Compendium of Challenge Summaries

This compendium contains four challenge summaries, one for each of the challenges that are at the heart of the *Future Challenges Project*, which the U.S. Geological Survey and U.S. Fish and Wildlife Service initiated during the summer of 2004. The four challenges are:

Global Climate Change

Biotechnology

Water for Ecological Needs

Invasive Species

The summaries are not intended to be comprehensive descriptions of how global change, biotechnology, water for ecological needs, and invasive species are likely to affect biodiversity and alter ecosystem function and structure. Rather, they focus on effects that are most relevant to the missions and responsibilities of the USGS and FWS. Likewise, they focus on actions the two bureaus can take to address the potential effects of global change, biotechnology, water for ecological needs, and invasive species on fish and wildlife resources and their habitats. As such, the primary purpose of the challenge summaries is to promote additional dialogue about strategies and actions the bureaus can use to address these challenges.

The summaries contain information that was generated during the *Future Challenges* workshop the bureaus sponsored in August of 2004, at the Service's National Conservation Training Center at Shepardstown, West Virginia. In addition, they contain information that the project planning team wanted to distribute to employees of both bureaus and to partners and stakeholders who will participate in additional discussions and workshops in 2005 during the next phase of the *Future Challenges Project*.

Global Climate Change[1]

Changes in atmospheric composition (especially increased concentrations of greenhouse gases) have the potential to alter the radiative balance of the earth's atmosphere, so changing regional and global climates and affecting natural flows of energy and materials underpinning ecosystem processes. For example, average global temperatures are hypothesized to increase from 1 to 5°C in the next century, with the greatest increases occurring in the mid to high latitudes of the northern hemisphere. The rate of temperature increase is unprecedented in the geologic and instrumental record and is likely to exacerbate existing stresses on ecosystems from land use change, invasive species, and extinctions, possibly leading to a non-linear response of ecosystems to climate change. The impact of climate change is predicted to vary regionally and may include increased magnitude and frequency of extreme events (floods, droughts); melting of permafrost, ice sheets and glaciers; sea level rise associated with melting glaciers; and changes in vegetation type and structure leading to habitat loss and/or change in the spatial distribution of biomes and loss of biodiversity. Climate change is likely to cause significant and widespread changes in the distribution of plant and animal species. In general, ranges of terrestrial species are expected to shift northward and to higher elevations, although species will vary in their ability to successfully change their ranges. Less mobile species and those with very specific habitat requirements may be extirpated. The composition of ecological communities will likely change, with unknown consequences for community function. Changes in phenology independent of photoperiod could lead to decoupling of beneficial interspecies relationships.

Some habitats and regions are expected to be particularly affected by climate change. For example, sea-level rise associated with melting ice and thermal expansion of oceans may cause inundation of coastal wetlands. In some inland areas, increased temperatures and decreased precipitation could lead to larger and more frequent forest fires and increased prevalence of insect-pest infestations. Altered hydrologic cycles could cause lowering of lake levels and loss of wetlands, with potentially widespread negative effects on aquatic species. In general, ecosystems and species already experiencing environmental stressors (e.g., anthropogenic habitat fragmentation and infestations of exotic species) may be less resilient and more vulnerable to adverse effects of climate change. Climate change effects may alter these stresses in ways that give rise to new thresholds of ecosystem response.

High latitudes are expected to experience the most rapid and severe changes. Potential effects include extirpation or extinction of some ice-associated species (e.g., polar bears) and other arctic specialists (e.g., some mosses and lichens), permafrost thawing and alteration of fresh-water habitats, and vegetation shifts (e.g., encroachment of tall shrubs and forests on tundra). There is mounting evidence that many of these effects are already being expressed at high latitudes. Further, reduced surface reflectivity associated with loss of sea ice and vegetation change is expected to amplify warming in these regions.

Potential synergisms between changing precipitation and temperature regimes and other ecological stressors are anticipated, which complicates prediction of effects of climate change. Accurate prediction is further complicated by inherent uncertainties in global climate models.

[1] The first part of this challenge summary describes how global climate change is expected to affect fish and wildlife resources and their habitats. The second part explains the responsibilities of the U.S. Geological Survey and U.S. Fish and Wildlife Service and how both bureaus can address the effects of climate change.

Fish and Wildlife Service

The mission of the Fish and Wildlife Service (Service) is to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the benefit of people. The Service manages a system of 544 National Wildlife Refuges comprising over 96 million acres, many established to protect important habitats or species. The Service also has responsibility for protecting trust resources, including (but not limited to) migratory birds, certain subsistence resources, interjurisdictional fishes, wetlands, listed species, and some marine mammals. In addition to refuges, other Service divisions and programs responsible for protection of trust resources include Fishery Resources, Subsistence Management, Migratory Bird Management, Marine Mammals Management, Habitat Conservation, Environmental Contaminants, and Endangered Species. To a large degree, the mission success of the Service has historically depended on management of relatively stable ecosystems. Global climate change presents a significant challenge to this paradigm, and is likely to require a different approach in implementing the mission of the Service.

Accomplishment of the Service's mission and responsibilities will require increasingly flexible and innovative approaches given the rapidly changing and variable climate predicted for the 21st century. Shifting plant and animal ranges, novel interspecies associations, and the emergence of new pests and diseases are just a few of the challenges that biologists and managers will face. Managers must increasingly adopt an adaptive approach to decision making. It will be necessary for biologists and decision-makers to become more proficient at describing and accepting scientific uncertainty, and in conducting risk analyses. Enhanced partnerships with landowners and strategic land acquisitions will likely be required to sustain populations of plants and animals facing changing climatic conditions.

It will be critical that predictive climate models continue to be developed and refined to reduce uncertainty. Further, these models should be scaled down to predict effects at the ecosystem and species levels, and the influence of potentially synergistic environmental stressors should be evaluated. Refinement and testing of models will require extensive monitoring data, which can be collected on Service lands. Service biologists and managers should work cooperatively with climate modelers and others in the scientific community. It will be important to continue to build scientific capacity within the Service to develop and implement flexible, adaptive management plans. It will also be essential to develop efficient means to manage large amounts of disparate data and to disseminate information effectively to scientists, decision-makers, and the public.

U.S. Geological Survey

The mission of the USGS is to provide reliable scientific information on the characteristics of the Earth, minimize the impacts of natural disasters, and manage the nation's resources. As discussed above, climate change would significantly alter the characteristics of the Earth and impact the nation's biological resources.

The USGS supports multidisciplinary studies of past environmental and climatic changes (climate history); process studies that explore the sensitivity of the earth-surface, the hydrologic cycle, and ecosystems to climate variability; and forecasting of potential future changes and their effects on landscapes and ecosystems (particularly on public lands). The combination of these studies provides integrated long-term perspectives on the effects of climatic change and variability and on the interactions through time among climatic, geologic, and biologic systems on regional and landscape scales.

- The Earth Surfaces Program of the Geologic Discipline conducts research on past climate variability and change and the impacts of climate change on landscapes and ecosystems.

- The Water Resources Discipline maintains a network of stream gages that can provide information to monitor the effects of changes in climate on water resources and conducts research on carbon cycle dynamics, hydroclimatic processes, and the response of the components of the hydrologic cycle to climate change.

- The Biological Resources Discipline addresses a variety of issues related to the impact of climate change on organisms and ecosystems, as well as assessing the status and trends of biological resources and predicting their responses to causal agents, such as climate change. It also maintains the National Biological Information Infrastructure (NBII), a collaborative program seeking to consolidate and disseminate information on the status of the species present in the country.

- The Geography Discipline conducts research directed to understand the rates, causes, and consequences of landscape change over time, as well as archiving and disseminating the remotely sensed images required for such research. The resulting knowledge is used to model processes of landscape change and to forecast future conditions. Studies are designed to document and understand the nature and causes of changes occurring on the land surface; the impacts of land surface changes (including urbanization) on ecosystems, climate variability, biogeochemical cycles, hydrology, and human health, and to develop the best methods of incorporating science findings in the decision making process.

Biotechnology[2]

In a very broad sense, biotechnology and bioengineering are tools used in managing and conserving plants, animals and their habitats.[3] In 2000, an estimated 109 million acres worldwide were planted with genetically modified crops to increase yield, product viability and desirability, or economic return. The United States is the world leader in this agricultural practice, and its use of genetically modified organisms (GMOs) continues to increase.

Production and use of genetically modified, genetically engineered, or transgenic organisms poses significant challenges for natural resource managers. Introduction of GMOs into natural environments may be planned, as in the case of agricultural crops and farm animals, or unplanned, as in the case of accidental release of fish and other hatchery organisms from aquaculture operations. While the effects of intentional and unintentional introductions on biodiversity and ecosystem function have not been studied extensively, many fish and wildlife biologists and research scientists presume that the consequences increase in scope and magnitude as the frequency and magnitude of introductions increase. Some potential unintended consequences of interactions between GMOs and native flora and fauna include:

- Transfer of genetic material between species (transgenic transfer through cross-pollination)
- Competition within species between genetically modified and unmodified individuals
- Impacts of reproduction between genetically modified and unmodified individuals on fitness
- Impacts of disease transmission and resistance
- Loss of biodiversity
- Impacts on microbial communities and resulting ecosystem functions
- Exacerbating the effects of global climate change and invasive species

Fish and wildlife managers and scientists believe that the same biotechnology tools that can place natural systems at risk can potentially be used to benefit those systems. For example, the survival of imperiled species could be enhanced by using biotechnology tools that would increase their resistance to pathogens, diseases and invasive species, or increase their abilities to survive in degraded environments.

Fish and wildlife managers and scientists believe the development and use of biotechnology and bioengineering tools has broad implications for: 1) taxonomy and the way resource managers and scientists look at speciation; 2) forensics; 3) microbiological diversity; 4) methods of evaluating the health of populations; 5) methods of monitoring biodiversity and community dynamics; 6) determinations of the origin of non-native species; 7) questions on the extent of hybridization; and 9) many other aspects of restoring habitat and water resources.

To address these issues, the scientific and resource management communities will need: 1) ethical and professional guidelines within which to operate; 2) defined roles within the regulatory processes; 3) risk assessment and risk management tools; and 4) results monitoring. Techniques for professional improvement over time, such as conducting symposia to create communities of practice, regional and basin level working groups, inclusion of partners, and providing leadership in linking biotechnology and ecology, will also be needed.

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[2] The first part of this challenge summary describes how biotechnology is expected to affect fish and wildlife resources and their habitats. The second part explains the responsibilities of the U.S. Geological Survey and U.S. Fish and Wildlife Service and how both bureaus can address applications of biotechnology that enhance natural systems and those that do not.

[3] Biotechnology, for purposes of the *Future Challenges* project focuses on capabilities to alter the genetic structure of organisms and populations, primarily to increase the frequency of desired phenotypes (i.e., "traits"). Genetic modification, genetic engineering, genomics, advanced techniques and gene modeling are all parts of this issue.

Fish and Wildlife Service

The Fish and Wildlife Service directly manages more than 540 National Wildlife Refuges and 70 National Fish Hatcheries. It also manages threatened and endangered species under the Endangered Species Act; provides grants and aid to states and other partners for habitat conservation; and develops, manages, and disseminates information to bureau and other audiences on the conservation of the nation's natural resources. Consequently, the Service seeks to refine its understanding of two things: 1) how biotechnology tools can facilitate its efforts to conserve biodiversity and sustain ecological function on private and public lands and waters; and 2) how those same tools can hinder such conservation efforts.

The Service is committed to expanding its understanding of the potential risks and benefits associated with intentional and unintentional uses of GMOs and other biotechnology tools. Genetically modified organisms may play a role in species and habitat restoration, control of invasive species, or improved survival of individuals in degraded environments. Conversely, GMOs may alter ecosystem function and structure and may outcompete desired native species.

The Service has capability to explore the feasibility and desirability of using these types of applications of biotechnology to help achieve its conservation mission. Service lands might be used, under strictly controlled conditions, as natural laboratories to describe and test impacts of introductions of GMOs into the environment. Service fish hatcheries, also under strictly controlled conditions, could investigate possibilities of using genetically-altered aquatic species in fishery restoration and management, in partnership with the Service's Fish Technology and Health Centers, USGS Science Centers, and USGS Cooperative Fish and Wildlife Research Units.

As a precursor, the Service needs to identify its current base capacity for this type of work. While 150 scientists within USGS have self-identified as having expertise with the genetics/molecular biology fields and while the FWS is a recognized leader in aquatic genetics, the Service does not have a complete inventory of its current genetics capabilities and assets, and has not yet determined which of its priority genetics issues it can handle within current capabilities and which of its genetics issues will require additional genetics capabilities.

U.S. Geological Survey

USGS performs research to provide robust and reliable scientific information to the Fish and Wildlife Service and others to assist in resolving complex natural resource issues such as those posed by the introduction of GMOs in the environment. Over the past decade, USGS has built a nationwide capability to perform cutting edge research to address emerging and complex issues in molecular genetics and biology. The USGS serves as the Department of the Interior's vanguard for developing advanced molecular technologies for addressing natural resource issues.

USGS's research includes the development and application of molecular and genetic techniques and tools to assist in species and habitat conservation. USGS research in genetics has been used to:

- develop genetic and molecular markers in a wide variety of animals and plants
- resolve taxonomic issues in declining species and species of concern
- identify population structure and appropriate units for management
- understand the mechanisms of disease.

The genomics revolution is providing USGS with information needed to develop DNA constructs that can be incorporated into the genomes of invasive species which may allow the manipulation of reproductive potential (for example, so-called daughterless technologies) which may assist in the eradication of these species. Proposed future work in this area will focus on genomics, gene expression, and microbial biotransformation and bioremediation, all areas critical to understanding the impacts of GMOs on native communities.

The USGS also has other capabilities to address biotechnology and bioengineering challenges:

- The Biological Resources Discipline studies the effects of natural processes and human activities on biodiversity and ecological function. It also assesses the status and trends of biological resources and can predict their responses to causal agents, like GMOs.

- The Geography Discipline conducts research directed to understand the rates, causes, and consequences of landscape change over time. It also has the capability to map the distribution of organisms and their habitats. Both capabilities could be applied to GMOs to better understand their distribution and their effects on native species and communities.

Water for Ecological Needs[4]

Clean water in sufficient quantity to provide for fish and wildlife and other ecosystem services has been an environmental issue for decades, but this issue will continue to intensify in the 21st Century as human population and demand for appropriation of fresh-water increase. It is noteworthy that in a review of recent scientific literature and reports prepared by a wide variety of scientists, scientific organizations, and governmental institutions (for example, National Academy of Sciences subcommittees), water resource issues were consistently listed as the most important, or among the most important, environmental challenges for our nation and the world. Despite the historic attention to water resources shown by industry, private citizens and government agencies, including the U.S. Geological Survey and the Fish and Wildlife Service, the future challenge will be to develop new research initiatives, new workforce skills and capacities, and new management strategies that reflect the changing societal values about water resources that have emerged simultaneously with a growing human population placing high demands on water use.

Societal water management goals of the 21st century include maintaining and enhancing natural aquatic communities and ecosystem services. In other words, now healthy aquatic communities, sedimentation control, flood plain connectivity, high water quality, and riparian corridor enhancement are often viewed on par with the previously existing goals of water supply, flood control, channel maintenance, power production, and commerce. Thus, the paradigm has shifted from a simple question of "How much water can be taken from streams and lakes for human use?" to a more complex question of "How much water needs to be left in streams and lakes to sustain critical water-dependent natural resources?" The new paradigm includes a shift to a full range of scales rather than only small scale, consideration of the whole hydrograph not just minimum flows, a dynamic channel as opposed to a static channel, linkage of surface water and ground water, and ecological communities rather than single species. These shifts in scale and endpoints of concern have created gaps in the scientific information base available for management decisions, and point to the areas of greatest need for new research.

Historical evaluation of water availability focused on human needs, while providing less emphasis on the sustainability of ecosystems and the high costs of replacing the ecosystem services of functional wetlands, floodplains, and naturally clean water resources with technological processes and fixes. The use and protection of water resources are expected to be controversial and increasingly litigated in the United States and around the world. Humans withdraw freshwater from lakes, rivers, streams, and ground water for public and domestic supply, and for commercial, agricultural, and industrial activities. Surface-water withdrawals, ground-water mining, dams and other types of flow regulation, channel modification, water development, and riparian vegetation management can result in water-level depletion and (or) alteration of natural flows and levels. Atmospheric deposition and terrestrial loadings to streams, rivers, wetlands, lakes and ground water introduce contaminants, nutrients, and sediment that cause toxicity, eutrophication and siltation, respectively. Many aquatic systems have been compromised to the point where the dependent fauna and flora have been severely affected. Groundwater withdrawals cause declines in ground-water levels, resulting in decreased streamflow during dry periods and increasing stream temperatures. Depletion and contamination of water resources have serious consequences for water-dependent natural resources in all areas of the Nation, not just in arid regions.

[4] The first part of this challenge summary describes how water use and allocation are expected to affect fish and wildlife resources and their habitats. The second part explains the responsibilities of the U.S. Geological Survey and U.S. Fish and Wildlife Service and how both bureaus can better: 1) identify the water needs of fish and wildlife; 2) ensure that those needs are reflected in water allocation plans and decisions; and 3) anticipate and address any adverse effects on fish and wildlife caused by shortfalls in water allocations.

Scientific information about water availability and quality will play an increasingly important role in water-resources decision-making. What is needed is interdisciplinary research aimed at improved understanding of the linkages between streamflow, habitat, and biological communities. From this research it will be possible to build the needed models and decision-making tools. Emphasis needs to be on long-term data sets of wholistic aquatic systems including flow, water quality, ground-water levels, and the dependent biota. Obtaining, distributing, and applying this information to decision-making will be the scientific and management challenge for the USGS and the FWS.

The following areas of inquiry are important to this issue:

- What species, species assemblages, or diversity indices are appropriate indicators of aquatic health in various ecosystems?
- Modeling flow regimes to protect important life stages of various biota in aquatic systems
- Links between hydrologic models and ecosystem outcomes
- Identification of species dependent on ground water exchange with surface water sources
- Response of estuarine systems to flow and salinity induced changes in food web and energy transport functions
- Improving information transfer activities to inform public and private decision-making.

From these activities, the appropriate science-based tools for water-resources decision-making and a compelling message about the science as well as costs and benefits of managing water to meet the needs of humans and ecosystems would emerge. This message should be based on a philosophy of using science to support critical water-resources decisions and an appreciation of the contribution of ecosystem goods and services to society.

Fish and Wildlife Service

The mission of the FWS is working with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. Regarding the challenge of increased competition for water resources, the FWS critically needs to better predict the ecological outcomes and risks of water management options, such as changing flow regulation, dam removal, channel modification, water development, and riparian vegetation management. In particular, FWS needs increased ability to make timely, high quality, science-based recommendations regarding water management options in any given situation, and it needs to provide continuing scientific support along the way as water management options are considered.

Also, due to its mission, the FWS must recognize that water resource issues, in particular, are in a highly social context and that we need to communicate resource management needs and messages to the public. There is a need to communicate a compelling message about the science and the cost/benefits of ecosystem services/values. FWS needs to build capacity regarding water conflict communications.

FWS, in partnership with USGS, needs to establish the ability to communicate advances in science-based analytical tools to meet the new water paradigm of: understanding water resources on a large (ecosystem) scale, the whole hydrograph, dynamic channels, influences and importance of both surface and groundwater, and needs of entire aquatic communities (rather than a species-by-species management approach). Opportunities should be pursued to advance effective partnerships on water issues with the Bureau of Reclamation, Environmental Protection Agency, Army Corps of Engineers, National Oceanic and Atmospheric Administration, Natural Resources Conservation Service, other federal agencies, state natural resource and water management agencies, scientific societies, universities, non-governmental organizations, advocacy groups, watershed councils, and local water management districts.

U.S. Geological Survey

The USGS serves the Nation by providing reliable scientific information to 1) describe and understand the Earth; 2) minimize loss of life and property from natural disasters; 3) manage water, biological, energy, and mineral resources; and 4) enhance and protect our quality of life.

The USGS has a nationwide capability to perform cutting-edge research in interdisciplinary earth-system science that encompasses hydrology and ecology along with geology, geography, and information science. The ability of the USGS to perform interdisciplinary investigations is critical to understanding the ecological requirements of aquatic and terrestrial living resources for water resources. The USGS has the ability to qualitatively and quantitatively describe the variability in biological systems and the relation between biological systems and hydrologic variability.

The USGS would benefit from increasing its capabilities to develop predictive models of ecological requirements for water and to apply these models in real world situations. The USGS has the knowledge and demonstrated skills in supporting and sustaining long-term monitoring, data management and interpretation, and information transfer and dissemination. The processes for dissemination of information and knowledge are a critical need for the Nation to meet the current and future needs for freshwater while preserving our valued biological resources.

Constituencies include: International organizations involved in boundary-waters management like the Council on Economic Cooperation and the International Joint Commission; nations such as Canada and Mexico; Tribes and First Nations; DOI agencies including the Bureau of Reclamation, FWS, the National Park Service and other federal agencies including the USDA-Natural Resources Conservation Service, -Forest Service, and -Agricultural Extension Service, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, and National Oceanic and Atmospheric Administration; intergovernmental and inter-state compact commissions such as the Western Governors' Association and the Council of Great Lakes Governors; State and local governments; Joint Ventures; nongovernmental organizations like Ducks Unlimited, Trout Unlimited, and American Rivers; and private sector interests such as the electric power industry.

Invasive Species[5]

Because of the size of the United States and the diversity of environmental conditions and ecosystems across the country, our nation is especially vulnerable to invasions of non-native species. Many invasive species have been introduced intentionally for agriculture, horticulture, fisheries, hunting, the pet trade, range improvement, erosion control and a host of other purposes. Some invasive species have been introduced accidentally, as hitchhikers in agricultural, horticultural and other biological shipments; in shipping containers; on aircraft, vehicles and construction equipment; and in ballast water. Scientists estimate that because of these intentional and unintentional introductions, an additional 6,500 species of plants, animals, and pathogens now reside in our country.

Impacts of invasive species are widespread, but are particularly severe in certain areas, such as islands (especially Hawaii and Pacific territories), western riparian areas and rangelands, and inland waters – including the Great Lakes and Everglades. Invasive species rank second to habitat loss as a cause of endangerment to native species, and transform the structure and functions of ecosystems by altering fire regimes, nutrient cycling, hydrology, and energy flows. Invasive species typically have high reproductive rates, disperse easily, and can tolerate a wide range of environmental conditions. Often, they lack predators in their new environments. As a result, invasive species can sometimes out-compete native species for prey or other resource needs (e.g., breeding sites). They may also prey upon native species, spread pathogens and parasites, or alter the genetic make up of closely related species. The effect on fish, wildlife, and plants is clear: up to 46 percent of the plants and animals Federally listed as endangered species have been negatively impacted by invasive species. Invasive species have also been identified as causing significant economic impacts, particularly to agriculture, horticulture and industry. Cumulative economic impacts are estimated at $137 billion annually, which exceeds the cost of earthquakes, floods, fires and other natural disasters *combined*.

Invasive plants alone occupy more than 100 million acres in the United States. The Bureau of Land Management estimates that each day they spread to another 4,600 acres of natural areas on Federal lands in the Western continental United States

Past efforts to detect, control and avoid invasions of non-native species in the United States have met with modest success. Improvements in effectiveness can be obtained by focusing additional resources and efforts on: 1) identifying and acquiring reliable information and methodologies needed to determine which habitats and ecosystems are most vulnerable to invasions and which species pose the greatest threats; 2) identifying cost-efficient and environmentally safe control and restoration techniques; and 3) developing models and other tools to predict future invasions and better understand their environmental, social and economic effects. Effective strategies to prevent or contain invasions will require: 1) understanding pathways of introduction and methods of spread; and 2) early recognition of the potential for invasiveness is an essential part of developing effective strategies to prevent or contain invasions. Reclaiming infested lands and waterways will require additional efforts to: 1) determine how invasive species have affected native ecosystems; and 2) identify the effectiveness of alternative control methods and strategies, and any consequences they may have for non-target species.

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Fish and Wildlife Service

More than six million acres of the National Wildlife Refuge System (NWRS) are infested with invasive plants, impacting the wildlife management objectives on nearly 50 percent of all refuges. Refuges use a combination of means including physical removal of organisms, cultural methods (native revegetation, prescribed burning, water management), biological controls, and chemical treatments to control and eradicate invasive species.

The Service also works with the national Aquatic Nuisance Species (ANS) Task Force to implement the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. The ANS Task Force coordinates the activities of its members to prevent and control aquatic nuisance species and develop educational activities and partnerships among Federal agencies. In addition, the Service combats invasive species in other noteworthy ways:

- The FWS also has seven regional ANS Task Force coordinators who respond to aquatic invasive species and their impacts.
- The Partners for Fish and Wildlife Program assists private landowners, tribes and others in improving wildlife habitat on their lands, including through invasive species management and reintroduction of native plants.
- The Coastal Program, Endangered Species Program, the Migratory Bird Partnership Programs, Law Enforcement, Project Planning, and the National Fish Hatchery System all play important roles in invasive species management and prevention.
- The International Affairs Program evaluates potentially invasive foreign species for inclusion on the list of injurious wildlife species and processes permit applications for importation and interstate transport of injurious wildlife species.

The Service has identified several strategies that appear to offer promise in combating invasive species:

- Additional scientific knowledge and capacity are needed to address the challenges of invasive species in the areas of prevention, early detection, monitoring, risk assessment, control, pathways analysis, basic ecological research, database integration, mapping, ecological and economic modeling and forecasting, and restoration.
- Operational programs need to incorporate consideration of invasive species issues into their resource management strategies. Various plans

U.S. Geological Survey

The mission of the USGS is to provide reliable scientific information on the characteristics of the Earth, minimize the impacts of natural disasters, and manage the nation's resources. As discussed above, invasive species can significantly alter the characteristics of the Earth and impact the nation's biological resources.

The USGS has several mechanisms that have helped produce scientific knowledge and establish scientific capacity that has been instrumental in addressing conservation challenges associated with invasive species:

- USGS's Institute of Invasive Species Science (IISS) is a consortium of partnerships that leverage USGS capabilities with those of other agencies and organizations to meet user needs. IISS facilitates the National Biological Information Infrastructure's Invasive Species Information Node, which provides access to invasive species information and tools. Through IISS, USGS is developing national early detection, monitoring, and forecasting capabilities (in cooperation with the NASA and other partners), and providing technical assistance and training to resource managers in using available information and tools to support effective responses to invasive species. This effort includes development of a national database for the NWRS that will enable FWS managers to track and combat invasive species.
- USGS research focuses on the following areas:
  - <u>Prevention</u>. Identifying, quantifying, monitoring, and managing pathways and associated vectors of transport.
  - <u>Early detection and rapid response</u>. Identifying and reporting new invasions and assessing risks to natural areas.
  - <u>Monitoring</u>. Designing statistically reliable multi-scale monitoring of established invaders through integrated use of historical records, remote sensing/ GPS/GIS technologies, and field sampling methods that document invasion patterns.
  - <u>Identifying effects</u>. Providing information on factors influencing species invasiveness and habitat vulnerability, the effects of invaders on ecosystem processes and native species, and ecological risk assessments for priority species.
  - <u>Control and management</u>. Providing approaches to contain, reduce, and eliminate populations of invasive species and restore habitats and native species.
  - <u>Information management</u>. Facilitating one-

that the FWS either produces or reviews, such as refuge Comprehensive Conservation Plans, Fishery Management Plans, and endangered species Habitat Conservation Plans and Recovery Plans, need to contain realistic invasive species management strategies, including reallocations of resources if necessary. Land management plans should include an invasive species monitoring plan to help assess threats and facilitate cost effective management responses and should contain goals and objectives for working with partnerships to combat invasive species.

- Operational programs should have standard operating procedures (SOPs) for refuges and hatcheries that prevent the spread of invasive species. In addition, work contracts should be written so that construction companies are required to take precautions against spreading invasive species.

- Operational programs that are involved with or in some way regulate import and export of potentially invasive species should explore additional ways of "closing the door" on the import and export of potentially invasive species. At the national level, new policies, new legislation and new conservation authorities should be explored.

- More effective programs, policies and procedures are needed to: 1) oversee the use of new biotechnology tools in invasive species management; 2) encourage the application of such tools when they are compatible with protecting or restoring biodiversity and ecosystem functions: and 3) create a national system for mapping, monitoring and assessment of invasive species.

stop Internet shopping for information on all aspects of the invasive species issue and provide decision support through the NBII.