build into enormously rich biogeographic resources which can be tapped for many different purposes" (Green, p. 61, 1994).

The use of an existing network is a very important consideration in the development of the GISIN. The successful persistence and growth of an informal network of scientific professionals and information resources is often dependent on the resources of a single, sponsoring institution or organization (WCMC, 1996). Having been initially established to coordinate and facilitate data collection and exchange activities on a topic of increasing concern, such informal networks become more prominent and are accepted by decision-makers, and consequently become self-supporting bodies that eventually receive government recognition and adoption (WCMC, 1996).

The issue of information exchange in support of addressing global IAS problems is certainly not a unique or new one. Particular advances in Internet-based information exchange and management have already occurred in the field of molecular biology for example (Green, 1993). As concerns arise about potentially new IAS threats such as the invasion potential of genetically modified organisms and their environmental impact(s), new applications of biological data are identified (e.g. predictive modeling; GIS mapping; biodiversity genetics inventory and monitoring) (Jasieniuk *et al.*, 1999; Brown, 2000). The value of IAS-specific data has simply risen to the forefront of these issues. As evidenced by the partnerships, and distributed database systems currently under development, information managers from all over the world are collaborating via the Internet to combat the threat of IAS. It is this continued collaboration among stakeholders that will guarantee the success of the GISIN (WCMC, 1996).

Addendum 1 – Background

The threat posed by invasive alien species (IAS) has been receiving increasing recognition across the globe in recent years. Whether it's water hyacinth (*Eichornia crassipes*) choking the waterways of Eastern Africa, brown tree snake (*Boiga irregularis*) invading and threatening the unique avian communities of delicate island ecosystems, the Cactoblastis moth (*Cactoblastis cactorum*) threatening the cactus-rich region of the southern United States, or River Red Gum (*Eucalyptus camaldulensis*) invading Pakistan, IAS have wrecked havoc on national agricultures, economies, human and wildlife health, and continue to pose a significant threat to biodiversity on a global scale. As international travel and trade transactions escalate, so does the IAS threat.

Nations and regions, or groups of nations, are realizing the urgent need to coordinate and cooperate on IAS early detection, prevention, management, and eradication efforts. However, a vast chasm exists between the capabilities of developed and developing nations in successfully initiating these efforts. Some nations entirely lack the basic legislative policies, government recognition and community investment, funding support, and overall infrastructure to even begin to address IAS issues (McNeely, 2000). While other nations such as the United States possess multiple and often uncoordinated IAS information databases and systems that would be greatly valued by other nations if only they had ready access to the information contained within them.

An overall coordinating mechanism such as the Clearing-House Mechanism or a Global Invasive Species Information Network (GISIN), recommended by the Convention on Biological Diversity (CBD) would provide "one-stop shopping" to users of IAS information (Ricciardi *et al.*, p. 24, 2000; McNeely *et al.*, 2001). However such a coordinating mechanism is only as effective as its accessibility. Many IAS information resources already exist and are being used by institutions, non-government and government organizations. Yet as a consequence of their internal nature, or the technology that supports them, these resources are unavailable to potential users with common IAS-related needs and concerns, and who are not affiliated with those groups or organizations. As evidenced by recent online information management developments, it is undoubtedly the Internet that will play an integral role in enhancing the connectivity of information resources, supporting and facilitating data exchange, and providing unprecedented global data access to users in desperate need of information and capacity-building resources for combating IAS.

The first major meeting to consider the global character of the IAS threat was held in 1996 and was convened by the Norwegian government and various United Nations (UN) organizations. The GISP was developed as a result of this meeting (Ridgway *et al.*, 1999). In 2001, the GISP released a *Call to Action* at the 6th meeting of the Subsidiary Body on Science, Technology, and Technical Advice (SBSTTA) of the Convention on Biological Diversity (CBD), held in Montreal, Canada (GISP, 2001; invasivespecies.gov[1], 2003). The GISP described the effects of IAS as a global problem and recognized the fact that many nations affected by IAS do not currently have the capacity to address IAS. This *Call to Action* constituted a challenge to governments, intergovernmental organizations, non-governmental organizations, the private sector and all other interested parties to take steps to implement the Global Strategy on Invasive Alien Species (McNeely *et al.*, 2001).

At the 6th meeting of the Conference of the Parties (COP) to the CBD (or COP6), held in April 2002 at The Hague, The Netherlands, "GISP [was] designated as the International Thematic Focal Point on IAS under the Clearing-House Mechanism" (CHM) and was directed to identify standards and protocols for "implementation of the Global Invasive Species Information Network" or GISIN (CBD-COP, p.

4, 2002). Development of the GISIN constitutes one of the objectives of GISP's Partnership for Action work plan for global information management, which includes development and coordination of a collaborative distributed database network on IAS; exploration of opportunities to provide a thematic CHM on IAS for the CBD, and acting as a dynamic source of information exchange on IAS issues worldwide; and developing and disseminating information tools and technologies for IAS management. Although it has no current plans to develop an IAS database of its own, the GISP plans to develop and host an online database containing "information on organizations, prominent scientists, links to Web sites and IAS databases, conferences, and news items" from the international community (M. Cocks, Personal Communication, 2004).

Addendum 2 - Regional Workshops Coordinated by GISP

While standards and protocols are being developed, agreed upon and implemented, another important initial step in setting up sources of information exchange involves the assessment of the status of IAS-related activities and information resources currently existing throughout the world (Ricciardi *et al.*, 2000). From 2001-2004, seven regional workshops were held in different regions around the globe to assess the threats to biodiversity and national economic development posed by IAS (USDOS, USDOI & USAID, 2003). These workshops were coordinated by GISP, IUCN (Mesoamerica), and CABI (Western Africa). Proceedings from the 2001 Mesoamerica regional workshop, convened by the IUCN, the Environmental Center for America and the Caribbean, and the U.S. Embassy for Costa Rica, have been finalized (IUCN, 2001). The proceedings from five of the other workshops, held in Copenhagen, Brazil, Zambia, Thailand, and Hawaii in 2001 and 2002 are being finalized by the GISP, the U.S. – funded workshop coordinator. Proceedings from the final workshop convened by CAB-International in March 2004 to address the West Africa region, again with funding from the U.S. Department of State, will also be released shortly. The GISP will publish a synthesis document that summarizes the common threads from each of the seven regional workshops later in 2004 (J. Fisher, USDOS, Personal Communication, 2004). A brief schedule of these regional workshops, their regional focus, and locations is described in Table 1.

Date	Title	Location
21-23 May, 2001	The Prevention and Management of Invasive Alien Species: Forging Cooperation throughout the Baltic/Nordic Region	Copenhagen, Denmark
11-12 Jun., 2001	Invasives in Mesoamerica and the Caribbean. Results of the Regional Workshop on Invasive Alien Species: Meeting the Challenges by their Presence in Mesoamerica and the Caribbean	San Jose, Costa Rica
17-19 Oct., 2001	Prevention and Management of Invasive Alien Species: Forging Cooperation in South America	Brasilia, Brazil
10-14 Jun., 2002	Prevention and Management of Invasive Alien Species: Forging Cooperation throughout the Southern Africa Region	Lusaka, Zambia
14-16 Aug., 2002	Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia	Bangkok, Thailand
7-11 Oct., 2002	Prevention and Management of Invasive Alien Species: Forging Cooperation throughout the Austral-Pacific Region	Honolulu, Hawaii
8-10 Mar., 2004	Prevention and Management of Invasive Alien Species: Forging Cooperation throughout Western Africa	Ghana, Africa

Table 1. Regional Workshops on the Prevention and Management of Invasive Alien Species (adapted from J. Fisher, DOS, Personal Communication, 2004; USDOS, USDOI & USAID, 2003).

Joint declarations resulting from these workshops and others involving participants from South Africa and the United States (Kirstenbosch Declaration, 2000; Davis Declaration, 2001), members of the Baltic/Nordic region (Copenhagen Declaration, 2001), Russia and the United States (Russia-U.S. Declaration, 2001), and South American nations (Brasilia Declaration, 2001) stated each region's support of the CBD-COP's recommendations for increasing attention and focusing future efforts on defining and addressing the IAS problem including promoting information exchange and management technologies (i.e. databases), and cooperation between nations, and diverse organizations and groups.

At each regional workshop, delegates provided country reports on nationally recognized IAS,

related research, regulatory efforts, lists of species, experts or researchers and responsible agencies. With the exception of more developed nations, the most common theme identified was the need to improve national systems for coordination before regionally cooperative mechanisms, such as participating in a program like the GISIN, could be entirely successful. The common challenge to this goal, was a significant lack of the basic resources needed to even begin to address the IAS threat or participate in a GISIN. Such resources ranged from political infrastructure, policies, laws and regulations, and value applied to the issue of IAS, through to more tangible items such as computers, global position systems, vehicles and office space or buildings (GISP, 2002; Shine *et al.,* 2003; Pallewatta *et al.*, 2003).

Shine, Williams and Gündling (2000) reported on the essential role played by legal frameworks in supporting IAS management efforts at national and international levels. “The problem of biological invasions is largely soluble if infrastructure is established that responds to the multijurisdictional aspects of fighting biological invasions.” (Schmitz & Simberloff, p. 62, 2001). Several guides for designing legal and institutional frameworks on invasive alien species have been produced by GISP, IUCN-World Conservation Union and the CBD (IUCN, 1999; Shine, Williams & Gündling, 2000; CBD-SBSTTA[1,2], 2001; Williams, 2003).

The material needs identified by nations that are attempting to combat IAS and who would like to participate in the GISIN may only be met through provisions and funding supplied by other nation stakeholders such as those sharing borders or common invasion threats, and national and international organizations such as the United Nations Environment Programme (UNEP). Concomitantly, the financial costs of creating a global information system could also be met by a UNEP “or maintained by a national government agency such as the U.S. Geological Survey’s Biological Resources Division or the Norwegian Ministry of Environment” (Ricciardi *et al.*, p. 243, 2000).

Often as a result of the limitations reported by the workshop participants, not all species that are invasive have been identified or documented in many of the countries participating in the GISIN workshop and very little data exists particularly among developing nations. Indeed, unless identified as causing a clear and significant impact on national economic resources such as agricultural and aquacultural ecosystems or biodiverse areas supporting industries such as tourism, the IAS threat seldom receives the attention it deserves. Despite Pimental’s (2000) report that quantifies the US$334 billion spent per year by “six countries (the United States, South Africa, the United Kingdom, Australia, Brazil and India) in actions related to the containment, eradication and mitigation of invasive alien species”, lack-luster funding and resource allocation in combating the IAS threat is not a trait that is unique to developing nations (Pimental, 2000 cited in Hernandez *et al.*, p. 2, 2001). In 2001, Schmitz and Simberloff reported that in the United States, “…federal agencies…devote few resources to introduced non-indigenous species that lack an economically affected constituency” (p. 58).

Government spending on national protections against IAS in the United States has not kept up with the growing rate of international trade (Jenkins, 2002). In 2002, Jenkins reported that United States imports had increased by 82 percent over the past eight years, a statistic that raises the question of whether the introduction of IAS into the United States has also increased proportionally. For future funding mechanisms to be effective, the rate of funding increase must be directly proportional to that of trade and travel (two main factors contributing to increased global IAS movement) (Jenkins, 2002).

Despite the financial and material limitations that are experienced to varying degrees by all nations attempting to combat the IAS threat, increased recognition of the issues,

infrastructure development, data collection and the development of offline and online databases and information systems has proceeded with rapidity in recent years. As part of GISP Phase I (1997-2000) a pilot version of the Global Invasive Species Database (GISD) (#1) was launched at a GISP Phase I Synthesis Conference held in Cape Town, South Africa, in September 2000. The GISD included the 100 of the World's Worst Invasive Alien Species (#2) database (Waage, 1999). The GISD was developed by the Invasive Species Specialist Group (ISSG) to provide "global information on alien invasive species to agencies, resource managers, decision-makers, and interested individuals" (IUCN/SSC-ISSG, 2001; Panov & Gollasch, p. 117, 2004). Experts from around the world contributed the information that is contained within this database. The GISD is available online, and is also linked to the Baltic Sea Alien Species Database (#14), the Caspian Sea Biodiversity Database and the Regional Biological Invasions Center Information System (RBIC) (#8) "which is currently serving as a regional pan-European clearinghouse on invasive alien species and [as a] regional information hub of the GISIN" (V. Panov, Personal Communication, 2004). This network of linked databases is one of several that are growing around the world.

The efforts of developed nations such as the United Kingdom, Australia and New Zealand, South Africa and members of the Americas constitute other regional focal points or the beginnings of 'regional hubs', which are implementing and consequently testing the application of data exchange formats, standards and protocols for the GISIN. Information specific to the IAS issue has often been incorporated into more broadly focused biodiversity or taxonomic databases attempting to document all known species present in a nation or region. Many biodiversity databases have matured through several generations of design, but do not necessarily address IAS. However, biodiversity and taxonomic databases or those with a broad focus represent a valuable baseline against which future perturbations in the environment can be measured, including the impacts of IAS (Stinner, 1998). And it is only through cooperation among interested groups that such databases and the information they contain, will be used to support decision-making and the development of IAS management strategies (Ridgway *et al.*, 1999).

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Appendix C

Draft List of Invasive Alien Species (IAS) Online Databases and Databases Containing IAS Information.

Elizabeth Sellers, Annie Simpson, Shelaine Curd-Hetrick, Invasive Species Information Node, National Biological Information Infrastructure, United States Geological Survey, 12201 Sunrise Valley Drive, MS 302, Reston VA 20192. (703) 648-4385. esellers**AT**usgs.gov.

A preliminary draft document, prepared for the Experts Meeting Towards the Implementation of a Global Invasive Species Information Network (GISIN), Baltimore, Maryland, USA. 6-8 April 2004. It will be available online at http://www.invasivespecies.net/gisin.htm .

- DRAFT -

List of Invasive Alien Species (IAS) Online Databases and Databases Containing IAS Information

A preliminary draft document, prepared for the Experts Meeting Towards the Implementation of a Global Invasive Species Information Network (GISIN), Baltimore, Maryland, USA 6-8 April 2004

PLEASE READ THIS FIRST:

This document contains a list of Internet-accessible databases providing species, bibliographic, taxonomic, expertise, distributions, images and many other information types as they pertain to invasive, exotic, alien, introduced, non-native species and all other species of world flora and fauna.

NOTE: Information contained within this document is planned for future cataloguing. Databases are listed in no specific order or priority with the exception of the numbering and arrangement of databases into basic groups. This list of databases and related information is by no means intended to be comprehensive. If there is a database or information about a database that you feel should be included in this list, please do not hesitate to email Elizabeth Sellers at esellersATusgs.gov.

***** Additions incorporated after the 2004 Experts Meeting are highlighted with asterisks *****

Global Context - IAS Databases

1. Global Invasive Species Database (GISD)
URL: http://issg.appfa.auckland.ac.nz/database/welcome/ OR http://www.issg.org/database
Host/Originating Country: Invasive Species Specialist Group (ISSG) / New Zealand; National Biological Information Infrastructure (NBII) / USA.
Language: English
Description: Provides global information on alien invasive species to agencies, resource managers, decision-makers, and interested individuals. Information is supplied by expert contributors from around the world and includes all types of species. Data includes species ecology, distribution (native and alien ranges), impacts, general and management references, links, and expert contacts.

2. 100 of the World's Worst Invasive Alien Species (in GISD)
URL: http://www.issg.org/database/species/search.asp?st=100ss&fr=1&sts=
Host/Originating Country: Invasive Species Specialist Group (ISSG) / New Zealand; National Biological Information Infrastructure (NBII) / USA.
Language: English
Description: Species listing of information about 100 of the world's worst invasive alien species.

3. Global Compendium of Weeds (GCW)

URL: http://www.hear.org/gcw/alpha_select_gcw.htm
Host/Originating Country: U.S. Geological Survey, Hawaiian Ecosystems at Risk project (HEAR) / USA.
Language: English
Description: Reviews the information in the publication entitled "A Global Compendium of Weeds" by Rod Randall (Department of Agriculture of Western Australia [AgWest]). Contains references to approximately 20,000 taxa of plants, citing information about "weedy" characteristics of each.

4. World Weeds Database

URL: http://w3.to/weeds **(NOTE: non-functioning URL).**
Host/Originating Country: Oxford Forestry Institute, Oxford University, UK.
Language: English
Description: Displays information on more than 2400 weed species around the world, including non-native species, ranked according to the severity of infestation. Users can view data by country, plant, genus, or family.

5. Mammal Species of the World

URL: http://nmnhwww.si.edu/msw/
Host/Originating Country: Smithsonian National Museum of Natural History, Department of Systematic Biology Vertebrate Zoology / USA.
Language: English
Description: Contains the names of the 4,629 currently recognized species of mammals, including invasive species, in a taxonomic hierarchy that includes Order, Family, Subfamily, and Genus.

Non-USA Context - IAS Databases

6. IABIN – Invasives Information Network (I3N) (Americas)

URL: http://www.iabin-us.org/projects/i3n/i3n_project.html
Host/Originating Country: National Biological Information Infrastructure (NBII), USA.
Language: English
Description: A regional network of invasive species knowledge bases, providing direct access to national knowledge bases throughout the Americas. Includes a data search capability across all contributing countries, list of country catalogs, value-added products, fact sheets, and presentations.

i) I3N- Project - Argentina (InBiAr)
URL: http://www.uns.edu.ar/inbiar/database.asp
Host/Originating Country: Base de Datos sobre Invasiones Biologicas en Argentina (InBiAr) / Argentina.
Language: Spanish
Description: invasive species database.

ii) I3N- Project - Bahamas (Catalogs)
URL: http://www.iabin-us.org/projects/i3n/i3n_documents/catalogs/catalog_bahamas.html
Description: Includes invasive species lists for all species, plants and animals, and a Pest List of Ministry.

iii) I3N- Project - Bolivia (Catalogs under development)
URL: http://www.iabin-us.org/projects/i3n/i3n_documents/catalogs/catalog_bolivia.html

iv) I3N- Project – Brazil (I3N**AT**CRIA)
URL: http://i3n.cria.org.br/
Host/Originating Country: Rede de Informacao sobre Especies Invasoras / Brazil.
Language: Portuguese
Description: Catalog of researchers, projects information sources and a list of invasive species.

v) I3N- Project – Chile (Catalogs under development)
URL: http://www.iabin-us.org/projects/i3n/i3n_documents/catalogs/catalog_chile.html

vi) I3N- Project - Dominican Republic (Catalogs)
URL: http://www.iabin-us.org/projects/i3n/i3n_documents/catalogs/catalog_dominicanrep.html
Description: XML files for each of 19 organizations (each containing projects, datasets, experts, and lists of species for that organization); I3N Cataloguer with species, experts, projects, data sets; metadata on species and projects associated with experts, a list of species, a list of institutions, photos and details about 4 invasive species and a questionnaire.

vii) I3N- Project - Ecuador (Proyecto I3N)
URL: http://www.ambiente.gov.ec/AMBIENTE/i3n2000/I3N.htm
Host/Originating Country: Ministerio del ambiente / Republic of Ecuador
Language: Spanish
Description: Lists of research organizations and associated xml pages. I3N catalogs include species metadata.

viii) I3N- Project - El Salvador (Catalogs)
URL: http://www.iabin-us.org/projects/i3n/i3n_documents/catalogs/catalog_elsalvador.html
Description: 5 fact sheets on invertebrate species, and 2 fact sheets on plant species.

vi) I3N- Project – Guatemala
URL: http://www.geocities.com/otecbio_especies/
Host/Originating Country: Oficina Tecnica de Biodiversidad / Guatemala.
Language: Spanish
Description: Lists of invasive species, experts, projects, databases, a photographic gallery, information on *Verticillata hydrilla*. I3N catalogs include the I3N-Guatemala catalog of information on invasive species research and activities in Guatemala.

x) I3N- Project – Jamaica (I3N-JA)
URL: http://www.jamaicachm.org.jm/Catalogue/I3N-JA_Clgue.htm
Host/Originating Country: Jamaica Clearing House Mechanism (CHM), Natural History Division of the Institute of Jamaica, Jamaica.
Language: English, Spanish, Portuguese
Description: Animal and plant species taxonomic information, resource persons catalogue, bibliographic and research listings for Jamaica IAS.

(xi) I3N- Project – Mexico
URL:http://www.conabio.gob.mx/conocimiento/info_especies/especies_invasoras/doctos/especiesinvasoras.html
Host/Originating Country: Conabio / Mexico.
Language: Spanish
Description: Describes invasive species information system developments in Mexico, including the Biotica database # in this list, and the National System of Information on Biodiversidad (SNIB) as containing IAS information. I3N catalogs include species information, experts, projects and data sets.

(xii) I3N- Project – Paraguay
URL: http://www.seam.gov.py/i3n/index.htm
Host/Originating Country: Centro de Datos para la Conservación / Paraguay
Language: Spanish
Description: Catalogs include a species list and metadata.

(xiii) I3N- Project – Peru (Catalogs under development)
URL: http://www.iabin-us.org/projects/i3n/i3n_documents/catalogs/catalog_peru.html

(xiv) I3N- Project – USA
URL: http://www.iabin-us.org/projects/i3n/i3n_documents/catalogs/catalog_usa.html
Description: List of invasive species of concern of the NBII Invasive Species Information Node (clicking on the species name brings up a page, created from the XML, with the actual content of all the links): http://pick1.pick.uga.edu/cgi-bin/20q?act=x_checklist&path=INVASIVES and a Partial Species List with ITIS links.

7. InfoNatura – Birds, Mammals and Amphibians of Latin America
URL: http://www.natureserve.org/infonatura/
Host/Originating Country:
Language: English
Description: Information on bird, mammal and amphibian species of Latin America, including invasive species. Includes amphibian data for Mexico and Central America, bird and mammal range maps, photos, global conservation status, habitat description, distribution, population status, references, and maps.

8. European Information System on Invasive Alien Species (RBIC)
URL: http://www.zin.ru/rbic/
Host/Originating Country: Zoological Institute RAS / Russia
Language: English
Description: Web portal providing access to the global, regional and national internet resources on biological invasions. RBIC Information System is serving as a Regional Clearinghouse on invasive alien species and information hub of the Global Invasive Species Informational Network. Databases included in the RBIC are:

Aquatic Invasive Species of Europe - http://www.zin.ru/projects/invasions/gaas/AA_IDB.HTM
GIS Invader - http://www.zin.ru/rbic/projects/invader/default.asp
Alien Species of the Baltic Sea (#14 in this document)
European Research Network on Aquatic Invasive Species (ERNAIS) - http://www.zin.ru/rbic/projects/ernais/default.asp
Alien Species of North-West Russia information system (under development)

9. Nordic-Baltic Network on Invasive Species (NOBANIS)
URL: http://sns.dk/nobanis/
Host/Originating Country: Danish Forest and Nature Agency / Denmark.
Language:
Description: A gateway to databases on invasive species in the Nordic and Baltic region [under development]. Promoting the exchange of information on IAS, as well as experiences with eradication or control of IAS from Greenland to Northern Russia and from Northern Norway to Germany and Poland.

10. Nordic Network on Introduced Species (NNIS)
URL: http://www.sns.dk/natur/nnis/
Host/Originating Country: Danish Forest and Nature Agency / Denmark.
Language: English
Description: Lists of contact persons for marine, freshwater, terrestrial invasive species, and listed alphabetically; Downloadable lists (xls, pdf) of introduced species (taxonomy, observations, origin, vector) and references for introduced species in the Nordic countries, by a Nordic network of scientists and administrators working within the area of introduced/alien species.

11. Estonian Alien Species Database.
URL: http://www.envir.ee/looduskaitse/voorliigid_baas.html
Host/Originating Country: Estonia.
Language: Estonian, English.
Description: Provides access to PDF lists of aquatic invaders, introduced mammals, birds, terrestrial invertebrates and plants.

12. Marine Alien Species of Estonia
URL: http://www.sea.ee/Sektorid/merebioloogia/eesti/Marine_Alien_Species_of_Estonia.htm
Host/Originating Country: Estonian Marine Institute, University of Tartu Tallinn / Estonia.
Language: Estonian, English
Description: Provides information on invasive alien species of plankton, benthic invertebrates and fishes.

13. Danish Forest and Nature Agency (Denmark)
URL: http://www.sns.dk/natur/nnis/intro.htm
Host/Originating Country: Danish Forest and Nature Agency / Denmark
Language: Danish, English
Description: Includes a list of 1200 introduced species in Denmark and links to the Nordic Network on Introduced Species (http://www.sns.dk/natur/nnis/).

14. Baltic Sea Alien Species Database
URL: http://www.ku.lt/nemo/
Host/Originating Country: Coastal Research and Planning Institute, Klaipeda University, Lithuania.
Language: English
Description: Interactive tool, including DATABASE SEARCH, BALTIC SUB-REGIONS and SPECIES DIRECTORY. The information comprised in the Database comes from: a) members of the Baltic Marine Biologists Working Group on Non-indigenous Estuarine and Marine Organisms and other researchers involved in invasive biology studies; b) published papers, environmental reports, “grey literature”, Internet sites; c) a Database Questionnaire (under construction).

15. Alien Species in Poland
URL: http://www.iop.krakow.pl/ias/
Host/Originating Country: Poland
Language: Polish, English
Description: A database of 403 alien species of plants, animals and fungi, describing pathways, place and time of introduction to Poland, current distribution, population trends and impact upon native species, habitats and ecosystems. For some species, there are also suggested methods of control.

16. Lumonet - Finnish CHM of the CBD (Finland)
URL: http://www.ymparisto.fi/default.asp?node=5319&lan=en
Host/Originating Country: Finnish Environment Institute (SYKE) / Finland.
Language: Finnish, Swedish, English
Description: Biodiversity clearing-house mechanism of the CBD. Currently links to Baltic Sea Alien Species database, Nordic Network on Introduced Species (NNIS), Regional Biological Invasions Center (RBIC) and contains an RTF article by Petri Nummi on Alien Species in Finland.

17. Environmental Catalog (Sweden)
URL: http://www.svenskamiljonatet.se/
Host/Originating Country: Swedish EnviroNet / Sweden.
Language: Swedish, English
Description: Catalog of environmental information (literature, reseearch) and data for Sweden, including section on introduction and spread of alien organisms.

18. BIOLFLOR – Vascular Plant Search and Information System (Germany)
URL: http://www.ufz.de/biolflor/index.jsp
Host/Originating Country: Centre for Environmental Research (UFZ), The German Federal Agency for Nature Conservation (BFN) / Germany.
Language: German, English
Description: information system on vascular plants of Germany, including biological and ecological traits of alien plant species.

19. Invasive Plant Species in Germany (NeoFlora) (Germany)
URL: http://www.neophyten.de/
Host/Originating Country: The German Federal Agency for Nature Conservation (BFN) / Germany.
Language: German
Description: Information on invasive alien species in Germany, including legal framework, ecology, impacts and control measures.

20. *** Belgian Biodiversity Thematic Forum IAS List (Belgium) ***
URL: http://www.biodiversity.be/bbpf/forum/invasion/invspecies.html
Host/Originating Country: Belgian Biodiversity Platform, Belgian Clearing-House Mechanism / Belgium
Language: English
Description: List of IAS that live in Belgium and that are known to have a detrimental impact on the environment. Includes species of terrestrial plants, molluscs, crustraceans, insects, fish, amphibians, reptiles, birds, and mammals. Species names link users to fact sheets/profiles containing taxonomic information (including common name in English, French, Dutch and German), photographic images, a description of origin and distribution (including map of belgium with location points of feral populations), ecology and life history traits (habit preferences, life cycle, dispersion capacity, competition & predation, defense mechanisms), detrimental effects, population control, references, internet links, and contact email for those responsible for preparing the fact sheet/species profile.

21. *** Introduced Plants and Animals (in Russia) ***
URL: http://www.biodat.ru/db/intro/plant_e.htm
Host/Originating Country: Global Environment Facility, Quarantine Institute of the Russian Ministry of Agriculture, Institute of geography of the Russian Academy of Sciences / Russia.
Language: Russian, English
Description: Two databases (one of 1119 introduced plant records, and the other of 3250 introduced animal records) searchable by latin name, russian name, order, family, country of origin, and region of introduction. Information provided for species includes latin name, russian name, kingdom, order, family, point of exportation, country of exportation, region of exportation, manner of encroachment, detection point, area of introduction, country of introduction, region of introduction, biotype of introduction, year of introduction, population, dispersal dynamics, type of introduction, purpose of introduction, target organism, enemies and competitors, introduction results, economic importance, information source, year and scientific institution.

22. Invasive Non-Native Species in the UK.
URL: http://www.appliedvegetationdynamics.co.uk/IAAPwebsite/
Host/Originating Country: Applied Vegetation Dynamics Laboratory, University of Liverpool / UK.
Language: English
Description: Information on all Alien or Non-native organisms that are invasive in the UK providing information regarding problem species, management strategies and control techniques. Includes all taxonomic groups of multicellular organisms, classified as plants or animals, and aquatic (freshwater) or terrestrial. Marine species are included in a fifth section which includes; algae, higher plants and animals.

23. Non-native Marine Species in British Waters
URL: http://www.jncc.gov.uk/marine/non_native/
Host/Originating Country: Joint Nature Conservation Committee (JNCC) / UK.
Language: English
Description: An online listing of marine flora and fauna information sheets describing non-native marine invertebrates, algae, and plants in the United Kingdom.

24. Chinese Mitten Crab (NHM, UK)
URL: http://www.nhm.ac.uk/zoology/crab/index.htm
Host/Originating Country: The Natural History Museum / UK
Language: English
Description: Provides information on Chinese Mitten crab classification, life history, distribution and associated environmental problems.

25. Biological Records Center (BRC) (British Isles)
URL: http://www.brc.ac.uk
Host/Originating Country:
Language: English
Description: National custodian of wildlife distribution data for the British Isles. Provides species distribution information, including introduced crayfish and other marine invasive species.

26. EPPO (Pest) Alert List (Europe & Mediterranean)
URL: http://www.eppo.org/QUARANTINE/Alert_List/alert_list.html
Host/Originating Country: European and Mediterranean Plant Protection Organization (EPPO) /
Language: English
Description: Information on pests selected because they may present a phytosanitary risk for the EPPO region. Includes reports on pests that are new to science, new outbreaks, reports of spread, etc.

27. Atlas of Exotic Species in the Mediterranean Sea (CIESM)
URL: http://www.ciesm.org/atlas/
Host/Originating Country: International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM) / Monaco.
Language: English
Description: Provides a comprehensive, group by group, survey of recent marine 'immigrants' in the Mediterranean, which is undergoing drastic and rapid changes to its biota. Includes crustacean decapods and stomatopods, fishes, and molluscs.

28. Bibliography on* Caulerpa taxifolia *in the Mediterranean
URL: http://www.com.univ-mrs.fr/basecaul/
Host/Originating Country: Center of Oceanology of Marseilles / France.
Language: French.
Description: Provides a bibliography of publications on Caulerpa taxifolia in the Mediterranean.

29. Caulerpa taxifolia Web site (Mediterranean)
URL: http://www.isima.fr/ecosim/ct.html
Host/Originating Country: Institut Supérieur d'Informatique de Modélisation et de leurs Applications (ISIMA) / France.
Language: English
Description: Provides images showing the different stages for the simulation of Caulerpa taxifolia evolution in the north Mediterranean sea. Part of the Caulerpa modeling & simulation program.

30. Caspian Sea Biodiversity database
URL: http://www.caspianenvironment.org/biodb/eng/main.htm
Host/Originating Country: Caspian Environment Programme / Caspian Sea nations
Language: English, Russian (Common names also in Kazakh, Turkmenian, Azerbaijani)
Description: Information about aquatic alien invasive species in the Caspian Sea including taxonomic description (phylum, class, order, family, genus, synonyms), common names, photographic images or diagrams, description and map of distribution of species within the Caspian Sea (includes status as per International/National Red Data Books, references for the first record for the Caspian Sea and for the redescription of the species), general characteristics of the species, relation to abiotic environmental factors, feeding, reproduction, life history and development, interspecific relations, impacts, references, and name/affiliation of the record creator.

31. *** Introduction to Invasive Species In China ***
URL: http://monkey.ioz.ac.cn/bwg-cciced/english/cesis/invasive.htm
Host/Originating Country: Zoological Division of Chinese Biodiversity Information Center / China
Language: English, Chinese
Description: Brief description of criteria for defining invasive alien species and a partial list of invasive species in china including mammals, birds, fishes, crustaceans, mollusks, insects, nematodes, fungi, wildlife disease, plants).

Host Web site also provides information on biodiversity in China including the following databases/lists: Taxonomic codes of Chinese fauna – Vertebrates, Species Inventory Database of Chinese Animals, Endangered and Protected Species Database of Chinese Animals, Catalogue Database of Chinese Biodiversity Reference, Database of Expert on Biodiversity Study in China, Database of Medicinal Animal in China, Chinese Biodiversity Bibliography Database, Chinese Biodiversity Database Index, Fauna Sinica, and Zoological Journals Published in China.

32. Alien Invasive Species in China
URL: http://www.chinabiodiversity.com/shwdyx/ruq/ruq-index-en.htm
Host/Originating Country: XIE Yan, Institute of Zoology, Chinese Academy of Sciences / China
Language: Chinese, English

Description: Contains information and images of IAS in China as well as published articles and information on control strategies, mechanisms of introduction, human dimensions and IUCN Guidelines.

33. The Big Weed List (Australia)

URL: http://agspsrv34.agric.wa.gov.au/progserv/plants/weeds/weeds/weedlist.htm **Host/Originating Host/Originating Country:** Western Australia Department of Agriculture / Australia.
Language: English
Description: A compilation of records relating to plants as weeds anywhere in the world and the naturalized flora in Australia.

34. Weeds Australia database

URL: http://search.weeds.org.au/
Host/Originating Country: National Weeds Strategy Executive Committee / Australia
Language: English
Description: Search engine provides searchable access to weed-related web addresses, weed people, products, resources, current issues, weed management, training and materials, weed identification and a noxious weeds list. Assists in finding web based weed related information that is on Australian government and major community organization web sites. Information about weed species includes scientific name, other scientific names and declarations, preferred common name, other common names and a categorical description for its status in each Australian State where it is known to occur.

35. Exotic Species Database (Australia)

URL: http://www.weeds.crc.org.au/projects/project_1_2_1.html
Host/Originating Country: Cooperative Research Center for Weed Management / Australia.
Language: English
Description: Documents all introduced plants in Australia plus those potentially invasive species found in neighboring countries, allowing the calculation of the probability of certain plant species or groups becoming weeds. The aim of this project is to record all exotic species present in Australia and nearby countries, and use this information to calculate the probability of certain plant species or groups becoming weeds.

36. Weed Watcher (Australia)

URL: http://agspsrv38.agric.wa.gov.au/servlet/page?_pageid=449&_dad=portal30&_schema=PORTAL30
Host/Originating Country: Department of Agriculture / Australia.
Language: English
Description: A web-based interface for finding or reporting weed infestations from a map displayed on your computer screen. Currently over 50 environmentally and agriculturally significant weeds can be mapped across the SW of the state of Western Australia.

37. PlantNET (New South Wales, Australia)

URL: http://plantnet.rbgsyd.gov.au/index.htm
Host/Originating Country: Royal Botanic Gardens, Sydney / Australia.
Language: English
Description: Search for information on New South Wales plant names, their distribution and their conservation status, accessing the following databases:- Freshwater Algae, Casuarinaceae nomenclature and distribution, the Type Specimen Catalogue of the National Herbarium of New South Wales, the NSWplants (by NSW coastal region) system, a WeedAlert (by NSW coastal region) system (not public), a Plants**AT**Risk (by NSW coastal region) system, and WattleWeb (searchable database of Wattles of New South Wales).

38. National Introduced Marine Pests Information System (NIMPIS) (Australia)

URL: http://crimp.marine.csiro.au/nimpis/
Host/Originating Country: Centre for Research on Introduced Marine Pests (CRIMP), and CSIRO Marine Research, Hobart, Australia.
Language: English
Description: Information on biology, ecology and distribution of introduced marine invertebrates, algae, plants and fishes in Australia, including potential control options for those designated as pests. Also contains information for those species that are considered to be likely future introductions ('next pests').

39. Introduced Marine Invaders (Australia)
URL: http://www.fish.wa.gov.au/hab/broc/marineinvader/miintro.html
Host/Originating Country: Western Australia Department of Fisheries / Australia.
Language: English
Description: Information on introduced marine species found in the state of Western Australia.

40. Stowaways – Invasive Invertebrates in Natural Ecosystems (New Zealand)
URL: http://www.landcareresearch.co.nz/research/biosecurity/stowaways/
Host/Originating Country: Manaaki Whenua Landcare Research / New Zealand.
Language: English
Description: Information on invertebrate invasions in New Zealand including wasps, ants and mosquitos.

41. *** New Zealand Weeds ***
URL: http://weeds.massey.ac.nz/default.asp
Host/Originating Country: Massey University / New Zealand
Language: English
Description: Information on New Zealand important weed species including a database of weed species, an identification quiz, study zone and a list of links to related online resources. Information on the 68 species in the database includes photographs, common name, scientific name, comments (description), distinguishing features, and control methods.

42. *** Weed Index (New Zealand) ***
URL: http://envbop.govt.nz/Weeds/Weed-Index.asp
Host/Originating Country: Environment Bay of Plenty Regional Council / New Zealand
Language: English
Description: Alphabetical index of weed species providing information on each species including basic taxonomy (common and scientific names), photographs, identification, habitats, impact to biota and ecosystems, dispersal routes, vectors, infestation sources, management, and comments.

43. *** Aquatic Plant Management Species Guide (New Zealand) ***
URL: http://www.niwa.co.nz/rc/prog/aquaticplants/species/
Host/Originating Country: National Institute of Water and Atmospheric Research / New Zealand
Language: English
Description: Information on low-growing, tall-growing and floating aquatic plant species, free floating species and marginal aquatic species of invasive plants in New Zealand; including basic taxonomic information, description and photographs.

44. CARAPHIN Plant Pest Database (Caribbean)
URL: http://infoagro.net/health/caraphin/plantpest.cfm
Host/Originating Country: Caribbean Animal & Plant Health Information Network (CARAPHIN), Caribbean Regional Center (CaRC), Inter-American Institute for Cooperation on Agriculture (IIC) / Trinidad and Tobago.
Languages: English
Description: Search for occurrence, outbreak frequency and testing information for pests of plant species in Caribbean nations.

45. CARAPHIN Animal Pest Database (Caribbean)
URL: http://infoagro.net/health/caraphin/animalhealth.cfm
Host/Originating Country: Caribbean Animal & Plant Health Information Network (CARAPHIN), Caribbean Regional Center (CaRC), Inter-American Institute for Cooperation on Agriculture (IIC) / Trinidad and Tobago.
Languages: English
Description: Search for occurrence, outbreak frequency and testing information for diseases of animal species in Caribbean nations.

46. Invasive Plants of Canada (IPCAN)
URL: http://24.43.80.213/nbs/IPCAN/ and http://www.plantsincanada.com/
Host/Originating Country: National Botanical Services, Environment Canada / Canada.
Language: English
Description: Compiles information on the biology, distribution and control of invasive exotic plants for computer mapping

and analysis. Data is derived from; specimen records in national collections, from sight records made by naturalists and professional botanists, and from published reports. Provides a historical perspective on the origins and rate of spread of invasives and allows the determination of possible correlations with climatic and other environmental and land use factors using geographic information systems (GIS). Fact sheets, control case studies, invasive species of Canada survey 2002, invasive plants of Canada guide to species and methods control, documents, invasive plant alert bulletin and regional news.

47. Canadian Botanical Conservation Network
URL: http://www.rbg.ca/cbcn/en/invasives/i_list.html
Host/Originating Country: Canadian Botanical Conservation Network (CBCN) / Canada.
Language: English, French
Description: Provides an introduction to Invasive Plants of Canada, and links to a Bibliography on Invasive Plants, an Invasive Plant list, bibliographic lists, invasive plant alerts and invasive species information from the Federal of Ontario Naturalists.

48. National Alien and Invasive Species Database (NAISD) (Canada)
URL: http://www.atl.cfs.nrcan.gc.ca:8080/cfsnet/naisd-e.html
Host/Originating Country: Canadian Forest Service / Canada.
Language: English, French, Spanish.
Description: [Under construction]. Provides a central electronic facility for the storage, organization, exchange and dissemination of information on exotic pests that are potential threats to Canada's forests and to the trade of Canadian forest products.

49. *** Classical Biological Control of Weeds (Canada) ***
URL: http://res2.agr.ca/lethbridge/weedbio/index_e.htm
Host/Originating Country: Agriculture and Agri-Food / Canada
Language: English, French
Description: Information about the use of beneficial organisms for the control of weeds in Canada. Includes weed species lists by common name, species name or family name. Information on each species includes basic taxonomy, description, related problems, biological control, photographs, and references.

50. CIPM Noxious Weeds Database (U.S. and Canada)
URL: http://www2.montana.edu/weedcenter/queryweedsform.html
Host/Originating Country: Center for Invasive Plant Management (CIPM), Department of Land Resources and Environmental Sciences, Montana State University / USA.
Language: English
Description: Search for noxious weeds throughout the U.S. and Canada. The CIPM site also provides information on weed profiles, organic weed management, fire and drought, early warnings, education, grants, restoration and current events relating to weed species.

51. Non-Native Mammals of the U.S. and Canada (NBII)
URL: http://invasivespecies.nbii.gov/speciesinfo/mammal_list.html
Host/Originating Country: Invasive Species Information Node, National Biological Information Infrastructure (NBII) / USA.
Language: English
Description: A web-accessible and downloadable (excel format) list of non-native mammals introduced into the U.S. and Canada, compiled from the Integrated Taxonomic Information System (ITIS) as of August 2002.

52. *** Invasive Species in Canada (Wildlife Federation Canada) ***
URL: http://www.cwf-fcf.org/invasive/chooseSC.asp
Host/Originating Country: Canadian Wildlife Federation / Canada.
Language: English
Description: Species category and keyword search for information on invasive terrestrial and aquatic flora and fauna in Canada including species origin, invasive range, introduction method, and ecological impacts.

53. *** Purple Loosestrife InfoCenter (Canada) ***
URL: http://www.ducks.ca/purple/
Host/Originating Country: Ducks Unlimited Canada and the Manitoba Purple Loosestrife Project (MPLP) / Canada

Language: English
Description: Information center for ourple loosestrife (*Lythrum spp*.) management in Canada including newsletters and updates from the MPLP, lists of published papers and abstracts, bibliographies, relevant canadian research projects, brochures for download, information on biocontrol insect species used for manageing purple loosestrife, news releases, educational resources (e.g. posters), a photo gallery, and a list of ten frequently asked questions about the species.

54. *** Invasive Plant Program (Min. Forests / Canada) ***
URL: http://www.for.gov.bc.ca/hfp/noxious/introduc.htm
Host/Originating Country: Ministry of Forests / Canada.
Language: English
Description: Provides description of weed problems in British Colombia, information on methods of spread, prevention, IPM, weed biology, weed identification (by floral colors), biological control, emerging threats, weed facts, downloadable brochures, posters, and other educational materials, and links. Also provides access to the electronic fourth edition of the Field Guide to Noxious and Other Selected Weeds of British Colombia.

55. NatureServe Explorer (USA & Canada)
URL: http://www.natureserve.org/explorer/
Host/Originating Country: NatureServe / USA
Language: English
Description: Contains conservation information on more than 50,000 plants, animals, and ecological communities of the United States and Canada including invasive, rare and endangered species. Information for non-native species includes taxonomic information, distribution, references, global range comments, life history, and management.

56. 399 Invasive Plants and Weeds in Canada and the United States (NBII-ISIN)
URL: http://invasivespecies.nbii.gov/speciesinfo/399_list.html
Host/Originating Country: Invasive Species Information Node, National Biological Information Infrastructure (NBII) / USA.
Language: English
Description: A downloadable (Excel format) list of 399 records of invasive plants and noxious weeds in the United States and Canada; compiled by Rod Randall (per his weed list updated in 1998). Some names have been modified to agree with the Integrated Taxonomic Information System (ITIS) database.

57. Discover Life Global Mapper
URL: http://www.discoverlife.org/nh/tx/INVASIVES/
Host/Originating Country: U.S. Geological Survey (USGS), National Biological Information Infrastructure (NBII), University of Georgia Athens / USA.
Language: English
Description: Distribution maps of invasive species, information gathered from multiple online sources and delivered in HTML format.

58. SA Alien Invasive Plants Database (South Africa)
URL: http://fred.csir.co.za/plants/global/continen/africa/safrica/sppdb/index.html
Host/Originating Country: South African Water Research Commission and CSIR / Africa.
Language: English
Description: Accessed through a 'Gateway to Knowledge on Alien Invasive Plants'. Provides species information, distribution maps and species by biome search capability.

59. *** Alien Invader Plants Within South Africa ***
URL: http://www.geocities.com/wessaaliens/index.htm
Host/Originating Country: Hillside Aluminium, Wildlife and Environment Society of South Africa / South Africa
Language: English (common names in Afrikaans, Zulu)
Description: Invasive plant species listed alphabeticall by English, Afrikaans and Zulu names. Provides information on each species including photographs, basic taxonomy, categorical rank, control methods, description, origin, where found/problems caused, did you know (interesting facts), and suggestions for indigenous alternative species.

60. List of Invasive Species of Pakistan
URL: http://edu.iucnp.org/alist.htm

Host/Originating Country: Environment & Biodiversity of Pakistan, IUCN Pakistan, Sustainable Development Networking Programme / Pakistan.
Language: English
Description: Spreadsheet list of invasive species of Pakistan including scientific, family, english and local names, geographic origin and worst affected areas (in Pakistan).

61. (Aquatic) Non-Native Species in the Gulf of Mexico Region

URL: http://nis.gsmfc.org/
Host/Originating Country: Gulf States Marine Fisheries Commission / USA.
Language: English
Description: Information and examples of non-native aquatic species in the gulf of Mexico including biological description, pictures, references and links to other online resources. Search multiple U.S. State databases to see non-native or invasive species reports.

62. Invasive species of Mexico (CONABIO)

URL: http://www.conabio.gob.mx/conocimiento/info_especies/especies_invasoras/doctos/especiesinvasoras.html
Host/Originating Country: Comisión Nacional para el Conocimiento y uso de la Biodiversidad / Mexico.
Language: Spanish, English
Description: Database of invasive species in Mexico providing information for 665 plant species, 77 fish, 10 amphibian and reptile, 30 bird and 16 mammals species including origin, commentaries (e.g. biogeography) and links to ITIS and Google resources on each species.

63. Invasive Species of India (NCBI)

URL: http://www.ncbi.org.in/invasive/search/index.html
Host/Originating Country: National Chemistry Laboratory (NCL), Center for Biodiversity Informatics (CBI) / India
Language: English
Description: Search for invasive species by kingdom, common or scientific name, country of origin, and keywords to retrieve information including taxonomic heirarchy, redlist category, invasive and alien status, taxonomic scrutiny status, taxonomic synonyms, common names, genetics, DSN, biogeography, and Google Images.

*64. *** Exotic Animal Species in the Canary Islands ****

URL: http://www.gobcan.es/medioambiente/biodiversidad/introducidas/especiesinvasoras.html
Host/Originating Country: Regional Department of Environment / Canary Islands
Lanugage: English, Spanish
Description: Lists of alien species in the Canary Islands with known breeding populations; without known breeding populations; of uncertain origin with breeding populations; and translocated native species; and a bibliography. Lists are indexed by scientific and common names, and including taxonomic authority and year.

*65. *** Alien Species (introduced into the Pertuis Charentais Sea) ****

URL: http://www.ifremer.fr/crema/PGSauriau/Alien%20species/Index%20alien%20species/alien_species.htm
Host/Originating Country: French National Center for Scientific Research / France
Language: English, French
Description: List of six molluscan species accidentally or intentionally introduced into the Pertuis Charentais Sea. This list is non-exhaustive and will be updated after the publication by Goulletquer et al. (in prep) of a global synopsis of the 104 alien species that have been reported along the European Atlantic (France to Portugal). Currently includes information on vectors, date of introduction and native range or origin.

USA Context - IAS Databases

66. Nonindigenous Species Database Network (NISbase) (SERC)

URL: http://invasions.si.edu/nemesis/merge/SpSearch.jsp
Host/Originating Country: Smithsonian Environmental Research Center (SERC) / USA.
Languages: English
Description: A distributed database portal developed by SERC and the U.S. Geological Survey to provide simultaneous search access to multiple aquatic invasive species databases.

Nonindigenous Aquatic Species database (NAS) - http://nas.er.usgs.gov/

Chesapeake Bay Exotic Marine and Estuarine Species Information System - http://invasions.si.edu/nemesis/chesdb/index.html
Nonindigenous Species in the Gulf of Mexico Exosystem - http://nis.gsmfc.org/
National Introduced Marine Pest Information System (NIMPIS) - http://crimp.marine.csiro.au/nimpis/
Introduced Marine Species of Hawaii Guidebook - http://www2.bishopmuseum.org/HBS/invertguide/index.htm

67. Invasive Species of the Central Southwest/Gulf Coast Region (NBII-CSWGCIN)
URL: http://cswgcin.nbii.gov/(4kfjburecvpdln45gohh32ep)/issues/invasives/database.aspx
Host/Originating Country: Central Southwest / Gulf Cost Information Node, National Biological Information Infrastructure / USA.
Language: English
Description: An online list of invasive species of the central southwestern United States and gulf coast region. Species are grouped into virus, monera, plantae, fungi, and animalia. Some taxa listed do not have an entry in the ITIS database. Clicking on a species' scientific name provides access to general, classification, invasive datasets and inventories, bibliographic and in some instances photographic information.

68. Invasive Grassland/Shrubland Bird Indicators (NBII-ISIN)
URL: http://invasivespecies.nbii.gov/speciesinfo/bird_indicators.html
Host/Originating Country: Invasive Species Information Node, National Biological Information Infrastructure / USA.
Language: English
Description: A web-accessible list of 15 invasive grassland/shrubland birds used as indicators in the Heinz Report on The State of the Nation's Ecosystems. Scientific names for each species are linked to the Integrated Taxonomic Information System so that when the species' name is selected, ITIS information about that species is displayed.

69. Yellowstone National Park Invasive Species (NBII-NRIN)
URL:
http://mapserver.giac.montana.edu/maps/arcims/website/ynpweeds/viewer.htm?Title=Yellowstone%20National%20Park%20Invasive%20Species
Host/Originating Country: Northern Rockies Information Node, National Biological Information Infrastructure / USA.
Language: English.
Description: Part of the Greater Yellowstone Area GIS Database, created by many partners including Montana State University. An online interactive map generated by selecting GIS layers and adding them to the map.

70. Interactive Maps of Hawaii (NBII)
URL: http://66.91.142.167/imf/imf.jsp?site=hawaiian_islands
Host/Originating Country: Pacific Basin Information Node, National Biological Information Infrastructure (NBII) / USA.
Language: English
Description: Interactive map page was designed using ESRI ArcIMS Internet Map Server software. The interactive map layers integrate a variety of GIS layers including incipient weeds, aquatic species distribution (both native and non-native), remaining native natural communities, a LANDSAT TM satellite imagery mosaic, USGS 1:24,000 quadrangles, and a parcel-level managed land layer with level of protection quantified using the National GAP Status definitions.

71. Pacific Basin – Invasive Species (NBII-PBIN)
URL: http://pgin.nbii.gov/invasives.asp
Host/Originating Country: Pacific Basin Information Node, National Biological Information Infrastructure (NBII) / USA.
Language: English
Description: Species information, data & projects, organizations/researchers, management and geographic area information about invasive species in the Pacific Basin.

72. Exotic Species (in SERAMBO)
URL: http://www.main.nc.us/SERAMBO/exotic/
Host/Originating Country: South Eastern Regional Association of Medical and Biological Organizations, Mountain Area Information Network – The Community Network for Western North Carolina / USA.
Language: English
Description: Lists of exotic plants, information and photographs for species found in the Southern Appalachian region of the United States.

73. Guidebook of Introduced Marine Species of Hawaii (Bishop Museum)
URL: http://www2.bishopmuseum.org/HBS/invertguide/index.htm
Host/Originating Country/Originating Country: Bishop Museum and University of Hawaii / USA.
Language: English
Description: Searchable database separated into algae and invertebrates of the coastal waters of Hawaii.

74. INVADERS Database (Northwestern U.S.)
URL: http://invader.dbs.umt.edu/
Host/Originating Country: University of Montana / USA.
Language: English
Description: Exotic plant names and weed distribution records for five states in the northwestern United States. Users can query the system by scientific or common name, or by geographic region. Also includes a state/provincial noxious weeds query form, as well as a database of biocontrol measures. Researchers may also submit their own data to the database.

75. Alien Species in Hawaii (HEAR)
URL: http://www.hear.org/
Host/Originating Country: Hawaiian Ecosystems at Risk (HEAR), U.S. Geological Survey; University of Hawaii / USA.
Language: English
Description: Provides technology, methods, and information to decision-makers, resource managers, and the general public to aid in the fight against harmful alien species in Hawaii through access to the Harmful Non-Indigenous Species (HNIS) database and maps of alien species distributions in Hawaii and the HEAR Island Matrix.

i) Noxious Weeds – Hawaii (images and online info)
URL: http://www.hear.org/hawaiinoxiousweeds/
Host/Originating Country: Hawaiian Ecosystems at Risk (HEAR), U.S. Geological Survey; University of Hawaii / USA.
Language: English
Description: List of links to live, dynamic (Google) web searchers for images and other information regarding plant species officially declared as “noxious weeds” by the State of Hawaii.

ii) Harmful Non-Indigenous Species (HNIS) Database
URL: http://www.hear.org/hnis/index.html
Host/Originating Country: Hawaiian Ecosystems at Risk (HEAR), U.S. Geological Survey; University of Hawaii / USA.
Language: English
Description: Online source of up-to-date information (names, locations, pictures, control methods) about harmful non-indigenous (“non-native”, “exotic”) species in Hawaii. Provides a medium to allow feedback from scientists, professional resource managers, and the general public. Information is available on plants, invertebrates and vertebrates.

iii) Maps of alien species distributions in Hawaii
URL: http://www.hear.org/AlienSpeciesInHawaii/AlienSpeciesMapIndex.htm
Host/Originating Country: Hawaiian Ecosystems at Risk (HEAR), U.S. Geological Survey; University of Hawaii / USA.
Language: English
Description: Provides distribution maps for plants, vertebrates and invertebrates.

iv) HEAR Island Matrix
URL: http://www.hear.org/matrix/index.html
Host/Originating Country: Hawaiian Ecosystems at Risk (HEAR), U.S. Geological Survey; University of Hawaii / USA.
Language: English
Description: A cross-reference by island and species, containing expert opinions regarding the ISLANDWIDE controllability of selected alien plant species by island.

v) Pacific Island Ecosystems at Risk
URL: http://www.hear.org/pier/
Host/Originating Country: Hawaiian Ecosystems at Risk (HEAR), U.S. Geological Survey; University of Hawaii / USA.
Language: English

Description: Provides lists of plant species that are invasive (or potentially invasive) on Pacific Islands by scientific name, elevation, location, life form, and common name. Information retrieved on each species includes recognition status as a PIER environmental invasive, presence/absence on Pacific Islands, threat status in relation to elevation, risk assessment results (pest score), other latin names, common names (English, French, Hawaiian), habit, description, habitat/ecology, propagation, native range, specific recorded presence, comments (notes), control methods, additional information, and references. Other resources include survey reports on invasive species on Pacific Islands and risk assessments for invasive and potentially invasive species.

76. Exotic Forest Pest Information System for North America (Forest Commission)

URL: http://www.exoticforestpests.org/
Host/Originating Country: North American Forest Commission / USA.
Language: English, French, Spanish.
Description: Identifies exotic insects, mites, and pathogenic organisms that have the potential to cause significant damage to North American forest resources as well as background information on identified pests, serving as a resource for North American regulatory and forest protection agencies.

77. North American Non-Indigenous Arthropod Database (NANIAD) (USDA-APHIS)

URL: http://www.invasivespecies.org/NANIAD.html
Host/Originating Country: U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science and Technology / USA.
Language: English
Description: Contains the data for 2,273 species of non-indigenous insects and arachnids including classification, natural and immigrant distribution, economic and environmental impacts, disease vectors, establishment status, entry point and date, pathways, habitat, hosts, life history, and literature citations.

78. Federal Noxious Weeds Database (USDA-APHIS)

URL: http://www.invasivespecies.org/fedweeds.html
Host/Originating Country: U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science and Technology / USA.
Language: English
Description: Derived from the "Federal Noxious Weed Inspection Guide - Noxious Weed Inspection System." Contains fields such as scientific name, family name, synonym(s), common name(s), diagnostic characteristics, habitat, distribution outside of the U.S., distribution within the United States (if applicable), reason for listing as a Federal Noxious Weed (FNW), the form in which the plant is most likely to enter the United States, likely pathways of entry into the United States, general notes, photographs line drawings, and distribution maps.

79. APHIS Regulated Pest List (USDA-APHIS)

URL: http://www.invasivespecies.org/NewInitiatives.html
Host/Originating Country: U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) / USA.
Language: English
Description: Contains pest type, order, family, scientific name, author, common name, source, illustration, data sheet, citation, update, comment, host, distribution, and regulated site information.

80. National Agricultural Pest Information System (NAPIS) (USDA-APHIS)

URL: http://ceris.purdue.edu/napis/
Host/Originating Country: U.S. Department of Agriculture, Animal and Plant Health Inspection Service; Purdue University, Entomology Department, Center for Environmental and Regulatory Information Systems / USA.
Language: English
Description: Search access to the full NAPIS database is limited to employees of the USDA; however, important information concerning plant pests, including invasives, is available from this public access site. The Pest Information section profiles hundreds of pest species, and includes; fact sheets; survey and distribution maps; regulations; related links and photos. The State Reports section highlights specific pest issues for each state.

81. Identified Plant Pests Regulated by APHIS (IPPRA) (USDA)

URL: http://www.invasivespecies.org/ippra.html

Host/Originating Country: U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science and Technology / USA.
Language: English
Description: The IPPRA is an interactive database of plant pests regulated by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service. The focus of this database is at the species level. Several invasive insect species are also included in the database.

82. Federal and State Noxious Weeds in GRIN (USDA)
URL: http://www.ars-grin.gov/npgs/tax/taxweed.html
Host/Originating Country: U.S. Department of Agriculture, Agricultural Research Service, National Genetic Resources Program / USA.
Language: English
Description: Provides taxonomic nomenclature for 37,000 plant taxa, and 14,000 plant genera.

83. Team Leafy Spurge (USDA)
URL: http://www.team.ars.usda.gov/v2/infoproducts.html
Host/Originating Country: U.S. Department of Agriculture / USA.
Language: English
Description: Access to publications, integrated pest management resources, databases, manuals and biological information about Leafy Spurge (*Euphorbia esula*).

84. Slow the Spread Gypsy Moth Database (STS) (VA Tech)
URL: http://www.gmsts.org/operations/
Host/Originating Country: Virginia Tech, Department of Entomology / USA.
Language: English
Description: Provides data summaries by state, survey maps, and a decision-support system for reducing the rate of spread of gypsy moth in the U.S.

85. Noxious & Nuisance Plant Management Information System (PMIS) (USArmy Corp)
URL: http://www.wes.army.mil/el/pmis/pmishelp.htm
Host/Originating Country: U.S. Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory / USA.
Language: English
Description: Access to over 100 of the worst U.S. invasive plants, including detailed and summary information on plant biology, ecology, problems, identification, and associated management technologies.

86. Aquatic, Wetland & Invasive Plant Information Retrieval System (APIRS)
URL: http://plants.ifas.ufl.edu/search80/NetAns2/
Host/Originating Country: University of Florida, Center for Aquatic and Invasive Plants, Bureau of Invasive Plant Management, Florida Department of Environmental Protection Aquatic Plant Control Research Program, U.S. Army Corps of Engineers / USA.
Language: English
Description: Includes annotated citations for more than 60,000 research articles, books and reports about plant ecology, physiology, utilization and control of freshwater aquatic, wetland, terrestrial and aquatic invasive plants. Items in many languages dating back to the 18th century are in this inclusive database.

87. Weeds Gone Wild (APWG)
URL: http://www.nps.gov/plants/alien/index.htm
Host/Originating Country: Plant Conservation Alliance, Alien Plant Working Group / USA.
Language: English
Description: National list of invasive plants infesting natural areas throughout the U.S., including background information on the problem of invasive species, illustrated fact sheets that include plant descriptions, native range, distribution and U.S. habitat, management options, suggested alternative native plants, and selected links to relevant people and organizations.

88. Exotic Plant Information Center (EPICENTER) (Great Lakes region)
URL: http://www.glifwc.org/epicenter/

Host/Originating Country: Great Lakes Indiana Fish and Wildlife Commission / USA.
Language: English
Description: Established to raise awareness of several invasive non-native plants and their ecological impacts in the upper Great Lakes region; to provide effective tools for educational, management, and research needs.

89. Exotic Plant Database (Florida)
URL: http://www.fleppc.org/database/data_intro.htm
Host/Originating Country: Florida Exotic Pest Plant Council (FLEPPC), Florida Department of Environmental Protection, Bureau of Invasive Plant Management / USA.
Language: English
Description: Contains over 5,000 sight records of infestations of Exotic Pest Plant Council Category I and Category II species in Florida public lands and waters. Records are from local, state, and federal parks and preserves. Some records document infestations in regularly disturbed public lands such as highway or utility rights-of-way.

90. Floristic Inventory of South Florida (FISFbase) (Florida)
URL: http://www.regionalconservation.org/ircs/DatabaseChoice.cfm
Host/Originating Country: The Institute for Regional Conservation / USA.
Language: English
Description: Lists exotic plant taxa on conservation lands in a 19 county area defined as the South Florida Ecosystem by the U.S. Fish and Wildlife Service. * Requires registration.

91. *** Florida Exotic Species ***
URL: http://www.wildflorida.org/critters/exotics/exotics.asp
Host/Originating Country: Florida Fish and Wildlife Conservation Commission / USA
Language: English
Description: Basic statistics on over numbers of exotic species, established and breeding exotic species populations, populations trends, lists of exotic species along with the number of Florida counties they occur in. Exotic species lists include 196 species of birds, 30 mammal species, 47 reptile species and 4 amphibian species. Species names in the lists are hyperlinks to species fact sheets containing information on year of introduction or first record, established status, estimated Florida range, statewide trend, threats to natives, species account, habitats, a distribution map, references and links to more information.

92. CalWeed Database (California)
URL: http://endeavor.des.ucdavis.edu/weeds/
Host/Originating Country: California State Department of Food & Agriculture, California Interagency Noxious Weed Coordinating Committee, U.S. Bureau of Land Management; University of California-Davis / USA.
Language: English
Description: Contains weed eradication project profiles for invasive weeds, in California, including targeted invasive name(s); targeted species for (re)introduction; project location; lead and participating agencies; controls used; time frame for project; resource issues; and project contact information. Users can view the data by project, by targeted invasive, by county, or by control method.

93. Cal-IPC California Invasive Plant Council
URL: http://groups.ucanr.org/ceppc/index.cfm
Host/Originating Country: California Invasive Plant Council / USA.
Language: English
Description: Includes a list of invasive plants in California based on information submitted by land managers, botanists, and researchers throughout the state, and on published sources; access to Invasive Plants of California Wildlands book online;

94. CRISIS Maps - Weed Map and Data Center (NBII – CAIN)
URL: http://cain.nbii.gov/cgi-bin/mapserv?map=../html/cain/crisis/crisismaps/crisis.map&mode=browse&layer=state&layer=county
Host/Originating Country: California Information Node, National Biological Information Infrastructure / USA.
Language: English
Description: Maps of geo-referenced weed point observations and associated data in the North American regions of California and the Southwest.

95. *** California EncycloWeedia ***
URL: http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm
Host/Originating Country: California Department of Food and Agriculture, University of California, Davis / USA
Language: English
Description: Information on identification, biology, management of plants defined as noxious weeds by california State law. Includes list of weeds sorted by common and scientific name; noxious weed photographic gallery; list of weeds with country of origin, list of weeds sorted by pest rading; federal noxious weed list and other information resources related to weed species.

96. Southwest Exotic Plant Information Clearinghouse (SWEPIC) (USGS)
URL: http://usgssrv1.usgs.nau.edu/swepic/
Host/Originating Country: U.S. Geological Survey / USA.
Language: English
Description: Database of exotic plant distribution and status for the Colorado Plateau and the greater southwestern United States.

97. Southwest Exotic Mapping Program (SWEMP) (USGS)
URL: http://usgssrv1.usgs.nau.edu/swepic/swemp/maps.html
Host/Originating Country: U.S. Geological Survey, Colorado Plateau Field Station (CPFS) / USA.
Language: English
Description: A regional database of non-native invasive plant distribution maps for the southwestern United States (Arizona, New Mexico and adjacent areas of adjoining states).

98. Invasive Plant Atlas of New England (IPANE) (New England)
URL: http://invasives.eeb.uconn.edu/ipane/
Host/Originating Country: University of Connecticut / USA.
Language: English
Description: Provides access to invasive plant databases for the New England region, joined or linked to geographic boundary files for New England states, counties, towns, and other geographical areas.

99. Alaska Exotic Plant Mapping Project (AKEPMP) (Alaska)
URL: http://agdc.usgs.gov/akepic/
Host/Originating Country: U.S. Geological Survey, Alaska Science Center (ASC) / USA.
Language: English
Description: Regional database of GIS-based exotic plant distribution maps for Alaska.

100. *** Invasive Plants (Alaska) ***
URL: http://cnipm.org/plants.html
Host/Originating Country: Alaska Committee for Noxious and Invasive Plants Management / USA.
Language: English
Description: List of 24 plant species. Provides information on each species including photographs, basic taxonomy, description, and control methods.

101. Minnesota Weed Biocontrol Project (Minnesota)
URL: http://www.mda.state.mn.us/weedcontrol/
Host/Originating Country: Minnesota Department of Agriculture / USA.
Language: English
Description: A database of Minnesota state weed biocontrol project data, providing federal, state, and county agencies a means for assessing the status of natural enemy releases and the effects they are having on their target weeds.

102. Center for Invasive Plant Management (CIPM)
URL: http://www.weedcenter.org/
Host/Originating Country: Montana State University / USA.
Language: English
Description: Includes the CIPM Noxious Weeds Database

103. Halting the Invasion: State Tools for Invasive Species Management (USA)
URL: http://www2.eli.org/research/invasives/invasives_form.cfm
Host/Originating Country: Environmental Law Institute, USA
Language: English
Description: Searchable database, summarizing laws affecting invasive species management in each of the 50 United States.

104. Alien Plant Invaders of Natural Areas in the U.S. (USA-NPS)
URL: http://www.nps.gov/plants/alien/list/a.htm
Host/Originating Country: National Park Service / USA.
Language: English
Description: List of invasive plants affecting natural areas in the U.S.

105. Exotic Forest Pest Information System for North America (EFPISNA) (Forest Com)
URL: http://www.exoticforestpests.org/
Host/Originating Country: North America Forest Commission / USA, United States Department of Agriculture (USDA) Forest Service / USA.
Language: English, French, Spanish
Description: Identifies exotic insects, mites and pathogens with potential to cause significant damage to North American forests. Contains background information and fact sheets for each pest.

106. WeedWeb (USA)
URL: http://extension.usu.edu/weedweb/
Host/Originating Country: Rangeland Resources Department of Utah State University, Utah and Idaho Cooperative Weed Management Area / USA
Language: English
Description: Introduction and definition of noxious weeds, current status in North America, control methods, color photo library of weeds, identifying characteristics and ecology of 10 noxious weeds common “in the west”.

107. BLM Weeds Web site (BLM)
URL: http://www.blm.gov/weeds/
Host/Originating Country: Bureau of Land Management (BLM) / USA.
Language: English
Description: Access to weed species information by U.S. State (Alaska, California, Colorado, Montana, Nevada, Oregon, Washington, Utah, Wyoming).

108. Asian Longhorned Beetle (USA)
URL: http://www.uvm.edu/albeetle/
Host/Originating Country: University of Vermont / USA.
Language: English
Description: Provides description of the ALB problem, identification, host tree information, biological, management, infestation reports, distribution maps, research resources, contact numbers, products and publications relating to the issue.

109. InvasivePlants.net
URL: http://www.invasiveplants.net
Host/Originating Country: Cornell University Ecology & Management of Invasive Plants Program / USA.
Language: English
Description: Provides information on Phragmites, Purple Loosestrife, Garlic Mustard, Water Chestnut, Japanese Knotweed, Giant Hogweed including monitoring protocols, biocontrol information, resources and related events.

110. Invasive Species Forecasting System (NASA)
URL: http://bp.gsfc.nasa.gov/s2i.html
Host/Originating Country: National Aeronautics and Space Administration Office of Earth Science, United States Geological Survey / USA.
Language: English

Description: A National Invasive Species Forecasting System for the early detection, remediation, management, and control of invasive species on Department of Interior and adjacent lands.

111. *** N.J. (New Jersey Agricultural) Weed Gallery ***
URL: http://www.rce.rutgers.edu/weeds/
Host/Originating Country: Rutgers Cooperative Extension / USA.
Language: English
Description: A collection of photos and descriptions of 133 agricultural weeds found in New Jersey, indexed by common name, latin name, thumbnail images and contains selected references. Includes a list of print resources for weed identification.

112. *** Weed Identification Resources (Iowa) ***
URL: http://www.weeds.iastate.edu/weed-id/weedid.htm
Host/Originating Country: Iowa State University Extension, Department of Agronomy / USA.
Language: English
Description: Weed seedling identification images for 20 weed species. Includes *Identification of the weedy pigweeds and waterhemps of Iowa* http://www.weeds.iastate.edu/weed-id/waterhemp/default.htm guide.

113. *** Key to Common Weed Seedlings of Michigan ***
URL: http://www.msue.msu.edu/msue/iac/e1363/e1363.htm
Host/Originating Country: Michigan State University / USA
Language: English
Description: Graphical identification key for grass and grasslike weeds.

114. *** Noxious Weeds and Non-Native Plants (Colorado) ***
URL: http://www.cwma.org/2_bad_weed.html
Host/Originating Country: Colorado Weed Management Council / USA.
Language: English
Description: Includes list of 43 'Troublesome Weeds'; 8 'Ornamental Weeds'; and 5 'Potential Invaders' plant species. Information provided for each species includes photographs and basic description, origin, invasive character and associated problems.

115. *** Invasive Plants in NYS (New York) ***
URL: http://www.ipcnys.org/pages/top%2020.htm
Host/Originating Country: Invasive Plant Council of NYS / USA.
Language: English
Description: Primary list of invasive plants in New York State. Provides information on 24 plant species including photographs, biology, habitat, origin, NY range, spread, and associated problems.

116. *** Noxious Weed Lists and Monitor List (Washington State) ***
URL: http://www.nwcb.wa.gov/weed_list/weed_listhome.html
Host/Originating Country: Washington State Noxious Weed Control Board / USA
Language: English
Description: Access to several categorized weed species lists. Provides information on each species including photographs, basic taxonomy, description and variation, economic importance, habitat, geographical distribution, history (of introduction), growth and development, reproduction, response to herbicide, response to cultural methods, response to mechanical methods, biocontrol potentials, rationale for listing, and references.

117. *** Invasive Species of Concern in Maryland ***
URL: http://www.mdinvasivesp.org/invasive_species_md.html
Host/Originating Country: Maryland Invasive Species Council / USA.
Language: English
Description: Lists of invasive insects, other invertebrates, vertebrates, aquatic plants, terrestrial plants, viruses, fungi and other organisms. Provides information on each species including scientific and common names, photographs, basic description and links to other related State resources.

118. *** Idaho's Noxious Weeds *
URL: http://www.oneplan.org/Crop/noxWeeds/nxWeed00.htm
Host/Originating Country: Idaho State partners to the 'OnePlan' Program / USA
Language: English
Description: Information on 35 weed species indexed by common name, and including background (history of introduction and establishment), images, physical descriptions, distribution in the state of Idaho and control methods. Online version of *Idaho's Noxious Weeds*, by Robert H. Callihan and Timothy W. Miller.

119. *** Weed Identification Guide (Virginia Tech.) *
URL: http://www.ppws.vt.edu/weedindex.htm
Host/Originating Country: Virginia Tech Department of Plant Pathology, Physiology & Weed Science / USA
Language: English
Description: Includes a Grass Weed Identification Key, and alphabetical weed index. Information provided for each weed species includes photographs (mature and seedling), description (mature and seedling), and identifying characteristics.

120. *** Weed Identification (Univ. Illinois) *
URL: http://web.aces.uiuc.edu/weedid/
Host/Originating Country: University of Illinois, USA.
Language: English
Description: Online weed identification tool allowing users to describe type (grass, grass-like, broadleaf, both), foliage, floral, growth and life cycle characteristics to identify a weed species. Displays a list of weed species that is tailored as user's selections become narrow the possibilities for identification. Information provided on each species includes photographs, scientific name, brief morphological description, growth habit, life cycle, habitat and comments.

121. *** Missouri Weeds *
URL: http://www.psu.missouri.edu/fishel/Default.htm
Host/Originating Country: University of Missouri / USA
Language: English
Description: Lists of Weeds of Field Crops and Pastures; Weeds of Ornamentals and Turfgrass; and Weeds of Aquatic Sites. Information provided for each weed species includes photographs and brief descriptive text. A Summer Broadleaf Plant Key; Grasses and Grasslike Plant Key; and a Winter and Early Spring Broadleaf Plant Key, also provide access to photographs and brief descriptive text.

122. *** Weeds of lawns, yards, and flowerbeds in Mississippi *
URL: http://www2.msstate.edu/~jbyrd/turfweed.html
Host/Originating Country: Mississippi State University / USA
Language: English
Description: List of weed species by common name. Information provided for each species includes photographs.

123. *** Common Weeds of No-Till Cropping Systems *
URL: http://www.btny.purdue.edu/Extension/Weeds/NoTillID/NoTillWeedID1.html
Host/Originating Country: Purdue University / USA
Language: English
Description: Common name index of 15 weed species including basic information on common and scientific name, life cycle, control methods and photos of flowers, seedlings, and specific morphological characteristics (e.g. stems, leaves etc.).

124. *** Invasive Species Monitoring Resources *
URL: http://science.nature.nps.gov/im/monitor/invasives.htm
Host/Originating Country: National Park Service / USA
Language: English
Description: Includes information on the NPS Invasive Species Management Policy, monitoring guidelines for invasive plants, animals and other taxa, lists of prioritization tools, a list of databases, statistical resources, meetings and conferences, education and outreach, agencies and organizations, related websites and reports, research, references and invasive species bibliographies.

125. *** Electronic Data Information Source on Insects, Plant Diseases, Pesticides and Weeds *

URL: http://edis.ifas.ufl.edu/TOPIC_Insects,_Plant_Diseases,_Pesticides,_and_Weeds
Host/Originating Country: University of Florida Cooperative Extension / USA
Language: English
Description: Directory style information on Invasive Species in general (e.g. control), invasive insects, arachnids, molluscs and gastropods, weeds and animals. Information on each invasive species includes backgroun, description, range and habitat, food, reproduction, problems and solutions, control methods, legal aspects, suggested readings, and graphics.

126. *** Stevens County Noxious Weed List ***
URL: http://www.co.stevens.wa.us/weedboard/weed_list.htm
Host/Originating Country: Stevens County Noxious Weed Control Board / USA
Language: English
Description: Information on identification, maps, biocontrol methods for weed species in Stevens **County**, Washington states, USA. Specific information includes photographic images, identifying traits, biology and ecology, control (prevention, biological, cultural, mechanical, chemical), and location of observations.

127. *** Pest Plants of Hawaiian Natural Ecosystems ***
URL: http://www.botany.hawaii.edu/faculty/cw_smith/aliens.htm
Host/Originating Country: University of Hawaii, Botany Department / USA
Language: English
Description: HTML information pages for species listed by species and common names, containing photographic images, plant and invasion population descriptions.

128. *** WeedAlert.com Turf Weed Control ***
URL: http://www.weedalert.com
Host/Originating Country: PBI/Gordon, Inc./ USA.
Language: English
Description:. Online source for turf weed control options. Weed information for North America (divided into four major regions). Includes weed images, descriptions, control recommendations, germination dates, university links, links to weed and turf related societies, environmental issues (e.g. 2,4-D task force), research, and industry trade journals.

129. Non-Native Ants database
URL: http://home.sandiego.edu/~tmcglynn/exotic.htm
Host/Originating Country: Terrence P. McGlynn, Department of Biology,
University of San Diego / USA
Language: English
Description: Draft database of names and geographic distribution data of the known non-native ant species of the world including historical observation and introduction records, maps, references; and a directory of researchers (expertise).

130. Introduced Social Insects
URL: http://research.amnh.org/entomology/social_insects/introduced.html
Host/Originating Country: American Museum of Natural History / USA
Language: English
Description: Searchable database on introduced social insects (ants, bees, wasps, termites) providing taxonomic information, photographic images, biology, distribution, damage, control, and references for each species where available. A component of the Social Insects World Wide Web (SIWeb).

USA Context – Aquatic IAS Databases

131. Database on Introductions of Aquatic Species (DIAS) (FAO)
URL: http://www.fao.org/waicent/faoinfo/fishery/statist/fisoft/dias/index.htm
Host/Originating Country: Food & Agriculture Organization (FAO) of the United Nations.
Language: English
Description: Database of 3,150 records for introduced freshwater fish, mollusks, crustaceans, and marine species.

132. National Aquatic Nuisance Species Clearing House (NANSC) (USA)

URL: http://www.cce.cornell.edu/programs/nansc/nan_ld.cfm
Host/Originating Country: Cornell Cooperative Extension (CCE), Cornell University, National Oceanic and Atmospheric Administration (NOAA), State University of New York / USA.
Language: English
Description: International library of research, public policy, and outreach education publications pertaining to invasive marine and fresh-water aquatic nuisance species in North America.

133. National Exotic Marine & Estuarine Species Information System (NEMESIS) (SERC)

URL: http://invasions.si.edu/nemesis/index.html
Host/Originating Country: Smithsonian Environmental Research Center (SERC) / USA.
Languages: English
Description: Lists exotic marine and estuarine species in coastal bays of the continental United States. Currently provides access to the Chesapeake Bay Introduced Species Database.

134. National Ballast Water Information Clearinghouse (NBIC) (SERC)

URL: http://invasions.si.edu/NBIC/ballast.html
Host/Originating Country: Smithsonian Environmental Research Center (SERC) / USA.
Languages: English
Description: Information on ballast water and ballast-mediated invasion including; spatial and temporal patterns of ballast water delivery and management, patterns and rates of marine and estuarine invasions, directory of ongoing and past research on ballast water and ballast-mediated invasions.

135. National Marine and Estuarine Invasions Database (NIS) (SERC)

URL: http://invasions.si.edu/NIS.htm
Host/Originating Country: Smithsonian Environmental Research Center (SERC) / USA.
Language: English
Description: Contains synonomy, common names, invasion history, invasion mechanism, date of introduction, source region, history of spread, population biology, life-history characteristics, abundance, community ecology, habitat utilization, environmental tolerances, ecological interactions, economic impacts and references for marine and estuarine alien species in U.S. waters, including organisms that occur in tidal waters of all salinities (i.e., freshwater to full marine salinities). Also includes the Chesapeake Bay Nonindigenous Species List (http://invasions.si.edu/NIS/NIS_CBList.htm).

136. Zebra Mussel Information System (ZMIS) (USArmyCorp)

URL: http://www.wes.army.mil/el/zebra/zmis/zmishelp.htm
Host/Originating Country: U.S. Army Engineer Research and Development Center / USA.
Language: English
Description: Information identifying both adult and immature Zebra Mussels. Includes; life history, impact, monitoring and detection, management strategies, contaminant issues as well as an extensive bibliography.

137. 100th Meridian Database

URL: http://www.100thmeridian.org/database.htm
Host/Originating Country: University of Texas at Arlington / USA.
Language: English
Description: Part of a cooperative effort between state, provincial, and federal agencies to prevent the westward spread of zebra mussels and other aquatic nuisance species in North America. Contains zebra mussel-related information from infested states and provinces with summary data of areas surveyed, and records of boating movements across provincial borders within states.

138. Sea Grant Nonindigenous Species (NOAA)

URL: http://www.sgnis.org/
Host/Originating Country: National Oceanic & Atmospheric Administration (NOAA), Great Lakes Sea Grant Network / USA.
Language: English
Description: Research publications and education materials produced by Sea Grant programs and other research institutions across the country on zebra mussels and other aquatic nuisance species.

139. Coastal Species Alien Warning System (NOAA)
URL: http://www.ncddc.noaa.gov/MIS
Host/Originating Country: National Coastal Data Development Center, National Oceanic and Atmospheric Administration / USA.
Language: English
Description: Digital Aquatic Inventory and System for the Early Detection of Invasive Species for detection, species confirmation, warning to managers, and information on aquatic alien species. Report a species not listed in the baseline atlas, get information on U.S. and Canadian aquatic species, map species distributions, and acquire biological survey and monitoring data. Natural resource managers and scientists can get critical species information to help them assess the potential impact and develop response strategies before an exotic species expands beyond its point of introduction. Detailed species information includes identification characteristics, photographs, physiological and ecological requirements, distribution ranges, and the region to which it is endemic.

140. Washington's Freshwater Aquatic Plants Database (Washington state)
URL: http://www.ecy.wa.gov/apps/watersheds/aquaticplants/listbywria.asp
Host/Originating Country: Washington State Department of Ecology, Water Quality Program / USA.
Language: English
Description: Survey data from 1994 through 2001, for native and non-native aquatic plant species in Washington, U.S.A.

141. Aquatic Nuisance Species (Washington State)
URL: http://www.wdfw.wa.gov/fish/ans/ans1.htm
Host/Originating Country: Washington Department of Fish and Wildlife / USA
Language: English
Description: Information on aquatic nuisance species in Washington State, including a list of non-indigenous marine species and their natural ranges, a list of taxonomic experts, contacts for location maps, a list of species of concern and related Web links.

142. Nonindigenous Aquatic Species (NAS) Database (USGS)
URL: http://nas.er.usgs.gov/
Host/Originating Country: U.S. Geological Survey, Biological Resources Division, Florida Integrated Science Center, Center for Aquatic Resource Studies / USA.
Language: English
Description: Geo-spatially referenced biogeographic accounts of nonindigenous aquatic species in the United States, including scientific reports, online/real-time queries, spatial data sets, regional contact lists, and general information.

143. Whirling Disease Data Base (WHDDB)
URL: http://www.esg.montana.edu/whddb/
Host/Originating Country: Montana State University, Environmental Statistics Group / USA.
Language: English
Description: Search a Whirling Disease Database and a Fish Database. Map the results. Fish-pathogen combinations are displayed as points and circles on a map.

144. Aquatic Nuisance Species Program (South Carolina)
URL: http://water.dnr.state.sc.us/water/envaff/aquatic/index.html
Host/Originating Country: South Carolina Department of Natural Resources / USA.
Language: English
Description: Information about South Carolina aquatic nuisance species including SC Aquatic Plant Management Plan, Illegal Plant List, Habitat enhancement, and selected species such as Grass Carp and Zebra Mussel.

145. marineID
URL: http://www.marineid.org/marine/html/index.html
Host/Originating Country: Northeast Aquatic Nuisance Species Panel / USA.
Language: English
Description: An online tool for organizing and displaying information on marine invasive species and their distributions in the Northwest Atlantic (USA). Includes an interactive mapping and display of species distributions.

146. *** Exotic Species of the Monterey Bay National Marine Sanctuary *
URL: http://bonita.mbnms.nos.noaa.gov/sitechar/spex.html
Host/Originating Country: Monterey Bay National Marine Sanctuary / USA
Language: English
Description: List of terrestrial plant, algae, invertebrate, and vertebrate alien species of the Monterey Bay National Marine Sanctuary, including common and species name, origin, habitat and information source.

147. *** Ruffe homepage *
URL: http://www.fw.umn.edu/research/ruffe/default.html
Host/Originating Country: Northland College, University of Minnesota Department of Fisheries, Wildlife and Conservation Biology / USA.
Language: English
Description: Provides a general overview and literature synthesis on the ruffe (*Gymnocephalus cernuus*), detailing its geographic distribution, taxonomy and nomenclature, morphology, evolution and genetics, sensory physiology, habitat, reproduction and early life history, age and growth, diet and foraging behavior, egg predation, competition, predators, parasites and pathogens, introductions in Europe and Asia, and management. Other components of this site include Ruffe scientific resources (annoted bibliography, powerpoint presentations, field reports), a searchable Ruffe scientists list, and a categorized and searchable list of online resources on Ruffe.

148. *** Biological Control of Eurasian Water Milfoil *
URL: http://www.fw.umn.edu/research/milfoil/milfoilbc.html
Host/Originating Country: Northland College, University of Minnesota Department of Fisheries, Wildlife and Conservation Biology / USA.
Language: English
Description: Provides descriptive information about Eurasian watermilfoil (*Myriophyllum spicatum L.*), its invasion history and biocontrol species including the milfoil weevil (*Euhrychiopsis lecontei*) with distribution maps and photographs; a bibliography, a list of related online resources, access to a searchable literature database, current research projects (summaries of current Eurasian watermilfoil biocontrol research at the University of Minnesota), and a list of relevant online reports and literature.

149. *** Aquatic Plant Fact Sheets (Aquatic Plant Management Society) *
URL: http://www.apms.org/plants/plants.htm
Host/Originating Country: Aquatic Plant Management Society / USA and International.
Language: English
Description: Fact sheets for elevent aquatic plant species including photographs, scientific and common names, taxonomic information, US distribution, Worldwide distribution, ecology, economic importance, ecological importance, and notes.

150. *** Introduced and Cryptogrenic Species of Massachusetts (maps) *
URL: http://massbay.mit.edu/exoticspecies/exoticmaps/
Host/Originating Country: MIT Sea Grant Center for Coastal Resources / USA
Language: English
Description: Mapped observation data (interactive maps) and species descriptions for native and non-native species identified on and around floating docks and piers throughout the New England coast.

151. *** Invasive Species (Minnesota) *
URL: http://www.dnr.state.mn.us/exotics/index.html
Host/Originating Country: Minnesota Department of Natural Resources (DNR) / USA
Language: English
Description: Lists of invasive aquatic and terrestrial animals and plants including photographic images, species descriptions, ID cards and guides for each species in the state of Minnesota.

IAS Image Databases (international)

152. Invasive and Exotic Species of North America – INVASIVE.ORG (USDA-FS)
URL: http://www.invasive.org/
Host/Originating Country: A joint project between the University of Georgia - Bugwood Network and the U.S. Department

of Agriculture, Forest Service / USA.
Language: English
Description: Over 8,300 images, including over 1,000 new images of invasive species (including many weeds) and their biological control agents. Although most images are North American in nature, the system also contains images of organisms that are "Non-U.S. Natives", or are considered to be "U.S. Invasives".

153. Weed Photo Gallery (UC IPM) (California state)
URL: http://www.ipm.ucdavis.edu/PMG/weeds_scientific.html
Cost/Originating Country: University of California (UC) statewide Integrated Pest Management (IPM) program, Agriculture and Natural Resources / USA.
Languages: English
Description: Includes photos of weed species commonly found in California farms and landscapes.

154. UC IPM Online – Identification: Weed Photo Gallery
URL: http://axp.ipm.ucdavis.edu/PMG/weeds_common.html
Host/Originating Country: University of California / USA
Language: English
Description: Photographic weed identification gallery listed by common or scientific name, and including brief physical and habit description, and labeled identification diagrams for weed group identification.

155. Invasive Plant Images (Montana state)
URL: http://ag.msu.montana.edu/cipm/cipmpics.asp?type=list&flag=1
Host/Originating Country: Center for Invasive Plant Management (CIPM), Department of Land Resources and Environmental Sciences, Montana State University / USA.
Language: English
Description: Lists of photographic and line-drawing images of native and non-native invasive plant species in Montana, U.S.A.

156. TNC Invasive Species Photographic Library
URL: http://tncweeds.ucdavis.edu/photos.html
Host/Originating Country: The Nature Conservancy (TNC)/Wildland Invasive Species Team / USA.
Language: English
Description: Inventory of invasive species images.

157. *** Minnesota Weed Seedling Photo Collection ***
URL: http://www.extension.umn.edu/distribution/cropsystems/DC7376.html
Host/Originating Country: University of Minnesota Extension Service / USA
Language: English
Description: Close-up photographs of common Minnesota weed seedlings taken at the seedling and 3 - 5 leaf stages for 19 broadleaf weed species and 10 grass weed seedlings, indexed by common name.

158. *** Plant Protection Photo Gallery (of) Noxious Weeds ***
URL: http://www.ks-agr.org/plantpest/list.asp?Folder=Noxious%20Weeds
Host/Originating Country: Kansas Department of Agriculture / USA
Language: English
Description: Photographic images of 14 weed species, listed by common name.

159. *** Weed Manager Photo Library ***
URL: http://www.weedmanager.net/photo.html
Host/Originating Country: WeedManager.net / Australia
Language: English
Description: Photographic library of weed species.

160. *** (Weed) Photo Herbarium ***
URL: http://www.wssa.net/subpages/weed/herbarium0.html

Host/Originating Country: Weed Science Society of America / USA
Language: English
Description: Contains pictures of many plants that are common to North America. Some of the plant species listed are not generally considered weeds but may have toxic or poisonous properties, or are otherwise of general interest as wildflowers or herbs.

161. *** Weed Herbarium ***
URL: http://www.umassgreeninfo.org/fact_sheets/weed_herbarium/common_name_list.htm
Host/Originating Country: University of Massachusetts Amherst / USA
Language: English
Description: Photographic images of 129 plant/weed species listed (sortable by) scientific, common and family name.

162. *** Grass, Sedge and Broadleaf Weed Photo Gallery ***
URL: http://cropsolutions.fmc.com/Crop_Solutions/Insects_Weeds/
Host/Originating Country: FMC Corporation / USA
Language: English
Description: Photographic/common name index of 11grass weed species, 16 broadleaf weed species, and 1 sedge weed species. Includes photos and information on common and scientific name, affected crops, identification, geographic distribution and products labeled for use as weed control agents.

IAS Bibliographic Databases (international)

163. Institute for Biological Invasions Bibliographic Databases (IBI)
URL: http://invasions.bio.utk.edu/biblio_data/index.html
Host/Originating Country/Originating Country: Institute for Biological Invasions (IBI), University of Tennessee, Kentucky / USA.
Language: English
Description: Biological invasions library containing books, journal articles, government reports, conference proceedings, magazine and newspaper articles, and other 'gray' literature.

164. Invasive Mammals Bibliography (NewZealand)
URL: http://www.invasive-animals.org.nz/index.html
Host/Originating Country: Massey University and University of Waikato / New Zealand.
Language: English
Description: Provides scientific information including bibliographic databases of published research, including some abstracts, on five species of invasive mammals in New Zealand.

165. Catalog & Article Citation database (AGRICOLA)
URL: http://agricola.nal.usda.gov/
Host/Originating Country: National Agricultural Library, U.S. Department of Agriculture / USA.
Language: English
Description: Searchable database of books, serials, audiovisuals, journal articles, book chapters, short reports and reprints.

166. Web based Information System for Agricultural Research for Development (WISARD)
URL: http://www.wisard.org/wisard/home.asp
Host/Originating Country: WIS International / The Netherlands
Language: English
Description: A public domain information platform providing searchable information on experts, organizations, outputs and projects in the fields of Agricultural Research for Development (ARD), Natural Resource Management (NRM) and sustainable development (SD) from the mid-nineties to present.

167. *** Minnesotal Bibliographic Databases ***
URL: http://www.fw.umn.edu:591/
Host/Originating Country: University of Minnesota Department of Fisheries, wildlife and conservation Biological Filemaker Pro Instant Web Portal / USA.
Language: English

Description: Provides access to six bibliographic databases including Weevilbib (92 citations on weevil species relating to weed biocontrol); ShallowlakeBibl (1675 citations relating to aquatic invasive species); SEBiblio00 (2422 citations relating to watershed management and health), MNDNRreps (671 citations for Minnesota State Department of Natural Resources reports), Exoticsbibl (1985 citations on exotic species), and Aquaticplantbib (1125 citations on aquatic plants).

IAS Expertise Databases (international)

168. Eurasian Watermilfoil Resource List
URL: http://aquat1.ifas.ufl.edu/milfoil.html
Host/Originating Country: Compiled by John Madsen, Center for Aquatic and Invasive Plants, Institute of Food and Agriculture Sciences, University of Florida / USA.
Language: English
Description: List of taxonomists, ecologists, management experts, and resource managers or lake association activists with experience with the invasive Eurasian watermilfoil (*Myriophyllum spicatum*).

169. Ecological Information Network (EIN) Expertise Database (NBII)
URL: http://ein.nbii.gov/advsrch.html
Host/Originating Country: U.S. Geological Survey, National Biological Information Infrastructure / USA.
Language: English
Description: Search for ecological expertise on exotic/introduced species.

170. Integrated Pest Management (IPM) Expertise Database
URL: http://pestdata.ncsu.edu/ipmexperts/
Host/Originating Country: Center for Integrated Pest Management, U.S. Department of Agriculture / USA
Language: English
Description: Search for expertise in IPM.

171. IGLAR Expert Directory
URL: http://www.iaglr.org/experts/directory.php
Host/Originating Country: International Association for Great Lakes Research (IGLAR) / USA
Language: English
Description: Search for experts on aquatic nuisance/exotic species

172. Taxonomic Resources and Expertise Directory (TRED) (NBII)
URL: http://www.nbii.gov/datainfo/syscollect/tred/
Host/Originating Country: U.S. Geological Survey (USGS), National Biological Information Infrastructure (NBII) / USA.
Language: English
Description: Search for experts by name, general or specific taxonomic expertise, geographic expertise or habitat expertise.

173. World Taxonomist Database (WTD)
URL: http://www.eti.uva.nl/Database/WTD.html
Host/Originating Country: Expert Center for Taxonomic Identification (ETI) / The Netherlands
Language: English
Description: This database allows users to search the World Taxonomist Database for a name (person or institute) and/or taxonomic specialization.

174. Expert Center for Taxonomic Identification (ETI)
URL: http://www.eti.uva.nl/.
Host/Originating Country:
Language: English
Description: ETI is a non-governmental organisation (NGO) in operational relations with UNESCO. Our mission is to develop and produce scientific and educational computer-aided information systems, to improve the general access to and promote the broad use of taxonomic and biodiversity knowledge worldwide.

175. Fauna Europea (FAEU) Expert Database

URL: http://www.faunaeur.org/partners/EXPERT_DATABASE/experts.htm
Host/Originating Country: Fauna Europaea Secretariat, Zoological Museum Amsterdam / The Netherlands.
Language: English
Description: Provides names and contact information of experts according to phylum.

IAS Research, IPM, Databases (international)
(Weed Management, Integrated Pest Management etc.)

176. Aquatic Invasions Research Directory (AIRD) (SERC)
URL: http://invasions.si.edu/aird.htm
Host/Originating Country: Smithsonian Environmental Research Center (SERC) / USA.
Language: English
Description: Search for information on people, research, technology, policy, and management issues relevant to aquatic invasions, including the ecology of aquatic invasions (vectors, impacts, risk assessment and response), and the ecology of ballast water.

177. Ballast Water Treatment R&D Directory (GLOBALLAST)
URL: http://globallast.imo.org/index.asp?page=bwprojects.htm
Host/Originating Country: Programme Coordination Unit, Global Ballast Water Management Programme, International Maritime Organization (IMO) / London.
Language: English
Description: Lists research and development projects focusing on the physical, mechanical or chemical treatment of ballast water to prevent/reduce the transfer of aquatic organisms.

178. Weed Research & Information Center (WeedRIC)
URL: http://wric.ucdavis.edu/
Host/Originating Country: University of California (UC) / USA.
Language: English
Description: Search for; weed photographs/images, University of California Pest Notes, weed control and herbicide information sources, poisonous plants sources and weed-related publications.

179. Database of IPM Resources (DIR)
URL: http://www.ippc.orst.edu/cicp/
Host/Originating Country: Oregon State University, Integrated Plant Protection Center / USA.
Language: English
Description: Search for worldwide integrated pest management information on crops, pests, control tactics, regions, organizations and related topics.

180. UC IPM Online – Weed Identification Guide
URL: http://axp.ipm.ucdavis.edu/index.html
Host/Originating Country: University of California / USA
Language: English
Description: California State Weed Identification guide listing 22 species by common name and including information about identification, life cycle and biology, damage, management, and related publications for each species.

181. *** California Weed Mapping Handbook (CAIN/NBII) ***
URL: http://cain.nbii.gov/weedhandbook
Host/Originating Country: California Information Node, National Biological Information Infrastructure / USA
Language: English
Description: Online book currently in downloadable PDF format only but planned for internet publishing. A training resource for local groups involved in wildland weed mapping providing shared data standards and instructions on mapping techniques.

182. Agriculture Network Information Center (AgNIC)
URL: http://www.agnic.org/

Host/Originating Country: A voluntary alliance of the National Agricultural Library (NAL), land-grant universities and other agricultural organizations, in cooperation with citizen groups and government agencies. USA.
Language: English
Description: Search for; publications, references, and online databases related to exotic/ invasive species and agriculture.

183. Organic Garden Weed Management - Weed Database
URL: http://www.css.cornell.edu/WeedEco/WeedDatabase/index2.html
Host/Originating Country: Center for Invasive Plant Management in the Western United States, Department of Crop and Soil Sciences, Cornell University / USA.
Language: English
Description: Lists ecological data and general weed management strategies for the most common and difficult to control weed species in the state of New York. Includes weed descriptions, color photographs of weed life history stages, tips on distinguishing the species from similar looking species, summaries of major control strategies, and statements about various aspects of the species' ecology.

184. TNC Invasive Species Management Library
URL: http://tncweeds.ucdavis.edu/esadocs.html
Host/Originating Country: The Nature Conservancy (TNC), Wildland Invasive Species Team / USA.
Language: English
Description: Links to all TNC resources specific to individual invasive species including invasive plant ESAs (Element Stewardship Abstracts) written for The Nature Conservancy that summarize relevant aspects of an organism, including its ecology and control. Also includes species management abstracts and cultivar notes on invasive species.

185. Fire Effects Information System (FEIS) (USDA-Forest Service)
URL: http://www.fs.fed.us/database/feis/index.html
Host/Originating Country: U.S. Department of Agriculture, Forest Service Rocky Mountain Research Station, Fire Sciences Laboratory - Missoula, Montana / USA.
Language: English
Description: Literature reviews of botanical characteristics, life cycle, habitat, succession, distribution, impacts, fire ecology, and fire effects for 1000 plant and animal species, including 67 non-native invasive species.

186. Biota of North America Program (BONAP)
URL: http://www.bonap.org/ & http://www.invasivespecies.org/Bonap/
Host/Originating Country: North Carolina Botanical Garden; University of North Carolina at Chapel Hill, USDA, APHIS / USA.
Language: English
Description: Search for information on all vascular plants and vertebrate species (native, naturalized, and adventive) of the United States and Canada.

187. Pearl Harbor Legacy Project Species List
URL: http://www.bishopmuseum.org/research/natsci/invert/phlegacy.html
Host/Originating Country: Bishop Museum, The State Museum of Natural and Cultural History, Honolulu Hawaii / USA.
Language: English
Description: Lists taxonomic names and identifying authorities, collection dates, locations and references for 1141 taxa of marine algae, invertebrates and fishes that have been collected or observed in Pearl Harbor, Oahu, Hawaii since the first biological observations were made in the harbor in 1866. Species considered to be introduced or cryptogenic (not verifiably native or introduced) are so designated.

188. Release of Beneficial Organisms in the United States & Territories (ROBO) (USDA-ARS)
URL: http://www.ars-grin.gov/nigrp/robo.html
Host/Originating Country: U.S. Department of Agriculture (USDA), Agricultural Research Service (ARS), Biological Control Documentation Center (BCDC) / USA.
Language: English
Description: Contains collection, introduction, release, culture, establishment, recolonization, and impact of non-indigenous organisms and pollinators on pests in the United States. Includes information on arthropods (insects, mites and ticks), nematode and other invertebrate pests, weedy plants, and microbial (bacteria, viruses, fungi, protozoa) pests.

189. Integrated Pest Management in the Northeast (USA)
URL: http://northeastipm.org/
Host/Originating Country: Cooperative Extension and Land Grant University IPM programs of the Northeast, United States Department of Agriculture / USA.
Language: English
Description: Integrated Pest Management resources, information, methodology and research by U.S. State.

190. Bio-Integral Resource Center (BIRC)
URL: http://www.birc.org/
Host/Originating Country: Bio-Integral Resource Center (BIRC), California / USA.
Language: English
Description: Information in integrated pest management, including publications, an Organic Database, and a Pest Control Advisor Database.

191. WeedScience – International Surveys of Herbicide Resistant Weeds
URL: http://www.weedscience.org/in.asp
Host/Originating Country: Herbicide Resistance Action Committee (HRAC), North American Herbicide Resistance Action Committee (NAHRAC), Weed Science Society of America (WSSA) / USA.
Language: English
Description: Monitors the evolution of herbicide-resistant weeds and assesses their impact throughout the world. Supported by global collaboration between weed scientists. Provides access to searchable lists of researchers, herbicides, weed photographs, and herbicide resistant weeds.

192. Weed Control Manual for the Bay of Plenty (New Zealand)
URL: http://www.envbop.govt.nz/Weeds/Weeds.asp
Host/Originating Country: Environment Bay of Plenty Regional Council / New Zealand.
Language: English
Description: Terrestrial and aquatic weed plants in New Zealand.

193. Ranking Exotic Plants (Handbook) (USA-NPS)
URL: http://www.nature.nps.gov/publications/ranking/ranking.html
Host/Originating Country: United States National Park Service (NPS) / USA
Language: English
Description: Handbook for ranking exotic plants for management and control by Ronald D. Hiebert, National Park Service, Nebraska, USA.

194. Guide to Monitoring Exotic and Invasive Plants (Canada)
URL: http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/exotics/intro.html
Host/Originating Country: Environment Canada / Canada.
Language: English
Description: Online guide to monitoring exotic and invasive plants by Erich Haber, National Botanic Services, Ontario, Canada. Includes examples of monitoring projects.

195. Gateway to Online IPM Resources
URL: http://www.ippc.orst.edu/cicp/gateway/Index.htm
Host/Originating Country: Integrated Plant Protection Center, Oregon State University / USA.
Language: English
Description: Linked list of Internet resources on weeds and their control.

196. Biological Control: A Guide to Natural Enemies in North America (Cornell)
URL: http://www.nysaes.cornell.edu/ent/biocontrol/
Host/Originating Country: Cornell University / USA.
Language: English, Spanish
Description: Photographs and descriptions of biological control (or biocontrol) agents of insect, disease and weed pests in North America (currently includes individual pages of approximately 100 natural enemies of pest species); A tutorial on the concept and practice of biological control and integrated pest management (IPM).

197. Montana Integrated Pest Management Center
URL: http://scarab.msu.montana.edu/ipm/
Host/Originating Country: Montana State University Extension Service / USA
Language: English
Description: Provides integrated pest management information, guides, listings of diagnostics, personnel, reports, species information, and pesticide information.

General Fauna Databases Containing IAS Information (international)
(Aquatic & Terrestrial)

198. FishBase: A Global Information System on Fishes
URL: http://www.fishbase.org/home.htm & http://filaman.uni-kiel.de/home.htm
Host/Originating Country: The FishBase Project, The WorldFish Center / Philippines.
Languages: English, Spanish, Portuguese, French, German, Italian, Dutch, Swedish, Chinese.
Description: Search for taxonomic and descriptive information, for fish species of the world, including introduced species.

199. Elasmo World (Sharks and Rays – elasmobranches)
URL: http://209.35.44.130/elasmo/default.asp
Host/Originating Country: Elasmoworld.org / location unspecified.
Languages: English
Description: Contains over 4000 entries and over 10,000 keywords relating to elasmobranches, including invasive elasmobranches.

200. ReefBase
URL: http://www.reefbase.org/
Host/Originating Country: ReefBase is a project by The WorldFish Center / Philippines, and the International Coral Reef Action Network (ICRAN) / UK, financial support by United Nations Foundation (UNF) / USA.
Languages: English
Description: Search for coral information including information about threats to coral reefs such as IAS.

201. Avibase – the world bird database
URL: http://www.bsc-eoc.org/avibase/avibase.jsp?pg=home&lang=EN
Host/Originating Country: BirdLife International / UK
Language: English, Spanish, French, German, Italian, Dutch, Portuguese, Swedish
Description: Checklists of avian species by country – indicating total numbers of introduced species by country and status of each species (e.g. introduced, threatened etc.).

General Flora Databases Containing IAS Information (international)
(Aquatic & Terrestrial)

202. Flora of North America (FNA)
URL: http://www.fna.org/FNA/
Host/Originating Country: Flora of North America Association / USA.
Language: English
Description: Search for information on the names, taxonomic relationships, continent-wide distributions, and morphological characteristics of all plants native and naturalized in North America north of Mexico.

203. FloraBase^2 the Western Australian Flora
URL: http://www.calm.wa.gov.au/florabase/index.html
Host/Originating Country: Department of Conservation and Land Management, Government of Western Australia / Australia.
Languages: English
Description: Search for descriptive data for the families, genera and species of all vascular plants in the state of Western Australia, including names, images and distribution maps for weed species. * Requires registration.

204. Crop Profiles Database (USDA)

URL: http://pestdata.ncsu.edu/cropprofiles/pmcropprofiles.cfm?usdaregion=National%20Site
Host/Originating Country: U.S. Department of Agriculture / USA.
Language: English
Description: Profiles various crop species grown in the U.S., and includes data about the arthropod and plant pests that affect them, including invasive species. Search by crop type, region, and/or key terms. Each crop profile includes listings of pest species and their potential damage, monitoring techniques, pest life history, and possible controls.

205. PLANTS Database (USDA)
URL: http://plants.usda.gov/
Host/Originating Country: U.S. Department of Agriculture, Natural Resources Conservation Service / USA.
Language: English
Description: Provides names, checklists, automated tools, identification information, species abstracts, distributional data, crop information, plant symbols, plant growth data, plant materials information, plant links, references, and other plant information, a Federal Noxious Weeds List, a list of State Noxious Weed Reports, an Invasive Plants of the U.S. list; and an Introduced Plants of the U.S. list.

206. Aquatic Plant Information System Online (APIS) (USArmyCorp)
URL: http://www.wes.army.mil/el/aqua/apis/apishelp.htm
Host/Originating Country: U.S. Army Corp of Engineers, Engineer Research and Development Center, Environmental Laboratory / USA.
Language: English
Description: Provides information on five aquatic invasive plants (alligator weed, Eurasian water milfoil, hydrilla, water hyacinth, and water lettuce).

207. International Legume Database and Information Service (ILDIS)
URL: http://www.ildis.org/LegumeWeb/
Host/Originating Country: School of Biological Sciences, University of Southampton / UK
Language: English
Description: Catalogue of world legume species. Search for invasive legume species by scientific name. Results indicate existence of weedy populations, invasion impacts, invasive potential and status.

208. Flora Europaea
URL: http://rbg-web2.rbge.org.uk/FE/fe.html
Host/Originating Country: Royal Botanical Garden of Edinburgh / UK.
Language: English
Description: Searchable floral taxonomic database. Non-native species distributions are indicated by symbology including square brackets.

Appendix D (1 – 4)
Appendix D1 - Online Databases Survey (Survey 1)

Online Databases Survey (Survey 1)
Designed by Elizabeth Sellers and Shelaine Curd-Hetrick
Information International Associates Inc.
P.O. Box 4219, Oak Ridge, TN 37831-4219

This survey has 7 questions and should take approximately 3-5 minutes.
***Indicates a required field.**

Name of Respondent*
Position
Official Address
Postal Code or Zip Code
Country
Phone Number*
Facsimile Number
Email Address*Mailto:
Text (optional):

O1. The name of the database or distributed database system (DDS) I represent in my responses to this survey is: (If none, then enter *N/A* for Not Applicable.)*

O2. The URL of the database welcome (or home) page is:

Internet Address: http://

Text (optional):

O3. The URL of the database mirror page is:

Internet Address: http://

Text (optional):

O4. The online database is available (choose all that apply):

☐ To the public
☐ Through password protected login (for members/subscribers only)
☐ Other (see next question)

O5. If your answer to question O4 was *other*, please explain here.

O6. The database is served on the Internet or World Wide Web (WWW) using the following format (choose all that apply):

☐ HTML ☐ XML
☐ ASP ☐ JSP
☐ CGI ☐ Other (see next question)

O7. If your answer to question 06 was *other*, please explain here.

Appendix D2 – Database Content Survey (Survey 2)

Database Content Survey (Survey 2)
Designed by Elizabeth Sellers and Shelaine Curd-Hetrick
Information International Associates Inc.
P.O. Box 4219, Oak Ridge, TN 37831-4219

This survey has 24 questions and should take approximately 5-7 minutes.
*** Indicates a required field.**

Name of Respondent*
Position
Official Address
Postal Code or Zip Code
Country
Phone Number*
Facsimile Number
Email Address* Mailto:
Text (optional):

C1. The name of the database or distributed database system (DDS) I represent in my response to this survey is: (If none, then enter *N/A* for Not Applicable or go directly to C13.)*

C2. What language is the data or datasets available in? (choose all that apply)

☐ Mandarin ☐ Portuguese
☐ English ☐ Malay-Indonesian
☐ Hindustani ☐ French
☐ Spanish ☐ German
☐ Russian ☐ Other (see next question)
☐ Arabic

C3. The language of the data or datasets (if not listed above):

C4. The database contains the following information types: (choose all that apply)

☐ Taxonomic (species based)
☐ Taxonomic (specimen based, e.g. collection records)
☐ Bibliographic ☐ Expertise ☐ Distribution
☐ Biological/Ecological ☐ Genetic (e.g. AFLP identification)
☐ Research (e.g. projects)
☐ Interactive maps (including GIS data layers)
☐ Non-interactive maps (static images)
☐ Images (including photos and drawings)
☐ IAS management methodology/tools ☐ Other (see next question)

C5. The information type of the database (if not listed above):

C6. The taxonomic/terminology/data standard referenced by the database is: (choose all that apply)

☐ Integrated Taxonomic Information System (ITIS)

☐ Food and Agriculture Organization (FAO) Glossary of Phytosanitary Terms

☐ My database does not reference a taxonomic/terminology/data standard

☐ Other (see next question)

C7. The taxonomic/terminology/data standard referenced by the database (if not listed above):

C8. The subject or focus of the database: (choose all that apply)

☐ Aquatic species only ☐ Terrestrial species only

☐ Aquatic and terrestrial species

☐ Flora (plants) only ☐ Fauna (animals) only

☐ Flora and fauna (plants and animals, all taxa)

☐ Arthropods only ☐ Invertebrates only ☐ Vertebrates only

☐ Diseases (viral/bacterial/fungal) ☐ Other (see next two questions)

C9. The subject or focus of the database (if not listed above):

C10. The databases addresses the following individual or group of species/taxa (answer only if not listed in question C8 or C9):

C11. The geographic focus of the database is: (choose all that apply)
Local (an area within one part of a country/political unit)

☐ National ☐ Regional (more than one country/political unit)
☐ Global ☐ Other (see next question)

C12. The geographic focus of the database (if not listed above):

C13. Rank IAS database search criteria in order of importance to you. Use each number only ONCE. (1=most important, 7=least important)

Scientific Name (1 2 3 4 5 6 7)

Common Name (1 2 3 4 5 6 7)

Genus (1 2 3 4 5 6 7)

Higher Taxonomic Unit (1 2 3 4 5 6 7)

Geographic area (1 2 3 4 5 6 7)

Invasion pathway/method (1 2 3 4 5 6 7)

Keyword search (1 2 3 4 5 6 7)

C14. Database search criteria important to me (if not listed above):

C15. Rank IAS database search results listed below in order of importance to you. Use each number only ONCE. (1=most important, 6=least important)

Fact sheets / species profiles (1 2 3 4 5 6)

Distribution maps (either interactive GIS layers or non-interactive graphics) (1 2 3 4 5 6)

Species occurrence reports (1 2 3 4 5 6)

Management / control information (1 2 3 4 5 6)

Current / past research (1 2 3 4 5 6)

Bibliographic information / references (1 2 3 4 5 6)

C16. Database search results important to me (if not listed above):

C17. Select the taxonomic category that should be *required* in IAS debases: (choose all that apply)
☐ All taxonomic categories listed below
☐ Kingdom ☐ Phylum/Division ☐ Class ☐ Order ☐ Family ☐ Genus
☐ Species ☐ Other (see next question)

C18. Taxonomic category that should be *required* in IAS databases (if not listed above):

C19. Select the data type that should be *required* in IAS databases: (choose all that apply)

☐ Biology/Ecology (growth habit/rate, reproduction, fecundity, habitat preferences, etc)
☐ Geographic origin
☐ Natural geographic distribution (e.g. geo-referenced data points/maps)
☐ Un-natural geographic distribution (mapped non-native populations e.g. as crops)
☐ Current geographic distribution (e.g. geo-referenced data points/maps)
☐ Geo-referenced populations/data points (e.g. population/individual occurrence records)
☐ Introduction method (e.g. ballast water, natural packaging materials)
☐ Introduction date
☐ Introduction intent (e.g. accidentally, intentional)
☐ Invasion path/vector (e.g. seeds spread by air/water/cattle)
☐ Invasion impact (e.g. economic/biodiversity/human)
☐ Related GIS data layers (e.g. distribution maps)
☐ Other (see next question)

C20. Data type that should be *required* in IAS databases (if not listed above):

C21. Select the data type that should be *required* in IAS species occurrence reports: (choose all that apply)

☐ Originator/reporter (name, organization, contact information)
☐ Report submission date/date of observation
☐ Anecdotal location/invasive history notes (e.g. suspected invasion sources is garden plants)
☐ Invasion location description (e.g. west bank of stream)
☐ Geo-referenced location of invasives (including map coordinates)
☐ Species (name)
☐ Population size estimate (e.g. number of individuals)
☐ Population distribution estimate/known area
☐ Observed/potential impact (e.g. choking drainage system)
☐ Other (see next question)

C22. Data type that should be *required* in IAS species occurrence reports (if not listed above):

C23. Rank the issues listed below in order of importance to you, with respect to their influence on the future development of DDSs and the Global Invasive Species Information Network. (1=most important, 5=least important)

Agreement on taxonomy/taxonomic authority (1 2 3 4 5)

Agreement on standardization (standards) of database field formats (1 2 3 4 5

Agreement on standardization of a core group of required IAS data types to be included in databases (1 2 3 4 5)

Identification and procurement of funding (1 2 3 4 5)

Data ownership/copyright issues (1 2 3 4 5)

C24. Issue that is important to me with respect to its influence on the future development of DDSs and the GISIN (if not listed above):

Appendix D3 – Database Development & Technology Survey (Survey 3)

Database Development & Technology Survey (Survey 3)
Designed by Elizabeth Sellers and Shelaine Curd-Hetrick
Information International Associates Inc.
P.O. Box 4219, Oak Ridge, TN 37831-4219

This survey has 35 questions and should take approximately 9-11 minutes.
*** Indicates a required field.**

Name of Respondent*
Position
Official Address
Postal Code or Zip Code
Country
Phone Number*
Facsimile Number
Email Address*Mailto:
Text (optional):

D1. The name of the database or distributed database system (DDS) that I represent in this survey is: (If none, then enter *N/A* for Not Applicable and go to question D22.)*

D2. The database is available in the following format: (choose all that apply)

☐ Online (accessed through the Internet) ☐ Private (not available)
☐ Free or for purchase on CD ☐ Exportable electronic file
☐ Other (see next question)

D3. The database is available in the following format (not listed above):

D4. The data is extractable (e.g. database outputs) in the following format: (choose all that apply)

☐ HTML ☐ XML ☐ ASP ☐ JSP ☐ CGI ☐ Commas Separated Values file (CSV)
☐ Spreadsheet or flat file (e.g. Excel) ☐ Relational database (e.g. MS Access)
☐ Rich Text File (RTF) ☐ Other (see next question)

D5. The data is extractable in the following format (not listed above):

D6. Database development software in use is: (choose all that apply)

☐ MS Access ☐ SQL ☐ MS Access and SQL server ☐ Oracle ☐ Filemaker Pro
☐ Other (see next question)

D7. The database development software is custom programmed or not listed above: (please list and describe)

D8. Development of the database was funded by: (choose all that apply)

☐ Me (personal funds) ☐ My employer ☐ My organization ☐ State government funds
☐ National government funds ☐ Non-profit organization ☐ Private organization

☐ Education institution ☐ Other (see next question)

D9. Development funding source for the database (if not listed above):

D10. The database was developed by: (choose all that apply)

☐ Me ☐ Intern(s) ☐ Student(s) ☐ My employee(s) ☐ Private contractor(s)
☐ Contracting organization(s) ☐ Partner organization(s) ☐ Other (see next question)

D11. The database was developed by a developer not listed above:

D12. The database was developed in fulfillment of: (choose all that apply)

☐ Private research ☐ Educational degree/course (e.g. Masters, PhD) ☐ Local initiative
☐ National initiative ☐ Regional initiative ☐ Global initiative ☐ Other (see next two questions)

D13. If your answer to question D12 was *other*, please describe here.

D15. Is this database collaborating with another database or DDS?

☐ Yes (If *yes*, see next question) ☐ No

D16. If your answer to question D15 was *Yes*, what is the name of the collaborating database or DDS?

D17. Would you like to collaborate with another database or DDS?

☐ Yes ☐ No

D18. Rank the *technology* limitations most affecting your database development and collaboration. Please use each number only once. (1=most limiting, 4=least limiting)

Technological hardware quality/availability (1 2 3 4)
Software quality/availability (1 2 3 4)
Internet connection availability (1 2 3 4)
Internet connection speed (1 2 3 4)

D19. Other technology limitation(s) not listed above.

D20. Rank the *non-technology* limitations most affecting your database development and collaboration. Please use each number only once. (1=most limiting, 5=least limiting)

Funding (1 2 3 4 5)
Database design expertise (1 2 3 4 5)
Programming expertise (1 2 3 4 5)
IAS expertise (1 2 3 4 5)
Data ownership/copyright (1 2 3 4 5)

D21. Other non-technology limitation(s) not listed above.

D22. The computer hardware I predominantly use is: (choose all that apply)

☐ Personal computer (monitor, keyboard, mouse, central processing unit)
☐ Global Positioning System (GPS) ☐ Data-logger
☐ Other (see next question)

D23. The computer hardware I predominantly use (if not listed above):

D24. The computer platform I predominantly use: (choose all that apply)

☐ IBM ☐ Macintosh ☐ Other (see next question)

D25. The computer platform I predominantly use (if not listed above):

D26. The operating system I predominantly use is: (choose all that apply)

☐ Win98 ☐ WinME ☐ Win2000 ☐ WinXP ☐ WinNT ☐ UNIX ☐ LINUX ☐ MacOS
☐ Other (see next question)

D27. The operating system I predominantly use (if not listed above):

D28. The Internet browser application I predominantly use is: (choose all that apply)

☐ Internet Explorer version 5.x or LATER ☐ Internet Explorer version 4.x or EARLIER
☐ Netscape Navigator ☐ Netscape Communicator
☐ WebTV ☐ Other (see next question)

D29. The Internet browser application I predominantly use (if not listed above):

D30. The Internet access I experience is: (choose all that apply)

☐ I do not have Internet access ☐ I have reliable Internet access
☐ I have unreliable/intermittent Internet access ☐ Other (see next question)

D31. The Internet access I experience is different from above: (please explain briefly)

D32. The Internet connection speed I experience when I most commonly access my data/databases: (choose all that apply)

☐ T1 or T3 ☐ DSL ☐ Cable Modem ☐ Dial-up Modem at 56Kpbs
☐ Dial-up Modem at 28Kbps or less ☐ Other (see next question)

D33. The Internet connection speed I experience is (if not listed above):

D36. Rank the database types in order of their important to the GISIN (in your opinion). Please use each number only once. (1=most important, 7=least important)

IAS species/taxonomic database (1 2 3 4 5 6 7)

IAS expertise database (1 2 3 4 5 6 7)

IAS bibliographic database (1 2 3 4 5 6 7)

IAS research database (1 2 3 4 5 6 7)

IAS image/graphics database (1 2 3 4 5 6 7)

IAS geospatial database (1 2 3 4 5 6 7)

IAS databases in distributed database systems (1 2 3 4 5 6 7)

D37. The database type that I believe is most important to the GISIN is (or not listed above):

Appendix D4 – Evaluation of Surveys (Survey 4)

Evaluation of Surveys (Survey 4)
Designed by Elizabeth Sellers and Shelaine Curd-Hetrick
Information International Associates Inc.
P.O. Box 4219, Oak Ridge, TN 37831-4219

Please complete this evaluation if you have completed at least one of the surveys within the GISIN/Invasive Species Working Group Community.

If you take more than one survey, please complete an evaluation for each.
*** Indicates a required field**

Name of Respondent*
(If you wish to remain anonymous, please enter *ANON*)

S1. Survey being evaluated (choose one):*

☐ All Surveys ☐ Survey 1: Online Databases Survey
☐ Survey 2: Database Content Survey ☐ Survey 3: Database Development - Technology Survey

S2. The survey addressed the data and database-related issues/goals of the Global Invasive Species Collaborative Forum:

☐ Not at all ☐ Inadequately ☐ Adequately ☐ Well ☐ Very well ☐ Extremely well

S3. The length of the survey you took was:

☐ Too short ☐ Just right ☐ Too long

S4. Issues that should be considered for future consideration or included in a future survey are:

S5. Issues that should be included in the agenda of the 2004 GISIN Experts Meeting are:

Appendix E

Electronic Poster Abstracts

Invasive Species and the Compendium Programme at CAB International. *Soetikno Sastroutomo, CAB International, South-East Asia Regional Center.*

Abstract

The Compendium Programme, managed by CAB International (CABI), plays a coordinating role in compiling expert inputs on chosen topics into global knowledge bases ("Compendia"). These are presented through innovative and user-friendly technology (the "Compendium Technology") on CD-ROM and the Internet. The existing Compendia already provide a great deal of information on invasive species of importance to agriculture, forestry and animal health and are proven to assist users in assessing risks and evaluating impacts and control of potentially harmful organisms. A major enhancement of the Crop Protection Compendium in 2004 will add over 200 new data sheets on invasive weeds and other pests and provide information on 'invasiveness' and environmental impact on many more. Next year, the Aquaculture Compendium will include information on a range of invasive aquatic animals, plants and disease agents. CABI's Compendium Programme is well placed to make a greater contribution towards the provision of information for the management of invasive species and is keen to explore possibilities to achieve this goal.

Major Invasive Alien Species of Bangladesh. *Badrul Amin Bhuiya, Biodiversity Research Group, Bangladesh*

Abstract

As a sub-tropical country, Bangladesh is exceptionally rich in biodiversity. Several species of flora and fauna were deliberately introduced into the country mainly in order to increase productivity. The two most controversial genera of flora introduce are Acacia and Eucalyptus. Trading and import of these species have now been banned. A total of 15 species of fishes were introduced in Bangladesh; most of them are carps. The most “disastrous” species of alien invasive species in the country are *Clarias gariepimus*, *Pangasius sutchi*, *P. giganticus*, *Oreochromis mossambicus*, and *O. niloticus*.

Report of a Workshop on Invasive Alien Species: Global Biodiversity Forum. South and Southeast Asia Colombo, Sri Lanka. *Bhujang D. Dharmaji, IUCN-Regional Biodiversity Programme, Asia.*

Abstract

In view of the importance of the issue and with an aim to assess national and regional status of invasive alien species, the IUCN Regional Biodiversity Programme- Asia organized a regional workshop on the issue as a part of South and Southeast Asia Regional Session of Global Biodiversity Forum in Colombo, Sri Lanka during October 1999. Several country studies and status reports were presented during this workshop. Participants also came up with a set of recommendations from the discussions to deal with invasive alien species in the region.

We are pleased to present before you the country papers presented during the workshop along with the recommendations that came out of this regional workshop. We hope that countries in the region and policy makers will find the compilation useful to design interventions dealing with the issue. For more details: http://www.biodiversityasia.org/publications

Appendix F

Organizing Committee / Planning Team

* Please note that email addresses have been modified to prevent their being read by automated spammers.

Annie Simpson, Chair
National Biological Information Infrastructure
asimpson**AT**usgs.gov

Michael Browne
Invasive Species Specialist Group
m.browne**AT**auckland.ac.nz

Bonnie C. Carroll
Information International Associates, Inc.
bcarroll**AT**infointl.com

Vishwas Chavan
NCL Centre for Biodiversity Informatics, National Chemical Laboratory
(Information Division), Pune, INDIA
vishwas**AT**ems.ncl.res.in

Jeffrey Fisher
U.S.Department of State, OES
FisherJP**AT**state.gov

Mark Fornwall
USGS, Pacific Basin Information Node
Mark_Fornwall**AT**usgs.gov

Pam Fuller
USGS Non-Indigenous Aquatic Species database
Pam_Fuller**AT**usgs.gov

William Gregg
US Geological Survey
William_Gregg**AT**usgs.gov

Andrea Grosse
IABIN (Western Hemisphere) Invasives Information Network (I3N)
agrosse**AT**usgs.gov

Sergej Olenin
Klaipeda University, Lithuania
serg**AT**gmf.ku.lt

John Pickering
DiscoverLife
pick**AT**discoverlife.org

Jim Quinn
Information Center for the Environment
University of California at Davis
jfquinn**AT**ucdavis.edu

Michael Ruggiero
Integrated Taxonomic Information System
Ruggiero.Michael**AT**nmnh.si.edu

Greg Ruiz
Smithsonian Environmental Research Center
ruizg**AT**si.edu

Soetikno Sastroutomo
CAB International, Malaysia
s.soetikno**AT**cabi.org

Greg Sherley
Global Invasive Species Programme
Sherley**AT**nbict.nbi.ac.za

Marcos Silva
Secretariat of the Convention on Biological Diversity
marcos.silva**AT**biodiv.org

Tom Stohlgren
US Geological Survey
Tom_Stohlgren**AT**usgs.gov

Hans Svart
Danish Forest and Nature Agency
hes**AT**sns.dk

Yan XIE
Chinese Academy of Sciences, Zoology
xieyan**AT**public3.bta.net.cn

Silvia Ziller
Instituto Hórus / The Nature Conservancy , Brazil
sziller**AT**onda.com.br

Appendix G

Experts Meeting Participants

* Please note that email addresses have been modified to prevent their being read by automated spammers.

Mr. Phil Andreozzi
Program Specialist
National Invasive Species Council
1849 C Street N.W.
Washington, DC 20005 USA

Tel: 202 354 1884
Fax: 202 371 1751
Email:
phillip_andreozzi**AT**ios.doi.gov

Dr. Woodward Bailey
Project Lead, Global Pest and Disease Database
USDA-APHIS-PPQ
Center for Plant Health Science and Technology
woodward.d.bailey**AT**aphis.usda.gov
1017 Main Campus Drive Suite 2500
Raleigh, NC 27606 USA

Tel: (919) 513-1354
Fax: (919) 513-1995
Email:

Mr. Badrul Amin Bhuiya
Professor & Chairman
Biodiversity Research Group of Bangladesh (BRGB)
Department of Zoology, University of Chittagong, Bangladesh
Block-A, House # 51,
Paharika Housing Estate, Chittagong University
Chittagong 4331 Bangladesh

Tel: +880 31 017 203 1329 (cell)
Tel: +880 31 716552/716558
ext. 4305 (w)
Fax: +880 31 726310
Email: babhuiya**AT**hotmail.com

Ms. Joyce Bolton
Web Coordinator, Invasivespecies.gov
U.S.D.A., ARS, National Agricultural Library
10301 Baltimore Ave.
Beltsville, MD 20705 USA

Tel: 301-504-6454
Fax: 301-504-6892
Email: jbolton**AT**nal.usda.gov

Dr. Malika Bounfour (iSC)*
Entomologist and Plant Health Specialist
Direction de la Protection des Vegetaux,
DPVCTRF, Ministère de l'Agriculture, BP. 1308
des Controles Techniques et de la Repression des Fraudes
Rabat 10000 Morocco

Tel: 212-37-299193 /
212-37-729098
Fax: n/a
Email: mbounfour**AT**yahoo.com
(preferred)
mbounfour**AT**menara.ma

Ms. Kobie Brand
Communications Officer
GISP
c/o National Botanical Institute
Private Bag X7 Claremont
Cape Town 7735 South Africa

Tel: +27 21 799 8839
Fax: +27 21 797 1561
Email: brandt**AT**nbi.ac.za

Mr. Michael Browne
Manager, Global Invasive Species Database
IUCN SSC Invasive Species Specialist Group
University of Auckland (Tamaki Campus)
cnr. Merton and Morrin Roads, Glen Innes
Auckland New Zealand

Tel: +64 9 3737599 (X86814)
Fax: n/a
Email: m.browne**AT**auckland.ac.nz

Ms. Bonnie Carroll
President
Information International Associates, Inc.
1009 Commerce Park Dr. Ste 150
Oak Ridge, TN 37830 USA

Tel: 865-481-0388
ext 112
Fax: 865-481-0390
Email: bcarroll**AT**infointl.com

Ms. Christine Marie Casal
Research Associate
WorldFish Center
WorldFish Center - Philippine Office
Khush Hall, IRRI College, Los Baños
Laguna 4031 Philippines

Tel:1(650)8336620/8336621
local 2857
Fax: (632) 5805699
or (6349) 5360202
Email: c.casal**AT**cgiar.org

Dr. Charlotte Causton
Research Associate
Charles Darwin Research Station,
Santa Cruz Island, Galapagos Islands Ecuador

Tel: n/a
Fax: n/a
Email: causton(**AT**)fcdarwin.org.ec

Mr. Vishwas Chavan
Scientist
Information Division
National Chemical Laboratory, Dr. Homi Bhabha Road
Pune, Maharashtra, 411008 India

Tel: 91 20 25893457
Fax: 91 20 25893973
Email: vishwas**AT**ems.ncl.res.in

Mr. Steven Citron-Pousty
IPANE Technical Coordinator
IPANE project, UCONN
63 Nicoll St
New Haven, CT 06511 USA

Tel: 203-623-7218
Fax: n/a
Email: sic4**AT**pantheon.yale.edu

Mr. Martin Cocks
Project Coordinator & Internet Developer
International Ocean Institute - Southern Africa
Private Bag X17
Bellville Cape Town
Western Cape Province, 7800 South Africa

Tel: +27 21 959 3412
Fax: +27 21 959 1213
Email: mcocks**AT**uwc.ac.za
Url: www.gisp.org

Dr. Catherine Crosier
Ecologist
Fort Collins Science Center, USGS
2150 Centre Ave. Bldg C
Fort Collins, CO 80526 USA
Tel: n/a
Fax: n/a
Email: catherine_crosier**AT**usgs.gov

Ms. Shelaine Curd-Hetrick (Experts Meeting Staff)
Information International Associates Inc.
Biodiversity and Ecosystems Informatics Specialist
National Biological Information Infrastructure
1009 Commerce Park Drive
Oak Ridge, TN 37830 USA
Tel: 865-481-0388 x118
Fax: 865-481-0390
Email: shelaine**AT**infointl.com

Ms. Suzanne Davis
Senior Research Officer - Clearing-House Mechanism
Institute of Jamaica
Natural History Division, 10 -16 East Street
Kingston, KGN 6 Jamaica
Tel: (876)9220620-6
Fax: (876)9221147
Email: chm.nhd**AT**cwjamaica.com

Mr. Bhujangarao Durga Dharmaji
Regional Coordinator-SACNET & Senior Program Officer
IUCN-Regional Biodiversity Programme, Asia
53, Horton Place, Colombo -7
Colombo
Western Province, 07 Sri Lanka
Tel: +94 11 4710 439
Fax: +94 11 2662 941
Email: bhujang**AT**sltnet.lk

Mr. Rob Emery
Senior Entomologist
Western Australian Department of Agriculture
3 Baron-Hay Court
South Perth
Western Australia, 6006 Australia
Tel: +618 9368 3247
Fax: +618 9368 3223
Email: remery**AT**agric.wa.gov.au

Dr. David Farr
Research Mycologist
US Dept. Agriculture, Agriculture Research Service,
Systematic Botany and Mycology Laboratory
Rm. 304, Bldg. 011A
BARC-West
Beltsville, MD 20705 USA
Tel: 301-504-5274
Fax: n/a
Email: davef**AT**nt.ars-grin.gov

Mr. Lúcio Fialho
Consultant
Ministry of Environment
Avenida Presidente Vargas 509 – 4th Floor
Rio de Janeiro 20071003 Brazil
Tel: 55 21 2507 6350
Fax: 55 21 2507 6351
Email: lucio**AT**solucionar.com.br

Dr. Jeffrey Fisher
AAAS Fellow/Ecology Officer
U.S. State Department
2201 C Street
Room 4333
Washington DC 20520 USA
Tel: 2026470199
Fax: 2027367351
Email: fisherjp**AT**state.gov

Dr. Jennifer Forman Orth
Post-Doctoral Researcher
University of Massachusetts Boston, Biology Dept.
100 Morrissey Blvd.
Boston, MA 02125 USA
Tel: 508-405-0883
Fax: n/a
Email: jennifer.forman**AT**umb.edu

Ms. Pam Fuller
Program Leader
USGS
7920 NW 71st Street
Gainesville, FL 32653 USA
Tel: 352-378-8181 x312
Fax: n/a
Email: Pam_Fuller**AT**usgs.gov

Mr. Marco Gaiani
Head of the Bioinformatics Unit
Museo del Instituto de Zoología Agrícola,
Facultad de Agronomía
Universidad Central de Venezuela
Apdo. Postal 4579
Maracay Aragua 2101-A Venezuela
Tel: 58+243+2322444
Fax: n/a
Email:
mgaiani**AT**fundacite.arg.gov.ve

Dr. Stephan Gollasch
Senior Scientist
GoConsult
Bahrenfelder Str. 73 a
Hamburg 22765 Germany
Tel: +49 40 390 54 60
Fax: +49 40 360 309 4767
Email: sgollasch**AT**aol.com

Mr. Douglas Graham
World Bank
USA
Tel: n/a
Fax: n/a
Email: dgraham**AT**worldbank.org

Dr. William Gregg
Invasive Species Program Coordinator
U.S. Geological Survey
12201 Sunrise Valley Drive, MS 301
Reston, VA 20192 USA
Tel: 703-648-4067
Fax:703-648-4238
Email: william_gregg**AT**usgs.gov

Dr. Michael Grodowitz
Research Entomologist
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180 USA
Tel: 601-634-2972
Fax: 601-634-2398
Email: grodowm**AT**wes.army.mil

Ms. Andrea Grosse
Project Manager,
International Biological Informatics Initiatives
National Biological Information Infrastructure
12201 Sunrise Valley Dr., MS 302
Reston , VA 20192 USA
Tel: 703.648.4342
Fax: 703.648.4224
Email: agrosse**AT**usgs.gov

Dr. Ron Hiebert
Research Coordinator, Colorado Plateau
U.S. National Park Service
CPCESU, Northern Arizona University,
PO Box 5765
Flagstaff, AZ 86011 USA
Tel: (928) 523-0877
Fax: (928) 523-8223
Email: ron.hiebert**AT**nau.edu

Mr. Richard Huber
Principal Environmental Specialist
OAS
1889 F St NW
Suite 659
Washington, DC 20006 USA

Tel: 202-458-3227
Fax: 202-458 3560
Email: rhuber**AT**oas.org

Dr. Silvio Jablonski
Consultant
Ministry of Environment/
State University of Rio de Janeiro
Rua Casuarina, 100/401- Humaitá
Rio de Janeiro, RJ 22261-160 Brazil

Tel: 55 21 22865775
Fax: 55 21 25380367
Email: jablonski**AT**pobox.com

Ms. Kathryn R. Johnson
Project Administration Specialist
Information International Associates, Inc.
1009 Commerce Park Drive, Suite 150
P.O. Box 4219
Oak Ridge, TN 37831-4219 USA

Tel: 865-481-0388, ext 109
Fax: 865-481-0390
Email: kjohnson**AT**infointl.com

Ms. Kim Johnson (Experts Meeting Staff)
GIS/Mapping Coordinator
Fremont County WY Weed & Pest Control District
1446 Cowboy Lane
Riverton, WY 82501 USA

Tel: 307-856-2192
Fax: n/a
Email: fcwpmap**AT**direcpc.com

Mr. Jason Karl
GIS Manager
The Nature Conservancy
116 1st Ave North
Hailey, ID 83333 USA

Tel: 208-788-8988 x24
Fax: n/a
Email: jkarl**AT**tnc.org

Ms. Terri Killeffer
Botanical Research Associate
NatureServe
1101 Wilson Boulevard
15th Floor
Arlington, VA 22209 USA

Tel: 703-908-1892
Fax: 703-908-1917
Email:
terri_killeffer**AT**natureserve.org

Dr. Patricia Koleff
Director of Analyses and Priorities
Conabio
pkoleff**AT**xolo.conabio.gob.mx
Av. Liga Periferico Sur 4903 Col. Parques del Pedregal
Mexico City, D.F. 14010 Mexico

Tel: +52 (55) 55289175
Fax: +52 (55) 55289131
Email:

Dr. Mingguang Li
Professor
Sun Yatsen University
Dept of Biology/The Museum of Biology
135 Xin'gangxi Road
Guangzhou, Guangdong 510275 China

Tel: 86-20-84114063
Fax: 86-20-84110436
Email: LSSLMG**AT**zsu.edu.cn

Mr. Chau Chin Lin
Associate Scientist
Taiwan Forestry Research Institute
53 Nan Hai Rd.
Taipei, 100 Taiwan, ROC
Tel: +886-2-23039978 ext 2660
Fax: +886-2-23078755
Email: chin**AT**mail.tfri.gov.tw

Dr. Keng-Yeang Lum
Chairperson
ASEANET
c/o CABI-SEARC
P.O. Box 210, UPM Post Office
Serdang, Selangor 43400 Malaysia
Tel: +60 (3) 8943 2921
Fax: +60 (3) 8943 6400
Email: ky.lum**AT**cabi.org

Dr. Paivi Lyytikainen-Saarenmaa
Docent, University Lecturer
University of Helsinki
Department of Applied Biology, P.O. Box 27
Helsinki, 00014 Finland
Tel: +358-9-19158360
Fax: +358-9-19158633
Email: paivi.lyytikainen-saarenmaa**AT**helsinki.fi

Dr. Buddhisrilal Marambe
Dean and Senior Lecturer (Weed Science)
Faculty of Agriculture,
University of Peradeniya,
Central Province, 20400 Sri Lanka
Tel: (+)94-81-2388041,
(+)94-81-2388657
Fax: +94-81-2388041
Email: bmarambe**AT**pdn.ac.lk

.

Dr. Susan McCarthy
Technical Information Specialist
U.S.D.A., ARS, National Agricultural Library
10301 Baltimore Ave.
Beltsville, MD 20705 USA
Tel: 301-504-5510
Fax: 301-504-6892
Email: smccarth**AT**nal.usda.gov

Dr. Robert Meese
University of California, Davis (ICE)
Davis, CA USA
Tel: n/a
Fax: n/a
Email: rjmeese**AT**ucdavis.edu

Dr. Leslie Mehrhoff
Project Director
Invasive Plant Atlas of New England
University of Connecticut
Box U-43
Storrs, CT 06269-3043 USA
Tel: 860-486-5708
Fax: 860-486-6364
Email: vasculum**AT**uconnvm.uconn.edu

Dr. Laura Meyerson
Staff Scientist
The Heinz Center
1001 Pennsylvania Avenue, NW
Suite 735 South
Washington, DC 20004 USA
Tel: 202-737-6307
Fax: 202-737-6410
Email: meyerson**AT**heinzctr.org

Dr. Victor R. Morales
Advisor
Environmental National Council
Calle Erick Diaz Cabre 141
Urb Humboldt
Lima 18 Peru
Tel: +51-1-448.2260
Fax: n/a
Email: vrm2111**AT**neo.tamu.edu

Dr. Robert Morris
Professor of Computer Science
University of Massachussetts/Boston
Computer Science Department
100 Morrissey Blvd
Boston, MA 02466 USA

Tel: (+1) 617 287 6466
Fax: +1 617 287 6499
Email: ram**AT**cs.umb.edu

Ms. Rachel Muir
Biologist
U.S. Geological Survey
NatureServe, 1101 Wilson Blvd, 15th Floor
Arlington, VA 22209 USA

Tel: 703-908-1837 or 703-648-5114
Fax: 703-648-7031
Email:
rachel_muir**AT**natureserve.org

Dr. Sergej Olenin
Chief Scientist
Coastal Research and Planning Institute
Klaipeda University
H. Manto 84
Klaipeda, 5808 Lithuania

Tel: +370 46 398847
Fax: +370 46 398845
Email: serg**AT**gmf.ku.lt

Dr. Ching-I Peng
Research Fellow and Herbarium Curator
Institute of Botany, Academia Sinica
No. 128, Sect. 2, Academic Road
Nangang
Taipei, 115 Taiwan

Tel: 886-2-2789-3821
Fax: 886-2-2789-1623
Email: bopeng**AT**sinica.edu.tw

Mr. John Pickering
Discover Life
University of Georgia
717A Biological Sciences Bld.
Athens, GA 30602-2602 USA

Tel: 706-542-1115
Fax: 706-542-3344
Email: pick**AT**discoverlife.org

Dr. James F. (Jim) Quinn
Professor
University of California, Davis
Department of Environmental Science and Policy
Davis, CA 95616 USA

Tel: (530) 752-8027
Fax: (530) 752-9515
Email: jfquinn**AT**ucdavis.edu

Dr. Melba Reantaso
Aquatic Animal Research Pathologist
Cooperative Oxford Laboratory,
MD Department of Natural Resources
904 S. Morris Street
Oxford, MD 21654 USA

Tel: 410-226-5193
Fax: 410-226-5925
Email: mreantaso**AT**dnr.state.md.us

Ms. Debbie Reusser
Cartographer
USGS
1143 N. Beaver Creek Rd.
Seal Rock, OR 97376 USA

Tel: 541-563-6599
Fax: 541-563-4298 *
* (call first on 6599)
Email: dreusser**AT**usgs.gov

Dr. Barry Rice
Associate Scientist/Wildland Invasive Species Team
The Nature Conservancy
University of California
148 Asmundson Hall
Davis, CA 95616 USA
Tel: 530-754-8891
Fax: 530-752-4604
Email: bamrice**AT**ucdavis.edu

Dr. Lucie Rogo
Programme Officer, Taxonomy and Invasive Alien Species
The Secretariat of the Convention on Biological Diversity
The World Trade Centre
393 St. Jacques street, Suite 300
Montreal, Quebec H2Y 1N9 Canada
Tel: +514 2878718
Fax: +5142886588
Email: lucie.rogo**AT**biodiv.org

Ms. Donna M. Roy
U.S. Geological Survey
12201 Sunrise Valley Drive, MS 302
Reston, VA 20192 USA
Tel: 703-648-4209
Fax: 703-648-4224
Email: DRoy**AT**usgs.gov

Dr. Gregory Ruiz
Senior Scientist
Smithsonian Environmental Research Center
Smithsonian Institution
P.O. Box 28
Edgewater, MD 21037 USA
Tel: 443-482-2227
Fax: 443-482-2380
Email: ruizg**AT**si.edu

Dr. Hannu Saarenmaa (iSC)*
Deputy Director for Informatics
GBIF Secretariat
Universitetsparken 15
Copenhagen, 2100 Denmark
Tel: +45-35321479
Fax: +45-35321480
Email: hsaarenmaa**AT**gbif.org

Dr. Soetikno Slamet Sastroutomo (iSC)*
Senior Project Officer and Technical Secretary
CAB International and ASEANET
Glasshouse No. 2, Opposite Block G
MARDI Complex, P.O. Box 210
Serdang, Selangor, 43400 Malaysia
Tel: +60-3-8943-2921/3641
Fax: +60-3-8943-6400
Email: S.SOETIKNO**AT**cabi.org

Ms. Elizabeth Sellers (Experts Meeting Staff)
Information International Associates
NBII National Program Office
302 National Center
USGS Biological Informatics Office
Reston, VA 20192 USA
Tel: 7036484385
Fax: n/a
Email: esellers**AT**usgs.gov

Ms. Annie Simpson (iSC)*
Invasive Species Theme Coordinator
National Biological Information Infrastructure
US Geological Survey
12201 Sunrise Valley Drive, Mail Stop 302
Reston, VA 20192 USA
Tel: 703.648.4281
Fax: 703.648.4224
Email: asimpson**AT**usgs.gov

Dr. Richard Smith
Acting Director
BioNET-INTERNATIONAL
Bakeham Lane
Egham, Surrey, TW20 9TY United Kingdom
Tel: +44 (0)1491 829036
Fax: +44 (0)1491 829082
Email: rsmith**AT**bionet-intl.org

Dr. Wojciech Solarz
Senior Lecturer
Institute of Nature Conservation
Polish Academy of Sciences
Mickiewicza 33, Krakow Malopolskie 31-120 Poland
Tel: +48 609 440 104
Fax: +48 12 632 24 32
Email: solarz**AT**iop.krakow.pl

Ms. LeAnn Southward
Sea Grant Fellow
Office of Marine Conservation, U.S. State Department
1320 N. Wayne St. Apt. 102
Arlington, VA 22201 USA
Tel: 202-647-3464
Fax: 202-736-7350
Email: southwardlr**AT**state.gov

Mr. Brian Steves
Research Biologist
Smithsonian Environmental Research Center
4800 Williamsburg Ln
Unit #104
La Mesa, CA 91941 USA
Tel: 619-594-0798
Fax: 619-594-2035
Email: bsteves**AT**rocketmail.com

Ms. Angela M. Suarez-Mayorga
Chief Data Administrator
Biodiversity Information System,
Alexander von Humboldt Biodiversity Research Institute
Cra. 13 No. 28 - 01 Piso 7
Bogota, D.C. 1321 Colombia
Tel: (57-1) 3506064 / 7938 / 6619 / 9975
Fax: n/a
Email: amsuarez**AT**humboldt.org.co

Dr. Karl Suiter
Project Manager - Global Pest and Disease Database
North Carolina State University
920 Main Campus Drive
Venture II - Suite 100
Raleigh, NC 27606 USA
Tel: (919) 424-4411
Fax: (919) 424-4401
Email: Karl_Suiter**AT**ncsu.edu

Mr. Hans Erik Svart
Head of Section
Ministry of Environment
Haraldsgade 53,
Danish Forest and Nature Agency
Copenhagen Ø, DK-2100 Denmark
Tel: +45 39 47 20 00
Fax: n/a
Email: hes**AT**sns.dk

Mr. Philip Thomas
Invasive Species Information Database Administrator
Hawaiian Ecosystems at Risk project (HEAR)
P.O. Box 1272
Puunene, HI 96784 USA
Tel: +1 808 891 1754
Fax: n/a
Email: pt**AT**hear.org

Dr. Donna Turgeon
Senior Marine Ecologist
NOAA's National Ocean Service
Bldg. SSMC4, room 8113
1305 East-West Highway
Silver Spring, MD 20910-3281 USA

Tel: 301-713-3020x178
Fax: 301-713-4353
Email: donna.turgeon**AT**noaa.gov

Dr. Heike Vibrans
Profesor-Investigador Titular
Colegio de Postgraduados en Ciencias Agricolas
km 36.5 carretera México-Texcoco libre
Montecillo, Estado de México 56230 Mexico

Tel: +52 (595) 9520200 Ext. 1335
Fax: +52 (595) 9520247
Email: heike**AT**colpos.mx
or heike_texcoco**AT**hotmail.com

Dr. Inger Ravnholt Weidema
Project Co-ordinator, Ph.D.
Danish Environmental Ministry
Haraldsgade 57
Copenhagen, 2100 Kbh Ø Denmark

Tel: +45 3947 2258
Fax: +45 3947 2765
Email: IRW**AT**sns.dk

Mr. Randy Westbrooks
Invasive Plant Coordinator
U.S. Geological Survey, BRD
233 Border Belt Dr. PO Box 279
Whiteville, NC 28472

Tel: 910-648-6762
Fax: 910-648-6763
Email: rgwestbrooks**AT**earthlink.net

Dr. Yan Xie (iSC)*
Director
Interdiscipline Research Promoting Centre
Institute of Zoology, Chinese Academy of Sciences
25 Beisihuan Xilu
Beijing, 100080 China

Tel: 8610 6264 7675
Fax: 8610 6264 7675
Email: xieyan**AT**public3.bta.net.cn

Dr. Sergio Zalba
Professor
Universidad Nacional del Sur
San Juan 670
Bahía Blanca
Buenos Aires, 8000 Argentina

Tel: 0054-291-4595100
Fax: 0054-291-4595130
Email: szalba**AT**criba.edu.ar

Dr. Silvia Ziller (iSC)*
Coordinator – Brazil Invasive Species Initiative
The Horus Institute for Environmental Conservation
and Development/The Nature Conservancy do Brasil
Rua Dr. Manoel Pedro, 495/906
Cabral, Curitiba, PR, 80035-030 Brazil

Tel: 55-41-336-8777
ext. 239 / 55-41-253-0886
Fax: 55-41-336-8777
Email: sziller**AT**onda.com.br
Url: www.institutohorus.org.br

* iSC = interim Steering Committee

Appendix H

Interim Steering Committee (iSC)

* Please note that email addresses have been modified to prevent their being read by automated spammers.

Dr. Malika Bounfour
Entomologist and Plant Health Specialist
Direction de la Protection des Vegetaux,
DPVCTRF, Ministère de l'Agriculture, BP. 1308
des Controles Techniques et de la Repression des Fraudes
Rabat 10000 Morocco

Tel: 212-37-299193 /
212-37-729098
Fax: n/a
Email:
mbounfour**AT**yahoo.com
(preferred)
mbounfour**AT**menara.ma

Dr. Hannu Saarenmaa
Deputy Director for Informatics
GBIF Secretariat
Universitetsparken 15
Copenhagen, 2100 Denmark

Tel: +45-35321479
Fax: +45-35321480
Email: hsaarenmaa**AT**gbif.org

Dr. Soetikno Slamet Sastroutomo
Senior Project Officer and Technical Secretary
CAB International and ASEANET
Glasshouse No. 2, Opposite Block G
MARDI Complex, P.O. Box 210
Serdang, Selangor, 43400 Malaysia

Tel: +60-3-8943-2921/3641
Fax: +60-3-8943-6400
Email: S.SOETIKNO**AT**cabi.org

Ms. Annie Simpson
Invasive Species Theme Coordinator
National Biological Information Infrastructure
US Geological Survey
12201 Sunrise Valley Drive, Mail Stop 302
Reston, VA 20192 USA

Tel: 703.648.4281
Fax: 703.648.4224
Email: asimpson**AT**usgs.gov

Dr. Yan Xie
Director
Interdiscipline Research Promoting Centre
Institute of Zoology, Chinese Academy of Sciences
25 Beisihuan Xilu
Beijing, 100080 China

Tel: 8610 6264 7675
Fax: 8610 6264 7675
Email: xieyan**AT**public3.bta.net.cn

Dr. Silvia Ziller
Coordinator – Brazil Invasive Species Initiative
The Horus Institute for Environmental Conservation
and Development/The Nature Conservancy do Brasil
Rua Dr. Manoel Pedro, 495/906
Cabral, Curitiba, PR, 80035-030 Brazil

Tel: 55-41-336-8777
ext. 239 / 55-41-253-0886
Fax: 55-41-336-8777
Email: sziller**AT**onda.com.br
Url: www.institutohorus.org.br

Appendix I

DRAFT

Technical Framework for a Global Invasive Species Information Network (GISIN)

Workshop on the Global Invasive Species Information Network
Baltimore, MD April 6-8- 2004

James F. Quinn, University of California, Davis, *jfquinn**AT**ucdavis.edu*

The Challenge

Invasive species represent one of the foremost challenges to the integrity of agriculture, natural ecosystems, and biodiversity in the 21st century. Invasive species cost human societies hundreds of billions of dollars per year in control costs and losses to agricultural production, human health, and ecosystem services, far exceeding the combined cost of natural disasters such as floods, wildfires, oil spills, and earthquakes. It is now accepted that non-native plants, predators, and diseases rival land conversion as a cause of extinction. The challenge is global. Increasing movement of people and biological products in global travel and trade render every landscape on earth vulnerable to new infestations. Freely available information on sources, identities, modes of transport, and successes and failures of past control efforts provide our best protection against the onslaught of new invaders. Achieving a shared language and building a scalable network for exchanging this information among hundreds of governments and thousands of data providers and users poses new challenges in both informatics and technical cooperation.

Principles

A successful network for sharing invasive species information among hundreds of diverse participants using several languages will need to be highly distributed and ultimately highly scalable. Organizing principles for success include:

- Some of the most important information is developed by people and institutions with minimal technical resources. Therefore, the minimum equipment, software, and computational expertise required for participation should be simple

- Public information should be freely available, including to those using only free, open source, or public domain software and tools. Proprietary and commercial services should be free to repackage governmental invasive species information and provide added value to users of public data. However, invasive species policy requires the widest possible public awareness. Unless the critical information needed to recognize and manage invasive species is freely available on public sites and discoverable through widely used search technologies (e.g., Google™), many land managers, farmers, and schools will not find the information they need.

- The network should adopt widely used technical standards whenever feasible. At present, this implies embracing World-Wide Web technologies, especially XML (Extensible Mark-up Language), RDF (Resource Description Framework), and related technologies emerging as the “semantic web”.

- Successful sharing of information requires agreement on the vocabularies that may be used to describe comparable objects or concepts in different information sources.

Consensus on mutually-useful controlled vocabularies (also referred to as “thesauri”, or “name authorities”) will be essential to developing interoperable information systems.

- Timely access to data is especially critical in countering newly appeared invasive species. Therefore, a successful network includes incentives for sharing data. These include increased professional recognition for developers of databases, metadata strategies that help assure that providers of data are properly credited, tools to make preparation of standardized data and metadata easier and more automatic. Electronic publishing offers opportunities to provide peer review and recognition of intellectual achievements beyond the traditional journal papers, and should be encouraged as a means to recognize and validate the efforts required to share invasive species information with the wider community.

A Network of Nodes

The simplest configuration of a hemispheric invasive species information network hub is as a nexus of connected “nodes”, each contributing comparable information derived from its domain of geographic, taxonomic, and organizational expertise. Interlocking projects developing under GISP, NABIN, IABIN, NBII, IUCN-ISSG, and many other partners have begun to establish a network of regional and national invasive species nodes in the Americas, and a few elsewhere, that provide one model for a broader network. Each node agrees to catalog a minimum set of simple but widely applicable data types, and to express them on a website in a format (XML-based) readily accessible to the other nodes. Standards for the minimum set are still evolving, but include content on experts, metadata on data holdings, catalogs of invasive species management projects, lists of organizations concerned with invasive species and their species of concern, and actual locations and dates where particular invasive species have been documented to occur (sightings and specimens). Other kinds of resources, for example bibliographies and fact sheets, have been added at some nodes.

Recommendations for principles and minimum capabilities for establishing nodes are given in Appendix I (in prep). However, and effective and scalable network for invasive species practitioners cannot be exclusive. Any machine with an always-online web server should be able to act as a node, and tools and standards should permit a reasonably accomplished system operators and database manager to operate a bare-bones node with limited additional training. The linking technology should be platform-independent whenever feasible, and the information posted should be discoverable through standard search engines as well as specialized portals. Prototypes have outlined the information and training needs, but the workshop participants recommend that GISIN (probably with partners, such as GISP and GBIF) sponsor the development of full specifications.

Interoperability – XML, RDF, and the Semantic Web

Most of the data resources currently maintained on-line by workshop participants and the invasive community at large were constructed using commercial software (notably relational database management systems and geographic information systems). Nevertheless, the workshop recommends that open-source and public standards, such as those under development by the World-Wide Web consortium, be promoted for posting, harvesting, and searching public invasive species data. While there are other attractive approaches, the workshop participants believe that “semantic web” technologies (specifically XML, RDF, SOAP, and related technologies) should and will be widely adopted as a framework for

sharing invasive species information (and probably for much wider applications in biodiversity informatics).

Specifically, a technical session concluded that it is feasible and desirable for the participating nodes to quickly implement a standardized XML-based format for expressing information on experts, dataset and project metadata, and some document types (e.g., species fact sheets). They recommend that a Dublin Core formulation be considered for the minimal metadata for databases and similar data resources. The approach to a standardized XML expression for species occurrence data (the “Darwin Core”) developed by the SEEK project and others in the museum community can be adapted for use with invasive species occurrences, and is being prototyped for that purpose by several pilot projects. Standardized “semantic web” expressions of other core data types identified in GISIN’s partner projects described above are less mature, but should be developed under the auspices of GISP, GBIF, IUCN, and/or other international coordinating bodies.

Adoption of a semantic web approach does not imply that sites should not collect and store information in proprietary formats. XML can be produced as a report from many kinds of software, and may serve more as a data sharing standard than as a native format for the foreseeable future.

Agreement on XML and related technologies is only a first step toward interoperability. Information managers need specifications for detailed structures (e.g., XML “schemas”), which specify variables, standards and vocabularies used to express them, and the relationships among them. These have not been standardized for most invasive species data types.

Metadata

Metadata serves several functions in distributed networks. Minimal metadata, as represented by the Dublin Core, aids users in finding appropriate information. More complete specifications, such as the Federal Geographic Data Committee (FGDC) Spatial Metadata Standard, also document the content, methodology, and suitability for particular uses, but can be onerous to complete. Future formulations may provide for machine interpretation of data with less human interpretation than envisioned in the FGDC approach. Since rapid discovery of information is essential in many invasive species applications, GISIN should encourage universal use of at least minimal metadata to “tag” public invasive species data. Several widely used formations (Global Information Locator Service, Dublin Core, Ecological Metadata Language, Federal Geographic Data Committee Spatial Metadata Standard section 1, ISO 19115 metadata standard) express similar information content, and with care, can be expressed in XML and used interoperably. An important decision for North American data managers is the relative emphasis on FGDC vs. Dublin Core metadata. Several profiles of the FGDC system are widely used within government. Dublin Core is becoming more prevalent among other important data providers and users, including museums, libraries, and universities.

The choice of metadata tools depends in part on use. Simple tools (Dublin Core, EML, ISO 19115) work well for data discovery, but are too limited to provide the full documentation needed to use data for research or analysis (as envisioned by the FGDC Spatial Metadata Standard and its Biological Profile). Nevertheless, the core information needed for data discovery can be made simultaneously compliant with the Dublin Core, EML, and the identity portion of FGDC, and can be expressed in XML and/or RDF. We recommend that

GISIN and related efforts develop metadata content standards and tools that satisfy the intersection of these approaches (at the content level).

Acceptance and use of particular metadata formulations among the scattered and diverse contributors of invasive species data undoubtedly will depend upon the availability of straightforward metadata entry tools. Candidates for creating both Dublin Core and FGDC records are available, and could be specifically configured for invasive species applications (i.e., with pulldowns for application-specific information such as species names and vectors and pathways.) It would be very useful to develop de novo tools to create RDF tags to help tag and search web pages, scanned documents, images, and similar static information types.

As the network matures, metadata should probably be developed in several “tiers”, with minimal metadata for small and casual datasets (the frogs of Walden Puddle) nested under full metadata for important and ongoing data collection programs (e.g., the Non-Indigenous Aquatic Species system).

Any successful metadata tagging framework for the North American Hub should be accessible to general-purpose search tools, such as Google, as well as to specific engines and services maintained by GISIN partner websites themselves.

Content

Previous workshops have identified a series of information types that frequently occur in invasive species applications, and have recommended that they be adopted as the initial elements of a distributed invasive species information system. Products in development include web tools for data entry, databases for information on species, organizations, projects, experts, and bibliographic resources, shared among more than a dozen countries and multiple sites within some countries. The approach has been to specify a relatively small number of core fields or elements expected to be found in all nodes, but the ask that they be populated with entries chosen from standardized sources. Interoperability should arise from shared semantics (language). The list of core data types varies slightly from initiative to initiative (IABIN, NBII, GISP, IUCN-ISSG, North American Aquatic Invasive Species Program, NISbase, etc).

Some important data types held by GISIN data providers are summarized in Table 1.

In addition, the products include information services, such as interactive mapping, modeling, automated change detection, and early warning systems, which extract targeted information to “turn data into information.” Standards bodies and commercial vendors (e.g., IBM, Microsoft, Sun) are putting considerable resources into developing technologies to implement such services on-line as modular “web services”. One standard, SOAP (formerly Simple Object Access Protocol), is already widely implemented, and should probably provide the basis for initial implementation of web services within the GISIN network. The SOAP specification can be looked upon as metadata for a automated computational service on another machine, and can share structure and vocabularies with more familiar metadata for datasets and bibliographic resources.

Using such standardized approaches (especially with wide implementation in the commercial software development community) we expect that our ability to implement specialized, value-added applications (for example, early warning tools individually

configured for particular geographies, taxonomies, and risk profiles) will increase dramatically. An early application might be an ITIS (or GBIF) SOAP-based service to identify and return codes, authorities, and higher taxa for Latin binomials submitted by outside servers.

Data entry tools, document type definitions, and tools for creating, harvesting, and searching resulting XML are being tested for a subset, with the intention of “tagging” the data with consistent geographic, taxonomic, thematic (i.e., library card catalog subjects), and organizational attributes. The long term goal is to standardize the “tags” where a consensus can be developed, and to declare the source and authority for a “tag” where there are multiple usages. In practice, there has been relatively little standardization beyond that for species names. Table 2, adapted from a meeting in Davis, CA in 2002, gives data types for which workshop participants are developing shared XML expressions. The subsequent columns give candidate controlled vocabularies (or “thesauri”, or “naming authorities”, depending upon application).

Beyond taxonomy, there is little consistency in current usages, nor consensus on whether any single candidate is an acceptable “preferred” usage, and the workshop participants view this lack of consensus as the largest obstacle in information sharing. Working groups self-organized to develop recommendations on each vocabulary type, and encourages GBIF, GISP and other umbrella organizations to join in, add to, and endorse the effort.

Geolocation and Taxonomy

Geolocators, which include place names and a variety of GIS polygons that may be used to record the geographical domain of an information object, may be sufficiently standardized, at least in North American, that one of a few authorities might make a standard for data exchange (whatever usage is found in the raw data.)

Similarly, the ITIS system for indexing species names could, with relatively few enhancements, represent a tagging convention for taxonomic references. To fully meet the taxonomic reference needs of invasive species biologists and managers, ITIS would have to accelerate assignments of species codes for newly discovered invaders, provide more thorough cataloging of authorities, and have more provisions for referencing provisional identifications. These augmentations seem feasible within the existing program.

To support the highly distributed information systems incorporating GISIN and its collaborators, it is also important that taxonomic terms and codes in ITIS reflect the meaning of the same terms in invasive species databases. This is a challenge, as preferred taxonomic uses change over time, and these changes may trigger changes in how the same “taxonomic concept” is coded, rendering links in associated datasets obsolete. A robust system will also need to guarantee time-invariant usages, codes, and Uniform Resource Identifiers (URIs) (web addresses associated with the name, code, and authorities).

Better taxonomic services for non-technical users will also need to be developed over time. Most users, including the critical “eyes and ears” on invasive species that are provided by volunteer groups, schools, and other amateurs, use popular field guides rather than authoritative references. To interpret data collected by these users, ITIS needs to be better cross-referenced to the identification materials actually used in the field.

Next Steps

Invasive species information is sufficiently critical that numerous organizations, including multiple levels of government, are addressing the standards vacuum. It is important to the community that these efforts be consolidated, maybe under GISP, to provide more timely guidance. At the same time, the workshop sees multiple opportunities to voluntarily standardize – efforts that may help drive ultimate development of scalable standards and technologies.

It is important that the perfect not become the enemy of the useful. There are many gaps in information availability, standards, and technology between present efforts and a comprehensive distributed invasive species information system, so progress will necessarily be incremental. The workgroup perceives an order of need for coordinating activities of hub participants.

1 Resource discovery
2 Data exchange
3 Data services

that reflects the order of technological challenges. Tools to standardize the metadata and index data so that shared searches can discover other Hub participants' data will be a significant accomplishment for the first years or two of the initiative.

New Content Areas

Current efforts within GISIN participants have concentrated on cataloging data resources, projects, programs, species occurrences, and species identification information, as described earlier. A number of other kinds of resources (Table 1), are essential to researching and managing invasions, and several appear ripe for inclusion into GISIN activities. These include:

- Archives of legacy and gray literature, preferably marked up to increase accessibility. An example of how this might be done is provided by the American Museum of Natural History's museum literature database.

- Descriptions and drawings of invasive species. Of particular value would be an archive of original taxonomic descriptions of the several thousand species being actively managed or regulated in the region, since regulators and providers of taxonomic services need tools to make authoritative identifications before data sharing or policy decisions can be made with any confidence. It may require memoranda of understanding and/or royalty arrangements with publishers to provide such services.

- Image libraries. A technical issue to be resolved is how to mark up diagnostic images with taxonomic, source, and authority information. One attractive possibility is to embed header metadata info PNG, JPEG, TIFF and related image types, perhaps following the IPTC standard.

Network Architecture
Since all members of GISIN are parts of larger networks, the architecture connecting Hub sites will necessarily be heterogeneous, and will need to follow the developments of larger initiatives such as the National Biological Information Infrastructure in the U.S., the North American Commission on Environmental Cooperation (e.g. NABIN) in the trilateral region, and global efforts such as the Global Biological Information Facility (GBIF). Nevertheless, networking GISIN sites still requires some collaboration on network components.

Most important is a centralized access point, probably representing both a centralized index database (UDDI registry) addressing a number of distributed metadata, content databases and web services. The index may point to a number of data aggregators (e.g., regional data nodes, such as country nodes under IABIN), but should be capable of providing discovery services for lowest-common-denominator resources, such as metatags in HTML documents.

With current technology, a fully distributed system is likely to suffer severe performance limitations, at least in part simply because servers down or bandwidth limitation can prevent successful searches over the whole network at any one time. Addressing these performance issues probably requires some level of caching and off-site replication, although authoritative versions of most resources will still be held at the data provider's site.

Technical Challenges

Languages
One of the most immediate challenges is how to construct GISIN to integrate data and services for users speaking multiple official languages (much less a multitude of languages used by immigrants and indigenous peoples).

Suggested approaches include:

- Examining the applicability of off-the-shelf multilingual tools, such as Systran's software
- Adopting established multilingual controlled vocabularies, such as GEMET or those developed by IUCN or UNEP
- Developing look-up tables and schemas for core multilingual content issues, such as colloquial species names

There are important trade-offs in using established tools and vocabularies for multilingual applications. The existing software and files can be unwieldy, and may not correspond well to usages within any given language community. Whatever their virtues in automating translation services and multilingual queries, they will not work unless they provide ease of use in individual language settings.

Intellectual property
Any federation of databases that reference published literature must address the intellectual property rights of information providers. Even where information is completely in the public domain, it is important to identify and provide professional credit to the developers of each information resource.

The issue of intellectual property rights is vast, and was not systematically addressed by the workshop. However, immediate challenges to establishment of GISIN include how to access or license some important material copyrighted by third parties (such as species descriptions

from the technical journal literature and species identification resources from field guide publishers. Perhaps a more intractable long term issue is how to address the differences in the application of copyrights to raw data among participating countries (e.g., U.S. law does not currently protect published raw tabular data against reproduction, whereas Canada and Mexico provide substantial protections.) Property rights for databases will become even more complex as additional participants with conflicting copyright approaches, including the European Union and China, connect to the North American initiatives.

In the long run, effective cooperation on invasive species information systems probably requires that major participants adopt and expanded concept of the public domain, since the major problems of propagation and control of invasives can only be achieved by a commonality of purpose among scientists and managers working under a variety of cultures and laws. GBIF may provide leadership and working examples under the call for a "Biodiversity Commons" and the CBD charge to repatriate information to all contributing countries.

Effective solutions will also involve incentives for participation by individual scientists, land managers, librarians, curators, and interested citizens. An invasive species network is only as effective as the willingness of those who produce the information to participate, and for most of those, the major incentives are not financial. Some will participate because it is mandated by their organizations, or because it aids them in their immediate jobs. Many others may be more attracted by professional and public recognition, as in traditional journal publishing. Any well designed network must freely acknowledge its contributors. As it develops, it should probably also incorporate services, including peer-review, where appropriate, to validate and certify important contributions, and begin to document use and value of providers intellectual contributions to the international user community.

A Global Outlook

GISIN is one part of a collaborative network of governmental initiatives to address invasive species threats in an international arena. It was inspired by, and incorporates many good ideas from international efforts to share biodiversity information dating to the Convention on Biodiversity and beyond. While invasives are a high priority subset of general biodiversity questions because of their economic importance and roles as causal agents of landscape degradation and extinction, the protocols and architecture of an invasive species network addressing several thousand species should be broadly applicable to a biodiversity information network addressing several million.

Important and closely related efforts include the IABIN invasive species pilot project, which endeavors to catalog invasive species expertise, projects, and information resources in the Americas, NABIN, which has taken a lead on coordinating occurrence information from museums and using it to model the geographic spread of key species, GISP, whose conferences and working papers have raised awareness and sparked information sharing among a worldwide partnership of agencies, museums, NGOs, and professional organizations, and a variety of individual and bilateral information sharing exercises in the Americas, Europe, southern Africa, East Asia, and the Pacific. The recommendations of this workshop endeavor to identify key core elements of the global activity, and to highlight them for early adoption in countries currently represented in GISIN.

Table 1. Invasive Species -- Widely held data types

Resources:
- Expert Directories
  - Individual
  - Organization
  - Project
- Species Information

Descriptions

Fact Sheets
- Best Practices for Management
- Specimens/Observations Datasets
  - Vouchered Specimens
  - Observations
  - Photos
  - Trace records: tracks, samples, etc.
  - Genomic sequence data
- Document collections
  - [Physical Formats: Paper; Images PDF, etc.; E-text]

References/Citations

Partial List of Types of Publications (Relevant to invasives):
- Alerts
- Checklists
- "Fact Sheets"
- Field Guides
- Keys
- Leaflets
- Maps
- Methods Papers
- Posters
- Surveys/Inventories
- Taxon Treatments(descriptions/revisions)
- Manuscript collections
- Field notes
- Diaries
- Lab notes

Table 2 – Invasive species data types, and candidate naming authorities (or controlled vocabularies, or thesauri) for identifying them. From North American Invasive Species Hub meeting, Davis, California, 2002

Data Type

Organization/Expert
URI
Dataset
Project catalog
Observation/specimen
Image
Document/Factsheet
ID materials
Bibliography
Educational materials

Subject

LCSH
UMLS (for model)

CSA/NBII

CERES
OECD
UNEP Infoterra
GEMET

ENVOC

IS-specific types

vectors
risk categories
control methods

Taxon

ITIS

GBIF
Sp2000
WHOI
FNA

Location

Getty
GNIS
FIPS
ISO stds
Alexandria
Counties
Hydrological Units

Habitat, Vegetation, Ecoregion

Bailey
Kuchler
National Vegetation

Organization Name

LOC (corporate names)
ISI, etc.

Appendix J

NISbase (Non-Indigenous Species Database Portal): Information for Developers

*Brian P. Steves, Smithsonian Environmental Research Center, stevesb**AT**si.edu*

Introduction:

During the past decade dozens of non-indigenous species (NIS) database workshops have been held around the world. At the end of those meetings the general consensus is almost always the same; we need to develop better ways to share our data. If you've attended one of these workshops recently, it is likely you have heard terms like "XML" and "distributed databases" touted as the answer to our prayers. Well, NIS*base* is a relatively simple lightweight XML based distributed database system designed for NIS information by the Smithsonian Environmental Research Center and the USGS.

To test NIS*base* yourself, the current version of the portal website can be found online at http://invasions.si.edu/nemesis/merge/SpSearch.jsp.

How NIS*base* works:

The major concepts of NIS*base* were inspired by other distributed database systems being developed, particularly DiGIR (Distributed Generic Information Retrieval). DiGIR is currently being developed to share museum specimen collections by programs such as the Species Analyst and the MaNIS (Mammal Networked Information System). A DiGIR implementation of NIS*base* is currently under consideration and promises to add many improvements to the current system.

DiGIR http://digir.net
Species Analyst
http://speciesanalyst.net/index.html
MaNIS http://elib.cs.berkeley.edu/manis/

NIS*base*, like DiGIR, functions as a distributed system of portals and data providers (**Figure 1**). The portal's web interface allows the user to search records on more than one data provider at a time. Think of the analogy of searching one of the many travel planning sites (a.k.a. portals) for the best airfare from multiple airlines (a.k.a. data providers), this method is much more efficient than searching each airline's website individually. With NIS*base*, a user would search for NIS with the portal (**Figure 2**) and retrieve information from multiple NIS databases simultaneously. Search results are returned as a single table (**Figure 3**) with links to further information from the original data providers (**Figure 4**).

Figure 1. Basic NIS*base* schematic.

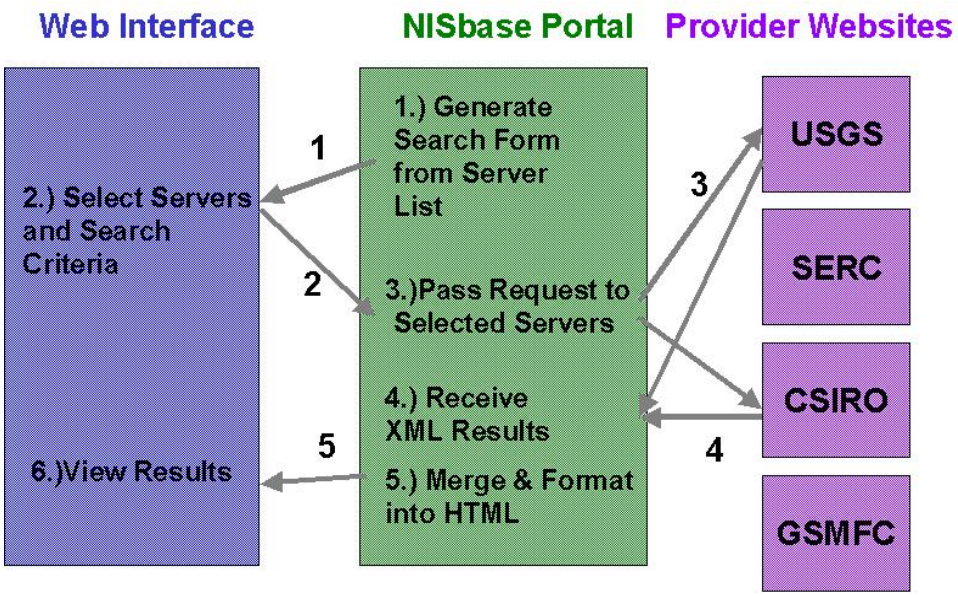

Figure 2. The NIS*base* Portal Search Form.

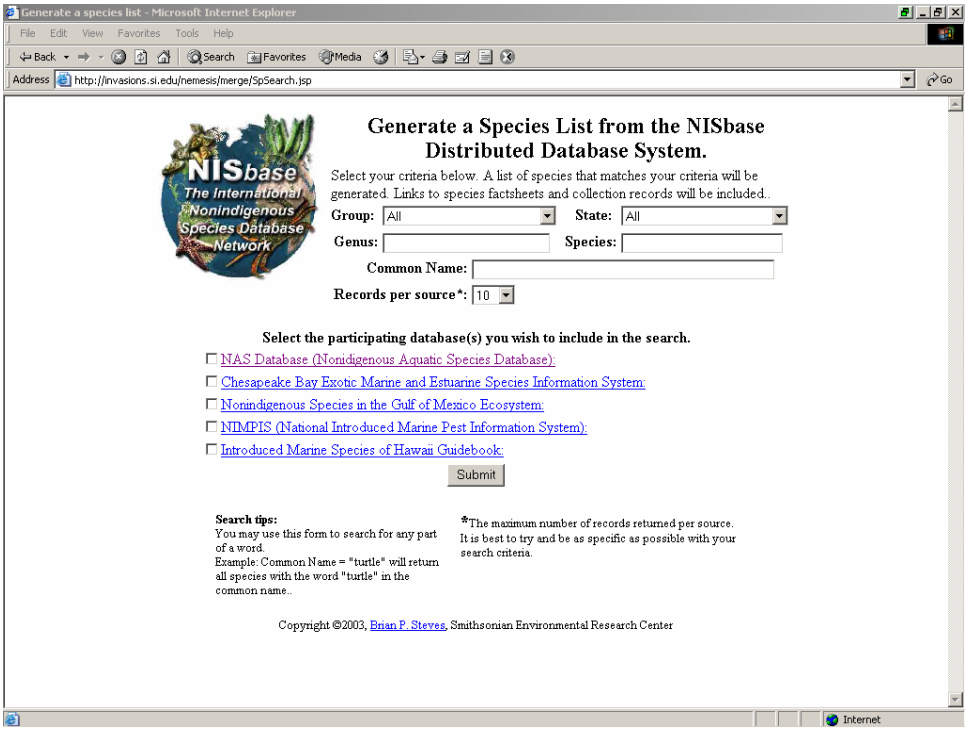

Figure 3. NIS*base* merged results table.

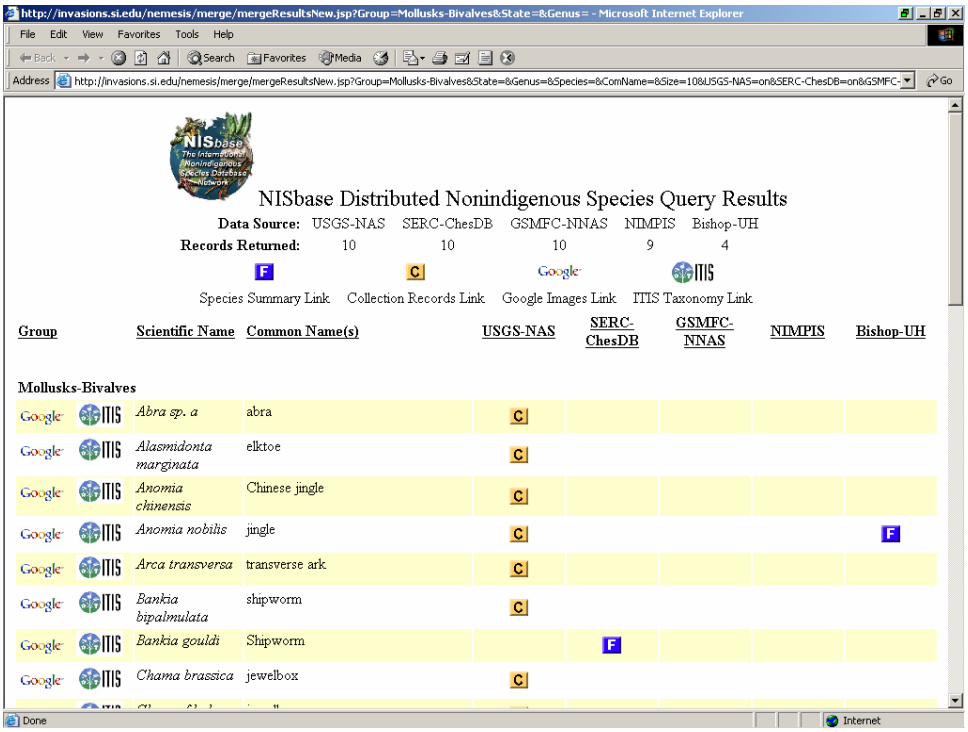

Figure 4. A species summary web page example.

The current implementation of NIS*base* takes advantage of the way many websites display their NIS information, one species at a time and in the form of species summaries or fact sheets (see **Figure 4**). Furthermore, websites that have search capabilities for their NIS information allow the user to search other simple fields such as common name, species name and taxonomic group.

Some online NIS databases contain more searchable fields than NIS*base.* To accommodate these databases we are developing an advanced version of NIS*base* to allow the user to search on these advanced fields such as invasion pathway, habitat invaded, and date of first observation.

*NIS*base *Provider Information*

If your website can dynamically create an html table from your NIS database, you should be able to create the XML results needed to participate in NIS*base*. If you're unfamiliar with XML, a visit to the following website can be helpful. http://www.w3schools.com/xml.

Provider Requirements:

1.) NIS information
2.) A web server with the ability to dynamically create html and xml through some scripting language (php, asp, perl, jsp, coldfusion, etc..)
3.) A database that the dynamic Web pages can draw data from (ms-sql, access, mysql, oracle, postgress, etc.)
4.) Ability to query database with the current NIS*base* search criteria
    a. Taxonomic Group
    b. Genus
    c. Species
    d. Common Name
5.) Ability to limit the returned result set based on the record limit parameter.
6.) Ability to return query results in XML following the NIS*base* format.
    -See http://invasions.si.edu/nemesis/SpQueryResults.dtd
7.) A static IP address on the server
8.) Creation of metadata for your database provider
9.) Acceptance by the NIS*base* charter members
    a. Verification that other provider requirements (1-8) have been successfully meet
    b. Acceptable of server response time
    c. Acceptable content

Once a query is submitted to the NIS*base* portal all selected database providers will be sent an http request of the following generic format.

http://providerIPaddress/../providerpage?Parameter1=X&PArameter2=Y

The current parameters passed to the provider by the portal are…

1.) ComName - "Common Name" this should be treated as though it is surrounded by wildcards when querying your database.
2.) Genus – "Genus"
3.) Species – "Species"
4.) State – "State" This is optional. If a state parameter is sent and you don't have State specific information, return a null result set to the portal. We will probably implement a "Country" parameter in a similar fashion.
5.) Group – "Taxonomic Group" This is a predetermined list of taxonomic groups hosted on the NIS*base* server. (It is currently under revision.)
6.) "Record set limit" – To prevent searches that return too many records to be reasonably processed, this establishes the maximum number of records each server may return.

The following example is a search request to the USGS-NAS database provider for all fish with a common name containing the word “oscar” http://nas.er.usgs.gov/queries/SpResultsXML.asp?ComName=oscar&Genus=&Species=&State=&Group=&Size=10

If other providers were selected they would receive similar requests from the portal. In this example, the database provider page “SpResultsXML.asp” is required to interpret the search parameters and return valid XML results in the NIS*base* format. The following is the XML returned from the USGS-NAS database provider for the previously mentioned search.

```
?xml version="1.0" encoding="iso-8859-1" ?
!DOCTYPE X SYSTEM "http://invasions.si.edu/nemesis/SpQueryResults.dtd"
- X
  - TAXON
      Taxa_SciName Astronotus ocellatus /Taxa_SciName
      Taxa_CommonName oscar /Taxa_CommonName
      Taxa_ITIS 169772 /Taxa_ITIS
      Taxa_Group Fishes /Taxa_Group
    - Record
        Record_Source USGS-NAS /Record_Source
        Record_ID 436 /Record_ID
        Factsheet_URL
            http://nas.er.usgs.gov/queries/SpFactSheet.asp?speciesID=436
            /Factsheet_URL
        Factsheet_Name USGS-NAS FactSheet /Factsheet_Name
        Collection_URL
            http://nas.er.usgs.gov/queries/spCollections.asp?SpeciesID=436
            /Collection_URL
        Collection_Name USGS-NAS Collection Info /Collection_Name
      /Record
  /TAXON
/X
```

Provider Metadata

A provider is added to the NIS*base* portal by adding some basic metadata to an XML file called InvServers.xml. The portal search page accesses this information so that users can select the databases they wish to search and to ensure that the data is sent to the correct URLs. The current InvServers.xml file can be viewed at the following URL.

http://invasions.si.edu/nemesis/merge/InvServers.xml

Here is the current listing for the USGS-NAS database.

```
- DATA_SOURCE
    NAME USGS-NAS /NAME
    NAME_LONG NAS Database (Nonidigenous Aquatic Species Database) /NAME_LONG
    URL http://nas.er.usgs.gov/queries/SpResultsXML.asp /URL
    HOME http://nas.er.usgs.gov/ /HOME
    OWNER United States Geological Service /OWNER
    LOGO http://nas.er.usgs.gov/images/c_usgsid.gif /LOGO
    ECOSYSTEM Freshwater /ECOSYSTEM
    SCOPE Animals /SCOPE
    SPATIAL All USA /SPATIAL
    DATATYPES Fact sheets; Collection Records; Maps; Images /DATATYPES
/DATA_SOURCE
```

1.) NAME – a short name for the database less than 12 characters long
2.) NAME_LONG – the full name of the database
3.) URL – the base url for the provider XML script page
4.) HOME – the home page for the database or project
5.) OWNER – the name of the organization that owns the database
6.) LOGO – a URL to a logo for the owner's program
7.) ECOSYSTEM – keyword(s) describing the ecosystem that the database covers
8.) SCOPE – keywords(s) describing the general scope of the database (animals, plants, weeds, fish, etc…)
9.) SPATIAL – the spatial scope of the database (a region, country, etc.)
10.) DATATYPES – the types of information provided by the database.

Basic Provider Implementation

1.) Make species summaries and/or collections data accessible on the web as static files (static html, pdf files, etc.).
2.) Create an NIS database that contains only the information needed to search and return the NIS*base* required XML including the URLs to the species summaries and collection web pages.
3.) Write a basic script that retrieves the search parameters from the portal, queries the database, and returns XML in the NIS*base* structure.

Advanced Provider Implementation

1.) Species summaries and/or collections data are dynamically generated for the web.
2.) Database contains many tables but a query can be written to access the information needed to search and return the NIS*base* required XML.
3.) A custom script that retrieves the search parameters, queries the database, and returns the XML.

*NIS*base *Portal Information*

Portal Requirements:

1.) Apache Tomcat or other servlet server
2.) NISbase.war

The portal is responsible for creating the search page based on a list of available data providers. Searches from the portal are passed to each provider and when XML

results are returned the portal merges the results from the providers and formats it into one HTML table of results. The portal is currently developed using JSP but other scripting languages may also be used.

Portal Installation:

1.) Install Apache Tomcat 4.X (java installation may be required)
2.) Place NISbase.war in the webapps directory of the Tomcat installation
3.) Point a browser to http://yourserver:8080/NISbase/

Portal Mirrors:
We encourage others to install the NIS*base* portal on their servers as it potentially lessens the load on the original portal server. We will make available a list of all known mirrored portals to allow users to find an alternative selection.

Thematic Portals:
We also encourage the development of thematic NIS*base* portals. An example thematic portal currently under consideration is NIS*base*-Pacific which will bring together NIS databases from Hawaii and other pacific islands. Other potential NIS*base* thematic portals might include NIS*base*-Weeds, NIS*base*-Fish, NIS*base*-Asia.

Thematic portals will likely have slightly different looks, sets of data providers, and modified search terms.

Appendix K

GISIN draft Framework Document for the Experts Meeting on Implementation of a Global Invasive Species Information Network (GISIN)

Prepared by: Annie Simpson for discussion during the Long-term Financial Viability Breakout Group

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1.0 BACKGROUND

The Global Invasive Species Information Network (GISIN) has been the subject of discussions and meetings over the last five years, mostly evolving as an idea of the Informatics Working Group of the Global Invasive Species Programme (GISP). Information management of invasive species and the idea to standardize or cross-search invasive alien species (IAS) databases has been a subject of discussion of several regional GISP meetings since 2000, and a summary can be found in the white paper prepared as a support document for this meeting.

The need for a Global Invasive Species Information Network was also described by Ricciardi et. al. in the March 2000 *BioScience* article, “Toward a Global Information System for Invasive Species.” These authors also state that an essential first step in forming the GISIN is identifying all current invasive species databases and all taxa and regions that require databases. Our preliminary efforts to identify these databases can be downloaded from the invasives community at http://my.nbii.gov.

Having participated in numerous regional meetings discussing how t go about creating a global network, a small group of information managers wrote a proposal for the US Department of State to hold this workshop in order to work out the details of how to implement a GISIN.

This document is a starting point for discussion of how to formalize the network and assure its long-term financial and structural viability.

1.1 Mission and Vision

During regional meetings of the GISP, a need for better information was stated by all groups. Our mission:

- To provide a platform for sharing invasive species information at a global level, via the internet and other digital means.
- To offer a central place for the reporting and tracking of new aliens species sightings via email listserv.
- To develop and share information management tools to better identify, map, and predict the spread of invasive species at regional and global levels.
- To build the capacity of network members in the development of invasive species information tools.

In fact, the GISIN as a network will have multiple facets. On one face, it will be an Internet-based resource with common infrastructures and content held together by commonly-agreed-on standards. A second facet is an institutional and human network or forum where the countries from around the globe can come together to facilitate developing and sharing of invasive species information tools. This sharing process includes identifying data requirements, facilitating data identification and access, and capacity building as a prerequisite to accomplish other goals.

The vision of the GISIN's infrastructure is that it will be an open, self-sustaining network where users can find accurate relevant invasive species information in a timely manner. The heart of the development of the GISIN is the building of information content covering invasive species information from around the globe and from all taxonomic groups and all realms. The most effective way to add content is through the connection of selected types of easily-shared and commonly-collected invasive species information.

2.0 GISIN STRUCTURE

Since GISIN is just beginning its implementation, it is important to provide a common baseline of understanding of where it is today and then to present the requirements that would form the basis of a Work Plan for the next 24 months.

Several terms are used interchangeably by our group, and any lack of agreement on terminology will not inhibit the work being accomplished. Invasive alien species, or IAS, or invasive species (or several other commonly-used descriptors), are all terms used to describe non-native species (or viable parts of species) to an ecosystem whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

2.1 Membership

The GISIN is an open forum with voluntary membership available to all who are interested. The GISIN is implementation focused. It is intended that the GISIN have broad participation from all sectors of society, including government, academia, non-governmental organizations, and the private sector. The main functions of the membership will be to:

- Communicate with other members on individual successes in database management
- Provide funding and manpower for the implementation of GISIN projects and progress

Meet once every two years and more frequently if needed

2.2 Governance

At this meeting, it is suggested that an Interim Executive Committee be established to carry through the requirements of governance to the first GISIN membership meeting. The EC's duties will be as follows:

- Create draft policies and procedures for GISIN governance.
- Support fund-raising activities at regional levels.
- Establish national consultation mechanisms as appropriate to stimulate national and subnational level involvement in GISIN activities.
- Represent their organizations' perspectives on technical issues.
- Seek funding opportunities for the development of invasive species information and GISIN.
- Identify new project ideas and priorities for their organizations.
- Remain informed of GISIN activities within their countries and act as a clearinghouse for such information.
- Represent GISIN interests in other forums, as appropriate.
- Act as a primary communications link for the network.

2.3 Executive Committee (EC)

The exact size of the GISIN EC will need to be determined, but for practical purposes, it is suggested that it not exceed 12 members. Also, the policies and procedures for operation of the EC and any other GISIN bodies need to be established.

The EC is policy focused. It has the authority to make decision and take action on behalf of the GISIN. The main functions of the EC will be to:

- Provide general orientation and recommendations for GISIN.
- Provide oversight and assessment of GISIN projects and progress.
- Meet once a year and more frequently if needed.
- Establish procedures for conducting the operational business of GISIN

Membership on the Executive Committee should be based on the following characteristics:

- Geographical representation
- Inclusion of non-governmental representation
- Election of members based on interest and commitment
- A four-year term, staggered on a rotational basis

2.4 Network Hub

In order for the GISIN to operate effectively, it must have a support staff dedicated to the development of the Network. The staff will form the Hub or Secretariat for the GISIN, which can be located at any institution and can be relocated as required. It is not intended to become a bureaucracy or to create an edifice. It should be headed by an Executive Secretary. The estimated initial size of the Hub should initially be three people. The staff should be multi-lingual.

The functions of the Hub include:

- Support for the organization, Executive Committee, and Technical Working Groups
- Promote cooperation among the network's partners (e.g., meetings, workshops, newsletters)
- Facilitate understanding of and commitment to the network's goals (e.g., issues being addressed, users to be served)
- Facilitate implementation of strategic plans agreed to by the Executive Committee (e.g., through formation of multi-partner teams)

- Facilitate access to data (e.g., through custodianship, data access agreements, Memoranda of Understanding, metadata, and standards)
- Facilitate the development of the network (e.g., identify areas for restructuring or investment, seek support)
- Market the network's products and services
- Coordinate support group activities
- Organize meetings and workshops for the network's partners
- Expedite network projects
- Provide editorial and office support for preparation of key documents (e.g., strategic plans, project proposals, marketing literature)
- Brief the network's partners on new opportunities, plans and progress (e.g., newsletters, e-mail)
- Handle inquiries about the network's activities, referring to individual partners as appropriate
- Maintain copies of the network's products and services for distribution to users
- Manage data on the status and availability of the network's capacity
- Manage central information services, including WWW site which may be located at a site with better Internet access than the Hub itself.

2.5 Technical Working Groups

In order to accomplish the technical work of the GISIN, Technical Working Groups (TWG) will be established as needed and for specific tasks and of specific duration. Any GISIN member can propose a TWG to the Executive Committee which will have the authority to recognize it and ask the Hub to assist in supporting its formation. The Chair will be selected by the Executive Committee based on technical competence and need not be associated with a GISIN member organization. In this way, broad expert participation can be encouraged. Similarly, the composition of the TWG will also be at the discretion of the Executive Committee. It is expected that some TWG will have money for their operations. The Executive Committee will oversee the management of such funds.

2.6 External Relationships and Partnerships

From its earliest formulation, the GISIN was to build upon such initiatives as the Global Invasive Species Programme (GISP), the Global Biodiversity Information Facility (GBIF), and the Invasive Species Specialist Group (ISSG) of the Species Survival Commission (SSC) of the World Conservation Union (IUCN).

Through close cooperation with ongoing GISP activities and endorsement by the Convention on Biological Diversity, the GISIN has been discussed as a model for a global implementation of uniform standards, formats and protocols for invasive species information management, as put forth by the informal experts meeting held at CHM headquarters in February 2002, and described in the document UNEP/CBD/COP/6/INF/18 that can be found online at http://www.biodiv.org/doc/meetings/cop/cop-06/information/cop-06-inf-18-en.pdf

The GBIF utilizes structures and protocols (XML schema and DiGIR) that may be useful for the accumulation of invasive species records in natural history collections, especially if there are notes concerning the status of a non-native species.

The ISSG has, since its inception, pioneered the collection and dissemination of invasive species information at a global level, with special emphasis on developing and island states.

Because it is a non-governmental organization, it exhibits a relatively non-partisan status that is important for the GISIN.

Possible affiliations for the GISIN that would be beneficial to pursue include the following:

- Initiatives that help create the GISIN infrastructure (national, regional, international)
- Initiatives that provide relevant content (national, regional, and global invasive species databases)
- Models and initiatives to assist with the specific issues that arise during the development of the network (GBIF, ISSG, GISP)

Specific criteria to evaluate their likely value and commitment to cooperation include their ability to:

- Advance GISIN objectives
- Advance cooperator objectives
- Provide open access to information
- Allow custodianship to remain with the owner of the data resource
- Provide metadata in the public domain

OBJECTIVES: Promote the GISIN as a visible initiative for Biodiversity Information Sharing on the Web. Develop a Plan for Partnerships.
ACTIVITIES: In terms of general visibility of the ongoing work efforts of the GISIN, there are two tangible products that could be developed. First, the GISIN community discussion, initially funded by the National Biological Information Infrastructure in conjunction with the April Implementation Meeting, will continue to be developed and promoted among the global invasives community. Second, publicly accessible portal with GISIN information will also be developed by the NBII at http://www.invasivespecies.net and maintained in the short term. It is the intent of the GISIN to internationalize and distribute its Web presence as much as possible. Each organization that wishes to participate will be linked to the site and can contribute information. It is expected that eventually the Hub will take over the implementation of the GISIN Web site.

3.0 GISIN ACTIVITIES

3.1 Technical Configuration and Standards Development

GISIN will be a managed network. It will have a distributed Internet-based architecture with a "hub" both in the institutional coordination sense and in terms of network services. For the former, this means a dedicated staff to support the technical standards development process that must strive to establish top-down goals and guidelines. It also means that there will be a GISIN Hub node on the network that will support the efforts of the other independent nodes. The Hub node could have such responsibilities as developing and maintaining or coordinating the development of directories of people, programs, and biodiversity information resources.

Initially, the Hub will coordinate and support the management of communications like list serves and the GISIN Home Page, although these may alternatively be developed or hosted by any GISIN participant. Working in conjunction with GISIN members, the Hub will also facilitate obtaining additional resources or network capabilities to meet the defined needs. The Hub in a managed network is a facilitator, not controller, of the network. It serves the collective interest that includes the stimulation of bilateral and multilateral efforts of its network members. The details of the architecture of the GISIN network need to be developed in the context of this

managed network model. The other input into the technical configuration of GISIN has to do with building pilot projects from the bottom up.

OBJECTIVES
- Establish a GISIN architectural model, reiterate GISIN standards, and set up a configuration management program.
- Complete and demonstrate a user-friendly GISIN front-end that can be used to locate, manage, and use global invasive species information.

ACTIVITIES
Because the GISIN will be a decentralized, managed network, it is important to lay out some top down guiding concepts so that the bottoms up decentralized contributions can be most effectively coordinated. An overall architectural model should be specifically defined and documented.
Within the context of the architectural model, an assessment should be made of the options for types and specific standards guidance that would be helpful to the organizations wanting to connect with the GISIN. Metadata is always an initial key standard in the development of information networks. There are already many metadata initiatives in process around the globe. We should look to the example of other organizations such as GBIF, IABIN, CHM and others for the development of the architectural model. Once the basic technical configuration is established, there should be a focus on developing a user friendly front-end interface to the GISIN network.

3.2 Capacity Building and Training
There are significant differences in infrastructure capacity among the GISIN parties. Internet connectivity is a significant challenge in many regions. A Capacity Building Working Group should define minimal system requirements for effective participation in GISIN.
As a prelude to our April meeting, a survey was made among participants to determine the status of their information needs. Preliminary results confirmed the wide range of experience and technical expertise of GISIN participants. Based on the survey results, a Training Program should be developed to include such things as:
- Train trainers at a regional level to multiply support in the area
- Promote adapting to new technologies
- Emphasize those institutions and persons which can facilitate continuity

Specific training topics still need to be developed. Topics should be oriented to both users and data providers. Once the training is implemented it is important to have a monitoring system to evaluate success.

OBJECTIVES
Establish a program of training and capacity building for GISIN members. Develop an assessment of the changing invasive species information management capacities of GISIN members and the impact of the GISIN on those capacities.

ACTIVITIES
- Workshops in conjunction with other biodiversity meetings
- Capacity-building programs in the use of GISIN tools

3.3 Financial Sustainability
One of the biggest challenges to any international cooperative undertaking is its ability to be financially sustainable. For the GISIN, this has two components. First, there has to be sources

for continuing funds for the operation of the regional nodes. There must be a way to encourage and sustain the contribution of resources by all members in terms of their internal funding for activities which are de facto their in-kind contribution to the development of the GISIN. Second, although it is not intended that the Hub become a major central operation, it is also clear that there are costs associated with coordination and support for decentralized, voluntary participation.
The April meeting is possible through a small grant from the Bureau of Oceans and International Environmental and Scientific Affairs (OES) of the U.S. Department of State, with in-kind donations and coordination by the US National Biological Information Infrastructure. Extensive work needs to be done to identify long-term donor(s), as well as to determine any formal or informal organizational affiliations to entities such as GBIF, GISP, and/or IUCN-ISSG.
Since the network will be built through the efforts of all its partners, the GISIN itself should not be viewed as a source of funding for projects. Rather it is a facilitating mechanism to aid its members and its projects find support for GISIN-related activities.

Support for the GISIN can come from many sources including:

- In-kind contributions
- Governmental donor organizations (e.g. OAS, GEF, World Bank, IDB, UNESCO, US AID, FAO, etc.)
- Private foundations and donors
- Corporate sponsorship

Other possible sources of income to sustain the GISIN at the regional or global level include:

- Dues
- Grants/Contracts
- Product Sales (May include training, data access, data products)
- Advertising
- Institutional/Corporate Sponsorships

OBJECTIVES
Year 1: Lay out a Strategy for the Long-term Sustainability of the GISIN.
Year 2: Have a major donor-supported GISIN program in place.

ACTIVITIES

- Develop plans for the financial sustainability.
- Develop and distribute via the Web and on CD a financial toolkit for members.
- Appoint a special subcommittee to look at models for financing such efforts.
- Explore the issue of charging for services among the other options.

3.4 Building Network Content
From the earliest meetings of experts on invasive species information management, it was clear that the connection of regional databases was the way to begin to build substance and content of the network. What is needed to achieve this is agreement on what types of information will be shared, and in what formats.

Common data types of priority interest among GISIN experts (these are meant as starting points and do not limit members from developing other common interests):

- Scientific name
- Common name

- Distribution (native and non-native), via maps and/or gazetteer place names
- Fact sheet/species profile information on ecology, life cycle, invasive impact/threat, etc.
- Control/management information
- Expertise of individuals and organizations
- Bibliographic information

Desirable criteria for the creation of GISIN nodes:
- Advances technical objectives
- Advances creation of the network (e.g., how much data is potentially added)
- Adds regional value
- Addresses transnational issues and resources
- Is achievable, realistic, and measurable
- Is scalable (adjustable in size; can be expanded)
- Can attract funding
- Supports interdisciplinary approaches
- Involves multiple institutions (local, indigenous communities, NGOs, et al.)
- Links to other efforts
- Advances education or public awareness

OBJECTIVES
- Complete initial directories of information that will be shared from member databases to the GISIN
- Begin the integration of content across the member databases and roll-out the GISIN demonstration system.

ACTIVITIES
As soon as the Technical Working Group on Pilots is formally established, it should set three processing in motion:
1. complete the development of criteria for defining the GISIN information types to be shared;
2. begin to develop content priorities and set up specific database groups from those realms or taxa which have member interests and commitment;
3. assess the status of the database integration achieved, during electronic meetings (but opportunities for face-to-face meetings should be created as resources are available.)

A resource directory of all the key people and institutions should also be developed to facilitate cooperation and as a tool to identify where to get assistance on particular issues. The initial set of GISIN resource directories based on participants in the April meeting plus those participating in the e-discussion will be available by the beginning of May. The directories will need regular updating and upgrading as the other parts of the GISIN evolve. A major upgrade of directories should be done in mid-2005.

4.0 PHASES FOR GISIN DEVELOPMENT

Chronological overview of the future of the GISIN, organized by topic
Governance and membership
- Election of Executive Committee/First Meeting
- Selection of Interim GISIN Hub
- Approve criteria for membership in the GISIN
- Annual review of GISIN progress

Financial Sustainability
- Set up TWG
- Create and distribute funding toolkit for nodes
- Business plan for the GISIN
- Develop options for long-term sustainability
- Submit Proposal to GEF or other possible funding bodies

Technical Configuration and Standards Development
- Set up TWG
- Assessment of GISIN information content and systems standards
- Present draft architectural model(s)
- Set up mechanism to manage technical configuration

Capacity Building and Training
- Set up TWG
- Determine priority areas based on participants survey results
- Offer workshops in conjunction with other relevant meetings

5.0 CONCLUSIONS

This draft plan of work toward the development of the GISIN is a very ambitious undertaking, given the wide variety of requirements, capabilities and commitments that need to be made at the global level. The overall target of a roll-out demonstration is totally dependent upon the commitment of participants in the April meeting and availability of funding for the Hub and the regional nodes of the GISIN. Ideas from the group at the April meeting will provide turning points around which to capture the work that has been done and then move forward in a more formal and focused manner.
This draft framework document provides a road map for this forward movement. It is based on the continuing commitments of the invasive species database managers from around the world and assumes that resources to support a GISIN Hub will be forthcoming.

DRAFT PLAN OF ACTION FOR THE NEXT 12 MONTHS TOWARD THE IMPLEMENTATION OF THE GISIN

Actions:
1. Select a planning team, location, and dates for the next GISIN meeting
2. Prepare a draft proposal document for submission to possible funding agencies for the Hub
3. Develop a GISIN Web site
4. Publish and maintain a complete catalog of online invasive species databases
5. Establish a listserv for GISIN members
6. Agree on a procedure to solicit assistance from the GISIN member organizations for letters of support
7. Create and distribute the funding toolkit and possibly a legal framework toolkit, via CD and on the Web
8. Prepare a draft report of April's GISIN implementation meeting to circulate among the IAS community.
9. Submit to the State Department the final report on the April implementation meeting
10. Publish on the Web the requirements for inclusion in the GISIN's IAS database consortium for cross search
11. Convene the GISIN Executive Committee, electronically or face-to-face

12. Create the GISIN Mid-term Work Plan
13. Prepare and submit a final GISIN Hub proposal

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Appendix L

Agenda

06April2004 Tuesday

7:30am	Continental breakfast
8:00	Pre-registration
8:30	Introduction and Setting the Stage (plenary) *Annie Simpson*
8:50	Databasing Invasions (summary of reports from prior workshops) (plenary) *Liz Sellers*
9:10	Participants Survey Results Summary (plenary) *Shelaine Curd-Hetrick*
9:30-10:00	Refreshments (view e-posters)
10:00	Purpose and description of breakout group format and goals (plenary) *Annie Simpson*
10:20	Divide up and go to break out groups
	Online DB infrastructure (Plaza B) *leader Hannu Saarenma, rapporteur Jenn Forman Orth*
	Online DB content (Plaza B) *leaders Vishwas Chavan & Bob Meese, rapporteur Catherine Crosier*
	Developing DB's & capacity building (Smith Room) *leaders Soetikno Sastroutomo & Silvia Ziller, rapporteur Philip Thomas*
	Organizational framework (Hopkins Room) *leaders Keng-Yeang Lum & Lucie Rogo, rapporteurs Shelaine Curd-Hetrick & Richard Smith*
12:00-1:00pm	Buffet lunch
1:00	Web Services: Who, What, Why, Where, and When? (plenary; information theory) *Bob Morris*
1:20	Baltic Sea Regional Database Cooperation (plenary; centralized database) *Sergej Olenin*
1:40	NISbase: A Distributed Database System (plenary; distributed database system) *Brian Steves, Shawn Dalton, Pam Fuller, Greg Ruiz*
2:00	Return to breakout groups
3:00-3:30	Refreshments (view e-posters)
3:30	Return to breakout groups
5:00	Summary reports from breakout groups
5:30	Informal presentation: European Research Network on Aquatic Invasive Species (ERNAIS) *Stephan Gollasch, Vadim Panov*
6:00	Informal presentation: FishBase: a Global Information System on Fishes *Christine Casal*

07April2004 Wednesday

7:30am	Continental breakfast
8:30	GBIF's Possible Role (plenary; information theory) *Hannu Saarenmaa*
8:50	DiscoverLife (plenary; centralized system) *John Pickering*
9:20	I3N: A Multinational Information Network in the Americas (plenary; distributed system) *Andrea Grosse, Sergio Zalba, Silvia Ziller*
9:40-10:00	Refreshments (view e-posters)
10:00	Return to breakout groups Additional breakout group: Aquatic Invasive Species *leader Brian Steves, rapporteur Rachel Muir*
12:00-1:00pm	Buffet lunch (view e-posters)
1:00	Invasive Alien Species in China (plenary; information theory) *Yan Xie*
1:20	NatureServe Explorer (plenary; centralized database) *Terri Killeffer, Rachael Muir*
1:40	Colombian IAS Database (plenary; distributed database system) *Angela Suarez-Mayorga*
2:00	Return to breakout groups
3:30-4:00	Refreshments (view e-posters)
5:00	Summary reports from breakout groups
5:30	Informal meeting for all who are interested in I3N *Andrea Grosse, Sergio Zalba, Silvia Ziller*
6:00	Informal presentation: Conabio: Mexico Biodiversity Information System *Patricia Koleff*

08April2004 Thursday

7:30am	Continental breakfast
8:30	Discussion of Action Plans, assigning tasks/responsibilities, discussion of Baltimore Declaration
9:30-10:00	Refreshments (view e-posters), taking of group photograph
10:00	Summary of accomplishments, sharing successes and new partnerships, presentation of interim Steering Committee, discussion of next steps
12:00	Adjourn