Strategic Science Plan

USGS Patuxent Wildlife Research Center

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The PWRC Vision

To be recognized by the conservation community worldwide as a scientific research institution that sets the standard for excellence in the science of wildlife conservation.

The PWRC Core Purpose

To develop the scientific information needed to provide the biological foundation for conserving and managing the Nation's biological resources most effectively.

The PWRC Mission Goals

- Strengthen the scientific basis for the conservation of wildlife and other biological resources, particularly those held in trust by the U.S. Federal government, and managed by the Department of the Interior.

- Identify and solve the most critical, and complex problems in wildlife and ecosystem management, through integration of biological science with decision-making science.

- Assess the status and trends of the Nation's biotic resources, and provide to resource managers scientifically sound databases and analytical products resulting from biological surveys.

- Identify the effects of human activity (including anthropogenic contaminants in the environment) to wildlife and ecosystems and assess the impact of those activities to wildlife, relative to other stressors.

- Cooperate with federal and state partners in wildlife conservation to meet their needs for scientific information, and work collaboratively with colleagues within the USGS or from other scientific institutions to provide integrated, interdisciplinary information when needed.

I. Introduction

Background. The U.S. Geological Survey (USGS) Patuxent Wildlife Research Center (PWRC) is a biological research center in the USGS, the science bureau for the Department of the Interior (DOI). Since its establishment in 1936 on the nation's first National Research Refuge established for the purpose of wildlife research, PWRC has become a leading, internationally recognized research institution. It is known for its wildlife and applied environmental research, for transmitting research findings to those responsible for managing the Nation's biological resources, and for providing technical assistance in implementing research findings to improve biological resource management. PWRC is home to nearly 55 scientists and more than 150 staff (post-docs, biologists, technicians, IT and Administrative staff, volunteers). PWRC headquarters is located on the U.S. Fish and Wildlife Service's (FWS) Patuxent Research Refuge in Laurel, Maryland. PWRC has eleven Field or Duty Stations from Maine to Mississippi, located at universities, partner agencies or other USGS offices. Our largest field station is the PWRC Biological Survey Unit, located at the Smithsonian Institution's National Museum of Natural History in Washington, D.C. Funds appropriated by Congress to USGS support a significant part of PWRC's science. However, much of the scientific research at PWRC is driven by the needs of other Federal management agencies and funding from those partners support a wide range of scientific work. In the five years since 2003, PWRC has made significant contributions to the science of wildlife populations and habitat management (Appendix A).

Purpose of the Science Plan. This Science Plan provides a blueprint for directing PWRC's science program over the next five years, 2008-2012. The Science Plan will be the primary source of guidance for funding allocations, organizational structure, staffing decisions, and decisions about support infrastructure. The Plan was written by a team of scientists and managers, drawing on the advice and ideas of other PWRC scientists and resource personnel. Specific goals and objectives for PWRC promote the broader goals of the DOI and the USGS, particularly those identified in the USGS science strategy, "*Facing Tomorrow's Challenges: U.S. Geological Survey Science in the Decade 2007-2017*."

II. The Current Science Program: Capabilities, Collaboration, and Relevance to Resource Management

Core Strengths. For decades, PWRC has produced innovative science in support of wildlife management, particularly the conservation and management of migratory birds. Over the past 40 years PWRC's research program has diversified in response to changing management agency needs and a changing fiscal climate. PWRC is a leader in many areas of wildlife, population, community and ecosystem-related science. Major areas of expertise include estimating demographic parameters in population ecology; applying adaptive management and other structured decision-making tools;

and developing, managing, and interpreting long-term wildlife surveys. PWRC has long been known for its key role in endangered species research and propagation, notably its current whooping crane program. PWRC is a leader in determining the effects of contaminant exposure on birds, mammals, and amphibians and developing new methods for identifying interactions among other stressors in wildlife populations. Additionally, PWRC is a leader in understanding the ecological dynamics of coastal marine environments including sea-level rise, wetland and riverine dynamics and management and methods of coastal restoration. PWRC has forged important milestones in the areas of avian, mammalian, and amphibian systematics. PWRC has become a major hub for understanding environmental impacts on migratory birds and developing and managing large and extensively used wildlife databases, including the N. American Breeding Bird Survey.

Partners in Resource Management Applications. PWRC has always worked closely with many Federal and state entities that have land and wildlife management responsibility; those close partnerships are evident in the section below on science achievements. Close partnership between PWRC and resource management agencies is essential for meeting their science information needs, to help increase awareness of new biological problems and to develop new methods for meeting the challenges of managing the Nation's natural resources. Federal agencies in the Department of Interior are our closest and most frequent partners (US Fish and Wildlife Service and National Park Service primarily), and we work with other federal (e.g. National Forest Service, Environmental Protection Agency) and state agencies (e.g. Natural Resource Departments of Maryland, Wisconsin, Georgia). Close interactions with these partners are maintained in a variety of ways, including personal relationships between scientists and resource managers, participation in regional and national planning meetings of other agencies, and meeting the needs for information expressed in cyclic funding programs in USGS that are dedicated to the priorities set by the FWS and NPS. Also, PWRC is a member of several more formally established partnerships dedicated to conservation issues or habitat preservation, including:

- Whooping Crane Eastern Partnership (WCEP)
- Adaptive Management and Assessment Program (AMAT)
- Partners in Flight
- North American Waterfowl Management Plan Joint Ventures: Atlantic Coast, Black Duck, Lower Mississippi Valley, and Sea Duck.

Collaborations. Collaboration is increasingly important scientifically, as problems can be attacked in a more integrated way leading to more comprehensive solutions, and operationally, as tight budgets demand joint contribution of labor, equipment and capabilities from scientists working together. Interdisciplinary collaboration within USGS has led to work with each of the other USGS disciplines (Geology, Hydrology, Geography). In addition, PWRC scientists are located in the Water District office in Augusta, Maine. PWRC scientists collaborate with a large number of University scientists. Collaboration with university faculty and students is an excellent way for PWRC scientists to incorporate new ideas and methods into our research; most PWRC Research Scientists have adjunct faculty appointments at various universities. In this

capacity, PWRC scientists advise graduate students, serving as major advisors (or co-major advisors) or committee members. Many graduate students have the opportunity to be employed at PWRC either through their university or directly by PWRC. Finally, scientists at PWRC are engaged in numerous collaborations with international groups including, the Chinese Academy of Sciences, Salim Ali Centre for Ornithology & Natural History (India), the Society for Wildlife Conservation (India), the Royal Society for the Protection of Birds (UK), the Canadian Wildlife Service, CONABIO – Mexico, the Western Hemisphere Migratory Bird Species, and the Canada-U.S. Whooping Crane Recovery Team.

III. Adapting our Science to Emerging Needs, 2007-2012 and Beyond

Managing a Diversity of Capabilities. With its diverse capabilities, PWRC is well equipped to address many of the complex environmental issues of the immediate and foreseeable future. The multiple research and monitoring strengths have not flagged in their relevance, because they either speak to statutory stewardship responsibilities of DOI for trust species or they address fundamental and long-term environmental threats. We believe, therefore, that it would be unwise to phase out any current core capability. Diversity of capability does not come without its challenges, however. An important challenge for the next five years is to overcome the natural tendencies for groups with different capabilities to become isolated from each other (organizational "stove-piping"). Collaborations among scientists in different technical specialties will be actively promoted within PWRC, and beyond our center to the other USGS Disciplines.

IV. Current and Future Directions, Goals and Objectives by Functional Category

PWRC science for the next five years is organized below by four core scientific capabilities central to the USGS mission: (1) Biodiversity: Systematics, Status and Trends, (2) Terrestrial, Freshwater, and Coastal Ecosystems (3) Contaminant Ecology, and (4) Wildlife: Terrestrial and Endangered Resources. These core scientific capabilities largely reflect BRD line-item funding Programs and each of these is described below in terms of current capability, as well as their future application and development over the next five years. Specific programmatic goals and objectives are stated for each core scientific capability, including plans for recruiting, both to replace staff lost through attrition and to acquire new expertise.

Conceptual themes for linking Core Capabilities. PWRC's stated mission:

> "…to excel in wildlife and natural resource science, providing the information needed to improve the management of the nation's biological resources."

is broadly inclusive and general. Both the wildlife management focus of our work and the more fundamental scientific underpinnings that we investigate are related to assessing and predicting responses of wildlife and wildlife habitats to environmental change. PWRC will likely be more competitive in attracting funds and more effective in delivering scientific information to partners if it moves toward unifying those capabilities around conceptually compelling themes. This is also a mechanism for fostering collaborations among PWRC scientists and among PWRC and other USGS scientists.

PWRC's has strong national and international leadership and growing strength in the theory and application of "**structured decision-making**" (**SDM**) and "adaptive management." The conceptual approach to environmental problem-solving embodied in the SDM framework will provide an overarching theme for much of the work undertaken by PWRC. In brief, SDM is a formal, model-based approach for natural resource managers to make informed management decisions. SDM brings quantitative rigor to the description and evaluation of wildlife-environment interactions and reduces the uncertainty in our understanding of complex, natural system dynamics. This approach to wildlife management in which management and science work closely together to reach measurable and testable solutions to management questions, is an important step forward in wildlife science. It has the additional merit of promoting interagency partnerships, which have become the standard mechanism for accomplishing wildlife research in the federal sector.

SDM has greater applicability to some of our core scientific capabilities than to others. Through internal training by our own experts, shifts in emphasis among existing programs, collaboration among our specialties, and strategic recruitment of new scientists, PWRC can make significant strides in the next five years toward making SDM a major methodological element of wildlife research.

The **impact of climate change on wildlife, and their habitats**, is another conceptual theme that shapes current PWRC research and will undoubtedly continue to organize future research efforts. Several PIs are also looking at the complex dynamics of coastal marshes in response to sea level rise, a natural consequence of a warming climate. These and other PWRC ecologists and modelers will be encouraged to seek opportunities to address specific climate change questions. PWRC Contaminants scientists have much to add here, and will continue to assist partners in ecological risk assessments and more formal Natural Resource Damage Assessments.

Similarly, the **ecology of transmission of disease organisms among vectors, wildlife and humans,** is a theme that has immediate environmental relevance that can benefit from the expertise of many of our scientists. Currently, several aspects of disease ecology (pathogen and immune factor transmission among generations, vector biology, immunotoxicology, and vaccine development) are studied at Patuxent and through marshalling of existing capabilities and through capacity-building, we will direct more of our scientific capacity toward this topic in the next five years.

In both of these areas, as well as in other more traditional areas of PWRC strength, a methodological theme is **techniques for spatial representation and interpretation of biological data at multiple scales**. We will look to capitalize on opportunities for improving our capabilities in spatial display (GIS) science and in modeling ecological attributes using spatial statistics.

PWRC will organize its many resources to address new questions about **migratory bird ecology,** in support of DOI resource management agencies. Important bird conservation and resource management questions will benefit from community-level studies at broad geographic scales and from more restricted investigations targeting management of focal species. PWRC resources that can be brought to bear include, but are not limited to, study and survey design, SDM, adaptive management, field avian ecology, database management, data analysis, and provision of web-based tools and products.

Alignment with the Bureau Science Strategy. PWRC's core capabilities contribute directly to three of the six draft Biological Resources Division Science Goals, which derive from the USGS science strategy. These are: **Goal 1** (Understanding Ecosystems and Predicting Ecosystem Change: Ensuring the Nation's Economic and Environmental Future); **Goal 3** (Land Use and Natural Resources: Providing a Scientific Foundation for Resource Security, Environmental Health, Economic Vitality, and Land Management); and **Goal 5** (The Role of the Environment in Human Health and in the Health of Other Biological Resources). As noted above, we seek to direct more attention to Goals 2 and 5. We already have extensive capability for addressing important research questions and data-gathering efforts related to Goals 1 and 3. **Goal 2** (Forecasting Climate Variability and Change: Clarifying the Record and Assessing Consequences) is also reflected in one of our core strengths (coastal and freshwater ecosystems).

A. *Biodiversity: Systematics, Status and Trends*

Current Program – Museum Science. Museum-based systematics research provides an evolutionary framework for understanding the diversity, relationships, and natural history of species of vertebrates and is crucial to managing ecological systems in biologically meaningful ways. Sound taxonomy is vital for management and conservation planning by resource agencies and organizations.

PWRC biologists at the Biological Survey Unit (BSU) in the National Museum of Natural History (NMNH), Smithsonian Institution, conduct original research on the systematic relationships, nomenclature, and biodiversity of four groups of vertebrates: amphibians, reptiles, birds, and mammals. This research contributes to our understanding of biodiversity by discovering and describing new taxa, determining evolutionary relationships among taxa, and providing taxonomic identifications and general museum support to several agencies within the Department of Interior (e.g., FWS), as well as to other federal agencies. Through a Memorandum of Understanding with the Smithsonian Institution, BSU scientists and staff are responsible for managing

the collections of nearly one million specimens of North American vertebrates that are part of the National Collection housed in the NMNH. The formal association between the Smithsonian Institution and the BSU (or its precursors) dates from 1889. Taxonomic and methodological expertise in the BSU and elsewhere at PWRC continues to make an important contribution to the preparation and revision of authoritative checklists of vertebrates and definitive guides for measuring and monitoring biodiversity around the world. In addition, BSU scientists provide important expertise on behalf of USGS to the Integrated Taxonomic Information System (ITIS), a standard for scientific nomenclature adopted by the Federal government.

Current Program – Population Surveys. PWRC is heavily invested in assessing the status and trends of continental bird and amphibian populations and managing databases that support long-term, surveillance monitoring. Paramount among these efforts is the Breeding Bird Survey (BBS), a statistically designed, roadside survey of birds breeding in North America conducted annually since 1966 by volunteers with bird identification expertise. Since its inception, the BBS has operated in close collaboration with the Canadian Wildlife Service, and recently has forged a partnership with Mexico's National Commission for the Knowledge and Use of Biodiversity to establish a Mexican BBS program by 2010. The North American Amphibian Monitoring Program (NAAMP), modeled after the BBS, provides information on the status and trends of calling amphibian populations in the eastern and central U.S. NAAMP staff manages an on-line atlas of amphibian distributions throughout North America. Survey biologists periodically explore the development of methods to monitor other groups of significant conservation interest, such as pollinating insects. Methods for sampling and monitoring native bee species are presently under development.

PWRC biologists also collaborate with various partner organizations to develop, improve, and implement monitoring designs and counting protocols for bird groups not well surveyed by the BBS (e.g., colonial waterbirds, secretive marsh birds, shorebirds) and priority species requiring more intensive efforts (e.g., painted bunting) . Database development and management is crucial to both internal and partner-driven monitoring efforts. PWRC's experience and capability for managing large population databases is unmatched in the Federal government. A national, on-line breeding bird atlas database is being built with the collaboration of the individual states that actually manage the atlas programs. Our databases, notably the BBS database, are regularly analyzed by PWRC scientists, to provide information on population trends and other attributes of bird species to the Fish and Wildlife Service and other agencies for management purposes.

Current Program – Bird Banding Laboratory (BBL). The BBL provides bird-banding permits and bands to a broad diversity of users including federal and state agencies, university scientists and other qualified users. The BBL manages the resulting database of nearly 60 million North American banding records and 3 million encounters. BBL has a long-standing partnership with the Canadian Bird Banding Office and is building a similar relationship with Mexico. Canadian banding and encounter data are processed by the BBL and are housed in the BBL database. Most

banding and encounter data are submitted by banders electronically, either via stand-alone software (bandings) or via the web (encounters). Although web-reporting of encounters is being strongly encouraged, a 1-800 phone service is still used for receiving a significant proportion of encounters reported by hunters. Paper transactions have declined to about 5% of encounters. Banding data continue to be used for a wide variety of scientific and wildlife management purposes, including estimation of game bird population and harvest statistics.

Future Directions – Museum Science. The productive partnership between the USGS/PWRC scientists and the Smithsonian Institution will continue. The BSU will provide research in taxonomy and biodiversity, and other services needed by DOI management agencies and the international scientific community. The BSU will contribute to new taxonomic databases: the National Ecological Observatory Network (NEON), the Consortium for the Barcode of Life (CBOL), the Catalogue of Life (CoL), and the Encyclopedia of Life (EoL). In the face of retirements likely in the next five years, we will maintain a core research and curatorial capability in amphibians, reptiles, birds, and mammals and add expertise in North American freshwater fish systematics. Expertise in molecular genetics laboratory techniques will become a standard requirement for a portion of the curatorial staff.

Future Directions – Population Surveys. Strong emphasis will be placed on improving the methodologies of long-term population monitoring programs by identifying and minimizing design problems that arise from the fact that a survey detects only a portion of the total population. These improvements will be enabled by close collaboration between survey biologists, biometricians, and research biologists specializing in population modeling and estimation. Additionally, we will seek out opportunities to improve the value of monitoring programs through collection of significant ancillary data. PWRC will continue to maintain and invest in its data management systems to ensure that state-of-the-art database management, storage, and retrieval capabilities are sufficient to meet the increasing demands for information by the conservation, management, and scientific communities. As opportunities arise for PWRC to develop or become a partner in new, long-term monitoring programs, the PWRC approach will be, first, to assess the relevance to resource management partners, the cost, and the potential for long-term base support. All ventures into new monitoring efforts will be contingent upon explicit statement of objectives, state-of-the-art statistical approaches to survey design, and survey protocols that consider detection and other potential biases and maximize collection of ancillary data.

Future Directions – BBL. The BBL will continue the current phased reorganization, necessitated by its fundamental transformation from paper-based to electronic modes of operation. Increased emphasis will be placed on improving both computer technology skills and biological training of staff. Use of the Internet, both to make data and other information available and to facilitate data input, will be greatly expanded. Full advantage will be taken of opportunities afforded by relational databases to expand the range of biological analyses possible and to permit analysis by remote users. The ongoing effort to have the science needs of population ecologists, natural resource managers, and other users of banding/encounter data drive the future direction of BBL

data management will continue. BBL data management must adapt to allow utilization of recent changes in analytical procedures such as capture-recapture theory. Much of this will be achieved through collaborations with PWRC population scientists.

Goals and 5-Year Objectives

Goal 1. Expand taxonomic scope of BSU and improve bio-molecular capabilities.

Objective 1: Maintain research and curatorial expertise in bird, mammal, and amphibians and reptiles.

Objective 2: Through training and/or recruitment, expand the skill sets of curatorial personnel to include laboratory skills in molecular genetics analysis. This expansion would be done in collaboration with the Smithsonian Institution, which has state-of-the-art lab facilities.

Objective 3: Hire a museum-collection-oriented, Ph.D.-level ichthyologist, specializing in systematics of fishes based on molecular genetics ***[position 1]***. This expansion of taxonomic coverage in the BSU will allow greater support to the Fish and Wildlife Service, particularly in their management of invasive species. Research focus should be on the diversity and relationships of North American freshwater fishes, temporal and spatial changes in their distribution, with an emphasis on the impact of invasive species on genetic integrity and distributions of native species.

Objective 4: (contingent on Objective 3) Recruit a museum specialist with knowledge of fish biology to serve as collection manager for the North American freshwater fish collection.

Goal 2. Incorporate technical improvements to enhance the integrity and applicability of monitoring programs.

Objective 1: Implement the recommendations and modifications to the BBS identified in the Strategic Plan for the North American Breeding Bird Survey: 2006-2010. Seek funding necessary to support expansion of BBS staff: (1) biological technician to support daily operations; (2) wildlife biologist to assist in testing and implementation of new field methods aimed at bias-reduction and detection-estimation ***[position 2]***; and (3) GIS technician both for daily operational needs and synthesis of BBS results.

Objective 2: Continue implementation of recommended improvements to NAAMP identified in the Programmatic Review of the North American Amphibian Monitoring Program. Seek additional resources necessary to conduct annual analyses of NAAMP data similar to those produced for the BBS, and institutionalize regular on-line reporting of results from NAAMP.

Objective 3: Collaborate with Federal and State governmental agencies and other partners within the broader bird conservation community to implement recommendations provided in the US NABCI Monitoring Subcommittee report, "***Opportunities for Improving Avian Monitoring***." Look for opportunities to use of data from long-term status and trends assessment programs to address specific management and conservation questions at various geographic scales.

Goal 3. Continue to improve the quality of services in BBL and promote the use of its databases for scientific purposes.

Objective 1: Implement operational recommendations of the BBL FACA (Federal Advisory Committee Act) Committee.

Objective 2: Increase staff biological expertise, and add new staff as appropriate for implementing recommendations of the BBL FACA Committee. IN order to facilitate the technological conversion to electronic modes of operation, hire a biologist with Infra-structure management skills ***[position 14]***. Hire a quantitative ecologist to bridge the gab between advancements in analytical methods and BBL data management ***[position 13]***.

Objective 3: Make databases and analytical tools available through the web.

Objective 4: Develop and manage a recapture database. Consult migratory bird research interests more fully in planning future refinements of the databases, to ensure that resources will be of maximum benefit to migratory bird management.

Objective 5: Update the banding regulations in the Code of Federal Regulations.

Goal 4. Expand support for Federal agencies, State agencies, Non-governmental organizations, and other partners involved in population monitoring activities.

Objective 1: Provide technical assistance to organizations developing new monitoring efforts, to help them achieve their goals with science-based survey designs (vis-à-vis recent assistance to Refuges described above). Incorporate structured decision-making as appropriate.

Objective 2: Provide guidance to state/local monitoring efforts that will enhance the future integration of information from these programs into conservation activities at larger geographic scales (vis-à-vis current work with State bird atlases and Northeast Coordinated Bird Monitoring).

Goal 5. Enhance and expand biodiversity expertise and provide better science and service to customers.

Objective 1: Initiate a program to monitor recent changes in the distributions and habitat use of certain species of North American vertebrates beginning with

mammals and look for patterns reflective of global warming, the spread of invasive species, and other regional changes. Evaluate these changes with regard to impacts on other native species.

Objective 2: Complete geo-referencing of data for North American vertebrate specimen records at the National Museum of Natural History and collaborate with the Smithsonian Institution to provide maximum on-line public access of electronic collections records.

Objective 3: Review the status of bee and other pollinator monitoring programs developed by PWRC by the end of the 5-year period. Considering both effectiveness and the needs of partner agencies, determine whether expanding capability in monitoring insects and perhaps other invertebrate populations is warranted.

B. *Terrestrial, Freshwater, and Coastal Ecosystems*

Current Program. Ecosystem science at PWRC is primarily focused on coastal eastern United States, with more limited activity in freshwater wetland, lacustrine, and riverine habitats in the interior of the country. Most investigations are interdisciplinary, involving partnerships with Department of Interior bureaus, USFWS and NPS, other federal, state, or local management organizations, other USGS disciplines, and universities. The research has focused on identifying and quantifying the relationships among natural and human-induced threats to ecosystem structure and integrity and their ecological consequences. PWRC researchers develop and apply models to predict how changes in coastal and wetland environments affect ecosystem structure and function. Although most of the research has been in the eastern United States, some is national and international in scope. The wetland ecosystems program has engaged scientists in the USGS Hydrology, Geography and Geology disciplines to provide broad-based scientific results for decisions concerning wetland and island restoration and management, population recovery, sea-level rise in the coastal zone, minimum flow needs for fish populations in altered river systems, and the impact of climate change on freshwater ecosystems. These results also guide the development of ecosystem monitoring programs.

Future Directions. Patuxent scientists will continue to seek out collaborative opportunities with physical and chemical scientists and engineers to tackle important coastal and wetland issues of regional, national and international concern. Large scale human and natural forces impact these habitats, so emphasis will be less on site-specific studies and more on comparative studies and larger scale analyses that have broad management and societal implications.

One particular area of focus will be potential threats to ecological resources and ecosystem services from global climate change. Emphasis will be placed on predicting wetland and aquatic ecosystem vulnerability and ecosystem responses to future changes in climate.

PWRC will develop tools to aid managers in monitoring, protecting, managing, and restoring coastal and wetland systems. Stresses to these habitats include sea-level rise, indirect effects of watershed development, river flow regime changes, direct ecosystem alterations, and others. Modeling approaches will include GIS-based decision-support systems, hydrologic-minimum flow models, marsh and barrier island morphological change models, and statistical models. Working with other scientists within and outside USGS, PWRC scientists will apply an adaptive management framework to improve restoration and monitoring programs. Activities include identifying appropriate variables for monitoring natural and restored systems, defining the natural temporal and spatial variability in monitoring variables, determining threshold values that signal shifts in ecosystem structure and function, and, especially, developing predictive relationships between monitoring variables and ecosystem response.

Goals and 5-Year Objectives:

Goal 1. Develop scientifically based methods for understanding ecosystem changes in coastal and freshwater ecosystems, and develop tools for forecasting future conditions under different scenarios.

Objective 1: Improve understanding of responses of selected community and ecosystem processes to multiple, interacting threats and stressors in coastal and freshwater environments, including climate change.

Objective 2: Construct predictive models that integrate effects of anthropogenic and natural agents of change on important coastal, riverine, and wetland habitats and selected fish and wildlife communities.

Objective 3: Develop decision support models allowing planners and managers to confront critical, natural resource management issues in an interactive environment.

Goal 2. Develop the scientific basis for regional comparisons of coastal and freshwater systems and the ability to generalize at greater spatial and temporal scales.

Objective 1: Develop models of coastal, riverine and wetland systems and their stressors that provide a basis for larger scale regional comparisons.

Objective 2: In partnerships with others (e.g., National Science Foundation (NSF) LTER program), invest in long-term, integrated research at reference sites to improve understanding of natural variation in key ecological processes and community structure at multiple temporal and spatial scales.

Goal 3. Develop the scientific basis for monitoring programs capable of detecting and predicting changes in the status of coastal and freshwater ecosystems.

Objective 1: Identify variables and indices with known relationships to specific ecosystem functions that respond to stresses in an interpretable manner, and are useful for predicting future changes in ecosystem structure or function.

Objective 2: Identify threshold values of monitoring variables and indices that signal shifts in ecosystem structure and function.

Objective 3: Improve and integrate existing monitoring schemes to allow for larger landscape assessments of watershed-level changes and their effects on riverine, wetland, and coastal systems and populations.

Goal 4. Improve the scientific basis for restoration and mitigation of impaired or altered freshwater and coastal ecosystems.

Objective 1: Develop new and improved methods for restoring and creating wetland, riverine, or coastal ecosystems and their component flora and fauna.

Objective 2: Work with resource managers to develop criteria for selecting and monitoring restored or artificially created sites, and to identify key, quantitative, performance measures for evaluating the success of coastal or wetland projects in an adaptive management framework.

Goal 5. Restore and enhance capability through personnel recruitment.

Objective 1: Expand scientific capability in ecosystem modeling/community ecology ***[position 3]*** through both recruitment and establishment of a postdoctoral program.

Objective 2: Increase research emphasis on global climate change impacts on the ecology of wetland systems ***[position4]***.

C. Contaminant Biology

Current Program. The primary focus of the Contaminant Biology group at PWRC is to detect, evaluate, and predict the effects of contaminants in terrestrial wildlife, although research is also undertaken in aquatic habitats and with plants. There has a long and productive history of ecotoxicological research at PWRC which has provided data and developed methods to improve wildlife conservation and management. The approach emphasizes coordinated studies on wildlife species in the laboratory and field which measures the effects of contaminants by dose and assesses their ecological significance. The information generated is directed toward the needs of partner agencies, particularly the U.S. Fish and Wildlife Service, National Park Service, and other land management bureaus within the Department of Interior. Research also supports the Environmental Protection Agency, the Department of Defense, and various state and local governmental agencies. Ecotoxicological research at PWRC primarily

works within the framework of the USGS Contaminant Biology Program, but the context and impact of the research inevitably overlaps with other BRD Programs.

Ecotoxicological research at PWRC meets the needs of partners by measuring the current impacts of well-known "legacy" contaminants, such as methyl mercury, lead, or PCBs that remain in the environment in harmful concentrations, and by studying the toxicological effects of newer or poorly known "emerging contaminants" that have only recently been detected in the environment such as polybrominated and perfluorinated chemicals, chlorpyrifos, industrial mixtures, or diclofenac. PWRC contaminants research continues to emphasize the benefit of data from controlled laboratory study (revealing dose-effect relationships) that are linked to data collected from field studies (for realistic exposure and measurement of ecological impact).

The Contaminants group develops methods that improve the evaluation of exposure on aspects of genetic expression, biochemical function and components of life history. Exposure of avian embryos by egg-injection has been perfected and various methods of whole animal exposure developed. PWRC research concentrates on birds; aquatic invertebrates and other vertebrate classes are actively studied. The captive colonies of kestrels and screech owls at PWRC are a unique resource, which are extremely valuable in the development of new protocols and for testing particular chemicals.

Future Directions. Future research will include: 1) investigation of exposure and effects of those contaminants of greatest interest to our partners, 2) assessment of the bioavailability and bioaccumulation of contaminants in wildlife and the ecosystems they occupy, 3) evaluation of new techniques to examine the effects of chemicals and chemical mixtures, and measure their interactions with other stressors, and 4) enhancement of information transfer to improve the accessibility of research information on contaminants to resource managers (e.g. FWS) or regulators (e.g. EPA).

Goals

Goal 1. Identify and quantify chemical and non-chemical stressors and understand their accumulation, distribution, interaction, and effects on biota and habitats.

Objective 1: Identify emerging contaminant issues and evaluate their significance (exposure, accumulation, effects) in biota.

Objective 2: Develop molecular, biochemical and physiological methods for determining the extent and mechanisms of toxicity, including development of methods that reduce the number of animal subjects or methods that eliminate them altogether

Objective 3: Conduct retrospective analyses of extant geographically-based ecotoxicological information to identify significant trends and data gaps.

Goal 2. Fulfill the short-term scientific and technical assistance needs of our client agencies.

Objective 1: Provide technical assistance to client agencies through such efforts as:

- analysis of established biomarkers, physiological assays or life history studies, or interpretation of monitoring data,
- design and implementation of studies in support of risk assessments, rule making, or registration and labeling of commercial chemicals
- evaluation of biotic impacts at Natural Resource Damage Assessment and Restoration (NRDAR) sites or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; "Superfund") sites,

Objective 2: Produce synoptic reviews, or other modes of information transfer, on the effects of contaminants on wildlife in support of wildlife management needs.

Objective 3: Develop decision support frameworks so that contaminants data can guide management decisions more effectively.

Goal 3. Sustain and enhance the capability of PWRC to conduct contaminants and ecotoxicological research through both hiring permanent staff and establishing of a postdoctoral program, and maintaining facilities.

Objective 1: Expand scientific capability in:

- ***Ecotoxicology***, with taxonomic expertise (e.g. herpetology, mammalogy,) ***[position 5]*** and experience conducting lab, pen or field studies ***[position 6]***.
- ***Toxicology/Biochemistry/Physiology***, with expertise in methods that are alternatives to animal testing, or developing methods for assessing new chemicals and mixtures (e.g. cell culture, *in vivo/in vitro* methods, embryo screening, etc.) relevant to wildlife species ***[position 7]***.

Objective 2: Augment and replace analytical equipment to improve research capabilities.

Objective 3: Maintain and improve facilities for studies on captive wild animals at PWRC.

Objective 4: Establish a funding mechanism for post-doctoral researchers, with emphasis on scientists with expertise that enhances the capability of the current staff.

D. *Wildlife: Terrestrial and Endangered Resources*

Current Program. PWRC is a rich center for population and community ecology because of the broad spectrum of skill sets and focal interests of its scientists and staff. At one end are the more traditional, field-oriented, species and system level biologists. Although the focus among PWRC field biologists has long been on birds, PWRC also has expertise in endangered species, mammals, amphibians, and animal community dynamics. Many of these scientists are internationally recognized authorities on the species and systems they study. At the other end of the spectrum are highly quantitative ecologists and biometricians, specializing in the three broad classes of methods used in science and management or conservation: (1) modeling, (2) estimation and statistical inference, and (3) adaptive decision making and management. This group works on a wide array of science and management projects, demonstrating the general applicability of their methods. They collaborate with managers from resource management agencies

to establish the framework of specific management problems and then follow through to identify and refine appropriate management actions.

In addition, there is a growing capability in this group in the natural history and ecology of diseases in wildlife. This expertise includes studies in a wide a range of biological organization from immunological response, development of vaccines, effects on exposed populations, ecological effects of pathogen introduction, to geographic trends in exposure and the risk to humans of zoonotic diseases.

Some of PWRC Wildlife expertise has developed over the years to give rise to operational components to the Wildlife program. The Whooping crane restoration effort embraces efforts from husbandry and production of trained chicks for release, to research on vaccines, captive behavior and population modeling that assists the restoration of whooping cranes in North America.

Future Directions. Structured decision making, using the construct of adaptive management and other decision-theoretic approaches, is a unifying theme that can be used to guide much research at PWRC. This approach will be used not only to meet the individual case specific DOI agency needs that match the USGS Wildlife Program but will be expanded to help inform the delivery of science for the other programs, i.e., Status and Trends, Ecosystems, and Contaminants. PWRC will continue to be an institution composed of scientists and staff who are leaders in the conduct of science and management and in the application of these broad methods to free-ranging animal populations and communities. PWRC's vision is one of increased collaboration and integration among Center biologists in all aspects of population and community research and management. PWRC plans increased efforts to collaborate with management agency personnel and increased involvement in the management process. This will entail a shift away from the traditional model of research providing various pieces of information to managers, with little guidance about exactly how this information is to be used, toward research more directly integrated with the process of arriving at good, and even optimal, management decisions. Monitoring specialists and quantitative PWRC scientists and management/conservation agencies will collaborate to tailor new programs to meet management needs. These will be important results that interact with our growing work on the ecology of disease, and impacts of global climate change, areas of research that will be expanded in the next 5 years.

Goals and 5-Year Objectives.

Goal 1. **Expand PWRC's leadership in quantitative ecology, including population and community modeling, statistical modeling and estimation, and sampling of biological populations.**

> Objective 1: Continue the development and application of hierarchical models to inform problems in ecological science.

Objective 2: Work with agencies on specific estimation and monitoring problems. Recent examples include population viability analysis (PVA) of the whooping crane and the golden-cheeked warbler in Texas.

Objective 3: Continue current developments in estimation and inference methodologies and apply these to populations of concern. Current developments include capture recapture for estimation of abundance and demographic parameters including survival, movement and recruitment; trend analyses from point count data; modeling animal community structure; and inference in metapopulation systems.

Objective 4: Provide training in quantitative methods to peer scientists, biologists in natural-resource-management agencies and others through the development and presentation of workshops and sabbaticals in academic settings.

Goal 2. Establish PWRC as a securely funded Center of Excellence in structured decision making and adaptive management. Increase PWRC capability as a center of methodological expertise in decision theory, providing tools for managers to make informed decisions in the face of uncertainty about ecological dynamics, environmental effects, and the impacts of management actions.

Objective 1: Continue the cooperative development of the adaptive harvest management process currently being utilized by the USFWS to guide harvest management of ducks, geese, swans, and other game species.

Objective 2: Utilize adaptive management approaches to guide the management of individual species, with particular emphasis on threatened and endangered species.

Objective 3: Develop adaptive management approaches to habitat management applications with special emphasis on the management of DOI land units, particularly USFWS Refuges.

Objective 4: Hire scientist with expertise in structured decision making and adaptive management ***[position 8].***

Objective 5: Develop and secure funding for a postdoctoral training program in structured decision making and adaptive management, to provide expanding capability for consulting with partner agencies.

Objective 6: Provide training in structured decision making and adaptive management to peer scientists, professionals in management agencies, and postdoctoral associates, through onsite courses, partnership with the USFWS National Conservation Training Center, and sabbaticals in academic settings.

Objective 7: Develop expertise through hiring a research scientist with expertise in incorporating dimensions of human behavior into methods of decision analysis ***[position 9]*.**

Objective 8: Develop approximate dynamic optimization techniques for problems of large dimension when exact solutions cannot be found in a practical time frame.

Goal 3. **Continue to meet the research needs of management agencies through field investigations of the population ecology of particular species, groups of species, and communities.**

Objective 1: Focus population ecology research on modeling population responses to management actions or land use changes. Examples of such agency driven questions facing PWRC over the next 5 years are evaluating effects of:

- Urbanization, habitat manipulations, wind power development and nest parasitism on bird populations;
- Exploitation on populations of horseshoe crabs, albatrosses, and diamondback terrapins;
- The effects of landscape structure on waterfowl (black ducks and scaup) distribution patterns.

Objective 2: Hire an Avian Ecologist ***[position 10]***, and a Vertebrate Ecologist ***[position 11]*** to concentrate on landscape level effects of Global Climate Change.

Objective 3: Continue development of a comprehensive whooping crane research program integrating Patuxent's captive breeding and research program with field research and development of modeling tools to support decision making by agency partners.

- Develop tools to facilitate population research and estimation of demographic parameters for wild cranes, e.g., development of marking technologies and/or genetic mark-recapture.
- Develop population models of crane population(s) to allow assessment of status, threats, and management actions.
- Continue to evaluate captive rearing and release procedures for cranes, and focus research on captive cranes to investigate drivers of post release success.

Goal 4. **Increase PWRC efforts to understand geographical spread and ecological effects of wildlife diseases, including zoonoses such as highly pathogenic avian influenza, West Nile viral syndromes, and Lyme disease, and to understand disease resistance and immune system defenses against these pathogens.**

Objective 1: Continue research on transmission dynamics of wildlife pathogens at the population and community levels.

Objective 2: Develop approaches to assess geographical trends of wildlife diseases in response to such factors as changing climate, human population distribution, and trends in global transportation.

Objective 3: Continue research on disease resistance using wildlife species to determine how ecological and evolutionary factors influence the nature and effectiveness of immune system defenses.

Objective 4: Hire an Avian disease ecologist ***[position 12]***

V. Implementation

PWRC will continue its leadership role in many areas of wildlife, population, community and ecosystem-related science. To be effective during periods of limited funding PWRC's workforce must be tailored to meet scientific the goals outlined above and our operating budget must be dedicated to projects that achieve them. This plan provides the basis for decisions about hiring and funding projects. A number of permanent positions for scientists have been identified to carry forward the DOI, USGS, and PWRC missions (Table 1). In addition, we will bring on post-doctoral researchers, SCEP students, technicians and persons in other positions to help achieve our goals for specific projects or tasks. In general, we will use reimbursable or cyclic funds that support a project budget to pay technical staff for term appointments; appropriated funds will be used to support fully the salaries of permanent staff. A more detailed explanation of hiring priorities and funding procedures is available in the Patuxent Wildlife Research Center Workforce Plan. The next five years will be an extraordinary challenge as we mobilize our resources to face difficult societal issues such as the effects of climate change, wildlife habitat degradation and loss, and threats of species extinctions.

TABLE 1. Positions planned for hire and current SCEP students at Patuxent Wildlife Research Center.

POSITION	PAGE	*Principal Investigators*	PATUXENT PROGRAM	GOAL	Objective	Priority
1	10	Ichthyologist	Biodiversity	1	3	8
2	10	Wildlife Biologist/Ornithologist	Biodiversity	2	1	12
7	17	Toxicologist/Biochemist	Contaminants	3	1	7
5	17	Wildlife Toxicologist	Contaminants	3	1	2
6	17	Ecotoxicologist	Contaminants	3	1	13
3	14	Community Ecologist /Ecosystem modeler	Ecosystems	5	1	1
4	14	Coastal Wetland Ecologist	Ecosystems	5	2	11
8	19	Wildlife biologist / Adaptive Management Scientist	Wildlife	2	6	10
9	19	Human Dimensions-Decisions Analyst	Wildlife	2	7	6
10	20	Avian Ecologist – GCC	Wildlife	3	2	4
11	20	Vertebrate Ecologist – GCC	Wildlife	3	2	5
12	20	Avian Disease Ecologist	Wildlife	4	4	9
13	11	Quantitative ornithologist	BBL	3	2	14
14	11	Information management biologist	BBL	3	2	3

APPENDIX A. 2003 – 2007 Patuxent Wildlife Research Center Science Accomplishments.

Assessing Biodiversity: Systematics, Status and Trends

Goal 1. Restore and enhance capability through personnel recruitment.

Objective 1: Recruit and hire for BSU a museum-collections-oriented, Ph.D.-level, 4-factor ornithologist skilled in modern taxonomic theory and in the tools of important developing fields such as molecular genetics (laboratory facilities available through the Smithsonian) with a research focus on North American birds.

This objective was accomplished.

Objective 2: Recruit and hire a biologist to coordinate development of waterbird monitoring efforts and databases.

Not accomplished, due to insufficient budget.

Objective 3: Recruit and hire a biometrician to institutionalize analytical support for the Status and Trends group.

Not accomplished, due to insufficient budget.

Objective 4: Recruit and hire a North American freshwater fish systematist for BSU.

Not accomplished, due to insufficient budget.

Objective 5: Review thoroughly the needs for both permanent and temporary science support positions (curatorial, field, GIS, data processing, programming, Internet) and develop a staffing proposal.

This objective was discussed, but no written policy was developed. Decisions on recruiting permanent staff were made on a case-by-case basis, considering mainly the need for the specific work over a period of many years (essentially, in perpetuity).

Goal 2. Enhance the reliability and applicability of monitoring programs by incorporating technical improvements, in collaboration with quantitative population scientists.

Objective 1: Evaluate the effectiveness of alternative methods of estimating detectability and incorporate methods as feasible into existing programs (specifically the BBS) and new designs to assess status and trends.

A major BBS strategic planning effort involving scientists, managers, and users succeeded in refining and prioritizing goals and objectives related to this concept and other aspects of BBS growth and operations.

Objective 2: Incorporate into operational status and trends programs, measurement of potential environmental correlates of population change, or adaptation of existing remote-sensing data.

Due largely to encouragement by PWRC and funding from the Status and Trends Program, experimental work on implementation of this objective is being undertaken by the North Carolina Cooperative Fisheries and Wildlife Research Unit.

Objective 3: Implement off-road surveys as a complement to the BBS.

Experimental testing of this objective was begun and additional work is planned. Actual implementation will require additional funding.

Objective 4: Collaborate with FWS and the broader bird conservation community to identify opportunities for tailoring long-term status and trends assessment programs to meet specific management/conservation needs as they arise, without compromising the ability to draw continental inferences.

PWRC assisted USFWS in the development of a monitoring program for the eastern population of Painted Bunting, aimed at providing data useful for managing breeding habitats and the overall conservation of this species.

Objective 5: Explore developing technologies for their ability to improve the processing and management of population databases.

New data management systems were developed for point count and secretive marsh bird surveys that are regularly conducted on refuges. Collaboration with NBII contributed to developing the electronic Breeding Bird Atlas for North America.

Goal 3. Enhance the benefits of biodiversity science to customers.

Objective 1: Complete development of a functional, peer-reviewed, on-line tutorial on monitoring concepts and methods for refuge and park biologists and other resource managers. Improve and update in response to user feedback.

Completed.

Objective 2: Continue production of the taxon-based series of books on standard methods for measuring and monitoring biodiversity.

One book on standard methods for assessing the biodiversity of fungi was published. Fungi are key environmental indicators, and some have been shown to be highly pathogenic to wildlife (e.g., chytrids on amphibians). Another volume dealing with methods for assessing reptile biodiversity is in the advanced stages of preparation.

Objective 3: Continue to develop sophisticated on-line tools allowing customers to communicate with population databases, emphasizing GIS applications such as those being developed for the NBII Bird Conservation Node.

Collaboration with NBII contributed to developing the electronic Breeding Bird Atlas for North America. The web page for reporting banding encounters was significantly improved, providing immediate feedback to the reporter. New bands now have the web address in place of a postal address. A new band data management program (Bandit) was developed for use by banders.

Objective 4: Expand collaborative data management programs with the FWS and explore the potential for other federal partnerships related to biodiversity databases.

In a very successful partnership with the USFWS Refuge Program, new data management systems were developed for point count and secretive marsh bird surveys that are regularly conducted on refuges.

Objective 5 & 6: Continue to collaborate with the Smithsonian Institution to provide maximum on-line public access of electronic collections records. Internet access of Natural History collection records will start in FY 2004. Complete geo-referencing of data for North American amphibian, reptile, bird, and mammal specimen records at the National Museum of Natural History, to facilitate use of locality information for research and conservation. .

Extensive progress was made throughout the National Collection in making specimen records available on line, and in the amphibian and reptile collection on geo-referencing specimen records.

Coastal and Wetland Ecosystems and Landscapes

Goal 1. Develop scientifically based tools for managing coastal and wetland populations, communities, and ecosystems and forecasting future ecological conditions.

Objective 1: Improve understanding of responses of selected populations, communities, and ecosystem processes to multiple, interacting threats and stressors in coastal and wetland environments.

Peer-reviewed articles were published from research focused on understanding ecosystem processes and forecasting responses to important threats and stressors. For example, papers based on the ongoing research using surface elevation tables in coastal wetlands increased current understanding of salt marsh ecosystem processes relative to sea-level rise and predicted future marsh structure and effects on wildlife and aquatic resources.

Objective 2: Construct predictive models that integrate effects of anthropogenic and natural agents of change on important coastal and wetland habitats and selected fish and wildlife populations.

PWRC scientists provided leadership for a number of regional, national and international workshops focused on a range of issues, including standardizing techniques for measuring and interpreting changes in coastal marshes, estimating the condition of submerged aquatic vegetation in coastal estuaries, and predicting effects of watershed conditions on riverine and estuarine ecosystems.

Objective 3: Develop decision support models that integrate scientific data within a geographic framework allowing planners and managers to address critical natural resource management issues in an interactive and predictive environment.

A series of ecosystem models was developed to better understand the implications of climate change on interior freshwater wetlands. Predictive models that were published in peer-reviewed journals were also provided to resource managers in useful formats: a USGS Fact Sheet on sea grass recovery from physical disturbance and a Fact Sheet on the impacts of climate change on wetlands in the Prairie Pothole Region and implications for sustaining continental waterfowl populations.

Objective 4: Develop applications of Adaptive Resource Management for enhancing plant, fish, and wildlife populations on federal lands.
[see Objective 3, above]

Goal 2. Develop expertise that provides a basis for regional comparisons of coastal and wetland systems and the ability to generalize at greater spatial and temporal scales.

Objective 1: Develop models of coastal and wetland systems and their stressors that provide a basis for larger scale regional comparisons.

Progress was made in "scaling up" from site specific studies to broader understanding and prediction of coastal and wetland changes.

Objective 2: Initiate long-term ecosystem studies at several reference sites nation-wide that form the basis for understanding the important time scales of critical ecosystem processes.

National parks and national wildlife refuges provided study sites that allowed PWRC scientists to develop regional networks to compare and contrast regional changes in ecological parameters. In addition, the number of study sites was expanded to include areas that are already part of long-term ecosystem studies, such as the NSF-supported Long-Term Ecological Research program and National Oceanic and Atmospheric Administration's National Estuarine Research Reserve System.

Objective 3: Integrate ecosystem studies addressing critical management issues in wetlands and coastal habitats in the Southeast.

This goal was dependant on hiring a new scientist to be stationed in Athens, GA, which did not occur due to budgetary limitations.

Goal 3. Develop an understanding of the impact of terrestrial and aquatic invasive species on coastal and wetland populations, communities, and ecosystems.

Objective 1: Develop models of wetland and coastal populations, trophic structure, and ecosystem processes affected by invasive species.
[see objective 2, below]

Objective 2: Develop management strategies that reduce the impacts of invasive species.

Patuxent scientists were responsible for a special issue of the journal *Estuaries and Coasts* that focused on the ecology and management of the invasive plant *Phragmites australis,* a workshop co-organized with the New Jersey Sea Grant Program assessing the current state-of-the-science on the invasive coastal wetland plant *Phragmites australis,* and peer reviewed publications presenting the results of ecophysiological studies comparing the characteristics of *Phragmites* compared to native coastal wetland species and implications for management

Objective 3: Develop quantitative ecological risk assessment models that make specific predictions regarding ecosystem vulnerability to threats of certain invasive species.

[see objective 2, above]

Goal 4. Develop scientifically based monitoring programs capable of detecting and predicting changes in the status of coastal and wetland ecosystems.

Objective 1: Identify variables and indices with known relationships to specific ecosystem functions that respond to stresses in an interpretable manner, and that are anticipatory, i.e., that are useful for predicting impending changes in ecosystem structure or function.

Considerable progress was made in identifying key variables for ecosystem functioning for implementation within monitoring programs focused on large river, coastal, and freshwater wetland systems.

Objective 2: Quantify information on the bounds of natural temporal and spatial variability of coastal and wetland monitoring variables and indices.

Research advances were made by obtaining Park- and Refuge-based data indicating the ranges of intra- and inter-system, geographic, and temporal variation.

Objective 3: Identify threshold values for monitoring variables and indices that signal shifts in ecosystem structure and function.

In 2006, NPS Regional I&M Coordinators recommended release of USGS cyclical funds for conducting a workshop on "Ecological Thresholds and Natural Resource Management," in advance of soliciting a follow-on research proposal.

Goal 5. Improve the scientific basis for restoration and mitigation of impaired or destroyed coastal and wetland ecosystems.

Objective 1: Develop new and improved methods for restoring and creating coastal and wetland ecosystems and their component flora and wildlife fauna.

Objective 2: Quantify ecological responses of restored/reconstructed ecosystems to particular methods used under conditions of existing, accompanying stressors on the recovering systems.

Objective 3: Develop models for evaluating and selecting restoration sites.

Objective 4: Identify performance criteria for evaluating the success of restored and created coastal and wetland ecosystems.

Objectives 1-4: PWRC scientists conducted research on a number of issues in this arena, including dam alterations and their effects on river systems and fisheries, shoreline stabilization studies on barrier islands, methods to mitigate the subsidence of coastal salt marshes, restoring urban wetlands, and restoring large islands using dredged material. In addition, several PWRC scientists were heavily involved in technical support roles as national panelists on coastal restoration in Louisiana and California.

Impacts of Contaminants

Goal 1. Develop multi-disciplinary, integrated investigations and modeling efforts that evaluate the role of contaminants as one of many stressors that affect wildlife. Stressors may include nutritional plane, disease states, predation pressure, or competition.

Objective 1: Improve understanding of the responses of selected wildlife populations, communities, and ecosystem processes to multiple, interacting threats and stressors.

Studies on ospreys in the Delaware River show the interaction of measures of habitat suitability with risk of contaminants exposure

Objective 2: Develop quantitative ecological risk assessment models with specific, measurable predictions regarding contaminant threats to selected species.

An analysis (Qualitative Risk Assessment) of 50 Important Birds Areas of the NE United States showed the relative risk of contaminants exposure to birds in these areas.

Goal 2. Become more active in identifying emerging contaminant issues. These emerging issues include: (1) the testing of pesticides in the process of registration for use, including genetically engineered pest control agents; (2) mobilization of metals from changing human activities; (3) exposure of wildlife to pharmaceuticals and human health care products; and (4) runoff of feed additives and fertilizer from agricultural habitats.

Objective 1: Construct predictive models that integrate effects of anthropogenic and natural agents of change on important wildlife populations.

An investigation of the toxicity of the non-steroidal anti-inflammatory drug diclofenac to New World vultures was recently initiated. Comparative embryo toxicity for polybrominated diphenyl ether flame retardants, a contemporary contaminant of international concern studies have been conducted in chickens (*Gallus gallus*), mallards (*Anas platyrhynchos*), and American kestrels (*Falco sparverius*). A study assessing the bioaccumulation of several groups of industrial chemicals, including fire retardants and perfluorinated chemicals, from sediment collected from the Conasauga River below a wastewater treatment plant's land-application site in Dalton, GA has also recently been completed. A study on the effects of a new class of pesticides (chlorfenapyr) on the physiology, pathology, and behavior of mallard ducks is nearly completed.

Goal 3. Develop molecular methods (e.g., proteonomics, genomics) or other bio-indicators and concepts that measure and predict the effects of contaminants in wildlife.

A new scientist with expertise in this area was hired.

Objective 1: Identify performance criteria for evaluating the success of restored or remediated habitats based on wildlife population structure.

A study conducted on white-tailed deer (*Odocoileus virginianus*) residing near the inactive Continental Mine in northern Idaho found that deer pellets collected in 2004 exhibited Pb levels as high as those observed prior to site remediation, indicating that although the cleanup successfully capped the mine tailings pile, remaining pockets of highly contaminated soil may still expose wildlife to toxic concentrations of Pb.

Goal 4. Test the application of new and proposed bio-indicators and provide guidelines for their implementation in long-term monitoring programs.

Objective 1: Develop and validate in the field state-of-the-art biomarkers of contaminant exposure and effects in wildlife.

Due to retirement of scientists with this expertise, this goal was not addressed.

Objective 2: Identify threshold values for biomonitoring variables and indices that signal shifts in population or community structure and function.

An ongoing study is addressing species-specific sensitivity to mercury in bird embryos in order to establish meaningful guidelines on safe levels of mercury in various avian species. A recently completed study generated biochemical, histopathological and lethality data to establish diagnostic

toxicity thresholds for birds exposed to vanadium compounds found at many fly ash ponds in the United States. Likewise, the previously described study on chickens, mallards and American kestrels established multiple toxicity thresholds for polybrominated diphenyl ether flame retardants. A study investigating reproductive thresholds in American kestrels (*Falco sparverius*) exposed to methyl mercury and an assessment of the comparative developmental toxicity of a mosquito larvicide (GB1111) to eggs of different species has also been completed. The data from these studies are essential for determining whether levels of the respective contaminants observed in wild birds are of biological significance and the data are used extensively by biologists, research managers, and risk assessors.

Goal 5. Detect through systematic monitoring contaminant biological effects that are ecologically relevant.

Objective 1: Develop and test new methods that evaluate or even link contaminants to demographic parameters and effects on population and communities.

Three recent studies have involved the development or testing of methods that are used for evaluating environmental conditions that may harm fish and wildlife resources 1) Assessment of alternative substrates for culturing *Lumbriculus variegates,* 2) Effects of hardness and alkalinity in culture and test waters on reproduction of *Ceriodaphnia dubia*, and 3) Evaluation of the combined use of habitat assessment protocols and sediment quality assessment protocols to provide an integrated assessment of stream quality.

Objective 2: Design and implement large-scale field investigations of regional to national scope.

A project funded by the state of Georgia to study the toxicity of anionic components in textile effluents in order to recommend potential substitutions within the manufacturing processes is in the final stages. Exposure to legacy and contemporary contaminants, and genotoxic and reproductive endpoints were determined in ospreys (*Pandion haliaetus*) nesting in Chesapeake and Delaware Bay. These data were used to document pollution gradients, relationships between contaminant exposure and reproduction, geographic areas in need of remediation, and to develop a new habitat suitability model for nesting ospreys. Multiple sediment-quality assessments have also been completed for the FWS (refuges and ES offices), which have provided information for management decisions.

Objective 3: Continue retrospective analyses of extant ecotoxicological information to identify significant trends and data gaps.

Creation of widely-used internet-accessible ecotoxicological databases: 1) Species Decline: Contaminants as a Contributing Factor, 2) Contaminant

Exposure and Effects—Terrestrial Vertebrates (CEE-TV) database, 3) Biological and Ecotoxicological Characteristics of Terrestrial Vertebrate Species Residing in Estuaries.

Objective 4: Evaluate the integration of biomonitoring methods for contaminant effects into other monitoring and assessments of federal lands (e.g., refuge monitoring, monitoring of rangeland health, and vital signs program of the National Park Service).

Data from the CEE-TV database have subsequently been used to conduct a risk assessment at 23 National Parks, which identified units warranting further contaminant biomonitoring and suggested management strategies to mitigate pollutant hazards.

Population and Community Ecology

Goal 1. Increase PWRC capability as a center of methodological expertise for the future development of the estimation of population abundance, trend, vital rates, and community parameters.

Objective 1: Recruit and hire a spatial statistician dealing with landscape modeling and estimation issues.

This objective was met.

Objective 2: Continue current developments in estimation methodologies and apply these to example populations. Current developments include capture-recapture for estimation of abundance and demographic parameters including survival, movement and recruitment; trend analyses from point count data; and community parameters such as species richness and patch dynamics.

PWRC continues to experience a high level of output on quantitative methods including several books and monographs: Williams, Nichols and Conroy (2002) and MacKenzie et al. (2006). A number of workshops on Bayesian methods, hierarchical models, occupancy modeling, capture-recapture, and related topics have been presented by scientists.

Goal 2. Increase PWRC capability as a center of methodological expertise in decision theoretics: tools for managers to make informed decisions in the face of uncertainty in biology, environmental effects, and the impacts of management actions.

Objective 1: Continue the cooperative development of the adaptive harvest management process currently being utilized by the FWS to guide harvest management of ducks.

Objective 2: Utilize adaptive management approaches to guide the management of individual species. Examples are management of endangered manatee and whooping crane populations.

Objective 3: Develop adaptive management approaches to habitat management applications with special emphasis on the management of FWS Region 5 Refuges.

Objectives 1-3: PWRC efforts, including briefings of the highest executive levels of USGS and DOI, prompted DOI to issue the DOI Technical Guide on Adaptive Management and endorse structured decision-making and adaptive resource management as best practices throughout DOI agencies. PWRC scientists, in collaboration with colleagues inside and outside DOI, developed tools and communicated technical aspects of decision analysis to stakeholders for three primary applications: harvest management of migratory birds, recovery of imperiled species (Florida manatee and whooping crane), and management of habitats in the National Wildlife Refuge system. Through a series of training workshops and technical presentations, and through production of numerous scientific publications, PWRC enhanced its reputation among federal, state, local, and international agencies as an expert institution in the application of decision theory to natural resource management.

Goal 3. Continue to meet the research needs of management agencies through field investigations of the population ecology of particular species, groups of species, and communities.

Objective 1: Focus population ecology research on modeling mechanisms that determine population responses to conservation management actions. Examples of such agency-driven questions facing PWRC over the next 5 years are evaluating effects of: (1) harvest on American woodcock; (2) agricultural practices on availability of food resources to waterfowl; (3) urbanization, habitat manipulations, and nest parasitism on bird populations; and (4) exploitation on populations of horseshoe crabs, albatrosses, and diamondback terrapins.

The whooping crane recovery took a big step forward with the successful initial introduction of an eastern flock of migratory cranes. The long-term population studies of Roseate terns allowed an evaluation of long-term impacts of the April 2003 Bouchard Barge Oil Spill in Buzzards Bay. Studies of diamondback terrapins in Chesapeake Bay were in part responsible for a ban on harvest in Maryland imposed by the Maryland DNR. Studies in support of U.S. Fish and Wildlife Service included

evaluation of management practices in the Mississippi Alluvial Valley for game and nongame birds and evaluation of the effects of wind power development on resident and migrating bird species.

Goal 4. Continue to develop and refine quantitative approaches to strengthening the scientific validity of monitoring program design and analysis, and disseminate assessments of monitoring data to agencies and the scientific community.

Objective 1: Develop approaches that incorporate detection into surveys resulting in measures of absolute and relative abundance. Potentially include other variables that will enable statistical inference of relationships between animal populations and the environment.

The quantitative group at Patuxent has been associated with a number of important advances during the period 2003 - present, ranging from recommendations on designing monitoring programs that are relevant to scientific and management objectives, to recommendations about the conduct of structured decision making, to the development of estimation methods ([1] occupancy modeling; [2] advanced capture-recapture modeling with (2a) multiple kinds of encounters, (2b) random individual effects, (2c) state uncertainty, (2d) spatial effects; [3] estimation methods for avian point counts; [4] estimation methods for species richness) to analyses with various organisms addressing questions about relationships between animal populations and communities and both management actions and environmental factors. These latter investigations include work on a wide variety of species (tigers, seals, manatees, elephants, passerine birds, ducks, shorebirds, raptors, frogs, salamanders, sea turtles, butterflies, etc.) on all 7 continents.

PWRC has maintained extensive collaborations with U.S. Fish and Wildlife Service, Canadian Wildlife Service, State, and non-government organizations (e.g., National Audubon Society) to develop, refine, and analyze monitoring programs. Publications on analysis of the Breeding Bird Survey, Christmas Bird Count, and many other surveys addressed estimation questions and detection bias in the estimation of population change and spatial analysis. PWRC continued to develop and use hierarchical estimation methods to analyze Breeding Bird Survey data and developed new approaches for surveying bald eagle populations. PWRC was also active in the following collaborative field projects with the USFWS: implementing independent, double-observer, point count methods for estimating density of grassland breeding birds as part of an applied management project that included 16 National Wildlife Refuges; developing an independent double-observer transect method for estimating the density of wintering grassland birds; and implementing a double-sampling method for estimating detection probability and absolute abundance of waterbirds in vegetated wetlands, during an applied management project that included 23 National Wildlife Refuges across two regions.