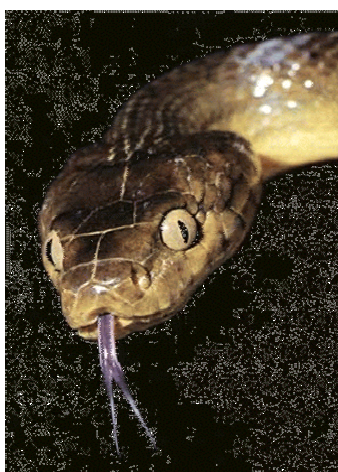


U.S. GEOLOGICAL SURVEY

INVASIVE SPECIES PROGRAM



FIVE YEAR PROGRAM PLAN

*FISCAL YEARS
2005-2009*

October 29, 2004

TABLE OF CONTENTS

INTRODUCTION 1

PURPOSE AND DEVELOPMENT OF THE FIVE-YEAR PLAN..... 2

THE NEED FOR INVASIVE SPECIES RESEARCH.....3

OVERVIEW OF USGS INVASIVE SPECIES RESEARCH PROGRAM..... 5

VISION FOR THE USGS INVASIVE SPECIES PROGRAM.....10

PROGRAM MISSION.....10

PROGRAM RELATIONSHIP TO STRATEGIC DOI AND USGS GOALS..... 10

PROGRAM GOALS.....11

THE FIVE-YEAR PLAN (2004 – 2009)..... 14

MAJOR INITIATIVES DURING THE PLANNING PERIOD.....14

RESEARCH ON PRIORITY PATHWAYS.....15

NATIONAL FORECASTING SYSTEM FOR INVASIVE SPECIES..... 15

 Early Detection and Rapid Assessment of New Invaders

 Cooperative Multi-Scale Monitoring and Forecasting

 Integrated Assessments of Invasive Species

 The National Institute for Invasive Species Science

INNOVATIVE CONTROL METHODS.....20

NATIONAL INVASIVE SPECIES INFORMATION NETWORK..... 21

INVASIVE SPECIES PROGRAM GOALS, OBJECTIVES, AND STRATEGIES..... 22

PREVENTION.....22

EARLY DETECTION AND RAPID ASSESSMENT OF NEW INVADERS.... 23

MONITORING AND FORECASTING OF ESTABLISHED INVADERS..... 23

EFFECTS OF INVASIVE SPECIES..... 24

CONTROL AND MANAGEMENT..... 25

INFORMATION MANAGEMENT.....26

IMPLEMENTING THE PLAN.....26

PROGRAM REVIEW..... 32

COMMUNICATION AND OUTREACH..... 32

WORKFORCE PLANNING..... 33

FACILITIES..... 34

BUDGET STRATEGY..... 35

REFERENCES..... 37

APPENDIX A: MEMBERS OF THE PLANNING TEAM..... 39

APPENDIX B: CAPABILITIES OF USGS RESEARCH CENTERS.....40

USGS INVASIVE SPECIES PROGRAM STRATEGIC FIVE-YEAR PLAN

Introduction

America is under siege by many harmful non-native species of plants, animals and microorganisms. More than 6,500 nonindigenous species are now established in the United States, posing risks to native species, valued ecosystems, and human and wildlife health. These invaders extract a huge cost. The current environmental, economic, and health-related costs of invasive species could exceed \$138 billion per year, more than all other natural disasters combined (Pimentel *et al* 2000).

Hundreds of species, some first introduced decades or centuries ago, have become invasive and are now causing widespread damage. Notorious invaders such as the Norway rat, fire ants, zebra mussels, dandelion, kudzu, salt cedar and chestnut blight are widely known. However, an increasing number of less well known species are becoming established in all regions of the U.S. New invaders, such as the Asian long-horned beetle, emerald ash borer, cactus moth, snakehead and sudden oak death threaten important native species and could disrupt ecosystems over large regions if they become widely established. Other recent invaders, such as the Asian tiger mosquito, are vectors of diseases, such as West Nile virus, that can cause illness and even fatalities in humans and wildlife in areas around the country. In addition to exotic species introduced from outside the U.S., species are also being introduced from one region or watershed where they are native into others where they become invasive. At the beginning of the 21st century, the gathering wave of established and incipient invaders is becoming one of the nation's most serious and complex environmental threats.

Hundreds of new species from other countries are introduced intentionally or accidentally into the U.S. each year. Based on past experience, 10-15% of these introduced species can be expected to establish free-living populations and about 1% can be expected to cause significant impacts to ecosystems, native species, economic productivity, and/or human health. The increasing threat of new invasions intensifies the need for scientists, managers, and the many stakeholders affected by invasive species to join forces to build better systems for preventing new introductions, quickly detecting and responding to new invaders, tracking, controlling and -- if possible -- eradicating established invaders, and restoring habitats damaged by invaders.

INVASIONS AT A GLANCE

The Northeast: Chestnut blight, Dutch elm disease, balsam woolly and hemlock adelgid, dogwood anthracnose, purple loosestrife, mile-a-minute vine, porcelain berry, and phragmites.

Southeast: Red imported fire ants, kudzu, Chinese privet, water hyacinth, giant salvinia and tropical soda apple, Brazilian pepper, old world climbing fern, green mussels, nutria, escaped fish from aquaculture, Asian swamp eel, and the cactus moth.

Great Lakes: Zebra mussels, sea lamprey, round goby, and the Eurasian ruffe.

The Midwest: Zebra mussels, Asian carp, and leafy spurge.

The Southwest: Saltcedar (tamarisk), buffelgrass, Bermuda grass, and Africanized bees.

Pacific Northwest: Eurasian water milfoil, hydrilla, smooth cordgrass, English ivy, and dozens of non-native fish.

Intermountain West: European knapweeds and thistles, hoary cress, and white pine blister rust. Cheat grass, which occupies over 100 million acres, is displacing natives, increasing wildfire, and transforming ecosystems throughout the American West.

The Rocky Mountains: Whirling disease of trout, New Zealand mud snail, Russian olive and saltcedar.

California: Yellow star thistle, sudden oak death, red brome, giant reed, Scotch broom, Asian clams, bullfrogs, and Chinese mitten crabs.

Hawaii and the Pacific territories: Hundreds of invasive species from microbes to mammals, including avian malaria, *Miconia*, African grasses, Argentine ant, Cuban tree frog, and the brown tree snake (on Guam).

Purpose and Development of the Five-Year Plan

The purpose of this plan is to outline goals, strategies, and requirements for significantly increasing U.S. Geological Survey (USGS) efforts during the next five years to help Department of the Interior (DOI) managers and the nation respond more rapidly and effectively to the growing threats from invasive species in U.S. ecosystems. The basic approach is to identify opportunities to enlist, increase, and, where appropriate, redirect, the capabilities of USGS biological research centers, integrating these capabilities with those of other USGS disciplines and other domestic and foreign research agencies, institutions, and

organizations helping to provide information, expertise, facilities and practical solutions to address complex invasive species problems.

A nine person writing team (Appendix A), which included program managers, center directors, and scientists whose collective expertise encompassed all major taxonomic groups of invasive species in terrestrial and aquatic ecosystems, developed an initial draft of this document. The writing team used strategic documents and reports that provide the national context for the plan (i.e., Invasive Species National Management Plan, ANSTF¹ Strategic Plan, FICMNEW² National Weed Strategy, etc.), and also considered the recommendations from a review of the invasive species program by an external panel of experts in 2000, a USGS report on broad future science directions for the program, the strategic plans of the DOI and the USGS, and more specific direction contained in the Director's annual program guidance.

The Need for Invasive Species Research

Although there is a long history of Federal efforts to protect public health and U.S. agriculture from introduced pests and diseases, serious Federal intervention to combat threats of invasions to ecosystems, natural areas and native species only began during the 1990s. A 1993 report on Harmful Nonindigenous Species in the United States by the now defunct Congressional Office of Technology Assessment first called national attention to the problem, the inconsistencies among Federal policies and programs that sometimes work at cross purposes, and the need for better information and tools to support coordinated Federal action (U.S. Congress, OTA 1993). Largely in response to the growing number of invaders in the Great Lakes, such as zebra mussels, being introduced in ballast water, Congress passed remedial legislation in 1990 (Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended, National Invasive Species Act of 1996) which established the Aquatic Nuisance Species Task Force to coordinate Federal responses. The legislation enabled the U.S. Fish and Wildlife Service (FWS) to increase its research on aquatic invaders and to initiate a National Nonindigenous Aquatic Species Database. In 1993, the Secretary of the Interior transferred nonindigenous species research functions of the FWS and other DOI bureaus to the newly established National Biological Survey, which in 1996 became the Biological Resources Division (now Discipline) of the USGS by congressional action. Through the mid-90s, the predominant research focus remained on Great Lakes invaders, the development of an aquatic nonindigenous species database, a long-standing research program on invasions in Hawaii, and a special research initiative to combat the spread of the brown tree snake in the Pacific territories. At the invitation of the co-chairs of the ANSTF, the USGS became an official member of the ANSTF in 2003.

By the mid-1990s, the taxonomic focus of interagency concerns had expanded to include invasive plants. The 16-member Federal Interagency Committee for the Management of Noxious and Exotic Weeds, which was established by Memorandum of Understanding in 1994, published a National Weed Strategy in 1998, which called for special efforts to prevent

¹ Aquatic Nuisance Species Task Force

² Federal Interagency Committee for the Management of Noxious and Exotic Weeds

and control invasive plants on public and private lands, and to restore lands through management actions. In FY 1998, in response to this new national effort to address the invasive plant problem, the USGS received additional appropriations for research on “Weeds in the West” to find ways to reduce the role of introduced grasses in increasing the frequency and intensity of fire in western rangelands, and for research on species of priority concern to resource managers in the east, such as butternut canker and the hemlock woolly adelgid. Also that same year, USGS published a Weed Fact Book entitled *Invasive Plants, Changing the Landscape of America*, in cooperation with FICMNEW (Westbrooks, 1998).

In 1999, President Clinton issued an Executive Order on Invasive Species (E.O. 13112) in response to the growing threat of invasives. The Executive Order laid out Federal agency responsibilities for combating invasive species, established the interagency National Invasive Species Council (NISC) to oversee the implementation of the Order, and authorized an Invasive Species Advisory Committee (ISAC) to provide for involvement of other levels of government and public interests. The Order also called for development of an internet-based information-sharing system and preparation of a National Invasive Species Management Plan. The Council approved the first edition of the plan in early 2001. The plan identifies nine focus areas and 57 near-term actions for Federal agency implementation. The focus areas are leadership and coordination, prevention, early detection/rapid response, control and management, restoration, international cooperation, education and public awareness, research and information management. All focus areas benefit from the information and tools that USGS provides. USGS scientists participate in the task teams established to implement actions identified in the plan, several of which explicitly identify USGS as an implementing agency. The plan also includes a summary of Federal agency roles and thus helps define the USGS niche in Federal research and development efforts.

NISC coordinated preparation of an interagency cross-cut budget (beginning with FY 2004) which identifies priority interagency initiatives, desired outcomes, and performance measures. The annual initiatives have increased policymakers’ awareness of opportunities for Federal coordination, including the need for integrated research and better tools to combat invasive species threats. USGS scientists played important roles in most of the ad-hoc work groups established by NISC to formulate FY 2004 and 2005 cross-cut budgets for priority initiatives. In developing the FY 2006 budget, NISC has begun identifying issues involving significant interagency cooperation which may lead to budget cross-cuts in the future. By enhancing interagency cooperation, leveraging of resources, and accountability, these efforts have increased OMB³ and congressional support for invasive species in the President’s annual budgets.

Between 1998 and 2002, the President’s Committee of Advisors on Science and Technology, the Office of Science and Technology Policy, and the National Research Council (NRC) issued various reports containing recommendations for strengthening research on invasive species. In particular, the NRC report, *Future Roles and Opportunities for the U. S. Geological Survey*, noted that the “challenge for the future is sound management of the Earth’s ecosystems to maintain biodiversity and ecosystem function” and that, in addressing complex natural resource problems, the “USGS should place more emphasis on multi-scale,

³ Office of Management and Budget

multidisciplinary, integrative projects that address priorities of national scale.” In this context, the report goes on to state that the “USGS has an important role to play in conducting studies to reduce the spread and impact of non-native invasive plants, animals, and pathogens that have been intentionally or accidentally introduced from foreign countries into the United States.” The NRC’s report in 2002, *Predicting Invasions of Nonindigenous Plants and Plant Pests*, contains conclusions and recommendations for enhancing the science for predicting invasions of plants and plant pests, several of which underscore the importance of standardized methods for assessment -- an important strength of USGS. Although the USDA-funded report focuses on USDA⁴ activities, many recommendations are directly relevant to USGS strategic planning and capabilities.

The Government Accounting Office has called attention to deficiencies in Federal rapid response to invasions, and to the uneven progress in implementing the National Management Plan. Addressing these concerns requires increased investments in research and information systems to support informed policy and management decisions.

Invasive species are a top priority concern of DOI land managers. The National Park Service, Bureau of Land Management, and the Fish and Wildlife Service have adopted plans for improving their responses to invasions on public lands. The plans call for the kinds of information and tools that the USGS is uniquely positioned to provide. USGS has identified invasive species as one of eight priority future science activities and has developed the 5-year plan in recognition of concerns and recommendations in these plans.

Overview of USGS Invasive Species Research Program

The USGS Invasive Species Program provides methodologies and information to address the increasing threat to ecological systems and native species due to the introduction and spread of invasive species. As the primary research agency within the DOI, the Program places special emphasis on lands and waters managed by the Department. The Program supports cooperative efforts to document and monitor the introduction and spread of invasive species, study the ecology of invaders and factors in the resistance of habitats to invasion, to forecast probabilities and locations of future invasions, provide methods and information to assess and manage risks, and develop methods to prevent and control invasive species and minimize their environmental impacts.

In 2002, USGS research activities within the Biological Resources Discipline (BRD) were consolidated into six research programs (Invasive Species [INV], Terrestrial, Freshwater, and Marine Ecosystems [ECO], Wildlife: Terrestrial and Endangered Resources [WTER], Fisheries: Aquatic and Endangered Resources [FAER], Status and Trends of Biological Resources [S&T], and Contaminant Biology [CBP]) as well as the Biological Informatics Program (BI) and Cooperative Research Units (CRU) programs. Research on invasive fish and wildlife pathogens recently introduced into the U.S. such as Whirling Disease and West Nile Virus (referred to as “emerging diseases”) was subsequently transferred from the

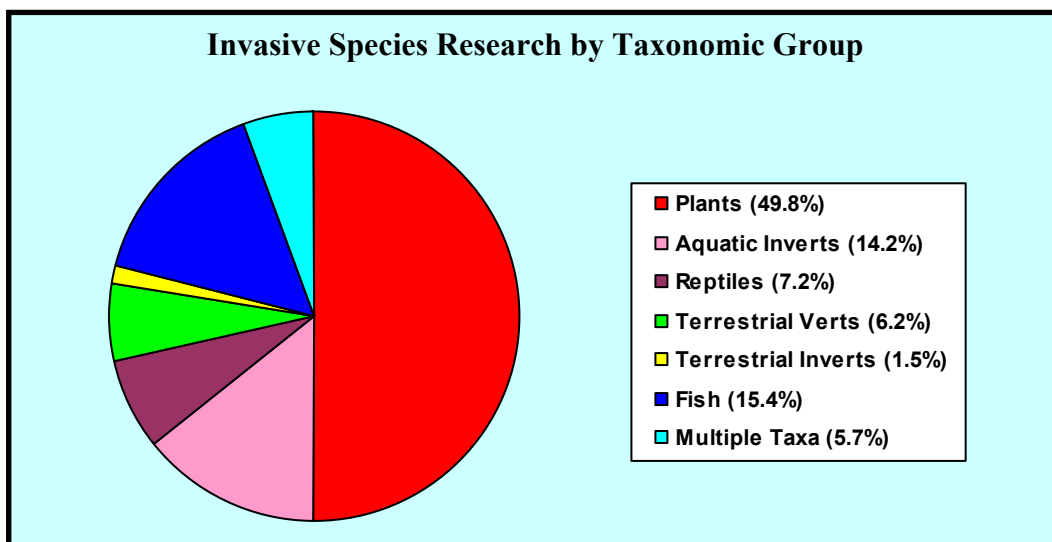
⁴ United States Department of Agriculture

Invasive Species Program to the FAER and WTER programs. These programs thus play major roles in research on invasive organisms with significant effects on native species and, in some cases, human health. The BI and CRU programs, also play cooperative roles in invasive species research, as do other USGS programs in BRD and various programs in the Geospatial Information Office and the Geography, Water Resources, and Geology disciplines. The development and expansion of these cooperative relationships is an important emphasis of this plan.

There are currently 77 tasks and subtasks in projects involving 13 biological research centers in FY 2004, contributing to one or more Invasive Species Program goals. The majority provide information and methods to support control of established, and usually widespread, invaders, including limited research on the pathways and vectors that influence their introduction and spread into new areas. A much smaller number focuses on monitoring and assessment of established invaders, early detection of new invaders, and information.

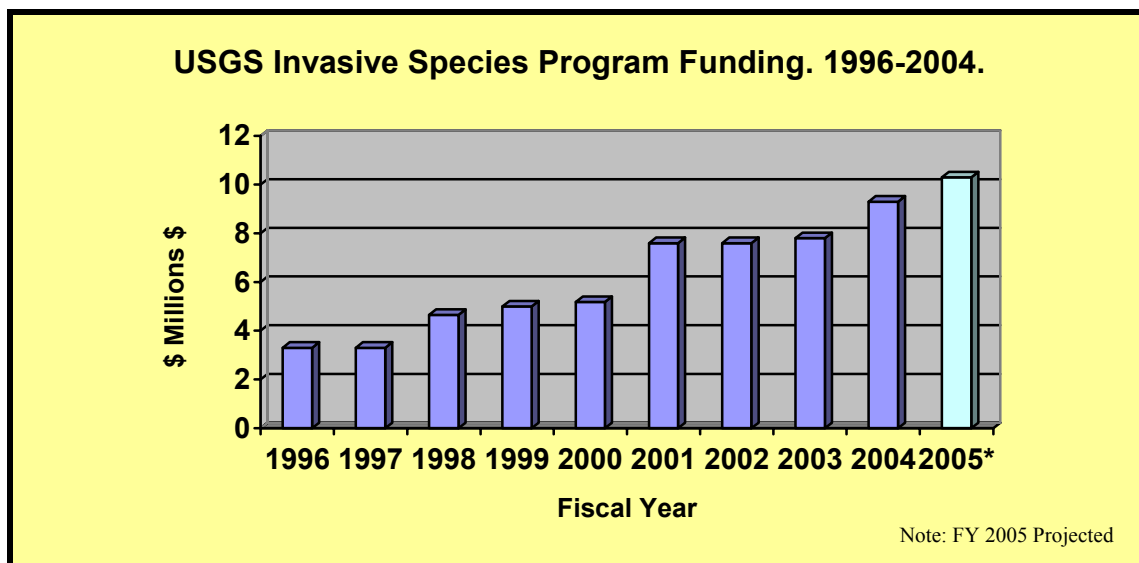
Geographic Emphasis. The program includes research in all major regions of the U.S. and in a wide range of terrestrial and aquatic ecosystems. Emphasis is in regions facing significant threats from rapidly spreading invasive species where one or more USGS research centers have longstanding invasive species research programs, i.e., the Pacific Islands, western rangelands, the Great Lakes, and eastern wetlands and waterways. In the continental U.S., the two-thirds of the country east of the Rocky Mountains historically have received less attention than the West.

Taxonomic Emphasis. The current invasive species program focuses on a wide range of taxa including aquatic invertebrates, fish, terrestrial invertebrates, terrestrial vertebrates (birds, mammals etc.), reptiles, and plants (see figure below). The majority of research activities focus on vascular plants (49.8%), fish (15.4%), and aquatic invertebrates (14.2%). Insects, which include a growing number of incipient invaders (e.g., hemlock adelgid, emerald ash borer, cactus moth, and fire ants in Hawaii) that are potentially devastating to native species, are a focus in less than 1.5% of the activities.



Specific taxa targeted in 2004 included zebra mussel (*Dreissenia polymorpha*), Asian clam (*Corbicula fluminea*), large mouth bass (*Micropterus salmoides*), rainbow smelt (*Osmerus mordax*), Asian carp (silver carp [*Hypophthalmichthys molotrix*], bighead carp [*H. nobilis*] and black carp [*Mylopharyngodon piceus*]), swamp eel (*Monopterus alba*), snakeheads (*Channa* spp.), Culex mosquito (*Culex* spp.), Argentine ant (*Iridomyrmex humilis*), nutria (*Myocaster coypus*), feral pig (*Sus scrofa*), brown tree snake (*Boiga irregularis*), salt cedar (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), Canada thistle (*Cirsium arvense*), leafy spurge (*Euphorbia esula*), sweet clover (*Melilotus officinalis*), Chinese tallow (*Triadica sebifera*), Kahili ginger (*Hedychium gardnerianum*), Sahara mustard (*Brassica tournefortii*), fountain grass (*Pennisetum alopecuroides*), giant salvinia (*Salvinia molesta*), beach vitex (*Vitex rotundifolia*), cactus moth (*Cactoblastis cactorum*), cogongrass (*Imperata ciliata*) and cheatgrass (*Bromus tectorum*).

Funding History. Appropriated funding for invasive species research has steadily increased over the past eight fiscal years, from \$3.3M in FY 1996, to the current level of \$9.3 million in FY 2004 (see chart below) or roughly 1% of the USGS total budget. The first increase of \$1.35M in FY 1998, for “Weeds in the West” and “Exotics in the East” enabled expansion of USGS research on plant invasions in western rangelands and Hawaii, and aquatic invaders in eastern waterways. The next significant increase in FY 2001 (to \$7.6 million), included a \$500K earmark for ballast water research at the Western Fisheries Research Center (also included in FY 2002 and 2003) and funding to assist in emergency outbreaks of invasive organisms, including West Nile virus. Funding remained generally constant in FY 2002 and 2003 (\$7.8 million). During the past several years, the Biological Informatics Program has played an increasing role in developing the National Invasive Species Information System called for in the Invasive Species Executive Order as funding for the National Biological Information Infrastructure’s (NBII) network of biological information nodes has increased. Several information nodes (Pacific Basin, California, Fisheries) are actively involved in facilitating access to data and information on nonindigenous species. In 2003, an Invasive Species Information Node (ISIN) was established to coordinate the development of a distributed invasive species information network linking the NBII nodes and databases managed by numerous domestic and foreign entities.



In FY 2004, the USGS appropriation included an increase of \$2.05M for invasive species research, of which \$1.0M was earmarked for Mississippi State University (MSU). The increase enabled base funding of ballast water research at the Western Fisheries Research Center, initiation of new multi-center research projects to support control of priority species (tamarisk in the southwest and nutria in Louisiana and the Chesapeake Bay region), and cooperative research with MSU on early detection, assessment, and control of terrestrial plants, aquatic plants, and cactus moth in the central Gulf states region. The appropriation also included \$1.0M to the BI Program for biological information management and delivery related to early detection and rapid assessment of invasive species. The President’s proposed FY 05 USGS budget includes \$1.0M for research to support innovative control and effective responses to priority aquatic invaders, such as Asian carp, and control of brown tree snake

First External Program Review. For most of the past decade, research projects have been developed largely in response to immediate client needs, especially to address major invasions in natural areas. The development of NISC’s National Plan provided a catalyst for strengthening the strategic role of the USGS invasive species program in responding to national priorities.

The USGS conducted the first external review of the invasive species program in October, 2000. The review panel included subject matter experts from client agencies and academia. They concluded that USGS had several opportunities and niches to fill in research related to invasive species:

- To provide proactive research that can be applied to help solve invasive species management problems with a focus on natural systems (as opposed to agricultural)
- To utilize the full range of research skills, expertise, and bureau resources (including integrating the capabilities of other USGS programs into invasive species research)
- To provide management implications along with the research (the education/outreach component)

- To coordinate closely with USDA, NOAA⁵, States, universities, and others to address invasive species research and recognize overlaps in responsibilities and activities
- To expand partnerships between scientists and natural resource managers

The guiding principles they proposed for the program included strong leadership, customer service (relevance), partnerships, coordination at all levels, shared vision, goal-orientation, and allocation of significant resources. The review also identified important areas of concern, such as prevention (interdiction at the borders and containment of incipient infestations), early detection and rapid assessment to support rapid response to new invaders, inventory and monitoring of established invasions, forecasting invasions and risk assessments – all of which provide fruitful opportunities for future program growth and enhanced benefits to clients and U.S. society. Increased research and availability of information in these strategic areas of concern are urgently needed because of the rapid diversification of pathways for movement of invaders associated with the globalization of trade and travel and increasing human disturbance of natural ecosystems which favor the spread of invasions. These new thrusts are consistent with the National Invasive Species Management Plan and associated priority NISC initiatives.

⁵ National Oceanic and Atmospheric Administration

Vision for the USGS Invasive Species Program

As the scope of the invasive species problem has broadened, so has the research needed to address it. Future USGS research will focus on developing predictive understanding of the relationships between invasive species, environmental drivers (e.g., extreme natural events and changes in physical disturbance regimes, climate, chemical pollution, and atmospheric conditions), and biological processes operating at many spatial and temporal scales. USGS research on invasive species will be guided by the following vision:

THE VISION...

USGS will be a collaborative leader of Federal research on invasive species in terrestrial and aquatic ecosystems in the United States and beyond.

A recent report on Future Science Directions for the Invasive Species Program elaborates the long-term vision as follows: “*In the next 25 years, we envision the USGS becoming the leader in understanding the current and future effects of invasive species on human health, the economy, native biodiversity, and ecosystem processes. The USGS will have a major future role as the only government agency providing research information on all taxa from “microbes to mammals” to support adaptive management of invasive species through integration of interdisciplinary research, monitoring, and management approaches in all ecological regions of the U.S.*”

The USGS will lead efforts to develop methods for sharing and integrating available information on invasive species, and for monitoring invasions, predicting probabilities for spread, and assessing risks to ecosystems and native species. The USGS emphasis on natural and semi-natural ecosystems will complement the role of USDA in providing information and tools to prevent and combat invasions in agricultural ecosystems and managed forests.”

Program Mission

The mission of the Invasive Species Program is:

To provide reliable information and useful tools for documenting, understanding, predicting, assessing, and addressing threats from invasive species in U.S. ecosystems.

Program Relationship to Strategic DOI and USGS Goals

The Invasive Species Program supports DOI’s Resource Protection Strategic Goal of sustaining biological communities on DOI-managed and influenced lands and waters. The USGS provides the natural resource management community with scientific information on

invasive species to implement resource management decisions based on sound science to sustain biological communities.

The Program also supports the USGS Strategic Plan through the Environmental and Natural Resources Mission Goal:

To provide science for a changing world in response to present and anticipated needs to expand our understanding of environment and natural resource issues on regional, national, and global scales and enhance predictive/forecasting/modeling capabilities.

Program Goals

The long-term goals of the USGS Invasive Species Program are being driven by the need to provide the knowledge and tools to support effective science-based strategies for prevention, early detection, and prompt eradication of new invaders and for control of rapidly spreading species representing all major taxonomic groups of invaders in U.S. ecosystems. Specific long-term goals and the kinds of activities that will be conducted to meet them are outlined below:

1. PREVENTION: *Conduct research and develop methods and technologies to prevent the introduction of invasive species.*

- Development of methodologies and approaches for identification, quantification, monitoring, and managing pathways and associated vectors of transport.
- Development of methodologies for assessing the effectiveness of prevention methods and technologies (e.g., ballast water treatment).
- Research on interacting environmental processes, socioeconomic factors, and human behaviors that influence the contributions of various pathways and vectors to the introduction and spread of known or potentially invasive species.

2. EARLY DETECTION AND RAPID ASSESSMENT OF NEW INVADERS: *Identify and report new invasions and assess risks to natural areas and waters.*

- Methods for improved taxonomic identification, including molecular applications.
- Field survey and mapping methods for early detection.
- Design of reporting networks.
- Syntheses of available information on species distribution and ecology in native and invaded ranges.
- Geographic information system (GIS) technologies and methodologies for modeling and forecasting to help predict potential spread and probable risks of species new to the U.S. and outbreaks of established invasions in new ecological regions, ecosystems and watersheds.
- Development of assessments to support decisions on response strategies.

3. MONITORING AND FORECASTING OF ESTABLISHED INVADERS: *Assess changes in populations and distributions of established invaders.*

- Applications of cost effective methodologies for statistically reliable monitoring of the spread of invasive species in U.S. ecosystems (in cooperation with the Status and Trends Program).
- Integrated use of historical occurrence records, remote sensing and global positioning system (GPS) technologies, improved field sampling methods, and GIS to document spatial and temporal patterns of expanding invasions at site, landscape, and regional scales.
- Methods for systematic observations of invader populations to understand factors influencing the lag period – sometimes spanning many decades – between the initial establishment of a free living population and the appearance of invasions at landscape and regional scales.
- Methods for monitoring the effectiveness of measures to reduce or eliminate invasive species populations and to restore native communities.

4. EFFECTS OF INVASIVE SPECIES: *Determine effects of invasive species and susceptibility of habitats to invasion.*

- Research to provide basic understanding of the biology, ecology and population dynamics of invasive species, including studies to determine species' environmental requirements and tolerances.
- Research on how and why nonindigenous species become invasive including biotic and abiotic factors influencing the lag time between introduction and invasion.
- Research on interacting factors (e.g., fire, erosion and deposition processes, atmospheric and climatological stresses, chemical pollution, land use changes, and management practices) that facilitate invasion of a particular species or taxonomic group in U.S. ecosystems.
- Research on factors influencing species invasiveness to facilitate risk assessment and screening of potential new invaders.
- Research to determine the individual and cumulative effects of invasive species on ecosystem processes and native species (Note: invasive species must be the primary factor under study. Research on interacting factors in ecosystem processes should be included in the Ecosystems Program).

5. CONTROL AND MANAGEMENT: *Provide approaches to contain, reduce, and eliminate populations of invasive species and restore habitats and native species.*

- Research to develop and test approaches to control populations of invasive species. Emphasis is on genetic, molecular, biological, chemical, and ecological methods that reduce impacts of invasive species at landscape and regional scales.
- Research on adaptive management methods for invasive species that help restore ecosystem processes and populations of native species, especially those that are endemic or threatened.

6. INFORMATION MANAGEMENT: *Provide and coordinate the collection, synthesis, and accessibility of invasive species information.*

- Methods for compiling and synthesizing accurate and reliable data and information on invasive species, and the development of information products to meet user needs, for inclusion in a distributed and integrated web-based information system. (Note: includes databases supported by USGS research centers and cooperation with the ISIN of the NBII, GIO, and other USGS programs, e.g., in development of data standards and information management tools).
- Methods to facilitate user interaction with the information, methods, and tools developed under the other goals of the Invasive Species Program.

The Five-Year Plan (2005 – 2009)

The Five-year Plan is organized around each of the six strategic program goals. Within each goal, objectives are defined that establish the focus of USGS activities to achieve the goal during the next five years. Each objective includes one or more recommended strategies for further development and implementation during the next five years. Each strategy will be associated with one or more performance measures for implementation during the next five years. Performance measures for outyears will be subject to adjustment and augmentation to reflect annual appropriations, opportunities for leveraging and reimbursable funding, and new scientific and technological advances.

The organization of the Five-year Plan takes into consideration the structure of the National Invasive Species Management Plan, which identifies actions for implementation by particular agencies in each of the nine focus areas, one of which is Research. It also takes into consideration the organization of NISC's annual priority crosscut budget initiatives, which help focus interagency efforts in implementing the plan and facilitates development and coordination of agency requests for appropriations. Each NISC initiative identifies an overall objective for interagency cooperation and one or more strategies for implementation during the timeframe of the initiative, which is typically several years.

The proposed objectives in the Five-Year Plan include a variety of strategies for implementation during the next five years. Significant progress in achieving some objectives can be made utilizing current levels of funding, USGS scientific capabilities, facilities, and partnerships. Implementation of other objectives will depend on additional resources, new partnerships, or other factors (such as NISC priorities). Thus, the Five-year Plan is a flexible "living" document that will be reviewed periodically and adapted to changing conditions and opportunities, national priorities, and client needs. The recommended strategies in the Five-Year Plan are strongly influenced by NISC priorities. In view of the increasing numbers of both new and established invaders, and their increasing economic and environmental impacts, Federal invasive species research programs are expected to expand during the timeframe of this plan. Given the unique role and capabilities of USGS in addressing invasions in natural ecosystems, we have assumed that program growth will continue to be fueled by the needs and demands of a growing number of clients for USGS research products, tools, and technical assistance.

MAJOR INITIATIVES DURING THE PLANNING PERIOD

The Invasive Species Program will implement several major initiatives aimed at increasing USGS leadership in key areas of invasive species science: priority pathways, forecasting, control methods, and information system development. Each initiative will:

- Develop, expand, and integrate USGS research to support the National Invasive Species Management Plan and priority needs identified by DOI partner bureaus;
- Include activities that utilize and integrate the capabilities of multiple USGS research centers;

- Include many research tasks that contribute to various invasive species program goals; and
- Require increasing cooperation among USGS programs in various Disciplines, and increasing investments in developing new scientific capabilities, partnerships, and facilities.

RESEARCH ON PRIORITY PATHWAYS

Goals Addressed: Prevention, Effects of Invasive Species

USGS will expand research on the effects of priority pathways for the introduction of new invasive species from other areas of the world into the U.S., and from one region of the U.S. to another. In FY 04, NISC identified improvement of ballast water management as a priority focus area. To support this initiative, the USGS, in cooperation with NOAA, the FWS, the Maritime Administration, and other partners, will continue research on new technologies for ballast water management (e.g., research on pressurized stack gases in ballast tanks), and initiate research on indicator species and assemblages for assessing the effectiveness of treatment technologies (through increase in FY 04 base funding). Another NISC Initiative focuses on screening of deliberately introduced non-native organisms. To support development of improved screening systems, USGS will increase efforts to develop, test, and validate models and tools for predicting the potential invasiveness of species not yet established in the U.S., building on recent USGS research on aquatic invaders, including assessment and management of probable threats⁶. We will expand cooperation with domestic and international agencies and organizations having interests and experience in developing risk assessment methods (e.g., National Park Service, The Nature Conservancy, Australia, and New Zealand). We will also encourage and support cooperative research (e.g., through NISC and the North American Commission on Environmental Conservation) to quantify the contributions of important pathways for the introduction and spread of invasive species in U.S. ecosystems, such as aquaculture, the pet trade, and the ornamental plant trade. We will continue cooperation with APHIS to develop methods and a database for monitoring e-commerce in invasive plants.

NATIONAL FORECASTING SYSTEM FOR INVASIVE SPECIES

Goals Addressed: Early Detection and Rapid Assessment of New Invaders, Monitoring and Forecasting of Established Invaders, Effects of Invasive Species and Information Management

Effective and timely responses to invasive species require better methods for predicting their probable spread and the vulnerability of U.S. ecosystems to invasion. In FY 2004, the USGS Invasive Species and Biological Informatics Programs received significant new appropriations to help develop national capabilities in early detection, monitoring, and assessment of

⁶ Research to support screening, risk assessment and risk management of potential pathogens and parasites will be conducted cooperatively with FAER and WTER.

invasive species. We propose to develop these capabilities as components of a National Invasive Species Forecasting System, which will help support decisions on effective responses to both new and established invaders in U.S. ecosystems, with particular emphasis on DOI lands, including non-native species being introduced into the U.S. that have characteristics indicative of potential invasiveness. The programs will work closely together and with many partners to develop these capabilities, with the Invasive Species Program focusing on improving methods for detection, monitoring, modeling and assessment and the Biological Informatics Program on information standards, systems, and tools to facilitate data reporting, management, and accessibility.

Through this initiative, the Invasive Species Program will develop methods to systematically obtain reliable georeferenced data on the occurrence of new and established invasive species and their rates of spread. We will develop geospatial models that integrate these data with environmental datasets to predict probable future spread and impacts of both new and widespread invaders in U.S. ecosystems. For new invaders, we will develop and improve methods for early detection of initial local establishment of invaders new to the nation, or to a new ecoregion, watershed, or ecosystem within the U.S. For established invaders, we will develop improved “smart monitoring” methods utilizing remote sensing, field plots, and systematic observations to track their spread in vulnerable habitats and facilitate forecasting across many temporal and spatial scales. We will obtain and analyze available information on invasive species’ biology, environmental tolerances, and habitat requirements in their native ranges, as well as the history of invasiveness elsewhere. Where information is unavailable, we will conduct research to obtain essential information to help parameterize forecasting models. Finally, we will utilize available information and forecasts based on predictive modeling to prepare assessments that help support rapid responses to new invasions, and efforts to reduce the effects of widespread invaders.

Early Detection and Rapid Assessment of New Invaders

Systems for early detection and rapid assessment to support rapid response to invasive pests and diseases in agriculture and new diseases of domestic animals and humans have been developed. However, such systems are not yet in place and are urgently needed to support rapid response to new invaders in U.S. ecosystems. The components of Early Detection/Rapid Response (ED/RR) systems are described in guidance prepared by NISC and FICMNEW. Proposed USGS contributions during the next five years (listed below) will be consistent with this guidance and developed in cooperation with Federal and state agencies with ED/RR responsibilities. Areas in which the Biological Informatics Program has the primary USGS role are indicated by asterisk (*).

***Identification** – development of web-based species identification keys including taxonomic information and images, as well as access to a network of taxonomic experts.

***Reporting** – development of tools (e.g., for electronic reporting by Email or the Internet, 800 number, etc.) that enable scientists, managers, and citizens to notify the system of the presence of a suspected invader and for integrating reports into a database to be accessible through the ISIN.

***Informatics** – development of systematic organization and standards for data and information in the database, with emphasis on geospatial and temporal referencing, and inclusion of nonindigenous species in the Integrated Taxonomic Information System.

***Retrieval** – development of tools to enable users to interact with the database in meaningful ways.

***Notification** – development of a directory of organizations and contacts to receive invader reports.

Outreach and training – development of materials and expertise to inform users on how to interact with the ED/RR system, through workshops, training sessions (including web-based training), and technical support. Outreach will be targeted to specific user communities in response to stated needs. Training and technical assistance for early detection will emphasize expanded partnerships with DOI bureaus and state natural resource and fish and wildlife agencies.

Ecological Range Studies – development of information on tolerances and requirements of newly established species to facilitate forecasting of probable spread and environmental risks.

Rapid Assessments – syntheses of available information on the natural history; potential species invasiveness; vulnerability of U.S. ecosystems; potential environmental, economic and health risks; control methods; and other information relevant to developing a timely response.

A growing number of Federal natural resource agencies as well as local, state and multi-state partnerships are initiating ED/RR programs, particularly to address weed invasions. The USGS is cooperating in several such efforts (e.g., in New England, Colorado, Hawaii, and the mid-South) and will seek to expand these relationships to include additional areas and taxonomic groups of invaders during the next five years. USGS is ideally positioned to play a leading role in developing the information, methods, and tools to support these efforts. USGS is also well positioned to facilitate the gradual integration of these efforts into a coordinated national early detection system that eventually will include all taxonomic groups and U.S. ecosystems. The primary initial focus in FY 04 on terrestrial plants will be expanded, with increased funding, in the outyears to increase emphasis on insects and other terrestrial invertebrates (with USDA), invaders in inland waters, coastal/marine invasions (with NOAA and SERC⁷) and terrestrial vertebrates. Early detection and assessment of invasive fish and wildlife diseases will be conducted through the Fisheries (FAER) and Wildlife (WTER) programs.

Cooperative Multi-scale Monitoring, Modeling and Forecasting

A cooperative multi-scale monitoring program for coastal/marine ecosystems, inland waters and terrestrial ecosystems is essential for any efforts to support both early detection and forecasting of the probable spread and impacts of invasive species. The USGS will expand support for developing and applying methods for multi-scale monitoring of invasive species in certain areas using appropriate combinations of remote sensing (with a strong ground-truthing component), active and passive field sampling, and new field technologies (e.g., GPS, hand-held computers) for collecting and reporting georeferenced occurrence data on invasive species. Emphasis will be on providing data to accurately map the spread of established invaders and to monitor the effects of management actions in reducing or

⁷ Smithsonian Environmental Research Center

increasing invader populations, and on developing and refining models for forecasting the probable temporal and spatial spread of invaders and vulnerability of particular habitats. (The iterative refinement of these models as monitoring data increase will be of particular use in detecting new outbreaks of invaders in susceptible habitats). Models will be developed for terrestrial plants, insects, aquatic species (plants, fish and invertebrates), and other wildlife species.

This component of the National Forecasting System will be closely coordinated with projects and activities conducted through the USGS Status and Trends in Biological Resources Program. Emphasis will be on developing protocols for monitoring invasive species on DOI lands, building on ongoing cooperative efforts with FWS (through the Science Support Program) and NPS (in cooperation with the NPS Inventory and Monitoring Programs). The initial focus on invasive plants will be gradually expanded to include development of protocols for additional taxonomic groups and geographic areas. In cooperation with NASA and the USGS Land Remote Sensing, and Geographic Mapping and Analysis Programs, increased emphasis will also be placed on developing applications of remote sensing technologies in mapping invasions and their impacts, and in integrated modeling and analysis of invasion processes.

Integrated Assessments of Invasive Species

We propose to develop integrated assessments to provide information for evaluating the imminence and significance of threats from new and widespread invaders in ecoregions to help facilitate informed decisions on species priorities and response strategies. Each assessment would include a state-of-knowledge review and synthesis of: the principal pathways and vectors for invasions; characteristics influencing invasiveness; factors influencing the vulnerability of habitats to invasion; and the roles of anthropogenic disturbance/land management actions, including land conversion and fire. Each assessment would address (1) species not yet in a region but predicted to pose a significant threat because of invasive characteristics in potentially vulnerable habitats; (2) incipient invaders, locally established, with some distributional data available for forecasting probable spread and impacts; and (3) widespread invaders with extensive distributional data available for forecasting probable spread and impacts. It would also include detailed maps of the existing and potential distributions of invasive species posing the greatest known and potential threats to the region, as determined by management experience and forecasting models using high speed computing for integrating data on species distributions and environmental conditions in native and invaded ranges. Although the selected species would always be of priority concern in the particular region, mapping and forecasting would include areas outside the region within their known and potential ranges. Each assessment would include the development and testing of iterative sampling techniques for early detection, monitoring, and reporting of invasive species using data collected from published records and by volunteers, systematic statistical surveys, and remote sensing methodologies, with the objective of providing near real-time mapping and ever more accurate forecasting of invasions as additional data are available. Rapid assessment of newly reported invasive species and outbreaks of established species in new ecosystems would be an integral component of each ongoing biogeographic assessment project. Maps and assessments would be made available through the NBII's ISIN (invasivespecies.nbii.gov) and the NISC website (invasivespecies.gov).

Initial assessments would logically focus on biogeographical regions including significant DOI trust resources where USGS is participating in multi-sector partnerships for early detection and monitoring of invasive plants: Hawaii and the Pacific Territories (tropical forest; initiatives through Invasive Species Committees on 5 Hawaiian islands), the southwest (desert/semi-desert - Southwest Exotics Mapping Project and tamarisk mapping initiative), the central gulf states (warm temperate/subtropical evergreen forest; new initiative funded through congressional earmark in FY 2004), and New England (temperate deciduous forest - Invasive Plant Atlas of New England). Additional taxonomic groups and biogeographical regions would be incorporated into the initiative as resources become available. Opportunities for including plant pests and diseases in assessments will be explored with USDA to facilitate interagency development and coordination of survey, modeling, and forecasting methodologies.

The National Institute for Invasive Species Science

(<http://www.nrel.colostate.edu/projects/niiss/niiss.html>).

The National Institute for Invasive Species Science (NIISS) helps facilitate USGS leadership in meeting America's needs for reliable information, methods and tools for responding to the growing threats of invasive species in U.S. ecosystems. The Institute focuses on developing partnerships involving USGS and other government and non-government organizations. It is facilitated by USGS and administratively housed in the Fort Collins Science Center in Colorado. It is a focal point for identifying emerging issues in invasive species science, fostering scientific cooperation among USGS programs and with other agencies and organizations, and helping to leverage USGS scientific capabilities with outside entities.

The Institute's primary research emphasis in the next five years is to support development of a National Forecasting System for Invasive Species in U.S. ecosystems. In cooperation with NASA and other partners, the Institute will develop improved methods for early detection and rapid assessment of new invasions, mapping and multi-scale monitoring of established invasions, modeling and forecasting of the probable spread and impacts of invasions in U.S. ecosystems, and integrated assessment of invasions across a wide range of temporal and spatial scales. Another emphasis is to provide technical assistance and training that helps DOI and other resource managers and stakeholders set realistic priorities and determine appropriate responses based on the best available scientific knowledge.

The Institute's home base is at the Fort Collins Science Center, which provides administrative support for its Science Director and a small staff of specialists based at the Center and the Natural Resource Ecology Lab at Colorado State University. Through a partnership with NASA⁸, the Institute now has onsite supercomputing capacity which facilitates the integration of many large environmental datasets in mapping, modeling, and forecasting of invasions and vulnerable habitat, with initial emphasis on invasive plants of the mid-continent region, such as tamarisk. Developing these capabilities will increasingly rely on other USGS centers, programs, and partner organizations to provide research information for improving forecasts, and broadening the scope of applications to include additional taxa, regions, and ecosystems.

⁸ National Aeronautics and Space Administration

Similarly, improved forecasting will facilitate the formulation of new research hypotheses to support more effective responses.

In addition to its research funding from the Invasive Species Program, NIISS also receives support through the Biological Informatics Programs to facilitate the NBII's ISIN. The Node seeks to enable interoperability among many databases to provide "one stop shopping" on the Internet for information on the biology, effects, pathways, vectors, and management of invasive species in U.S. ecosystems, and provides essential support for NIISS research and technical assistance activities.

A USGS Steering Committee for the Institute was established in 2004 to provide direction and oversight and facilitate coordination with NISC, ISAC, and interagency committees on particular groups of invasive species. The Committee is chaired by the Invasive Species Program Coordinator and includes the invasive species coordinator of the Biological Informatics Program, a representative from each USGS region, center directors, and senior specialists with a wide range of expertise in invasive species science. A strategic business plan for the Institute, to be completed by the end of 2004, will set forth a coordinating structure that facilitates the broadest possible consultation, cooperation and coordination in planning and implementing the Institute's research agenda. In view of the Institute's growing role in developing national capabilities in early detection, mapping, monitoring, forecasting and assessment, the Invasive Species Program will give top priority to providing the core scientific, technical, training and administrative staff in accordance with the Institute's business plan.

INNOVATIVE CONTROL METHODS

Goals Addressed: Control and Management, Effects of Invasive Species

The USGS invasive species program provides the DOI and other natural resource managers with scientific information on invasive species and effective methodologies to implement sound resource management actions to protect and conserve biological communities. The National Management Plan (Action 46) underscores the need for Federal research to address priority invasive species issues, including development and testing of control protocols, tools, and strategies to help prevent introduction and spread and support rapid response, restoration and containment strategies, including the evaluation of impacts from management activities. The increasing costs of combating an ever growing number of invaders in the U.S. will continue until additional methods and strategies are developed to achieve systemic and affordable control and, if possible, eradication. This USGS initiative will address the need for systemic control by expanding research on biological control, habitat management techniques, and integrated approaches using combinations of mechanical, chemical, and biological methods to support adaptive responses to invasions. In particular, the USGS will explore applications of recent advances in genetics, molecular biology and systematics, and genomics in identifying, evaluating, and monitoring invasive species populations, understanding their ecological interactions, and developing effective control and eradication methods. Research supporting the integrated assessments of invasive species will also be utilized in developing

control methods. This initiative will include technical assistance and training to enable DOI resource managers to effectively utilize the tools and approaches developed.

Special emphasis will continue to be given to species identified cooperatively by USGS and DOI partner bureaus and in DOI and NISC budget cross-cuts. From FY 2004 – 2006, USGS research has been initiated or proposed to support interagency initiatives for control of tamarisk in the southwest, leafy spurge in the Great Plains, Brazilian pepper tree in south Florida, nutria in Louisiana and the Chesapeake Bay region, Asian carp in the upper Mississippi River basin, and cactus moth in the southeast.

NATIONAL INVASIVE SPECIES INFORMATION NETWORK

Goals Addressed: Information Management

The development of an invasive species information network using the Internet is specifically referenced in the Invasive Species Executive Order and is a NISC priority. The Biological Informatics Program plays a key role in developing information standards and technologies to facilitate the availability and integration of invasive species data and information on nonindigenous plants, animals, and diseases in U.S. ecosystems through the NBII's Invasive Species Information Node. The program includes international cooperation in developing an invasive species database for the Western Hemisphere as an initiative of the Inter-American Biodiversity Information Network, and globally through the Global Invasive Species Information Network. These networks provide important support for early detection, forecasting, and assessment to help enable effective responses to invasions. Public Internet access to information from each of these networks is provided by the individual network through the NISC website (invasivespecies.gov).

The Invasive Species Program contributes to the Network primarily through development of databases at several USGS centers. These databases provide reliable information nationally on nonindigenous aquatic species and regionally on invaders in particular geographic areas (e.g., Hawaii, Four Corners area). The program also supports NIISS efforts to obtain and integrate invasive species and environmental datasets for use in mapping, modeling, and forecasting. As new taxa are introduced and the range of those previously established continues to increase, these databases facilitate precise tracking of their status and distribution for use in decision making and resource management.

INVASIVE SPECIES PROGRAM GOALS, OBJECTIVES, AND STRATEGIES

Following are the goals, objectives, and strategies recommended for implementation during the next five years. Proposed USGS strategies associated with NISC priority initiatives are italicized. Various strategies in the Plan are being implemented by the Biological Informatics Program as components of integrated initiatives with the Invasive Species Program.

PREVENTION

Major Initiative: Research on Priority Pathways

Program Goal 1: Conduct research and develop methods and technologies to prevent the introduction of invasive species.

Objective 1.1. Develop/improve/evaluate methods for management of priority pathways.

Strategy 1.1.1. Develop new technologies for ballast water management and methods for assessing effectiveness of shipboard treatment including research efforts to assist in the development and implementation of regulatory standards (NISC Action #16a).

Strategy 1.1.2. Conduct pathways analysis to identify which foreign ports/ship routes/seasons pose the greatest risk and contain species likely to successfully invade by virtue of seasonal patterns in densities of planktonic larvae likely to be entrained in ballast water at ports of origin.

Strategy 1.1.3. Evaluate the effects of major pathways for introduction and spread of invasive species in U.S. ecosystems, including socioeconomic factors: e.g., for horticulture, aquaculture, the bait trade, the pet trade, the live food industry, and landscape corridors (natural and man-made).

Strategy 1.1.4. Identify high-risk pathways that are not currently managed or are under-managed (NISC Action #17).

Objective 1.2. Support development of indices of potential invasiveness for species not yet established in U.S. ecosystems (based on available global data from native and introduced ranges). USGS information will increase public awareness of potential invaders, facilitate development and testing of screening for intentional introductions, assessment of effectiveness of voluntary codes of conduct, etc. (NISC #14, #46a).

Strategy 1.2.1. Conduct and implement cooperative research to support effective screening, for any purpose, of (a) nonindigenous species into Hawaii, Pacific & Caribbean territories; and (b) nonindigenous plants, land animals and aquatic organisms within the continental U.S. (NISC #15b-e).

Strategy 1.2.2. Initiate/expand research efforts and cooperation with source countries for introduction of new invasive species into the U.S., e.g., China, Russia & Ponto/Caspian region, South Africa, Australia/New Zealand, Canada/Mexico (NISC #44a-b)

Strategy 1.2.3. Conduct research on factors influencing species invasiveness and develop improved tools for assessment and management of probable threats (risk assessment/risk management).

EARLY DETECTION AND RAPID ASSESSMENT OF NEW INVADERS

Major Initiative: National Early Detection and Rapid Assessment System for New Invasive Species (Part of National Forecasting System)

Program Goal 2: Identify and report new invasions and assess risks to natural areas and waters.

Objective 2.1. Develop techniques and methods for detecting and reporting new invasions to natural areas and waters.

Strategy 2.1.1. Develop “user friendly” means for identifying and reporting occurrence of invasive species, including public-private partnerships for mapping high priority species (NISC #21d).

Strategy 2.1.2. Develop models and methods to detect incipient invasive species.

Strategy 2.1.3. Design and implement systematic monitoring of locations where introductions of invasive species are most likely to occur (NISC #21c).

Objective 2.2: Support rapid assessment and response for new invaders affecting U.S. ecosystems and native species.

Strategy 2.2.1. Provide scientific expertise and technical assistance to support assessment of new invaders and interagency rapid response teams (NISC #23a).

Strategy 2.2.2. Cooperatively develop a nationwide early detection network of trained professionals and volunteers (NISC Action #21.)

MONITORING AND FORECASTING OF ESTABLISHED INVADERS

Major Initiative (Parts of National Forecasting System):

- **Cooperative Multi-scale Monitoring of Nonindigenous Species**
- **Integrated Assessments of Invasive Species**
- **National Institute for Invasive Species Science**

Program Goal 3: Assess changes in populations and distributions of established invaders. In cooperation with the Status and Trends Program, the program will develop multi-scale monitoring and forecasting of established invasive species in U.S. ecosystems (by ecosystem and taxonomic groups).

Objective 3.1: Develop multi-scale monitoring, modeling and forecasting of established invasive species in U.S. ecoregions (by ecosystem and taxonomic group).

Strategy 3.1.1. Develop tools to assess risk of invasion and accurately predict an area's vulnerability to invasion.

Strategy 3.1.2. Develop and apply tools for multi-scale monitoring, modeling and analysis using a variety of remote sensing and field sampling methodologies to provide reliable information on the spread of invasive species in identified areas.

Strategy 3.1.3. Expand monitoring to support research on factors determining lag period between establishment and widespread invasion of priority invaders (NISC Action #46b.)

Strategy 3.1.4. Conduct ecoregional assessments of invasive species.

EFFECTS OF INVASIVE SPECIES

Major Initiatives: Research on Priority Pathways, Integrated Assessment of Invasive Species (Part of National Forecasting System)

Program Goal 4: Determine effects of invasive species and susceptibility of habitats to invasion.

Objective 4.1. Expand research on effects of priority invasive species on native species (including threatened and endangered species), habitats, and ecosystem functions (NISC Research #46c,d).

Strategy 4.1.1. Develop capabilities to assess the impacts of potential biological control agents on non-target species and habitats.

Strategy 4.1.2. Determine the potential effects of invaders on aquatic ecosystems and native communities and ESA⁹ listed aquatic species.

Strategy 4.1.3. Determine the potential effects of invaders on terrestrial ecosystems.

⁹ Endangered Species Act of 1973

Objective 4.2: Develop reliable methods for better understanding of the socio-economic impacts of invasive species.

Strategy 4.2.1. Develop capabilities to conduct economic analyses of high-priority non-native invaders.

CONTROL AND MANAGEMENT

Major Initiative: Innovative Control Methods for Priority Species

Program Goal 5: Provide approaches to contain, reduce, and eliminate populations of invasive species and restore habitats and native species.

Objective 5.1: Develop effective methods for control of priority invasive species threatening public lands and waters.

Strategy 5.1.1. Develop effective biological control measures.

Strategy 5.1.2. Develop innovative control measures including chemical, molecular and integrated approaches for controlling highly invasive species (NISC Action #46e).

Strategy 5.1.3. Develop invasive species control methods to break the fire-invasion cycle in western rangelands and monitor effectiveness of management treatments (NISC Actions #46c, d, e).

Strategy 5.1.4. Develop and test methods for control of invasive wildlife in coastal wetlands (NISC Action #46e).

Strategy 5.1.5. Develop and test methods for control of invasive plants in U.S. riparian habitats (NISC Action #46e).

Strategy 5.1.6. Develop methods for effective control of invasive organisms in U.S. aquatic systems (NISC Action #46e).

Strategy 5.1.7. Develop criteria for successful assessment and monitoring of lands that have been treated for invasive species (NISC Action #46e).

Objective 5.2: Gather information and provide technical assistance to support use of effective control/ management/eradication methods and evaluate options in varied environments and circumstances.

INFORMATION MANAGEMENT

Major Initiative: National Invasive Species Information Network – a partnership between the Invasive Species and Biological Informatics Programs.

Program Goal 6: Provide and coordinate the collection, synthesis, and accessibility of invasive species information.

Objective 6.1: Increase availability of data on nonindigenous species.

Strategy 6.1.1. Develop web-based tools to support accurate identification of invasive taxa.

Strategy 6.1.2. Develop *e*-government model with the public participating as both informant and user of information as part of a campaign for public outreach and education on the importance of ED/RR.

Strategy 6.1.3. Expand databases for major groups of nonindigenous and invasive species.

Strategy 6.1.4. Develop a distributed network of invasive species information that links USGS databases with Federal, state and international databases (including the Global Invasive Species Information Network) (NISC Action# 22).

Objective 6.2. Provide syntheses of invasive species information to guide policy and inform the public.

Strategy 6.2.1. Develop and publish information syntheses.

Objective 6.3. Facilitate user access to and interaction with the methods and tools developed through other program goals

Strategy 6.3.1. Provide technical assistance to resource managers in the use and application of methods and tools for early detection and monitoring of invasive species, with emphasis on DOI lands.

Implementing the Plan

Invasive species are a crosscutting issue requiring the participation of all USGS disciplines. In serving the needs of the diverse stakeholders with effective responses to the growing threats, the Invasive Species Program will need to rely on many USGS programs for information, tools, expertise, and facilities. The program will expand cooperation with other Biology programs that focus on native species, ecosystems, biological monitoring and assessment, and the effects of stressors, such as contaminants and climate change, on various

levels of biological organization. We will continue to integrate invasive species research with the development of a distributed invasive species information network through the NBII, including joint budget initiatives. Because research on invasive diseases of native species is conducted through other biological research programs (WTER, FAER), close cooperation with the planning, budget formulation, and implementation of these programs will be required. Cooperation with programs in other USGS disciplines will be essential in implementing particular program goals. For example, the capabilities of the Geography Discipline and the Geospatial Information Office in the applications of remote sensing, geographic information systems, and geospatial technologies are essential in providing reliable data to map and forecast the spread of invasive species. The Water Resource Discipline's programs on surface and groundwater resources provide essential data for understanding and predicting the spread and effects of aquatic and wetland invaders, and assessing alternative management responses. The Geology Discipline's research on coastal processes provides information for assessing the impacts of invasive species, such as the nutria, on coastal wildlife habitat.

The National Invasive Species Council (NISC) provides broad guidance for agency invasive species activities. As of mid-2004, the Council includes 12 Federal departments and agencies. NISC's National Invasive Species Management Plan identifies broad areas for interagency cooperation on invasive species and specific actions for near-term implementation by participating agencies. The majority of actions identify DOI as an implementing agency, and many explicitly or implicitly include USGS research and information components. The Council has established various permanent committees to coordinate agency efforts under broad areas of the plan, including a research committee, in which USGS participates.

The Invasive Species Advisory Committee (ISAC), appointed by the Secretary of the Interior under Executive Order 13112, has approximately 30 members representing a very broad range of stakeholders, including state and local governments, major economic interests (e.g., horticulture, pet trade), academia, and nongovernmental organizations. ISAC identifies opportunities and recommends priorities for consideration by the Council. Under ISAC, various task teams have been established to facilitate coordinated implementation of particular components of the National Invasive Species Management Plan. The Task Teams include representatives from DOI bureaus, including USGS, on teams where our research and development capabilities contribute.

Continuing interaction between USGS and the NISC/ISAC committees and Task Teams help facilitate interagency identification of annual NISC priorities which reflect consideration of the interests of both Federal agencies and the non-Federal stakeholders. For USGS, NISC priorities provide broad guidance from the Administration for implementing our Invasive Species Five-year Program Plan through the USGS planning process. NISC priorities also facilitate modification of the USGS Five-year Plan to reflect the changes in policies, the status of invasions and opportunities for effective responses.

USGS also participates in interagency committees that facilitate information exchange and coordination of the Plan with other Federal research and monitoring activities, relating to

particular topics or taxonomic groups of invasive organisms. Within USGS, NISC priorities are considered in identifying opportunities for USGS R&D through program redirection, leveraging funding from other USGS programs and outside sources, and budget increases. The USGS also considers priorities and opportunities for invasive species research identified by interagency programs, such as the U.S. Global Change Research Program and the Joint Fire Science Program. The Program Coordinator (PC) works with the coordinators of relevant USGS programs, the Regional Executives, and the USGS research centers, to identify opportunities for USGS contributions in furthering these national priorities through initiatives involving particular species, geographic areas, and research topics. The PC and Regions may use workshops, meetings, listserves, listening sessions with clients, etc., to explore particular opportunities in detail using, where appropriate, the auspices of the NISS (described below) to facilitate broad participation of specialists from within and outside the USGS. Priorities for coordination among USGS programs in addressing invasive species problems will be recommended at the annual fall meeting of Program Coordinators and Regional Executives, and in the Director's Annual Program Guidance.

Partnerships. As the primary science agency within the DOI, the USGS provides science support to DOI bureaus that are responsible for managing invasive species on Federal and tribal lands. In carrying out its mission, USGS cooperates with numerous other Federal and state agencies, counties, non-governmental organizations, and international partners, in addressing all types of invasive species that impact state and private lands. Increasing collaboration and partnering to meet the needs of new and traditional cooperators will be necessary as the USGS role in providing useful information and tools becomes more widely recognized. Because of their particular role in prevention and control of invaders, partnership with state natural resource agencies and state invasive species councils will become increasingly important.

As shown in the chart below, there is tremendous potential for expanding ongoing collaborative efforts to address the needs of traditional cooperators over the next five years. The Program will give particular attention to expanding cooperation with USDA, NOAA, NASA and other Federal agencies having particular research capabilities and facilities that complement those of USGS. Such partnerships will avoid costly duplication of effort and facilitate robust application of integrated science to invasive species issues. Opportunities will be explored through scientific bodies established through NISC, ANSTF, FICMNEW, ITAP or through forums to implement particular program goals. Efforts by NISC to coordinate an effective Federal response to invasive species provide opportunities for USGS to collaborate with non-traditional partners in developing new approaches for addressing invasive species threats.

USGS will also pursue research opportunities with other countries to obtain information on the distribution and ecology of invasive species in their native ranges and invaded areas in other parts of the world for use in models to forecast species invasiveness and habitat vulnerability in the U.S. Cooperative international research will also include identification of associated predators, pathogens, and parasites in these areas, which may facilitate control in the U.S. Particular emphasis will be placed on cooperative research with countries, such as Australia, with unique capabilities in particular areas of invasive species science, as well as

with U.S. trading partners in source regions having environmental conditions similar to parts of the U.S., such as Canada and Mexico, which share large ecoregions with the U.S., China, Russia and various Pacific Rim countries(especially on ballast water-related organisms and related technology development); and various countries in South America, especially Argentina and Brazil. International research will also be encouraged to support risk assessments of species not yet established in the U.S.

Cooperator	USGS Program Goals						Principal Focus
	Prevention	Early Detection & Rapid Assessment of New Invaders	Monitoring and Forecasting of Established Invaders	Innovative Control and Management	Effects	Information Management	
U.S. Department of the Interior							
BIA		P	X			X	Tribal lands, invasive plants
BLM		X	X	X	X	X	Western rangelands, invasive plants, decision support
BOR	P	X	X	X	X	X	Rivers & dams, invasive plants, decision support, interbasin transfers
FWS	P	X	X	X	X	X	FWS refuges, invasive plants, aquatic invaders, decision support
NPS		X	X	X	X	X	National parks, invasive plants, decision support
U.S. Department of Agriculture							
APHIS	P	P	X			P	Private lands, early detection, ornamental plants, insect pests
ARS		P	X	X	P	P	Various taxa, biological control
CSREES		P	P	P		P	Private lands, early detection, monitoring, various taxa, diagnostics
ERS						P	Economic assessment methods
FS		X	X	X	X	X	National Forest System, forest pests and pathogens
NRCS		X	X			X	Private lands, national plant database, ED/RR & Monitoring
U.S. Department of Commerce							
NOAA NOS	X	X	X		X	X	Marine Waters, aquatic taxa, ED/RR, monitoring
NOAA NERRS		X	X	X	X		Estuaries, aquatic taxa, ED/RR, monitoring, effects.
U.S. Department of Defense							
COE		P	X	P	X	X	Navigable Waterways, aquatic

							species, monitoring, control methods, management info.
AFPMB		X	X	X		X	Military Reservations, various taxa
Other Federal Agencies							
DOS	X					X	Foreign Countries
NASA		X	X			X	Modeling & forecasting
USCG	X			X			Ballast water treatment technology and standards development
U.S. EPA		X	X	X		X	Monitoring & effects research
Smithsonian Institution		X	X			X	Marine taxa, ED/RR, monitoring, database
Other Domestic Partners							
State Agencies	X	X	X	X	X	X	All lands, ED/RR monitoring, control, various taxa
TNC		P	P				Private conservation lands, invasive plants
NatureServe		X	X		P	X	Private lands, all taxa, heritage databases
Primary International Partners							
Australia	P	X	P	P	P	X	Information exchange, screening, ED/RR, innovative control technologies
Canada		X	X	X	X	X	Information exchange, ED/RR monitoring, mostly Great Lakes
China	P	P	P	P	P	X	Information exchange, various taxa
Mexico		P	P			X	Information exchange, ED/RR, monitoring & forecasting various taxa
New Zealand	P	X	P	P	P	X	Information exchange, screening, ED/RR, various taxa
Russia	P	P	P	P	P	X	Information exchange, aquatic taxa, monitoring & control
W. Hemisphere (IABIN)						X	Information exchange, all taxa
Great Lakes Fishery Commission	P	P	X	X			Sea lamprey control, asian carp response

Key: AFPMB (Armed Forces Pest Management Board), APHIS (Animal and Plant Health Inspection Service), ARS (Agricultural Research Service), BIA (Bureau of Indian Affairs), BLM (Bureau of Land Management), BOR (Bureau of Reclamation), COE (Army Corps of Engineers), CSREES (Cooperative State Research, Education and Extension Service), DOS (Department of State), EPA (Environmental Protection Agency), ERS (Economic Research Service), FWS (Fish and Wildlife Service), NASA (National Aeronautics and Space Administration), NRCS (Natural Resources Conservation Service), NOAA – NOS – NERRS (National Oceanic

and Atmospheric Administration – National Ocean Service; National Estuarine Research Reserve System), TNC (The Nature Conservancy), USCG (Coast Guard – Department of Homeland Security). **P** (Potential), **X** Existing)

Opportunities for Integration of USGS Science. Because biological invasions are both a cause and a result of environmental changes, understanding and predicting invasions requires information on the complex factor interactions that influence these changes. Invasive species are therefore a cross-cutting issue that provides opportunities for integration of the capabilities of many USGS programs. In fact, the majority of USGS programs are either existing or potential cooperators in invasive species research. Particularly relevant programs and the nature of their existing or potential contributions to invasive species research are listed below.

Discipline/Program		Contributions to Invasive Species Research
Biology	Biological Informatics	Information standards, taxonomic information, information management, internet technologies, reporting systems for ED/RR
	Contaminant Biology	Effects of contaminants on invasion processes, effects of invaders on accumulation and cycling
	Cooperative Research Units	Outreach to state natural resource agencies; access to university research capabilities for addressing invasive species threats
	Terrestrial, Freshwater, and Marine Ecosystems	Effects of multi-factor interactions, including invasive species, on ecosystem processes, restoration, and adaptive management. Coordination with national fire science and global change research programs
	Fisheries: Aquatic and Endangered Resources	Effects of invasions on native aquatic biota, including special status species
	Status and Trends of Biological Resources	Mapping, monitoring and assessment methods for all levels of biological diversity; analysis of biological trends influencing invasions
	Wildlife: Terrestrial and Endangered Resources	Effects of invasions on native terrestrial biota, including special status species
Geography	Land Remote Sensing	Applications of remote sensing data and technologies in mapping and monitoring invasions
	Geographic Analysis and Monitoring	Methods for monitoring, analysis, modeling, and predicting land surface change influencing invasions
Geology	Coastal and Marine Geology	Effects of coastal processes influencing invasions
	Earth Surface Dynamics	Monitoring, modeling and forecasting earth surface processes and disturbances influencing invasions

	National Cooperative Geologic Mapping	Geological data for mapping, monitoring, modeling and forecasting invasions
Water Resources	Ground Water Resources	Ground water data for mapping, monitoring, modeling and forecasting invasions, especially in wetlands & riparian areas
	Hydrological Research and Development	Effects of interacting hydrological factors influencing invader establishment and spread
	National Water Quality Assessment	Data on water quality conditions and trends for use in mapping, monitoring, modeling and forecasting invasions

Program Review

The program is reviewed on many levels to ensure that products reflect national priorities, meet stakeholder needs, and maintain high scientific and technical standards. Within USGS, the Program Coordinator (PC) oversees program accomplishments in achieving national program goals and objectives. In cooperation with invasive species contacts in each regional office and participating research centers, the PC prepares an annual report at the beginning of each calendar year highlighting, for each research center, the significant accomplishments for the previous year and proposed initiatives for the current year and recommendations for future research directions. The report helps keep the Department, OMB, NISC, and our partners and customers, informed, and facilitates consultation and coordination on research issues and program directions. Federal interagency committees (NISC working groups, CENR Subcommittee on Ecological Systems, and committees concerned with invasive plants (FICMNEW), terrestrial animals and pathogens (ITAP), and aquatic species (ANSTF)), periodically review particular components of the program and provide input on future directions and opportunities for interagency initiatives.

The program is due for external review in 2005 based on the nominal five-year review cycle. However, it is suggested that the utility of this review would be improved by conducting the review in late 2006 or early 2007 in order to facilitate evaluation of the new directions initiated in the five-year plan and progress in achieving desired outcomes.

Communication and Outreach

Communication and outreach efforts related to invasive species are critical to the success of the Invasive Species Program. Efforts must be directed toward a variety of audiences in multiple formats such as public displays, web sites, fact sheets, scientific circulars, scientific journals, and other media (videos, etc.). Information disseminated will include technical and scientific reports as well as publications that convey scientific information to the general public. The Program web site provides the primary vehicle for general communication on program accomplishments, ongoing activities, and plans. The National Program Staff must

provide frequent updating to ensure the accuracy and timeliness of information. The Invasive Species Program will work closely with the Office of Communications to leverage efforts to educate the public about the role of the USGS and invasive species issues in general. The Invasive Species Program will also work with NISC and other partners in these efforts.

Workforce Planning

Workforce planning should aim to expand the USGS capacity to achieve the goals of the 5-year program plan in facilitating effective responses to all taxonomic groups of invaders. Plant insect pests and pathogens are major and growing threats in most U.S. ecoregions. The USGS needs to expand its capacity in entomology and plant pathology to help clients address these invaders, and to interact effectively with USDA and the academic community in developing research partnerships. Our capacity to investigate the genetics, physiology, and ecology of invasive plants needs to be strengthened, especially in the Eastern Region. Additional capacity is also required to investigate soil factors, such as mycorrhizal associations, that are increasingly implicated in plant invasions, as well as the poorly known impacts of invasive soil organisms. There is also a need to develop capacity to conduct research on the ecosystem roles of invertebrates and microbial species.

USGS must continue to strengthen its longstanding leadership in addressing invasions in freshwater ecosystems. Various USGS research centers have plans to increase their contributions to particular areas of invasive species science. The coordinated development of these capabilities is a top priority, with the goal of establishing a national network of cooperating centers for the study of aquatic invasions that covers all program goals and all regions. Workforce planning efforts in research centers should include recommendations for strengthening existing USGS capacities in applications of genetics, molecular tools and genomics in assessment and control of invasions (Leetown Science Center [LSC] and National Wetlands Research Center [NWRC]), innovative control methods (Columbia Environmental Research Center [CERC], Upper Midwest Environmental Sciences Center [UMESC]); information synthesis, forecasting and assessment (Florida Integrated Science Center [FISC], UMESC [in cooperation with the NIISS]); socioeconomic analysis and modeling to support integrated assessments and effective response strategies (FORT), ballast water technology and pathway research (Western Fisheries Research Center [WFRC] and LSC), and in the ecology and control of invasions in the Great Lakes (Great Lakes Science Center), the northeast (LSC), southeast (FISC, NWRC), midwest river systems (CERC, UMESC), and the Pacific Northwest (WFRC), and to develop programs for aquatic invaders in the southwest and Hawaii. Staffing for the National Nonindigenous Aquatic Species Database (FISC) should be increased, including support for an increased role in developing protocols for early detection and monitoring in aquatic ecosystems.

The NIISS should be staffed and operated in accordance with an approved business plan to develop a core national capability to support early detection, monitoring, modeling and forecasting, and integrated assessments of invasions in U.S. ecosystems, and provide related technical assistance and training to DOI resource managers and other clients. Development of this capability would include designation of coordinators for particular taxa and regions, who

would be based at USGS research centers with particular capabilities to support development of a National Invasive Species Forecasting System. These specialists would help leverage USGS and outside research and technical capabilities (e.g., with USDA and NOAA), and provide technical assistance to DOI bureaus and state and regional partnerships, such as the Invasive Plant Atlas of New England, in developing early detection, mapping, monitoring, forecasting and assessment capabilities, with initial emphasis on invasive plants. The first regional coordinator position was established in 2004 at the National Wetlands Research Center to facilitate development of these capabilities in the northern gulf/southeast region. Additional positions would be established as resources are available to gradually build out the System to include additional regions and taxonomic groups. The Invasive Species Program will cooperate with the Biological Informatics Program to ensure adequate staffing to support the Institute's role in facilitating the contributions of NBII's ISIN to supports these research activities.

Headquarters Staff (Program Development)

Headquarters program staff play a key role in developing a focused program that meets the needs of clients but also complements the efforts of other Federal research agencies involved with invasive species research. The Headquarters program staff should include individuals well versed in invasive species policy issues, the roles and responsibilities of interested agencies and organizations, and opportunities for applications of invasive species science and technologies to meet the needs of DOI resource managers and American society. The staff should include individuals who can represent USGS science with respect to the major taxonomic groups that must be included in the invasive species program (i.e., terrestrial plants, vertebrates and invertebrates; plant pests and pathogens, and aquatic invasive species) and major national and international initiatives, such as developing an early detection, assessment, and forecasting system. At full staffing, the core program staff consists of the Program Coordinator, Assistant Program Coordinator, and Program Assistant.

Facilities

While invasive species research generally requires facilities and equipment similar to those required for the study of native species, some invasive species work requires specialized quarantine, containment and disinfection facilities to ensure that the research does not contribute to the spread of invasive organisms. Much of the proposed USGS invasive species research can be done on site at existing USGS research centers. However, additional facilities and equipment will be needed to implement some of the initiatives described in the 5-year plan to support effective responses to the growing number of invasive species in U.S. ecosystems. Additional investments in facilities will be needed to support the increasing USGS role in developing and assessing prevention technologies, rapid assessment of new invaders, modeling and forecasting, and the development of innovative control methods. Areas of particular opportunity include:

- Facilities for mesocosm studies of ballast water treatment effectiveness

- Greenhouse and growth chamber facilities to support determinations of environmental requirements of invasive species (ecological range studies)
- Quarantine facilities to support research on existing and new invaders and biological control agents
- Modern biotechnology facilities for research to document, understand, and control invasive species populations, with initial emphasis on freshwater aquatic species
- Remote sensing technologies for high resolution mapping of invasions
- Continued development of supercomputing capabilities to support forecasting and assessment of invasions.

Budget Strategy

Despite efforts to plan for systematic growth, the invasive species program will likely be influenced by rapidly changing conditions that influence public concerns. New invaders, or established invaders that suddenly emerge from obscurity, often significantly influence budget priorities -- especially if the invaders pose significant economic or public health threats. The program must be poised to respond to these emergent threats and take advantage of opportunities to effectively utilize USGS research capabilities in cooperative response efforts.

The USGS has participated fully with NISC in the development of an interagency/interdepartmental crosscut budget on invasive species since 2004. The establishment of the crosscut budget process has facilitated the development of performance-based initiatives integrated across agencies. These crosscut budgets include proposed agency funding increases for new initiatives as well as base funding that is being utilized or reallocated to address issues identified as high priority by multiple agencies/departments.

For planning purposes, outyear (FY 2006 – 2009) growth in the program is assumed to continue at a rate not less than \$1M annually, representing a cumulative increase of roughly 57% above the 2004 enacted funding level, recognizing that significantly greater investment would be needed to fully develop the major national initiatives in this plan.

The increases will address the initiatives described in the previous chapter including the following:

FY 2004 – \$2 million increase (enacted)

- Initiation of all taxa Early Detection and Rapid Assessment System, including regional pilot projects, with a major emphasis on plants (part of the increase was earmarked to Mississippi State University where a cooperatively developed work plan includes ED/RA¹⁰ strategies primarily in mid-South Region. It is anticipated that this funding will be available to expand ED/RA efforts to other regions in the outyears). The initiative will include funding for rapid assessments of new invaders by teams of specialists from USGS and partner entities (coordinated through NIISS).
- Aquatic area monitoring and database development to support ED efforts

¹⁰ Early Detection and Rapid Assessment

- Species-specific focus on control of nutria and tamarisk (both the focus of recent legislation), including support for a DOI-effort to forecast and map tamarisk invasions.
- Ballast water technology testing and research to support the development of standards. Provide base funding for development of a long-term ballast water research project.

FY 2005 - \$1 million increase (proposed)

- Conduct research to support the development of innovative control methods for aquatic invaders, with emphasis on Asian Carp and other highly invasive fresh water aquatic species in the Mississippi River System.
- Conduct additional research to prevent and control the Brown Tree Snake.

FY 2006 – 2009 – Program Increases (undetermined)

- Work with other DOI agencies to implement new crosscut initiatives for tamarisk, leafy spurge/yellow star thistle, and Brazilian pepper tree
- Develop USGS capabilities to cooperate effectively with USDA to prevent the spread of cactus moth from existing invasion fronts in the southeast.
- Develop a research initiative to support screening of proposed importations of invasive species into the U.S. This has been identified within the National Invasive Species Management Plan as a high priority action that must be undertaken to prevent the introduction of additional invasive species into U.S. ecosystems. Special emphasis on Hawaii (e.g., methods for preventing introduction of fire ants).
- Support phased development of the National Forecasting System through NIISS including:
 - Develop modeling and forecasting abilities to support assessments of new invasive plants, fish, reptiles, amphibians and mammals.
 - Develop methods for integrating socioeconomic data into forecasting models for assessing invasive species and their pathways for introduction and spread in U.S. ecosystems.
 - Initiate integrated assessments of invasions in selected U.S. ecoregions, evaluating introduction/establishment, impacts, and effectiveness of response strategies by ecosystems and taxonomic groups.
- Conduct research on the development of innovative control methods for invasive terrestrial vertebrates.
- Upgrade facilities to support research to develop methods and technologies for prevention and control of invasive species and to prevent accidental releases to the environment.

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APPENDIX A MEMBERS OF THE INVASIVE SPECIES PLANNING TEAM

William P. Gregg – Invasive Species Program Coordinator, Headquarters (chair)

Pam Fuller – Research Biologist, Florida Integrated Science Center

Leslie E. Holland-Bartels – Deputy Regional Director, Alaska Science Center

Lloyd L. Loope – Research Biologist, Pacific Islands Ecological Research Center

Jeffrey E. Lovich – Chief, Flagstaff Field Center, Southwest Biological Research Center

Michael J. Mac – Director, Columbia Environmental Research Center

James R. Winton – Microbiologist, Western Fisheries Research Center

Thomas E. Stohlgren – Ecologist, Fort Collins Science Center

Randy G. Westbrooks – Invasive Plant Specialist, National Wetlands Research Center

APPENDIX B CAPABILITIES OF USGS RESEARCH CENTERS

Alaska Science Center, Anchorage, AK

The Alaska Science Center (ASC) plays a pivotal role in conducting research on fish, wildlife, and their vast habitats in Alaska. Nearly 88% of all National Wildlife Refuge and 65% of all National Park lands are in Alaska. ASC is responsible for research on the DOI trust lands, waters, and species in Alaska, and provides scientific information essential for resource management decisions. Alaska's National Parks have few invasive species compared to National Park units in other states. Therefore, the primary objective of the ASC invasive species project is to assist the National Park Service (NPS) in maintaining this relatively pristine gene pool, and to provide ED/RR capabilities when new invaders are observed.

Columbia Environmental Research Center, Columbia, MO

The Columbia Environmental Research Center (CERC) provides scientific information and methodologies for addressing national and international environmental contaminant issues, and assessing the ecological effects of toxic substances and habitat alterations, with emphasis on large-river floodplains, coastal habitats, wetlands, and lakes. As a national leader in integrated research on aquatic ecosystems, CERC is currently investigating the impacts of a number of invasive non-native fish including big head and silver carp, rainbow smelt, alewife, and black carp.

Center for Aquatic Resource Studies, Gainesville, FL

The Center for Aquatic Resource Studies (CARS) is a premier organization researching and disseminating information on invasive aquatic species and other nonindigenous organisms. The main facility of CARS, located in Gainesville, was founded specifically to be a major leader in what is now called invasive species research. A significant part of the original mission was to conduct field and laboratory studies of non-native fishes and to create and maintain a georeferenced database on aquatic organisms introduced into the United States. Goals of the CARS nonindigenous species program are to: 1) document the distribution, abundance, and dispersal of introduced organisms; 2) conduct integrated field and laboratory studies on the ecology and effects of introductions; 3) analyze life history attributes to identify potential management and control measures; 4) assess risks of current and proposed introductions, and 5) support DOI mission, other USGS programs, the South Florida Restoration effort, and other major Federal initiatives. In particular, CARS scientists play a special role in public education and outreach and technical assistance, as they are called upon hundreds of times each year to provide positive identification of exotic fishes and plants, for information on occurrence verification, distribution maps and inventories, and for presentations at professional and public meetings.

Forest and Rangeland Ecosystem Science Center, Corvallis, OR

Invasive species threaten millions of acres of terrestrial and aquatic ecosystems in the western United States. They reduce the economic potential of these areas by decreasing forage and habitat for livestock and wildlife, threaten native amphibian and fish populations, impact recreational opportunities, and threaten the natural environment of public lands. The Forest &

Rangeland Ecosystem Science Center (FRESC) collaborates with university and Federal research scientists and state and Federal land managers to develop research on major invasive species problems. Current emphasis is on the effects of invasive plants on arid and semiarid ecosystems, and of invasive fish and frogs on native amphibians in lakes, ponds and wetlands.

Fort Collins Science Center, Fort Collins, CO

The Fort Collins Science Center's (FORT) Invasive Species Program staff provide research and technical assistance relating to invasive species management concerns, including understanding how these species are introduced, identifying vulnerable areas, forecasting invasions, and developing control methods. To disseminate this information, FORT scientists are partners in developing the ISIN of the NBII, a comprehensive, accessible database of invasive species of plants, animals, and disease agents. From these data, and in partnership with Colorado State University, the National Aeronautic Space Administration (NASA), and others, FORT scientists are constructing models to understand and predict invasive species behavior for more effective management. FORT is also the administrative home of the NIISS, a growing consortium of partnership focusing on information management, research, modeling and forecasting, technical assistance and outreach.

Great Lakes Science Center, Ann Arbor, MI

The Great Lakes Science Center (GSLC) conducts a combination of field, laboratory, and modeling studies to provide information pertinent to prevention, containment, and control of invasive species. More than 160 invasive species have been documented in Great Lakes aquatic and wetland communities with many more known on lands throughout the watershed. Economic losses because of invasive species, such as the sea lamprey and zebra mussel, are in the tens of million of dollars annually.

Leetown Science Center, Leetown, WV

The Leetown Science Center (LSC) conducts research to provide information needed to restore, enhance, maintain and protect fish and other important aquatic and terrestrial organisms and their supporting ecosystems. Invasive species research at LSC focuses on use of molecular genetics to determine invasion history, current population structure and the use of real time PCR to identify DNA of invasive species in ballast water; development of ballast water control technologies; development of databases to track invasive species and GIS-based models and systems to detect early invasions; detection and evaluation of invasive "genotypes"; detection, evaluation and control of invasive pathogens; evaluation of species at risk from invasions; and impacts of terrestrial invasives on aquatic ecosystems. Research emphasizes partnerships with Federal and state agencies while also addressing regional issues of specific importance on public lands.

National Wetlands Research Center, Lafayette, LA

The USGS National Wetlands Research Center's (NWRC) mission is to develop and disseminate the scientific information needed to understand wetland and coastal ecology, as well as manage and restore the nation's wetland habitats. Invasive plants and animals have been recognized as playing a large part in the loss of wetland and coastal habitats. NWRC has been researching the impacts of exotic grasses on native plants and investigating the interactions between wild land fires and exotic invasive plants. NWRC scientists are also

leading a national effort to map and develop control methods for nutria, an invasive wetland mammal.

National Wildlife Health Center, Madison, WI

The National Wildlife Health Center (NWHC) was created in 1975 in large part in response to a wildlife disease (duck plague) introduced to North America, as well to increasing recognition of the changing patterns and emergence of North American wildlife diseases. NWHC provides technical assistance to Federal, state, and other domestic and foreign agencies in the diagnosis and control of wildlife disease outbreaks, conducts research on the epizootiology and ecology of wildlife diseases leading to an understanding of their impact and methods to control and prevent them, disseminates information on wildlife diseases, and provides training to wildlife officials.

Northern Prairie Wildlife Research Center, Jamestown, ND

The Northern Prairie Wildlife Research Center's (NPWRC) mission is to study the biological resources of the nation's interior grasslands and provide information needed by decision-makers to assess and predict the consequences of various policies and management practices. As a part of this mission, NPWRC's scientists conduct projects on all aspects of grassland ecology, including birds, mammals, plants, invertebrates, and amphibians, as well as disturbance ecology, prairie restoration, and control of invasive species.

Northern Rocky Mountain Science Center, Bozeman, MT

The Northern Rocky Mountain Science Center (NRMSC) conducts research in support of natural resources management in the mountains and plains of Montana, Wyoming and Idaho. NRMSC produces and disseminates scientific information needed for decision-making in collaboration with Federal and state land management agencies, Native American tribes, academic institutions, and organizations. Non-native and invasive plants, animals and diseases strongly impact the natural resources of the region in ways that affect all of these demands. The Center's current research on invasive plants addresses the effects of wildfire severity, coalbed methane extraction, and off-road vehicle use on native and non-native vegetation. Non-native disease work is focused on chronic wasting disease, whirling disease and brucellosis. In addition to research specific to non-native species, research on fishes, amphibians, large mammals, and global change all include opportunities for non-native species research as such species alter ecological systems and enter into feedback processes.

Pacific Island Ecosystems Research Center, Honolulu, HI

Almost all of the Pacific Island Ecosystems Research Center's (PIERC) work involves invasive species directly or indirectly, with the aim of protecting federally important resources, national parks and endangered species in Hawaii and the Pacific. Because of the evolution of endemic plants and animals in isolation, Hawaii and other Pacific Islands are much more vulnerable to invasions than most places in the U.S. More native species have been eliminated in Hawaii than anywhere else in the U.S. Although habitat destruction has been an important cause of extinction and endangerment, the introduction of invasive alien species has contributed in a major way in the past and is now the predominant cause of biodiversity loss in Hawaii. Other Pacific Islands, with less international commerce, have suffered less to date but have much to lose. PIERC works closely with the Pacific Basin

Information Node (PBIN) of NBII to make invasive species information available electronically to a broad audience.

Patuxent Wildlife Research Center, Laurel, MD

The Patuxent Wildlife Research Center's (PWRC) emphasis is on monitoring the status and trends of wildlife populations, restoring and maintaining wetlands and other ecological systems, and assessing the effects of natural and human impacts on biological resources. A core research focus is on the population biology and dynamics of migratory birds. Current research on invasive species focuses on the National Parks in the mid- and north-Atlantic regions, and on the population dynamics of the brown-headed cowbird.

Upper Midwest Environmental Sciences Center, La Crosse, WI

The Upper Midwest Environmental Sciences Center's (UMESC) mission is to produce information needed for management of biological resources, with emphasis on the ecosystems of the Great Lakes and Upper and Middle Mississippi River basin. The UMESC's core research programs focus on migratory birds, aquatic ecosystems, environmental contaminants, declining and endangered species, and fishery drug research and development, and include research on the effects and control of a number of invasive species. Center scientists have been involved in researching chemicals to control invasive aquatic fishes for decades. Control of sea lamprey populations in the Great Lakes has been particularly important. The invasive species program at UMESC has expanded beyond its traditional role of supporting chemical management programs for invasive species by actively seeking opportunities to address a variety of invasive species issues, particularly in the Great Lakes and Upper Mississippi Basins.

Western Ecological Research Center, Sacramento, CA

Nonnative plant species infest an estimated 4,600 new acres of Federal land each day. The Western Ecological Research Center (WERC) conducts research that will improve the ability to detect, monitor, and predict the effects of invasive species in California and Nevada, a region characterized by remarkable biodiversity in an unparalleled range of environments. The projects address critical needs in California's Central Valley, the Mojave and Sonoran deserts, selected national parks, and other sensitive areas. This research provides resource managers with the information and tools needed to better understand and control invasive weeds on the land they manage and to help them avoid or prevent future invasions. WERC is also conducting research on selected aquatic invaders as well.

Western Fisheries Research Center, Seattle, WA

The Western Fisheries Research Center (WFRC) conducts research and provides technical assistance to support the best possible stewardship of the nation's natural resources, emphasizing fish health, fish ecology, and aquatic ecosystems in the West. WFRC provides reliable science for its DOI partners and is working with other investigators nationwide associated with the Invasive Species Program to conduct research to characterize mechanisms of invasiveness, predict and assess risks, prevent and control invasions, focus on coastal/marine environments, and reduce risks from ballast water, microbial pathogens, and parasites. Research has focused on exotic fish pathogens, the interactions between invasive and native species, and ballast water treatment.

National Biological Information Infrastructure

The National Biological Information Infrastructure (NBII) <<http://www.nbio.gov>> is a broad, collaborative program to provide increased access to data and information on the nation's biological resources. The NBII links diverse, high-quality biological databases, information products, and analytical tools maintained by NBII partners and other contributors in government agencies, academic institutions, non-government organizations, and private industry. NBII partners and collaborators also work on new standards, tools, and technologies that make it easier to find, integrate, and apply biological resources information.