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Strategic Science Plan

USGS Patuxent Wildlife Research Center

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I. Introduction

Background. The U.S. Geological Survey (USGS) Patuxent Wildlife Research Center (PWRC) is a biological research center in the USGS, the premier Federal earth and biological sciences research organization in the Nation. PWRC is among the largest wildlife research centers in the world. It is home to nearly 70 scientists and 100 support staff. PWRC headquarters is located on the U.S. Fish & Wildlife Service's (FWS) Patuxent Research Refuge in Laurel, Maryland. PWRC has eleven Field or Duty Stations from Maine to Mississippi, co-located with universities or partner agencies (see Appendix 4). The PWRC Biological Survey Unit is located at the Smithsonian Institution's National Museum of Natural History in Washington, D.C.

As a research facility of the Department of the Interior (DOI), PWRC is charged with the task of conducting research and delivering scientific information necessary to fulfill DOI's responsibility to manage the Nation's fish and wildlife resources. Funds appropriated by Congress to USGS support a significant part of PWRC's science; however, because much of its science is driven by the needs of other agencies, funding from those partners provide a majority of the funds for PWRC research project operations and that support is essential for full realization of PWRC's potential production.

Since its establishment in 1936 on the nation's first and only research refuge, PWRC has become a leading, internationally recognized research institution for 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. Scientists at PWRC have been responsible for many important advances in biological resource conservation. PWRC's fundamental research strengths are in the areas of migratory bird conservation, wildlife population analysis, vertebrate systematics and biodiversity, habitat management, wetland and coastal ecology and management, restoration, contaminants, endangered species, and adaptive resource management. In addition to research, PWRC (i) develops, manages and/or coordinates a variety of national and regional bird and amphibian monitoring programs, (ii) has responsibility for the national Bird Banding Laboratory, and (iii) manages the largest flock of captive endangered Whooping cranes, developing the methods and producing offspring for restoration to the wild. PWRC scientific publications, technical assistance products and, wildlife databases, are used nationally and worldwide in managing biological resources.

The strength and future of PWRC is built upon the excellence of biological and ecological research. This derives from the combination of staff expertise in biodiversity, coastal and wetland ecology, contaminant science, endangered species science, population ecology, and survey design science, with a work environment that promotes good ideas and supports the full range of research activities. Ultimately, the content of PWRC science is shaped by the interaction between the natural resource needs of our partners in Federal resource management agencies (often mandated by the Migratory Bird Treaty Act, or the Endangered Species Act) and the intellectual creativity and motivation of its scientists and technical staff.

As PWRC evolves within the USGS strategic framework to meet new challenges of the twenty-first century, it must maintain expertise and leadership in innovative wildlife-oriented ecosystem sciences to meet the needs of partner agencies, the public, and the larger challenges of environmental science.

The purpose of this Science Plan is to provide a blueprint for the direction of science at PWRC over the next five years. It will be the primary source of guidance for management of financial resources, organizational structure, staffing, facilities, and other infrastructure. The Plan was written by a team of scientists and managers, drawing on the advice and ideas of Center scientists and resource personnel. Final goals and objectives were validated against Departmental and USGS missions, visions, and policies.

The PWRC Vision

To be recognized as a premier research institution for wildlife science, nationally and internationally.

The PWRC Mission and Goals

To provide information needed to strengthen the scientific foundation for managing the Nation's biological resources. We will:

- Strengthen the scientific basis of wildlife and biological resource conservation, particularly those resources held in trust for the nation by the Department of the Interior.
- Address and solve the most critical, pressing, and complex problems in wildlife and ecosystem management, through integration of our expertise in biological science, with capabilities of other USGS disciplines and agency partners.
- Serve as a leader in assessing the status and trends of the Nation's biological resources, and in managing and delivering to resource managers scientifically sound databases and analytical products associated with biological surveys.
- Improve understanding of ecosystem dynamics to determine and predict the effects of human impacts and natural processes on ecosystem changes.
- Improve understanding of the fate and effects of contaminants, disease and other stressors in the environment to determine and predict how much they affect wildlife populations.
- Develop methods for improving the restoration and monitoring of threatened and endangered populations or other key resources, including methods for a structured approach to management decisions.
- Support the Patuxent Research Refuge as a model of long term ecological research and a focal point for study and interpretation of the ecological and economic role of the green space in the agricultural and urban landscape of Maryland.

II. *Current and Future Science*

Overview 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 developing, managing, and interpreting long-term wildlife surveys. Patuxent has long been known for its key role in endangered species research and propagation, especially its whooping crane program. PWRC is a leader in determining the effects of contaminant exposure on mammals, birds, 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; investigating wetland and riverine dynamics and management; and investigating coastal restoration methods. Patuxent also has forged important milestones in the areas of avian, mammalian, and amphibian systematics. The Center has also become a major hub for developing and managing key wildlife databases as part of its Biological Informatics program. PWRC applies this wealth of expertise and knowledge to a wide variety of biological resource problems through extensive interactions within the U.S. Geological Survey and with other agencies of DOI and the Nation.

The emphasis for PWRC science for the next five years spans five conceptual themes central to the USGS mission: (1) Biodiversity: Systematics, Status and Trends, (2) Terrestrial, Freshwater, and Coastal Ecosystems (3) Contaminant Ecology, (4) Wildlife: Terrestrial and Endangered Resources, and (5) Information Science. Each theme is described and organized in terms of PWRC's current capabilities and its plans for development over the next five years.

Relevance: the role of Partners PWRC has always worked closely with many entities that have land and wildlife management responsibility; those close partnerships are evident in the section below on science achievements. Close partnership with operational agencies is essential for meeting their science information needs, and, to help increase agency awareness of new biological problems and methods for meeting those challenges to good management of 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, meeting the priority needs for information expressed in the cyclic funding programs in USGS dedicated to the priorities set by the FWS and NPS. Also, there are more formally established partnerships dedicated to an issue or habitat. Formal partnerships that engage PWRC scientists include:

- Whooping Crane Eastern partnership
- 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.

Collaboration: USGS, University scientists and others 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 contribution of labor, equipment and capabilities from scientists working together. Interdisciplinary collaboration within USGS is important to PWRC. Some PWRC projects have initiated interdisciplinary work with each of the other USGS disciplines. In addition, three PWRC scientists are located in the Water District office in Augusta, Maine. PWRC scientists also 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 a university. 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 Patuxent either through their university or directly by PWRC. Finally, scientists at PWRC are engaged in numerous international collaborations including with the Salim Ali Centre for Ornithology & Natural History (India), the Royal Society for the Protection of Birds (UK), the Canadian Wildlife Service, and CONABIO – Mexico.

Biodiversity: Systematics, Status and Trends

Current Program 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. Assessing the status, population trends, and abundance of taxa requires an appreciation and understanding of their biology and the functional roles they play in biotic systems. Sound taxonomy and reliable statistics are 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. They contribute 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 additions to and maintenance of nearly one million specimens of North American vertebrates that are part of the National Collection housed in the NMNH. This formal association between the Smithsonian Institution and BSU and 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.

PWRC has always played an integral role assessing the status and trends of continental bird populations and managing databases that support operational monitoring programs. 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 has recently forged a partnership with Mexico's National Commission for the Knowledge and Use of Biodiversity to establish a Mexican BBS program by 2010. PWRC biologists also collaborate with various partner organizations developing, improving, and implementing survey protocols for colonial waterbirds, secretive marsh birds, shorebirds, and other taxa that are not well surveyed by the BBS. Center biologists assume pivotal coordination responsibilities in the development of regional and continental bird population monitoring efforts, providing guidance on survey design, use of appropriate survey methodologies, and the intricacies of implementing these activities in the field. They also design, develop, and maintain data management systems in support of the monitoring efforts including the BBS, colonial waterbird surveys, secretive marsh bird surveys, avian point count programs, State breeding bird atlases, and the USFWS Focal Species strategy for the eastern population of Painted Bunting. PWRC's experience and capability for managing large long-term population databases is unmatched in the USGS; these capabilities are described in greater detail in the accompanying Biological Information Plan. Analogous efforts are also directed towards monitoring amphibian populations including the North American Amphibian Monitoring Program (NAAMP). NAAMP was modeled after the BBS and provides information on the status and trends of calling amphibian populations in the eastern and central U.S. It has also assumed responsibility for developing the on-line National Amphibian Atlas. PWRC investigates the development of methods to assess the status and trends for other taxa of interest to DOI agencies such as pollinating insects. Raw data, population trend estimates, and other outputs generated from these monitoring program databases inform conservation agencies and other organizations and help guide the establishment of conservation priorities and direct appropriate management activities for species of conservation concern.

The Bird Banding Laboratory (BBL) provides bird-banding permits and bands to qualified applicants and manages databases of all North American bandings and encounters. BBL has a long-standing close partnership with the Canadian Banding Office and is in the process of building a similar relationship with Mexico. Canadian banding and encounter data are processed by the BBL and are housed in the PWRC databases. Most banding and encounter data are now submitted by banders electronically, including a web application for encounters. Although this mechanism is being strongly promoted, a 1-800 phone service still accounts for a significant proportion of hunter-reported encounters. Paper transactions have declined to about 5% of encounters. Banding data continues to be used for a wide variety of scientific and wildlife management purposes, including estimation of game bird population sizes and

harvest rates. [See section on Information Science for technical information regarding management of large databases.]

Future Directions. The partnership between the USGS/PWRC scientists and the Smithsonian Institution has been very productive and will continue to grow, producing world-class research and providing service to the national and international scientific community that depends on access to the collections of vertebrates and their associated data housed at the NMNH. As the current staff ages and requests for voucher specimen deposition, specimen and data retrieval, and research assistance increase, the BSU will strive to expand its staff to meet the increasingly complex needs of both the biological and legal arms of the wildlife management and conservation communities for expert taxonomic evaluation and biodiversity assessment. Immediate priorities include maintenance of existing taxonomic expertise in mammals and birds, augmentation of that in amphibians and reptiles by adding a second research scientist, and expansion of taxonomic coverage with the addition of ichthyology to the museum program. Four important new initiatives will impact the work of the BSU, 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), have recently started; FWS and the NPS continue to expand their inventory and monitoring programs on public lands. The most important drivers of BSP work are the impacts on biodiversity and biogeography from global climate change, and from the increase in invasive species in North America. With additional support, BSU scientists are in key positions to contribute to those needs.

In the next five years, PWRC will place a greater emphasis on capability for measuring biodiversity and will expand biochemically based phylogenetic work, within the museum environment. Development and refinement of inventory and monitoring tools such as on-line tutorials and species identification keys and the on-going series of biodiversity monitoring methods handbooks must keep pace with the increasing demands of the resource management community, as well as those from other scientists and the public. New technology for real-time, on-line interaction with population databases will be developed and adapted for use by USGS partners. Collaboration with the National Biological Information Infrastructure (NBII), the USGS Geography Discipline, and the Smithsonian Institution will be expanded to improve capabilities in electronic data development, analysis, and sharing. The development of status and trends programs will require the expertise of quantitative ecologists and biometricians versed in population modeling and estimation to deliver the most credible procedures available.

PWRC long-term population monitoring programs will explore opportunities to identify and minimize biases in current survey designs, integrate methods for estimating detection probability into surveys, and improve the value of monitoring programs through collection of potentially significant ancillary data. Additionally, 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 (see Information Science). 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. Given

a decision to proceed, PWRC will require explicit objectives, state-of-the-art statistical approaches to survey design, and survey protocols that measure detection and other potential biases and maximize collection of ancillary data, consistent with survey objectives and operational feasibility.

The BBL will continue a phased reorganization, necessitated by its fundamental transformation from paper-based to electronic modes of operation. Increased emphasis will be placed on improving both IT and biological skills 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.

Goals and 5-Year Objectives

Goal 1. Enhance and expand the taxonomic and research capabilities in BSU.

Objective 1: Recruit and hire a museum-collections-oriented, Ph.D.-level, 4-factor herpetologist (**position 1** in Table 1, p. 31) skilled in modern taxonomic theory and the use of molecular genetics. The focus of research will be on North American amphibians and reptiles.

Objective 2: Expand the research capabilities of PWRC by recruiting and hiring a technical support person with laboratory skills in molecular techniques (**position 2**) to augment current BSU research in ornithology and to provide technical support for other disciplines in the museum. This expansion would be done in collaboration with the Smithsonian whose laboratory facilities are available, and may serve as a model for future interactions with other programs at PWRC (e.g., pollinating insect identifications and surveys).

Objective 3: Expand the taxonomic coverage of the BSU project in the NMNH by recruiting and hiring a museum-collections-oriented, Ph.D.-level, 4-factor ichthyologist (**position 3**) skilled in modern taxonomic theory and the use of molecular genetics. Research focus would be on the diversity and relationships of the North American freshwater fishes, temporal and spatial changes in their distribution, and the impact of invasive species on that diversity.

Objective 4: Recruit and hire a museum support person with knowledge of fish biology (**position 4**) to serve as collection manager for the North American freshwater fish collection. This expansion is endorsed by and in collaboration with the Smithsonian Institution which currently lacks expertise and curatorial focus in this geographic region and will provide taxonomic coverage for all the vertebrate species of interest to the USGS.

Objective 5: Recruit and hire a research support person (**position 5**) with general knowledge of vertebrate biology and skills in field investigation, data analysis, GIS applications, computers, and graphics. This person will provide research support to the scientific staff.

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. As

recognized in this plan, the implementation of these improvements will require additional staff beyond those currently available to the BBS:

- Recruit and hire a full-time biological technician devoted to support the daily operations and data management procedures within the BBS office.
- Recruit and hire a Research Wildlife Biologist (**position 6**) to assist in the implementation of new field methods aimed at strengthening the scientific credibility of the BBS results,
- Recruit and hire a GIS technician (**position 7**) to expand the geospatial capabilities necessary for the daily operation of the BBS office and the 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. Obtain additional resources necessary to conduct annual analyses of NAAMP data similar to those produced for the BBS and institutionalize the 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. Explore opportunities for the greater 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 to promote the use of its restructured databases for scientific purposes.

Objective 1: Develop QA/QC guidelines for BBL operations.

Objective 2: Implement recommendations of the BBL FACA (Federal Advisory Committee Act) Committee.

Objective 3: Increase staff biological expertise.

Objective 4: Make databases and analytical tools available through the web.

Objective 5: Develop and manage a recapture database.

Objective 6: 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 for new monitoring efforts to help achieve their programmatic goals. Current examples include monitoring for USFWS Focal Species such as the eastern population of Painted Bunting and group-based programs such as efforts to develop a coordinated monitoring program for secretive marsh birds.

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. Current examples include guidance for conducting breeding bird atlases in North America and developing the on-line National Amphibian Atlas.

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

Objective 1: Continue production of the taxon-based series of books on standard methods for measuring and monitoring biodiversity.

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 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.

Achievements since the 2003 Strategic Science Plan

This 5-year period was a period of fiscal austerity that hindered implementation of activities requiring new funding. For example, Goal 1 was directed at personnel recruitment, but only the 4-factor ornithologist position could be funded during this period. This, however, was an important step in providing BSU scientists with research capability in molecular systematics. Similarly, incorporating methodological improvements to the BBS (Goal 2, Objectives 1-3) could not be implemented. However 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. Considerable progress was made on Objectives 4-5 under Goal 2. For example, 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. Progress was also made on objectives under Goal 3. Examples include the on-line monitoring manual that was successfully launched as a technical resource for individuals involved in designing population monitoring projects. 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. Collaboration with NBII contributed to developing the electronic Breeding Bird Atlas for North America. Nine of 16 recommendations of the FY 2002 peer review of NAAMP were implemented over the period, including publication of a paper evaluating the monitoring potential of NAAMP and describing an analysis framework.

The North American coverage of vertebrates in ITIS was completed and work on other taxonomic groups started. 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. 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.

In BBL there has been a directed shift in skill sets since 2003 away from clerical and into professional skills, paralleling the conversion from hierarchical to relational databases (see Information Science). A new band data management program (Bandit) was developed for use by banders. Bandit, which replaces BandManager, is more user-friendly and provides a greater array of options desired by banders. A 1-800 band encounter reporting system was

established in Mexico, and the web page for reporting encounters was significantly improved, providing immediate feedback to the reporter. New bands now have the web address in place of a postal address. Communication with banding interests in Central and South America was enhanced through establishment of a collaborative dialogue. Significant progress was made toward assuring adequate (2-year) supplies of high quality bands for all types of uses, especially the “pre-season” waterfowl banding programs. A FACA committee was established to ensure broad stakeholder input to BBL operations, and an interim 5-year Strategic Plan was prepared.

Terrestrial, Freshwater, and Coastal Ecosystems

Current Program: Ecosystem science at PWRC is primarily focused on the coastal systems in the eastern United States, with more limited activity in freshwater wetland, lacustrine, and riverine systems in the interior of the country. Most investigations are interdisciplinary in nature, involving partnerships with Department of Interior bureaus, mostly U.S. Fish & Wildlife Service (FWS) and National Park Service (NPS), other federal, state, and 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. Combining observational, experimental and modeling approaches, PWRC researchers emphasize developing predictive relationships needed to forecast responses of ecosystem structure and function to agents of change in coastal and wetland environments. Although the geographic emphasis of the research has been in the eastern United States, some elements have become national and international in their scope. Major strengths of this Program have been its role in improving the scientific basis for resource management decision-making as well as its cross-disciplinary work with the Hydrology, Geography and Geology disciplines. Scientific results to date have provided key information needed for decisions concerning wetland and resource restoration and management, population recovery, sea-level rise scenarios in the coastal zone, minimum flow needs for fisheries in altered river systems, and the impact of climate change on freshwater ecosystems, as well as for guiding development and interpretation of ecosystem monitoring programs.

Future Directions: The future within the USGS will demand that scientists integrate their work across disciplines more than ever. Scientists in the Biological Resources Discipline at PWRC will work with chemical, physical, and engineering scientists at different levels in tackling important coastal and wetland issues of regional, national and international concern. Given the nature of changes taking place due to both human and natural influences, emphasis will be less on site-specific studies and more on comparative studies and larger scale processes that have broad management and societal implications. PWRC scientists in the ecosystem theme can use their expertise and comparative and experimental approaches to inform science-based decisions.

One particular area of focus will be potential threats to ecological resources and ecosystem services from global climate change. Emphasis will be placed on understanding wetland and

aquatic ecosystem vulnerability and potential ecosystem responses to future climate change scenarios, and on developing better predictive models.

PWRC will assume a lead role in the development of tools to aid managers in monitoring, protecting, managing, and restoring coastal and wetland systems. High priorities at Patuxent, and within USGS, will be developing predictive models of coastal and freshwater wetland ecosystem responses to natural and anthropogenic stress. Stresses include sea-level rise, indirect effects of watershed development, river flow regime changes, direct ecosystem alterations, and others. Approaches include GIS-based decisions 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 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 address 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., 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 for 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: Quantify ecological and physical responses of restored or constructed ecosystems to existing stressors, or particular management activities, using an adaptive management framework.

Objective 3: Assist in developing criteria for selecting and monitoring restoration sites, and identify key performance measures for evaluating the success of coastal or wetland projects.

Goal 5. Restore and enhance capability through personnel recruitment.

Objective 1: Strengthen scientific expertise in the Ecosystem group by hiring additional RGE scientists with expertise in ecosystem modeling/community ecology (**position 8**), and freshwater ecology (**position 9**). Hire a coastal wetlands ecologist, concentration on Global Climate change effects (**position 21**). Consider establishing a competitive post-doctoral position within the Program.

Objective 2: Ensure that all permanent federal employees are base funded.

Objective 3: Strengthen technical support at PWRC by hiring two permanent technicians (**positions 10 & 11**)

Achievements since the 2003 Strategic Science Plan

In the past five years, the Ecosystem Group has successfully used an interdisciplinary approach to meet the USGS PWRC science goals outlined in the 2003 Science Plan. The group's research has been funded by: internal USGS competitions in global change, POBS, NRPP, SSP, Director's Venture Capital Program; external nation-wide competitions including the EPA STAR Program and the National Science Foundation; and reimbursable funds from DOI and State Partners. Research results have appeared in leading peer reviewed journals including: *Journal of Ecology*, *Estuaries and Coasts*, *Wetlands*, *BioScience*, *Ecological Applications*, *Climatic Change*, *Environmental Management*, and others.

Goal 1: Developing tools and forecasting future conditions - PWRC scientists provided leadership for 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. 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.

A series of ecosystem models were 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.

Goal 2: Developing scientific information relevant to regional scales. Progress was made in “scaling up” from site specific studies to broader understanding and prediction of coastal and wetland changes. 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 NOAA’s National Estuarine Research Reserve System.

Goal 3. 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.

Goal 4. Monitoring programs. 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. Research advances were made by obtaining Park- and Refuge-based data indicating the ranges of intra- and inter-system, geographic, and temporal variation. Focus began on methods to determine where threshold values, or “triggers for management,” occur to aid land managers in their decision processes. PWRC scientists were heavily engaged with federal land managers in holding workshops and training sessions aimed at developing effective monitoring of key resources.

Goal 5. Improving the scientific basis for ecosystem restoration and mitigation. 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.

Although much of the focus of the work of PWRC scientists was oriented toward the Eastern Region, a good deal of the research has national and international scope. Patuxent scientists in this Group are active participants in many large-scale efforts and often leaders in national and international professional societies and national and international scientific panels. PWRC scientists participate in the development of products for international organizations

including the Intergovernmental Panel on Climate Change (IPCC) and national efforts such as the U.S. Government's Climate Change Science Program.

During the previous five-year period, two scientists retired, one passed away, and one new Coastal Geomorphologist was hired into this group.

Contaminants Biology

Current Program. Contaminants research at PWRC began in the 1940's with studies on DDT. Early work focused on field effects following application of DDT and other organochlorine pesticides, and was followed by toxicity and accumulation studies with game birds in pens in the 1950's and 1960's. In the 1970s, PWRC scientists made pioneering progress in understanding the impact of pesticides, metals, and other contaminants on avian populations. The 1980's brought the expansion of research into emerging contaminants of concern such as PCBs, lead, cyanide, selenium and cholinesterase-inhibiting pesticides. This expansion continued throughout the 1990's with a focus on amphibian toxicity, biomarker development, and toxicological significance of soil and sediment ingestion by wildlife. In the 21st Century, PWRC has continued its leadership role in research on the physiological and ecological effects of a wide range of legacy and contemporary contaminants and other human-related disturbances.

The primary focus of the Contaminants Biology Group at PWRC has been to detect, evaluate, and predict the effects of contaminants on in terrestrial wildlife. Research has emphasized a coordinated laboratory and field approach to measuring these effects. Our research has been directed towards the needs of partner agencies particularly the U.S. Fish and Wildlife Service, National Park Service, and other bureaus within the Department of Interior, but also the Environmental Protection Agency, the Department of Defense, and various state and local government agencies. The program at PWRC primarily works within the framework of the USGS Contaminant Biology Program, but the impact of the research, inevitably overlaps with other BRD Programs.

Our expertise includes multiple sub-disciplines of environmental toxicology including wildlife physiology, behavior, and endocrinology, ecological risk assessment, toxicogenomics, forensics, aquatic toxicity testing and aquatic habitat assessment. Ongoing research includes the following:

- Stable lead isotopes in tissues of experimentally-exposed nestling American Kestrels;
- Toxicity of the non-steroidal anti-inflammatory drug diclofenac to New World vultures Evaluation of forest injury from zinc smelting;
- Investigation of component toxicities within municipal and industrial wastewaters;
- Comparative embryo toxicity of polybrominated diphenyl ether flame retardants in chickens, mallards and American kestrels;
- Embryo toxicity of methyl mercury in multiple avian species;
- Mitochondrial DNA damage as an indicator of mercury and lead toxicity;

- Evaluation of oxidative stress in mercury-exposed terns in the San Francisco Bay area, colonial waterbirds along the Carson River, NV and common loons in Wisconsin;
- Exposure to legacy and contemporary contaminants, and their effects on genotoxic and reproductive endpoints in ospreys nesting in Delaware Bay.

Future Directions.

The Contaminants Group at PWRC is recognized as the premier wildlife toxicology research center in the world. This recognition is based on our unique ability to conduct combinations of laboratory, pen, and field studies that provide answers to the most pressing questions within the field of wildlife toxicology. Resource managers, risk assessors, regulators, and modelers in government, academia, and industry are extremely dependent upon the empirical data that we generate. Since joining the USGS a decade ago, over half of our wildlife toxicologists have retired and most of the remaining staff is eligible to retire. In order to meet the Department of Interior's resource management needs and maintain our capability there is a desperate need to immediately replace the staff that has been lost.

Our role is to generate sound data for use in risk and damage assessments and in ecological models, and to identify and address emerging contaminant issues. This information is needed and used by client agencies within the Department of Interior and elsewhere. Future research will include: 1) laboratory and field investigations of contaminant exposure and effects and environmental chemistry, 2) assessment of fate, transport, and bioaccumulation of contaminants in wildlife and the ecosystems they occupy, 3) examining the effects of chemical mixtures and understanding their interactions with other stressors. We will continue collaborative efforts within the USGS and with resource management agencies, universities, and conservation organizations. Although a formalized nationwide wildlife toxicology monitoring scheme no longer exists, we will continue to summarize current and historic findings to generate temporal and spatial trends and identify critical research needs.

Goals

Goal 1. Sustain and enhance the capability of PWRC to conduct contaminants and ecotoxicological research.

Objective 1: Hire five research scientists to replace the eight staff who retired since 2003.

The following areas of expertise are required in order of priority:

- Two ecotoxicologists (**positions 12 & 13**) with unique expertise (e.g. ornithology, mammalogy, herpetology) and experience in conducting lab/pen and field studies.
- Toxicologist/Biochemist (**position 14**) with expertise in cell culture alternatives to animal testing and in vivo methods (embryo screening methods) to generate empirical data in wildlife species.
- Immunotoxicologist (**position 15**) with experience in assessment of immune function in wildlife species using laboratory/pen and/or field studies.

Objective 2: Recruit and hire technical support staff (laboratory) with experience in toxicity test trials, biochemical analyses, and/or molecular biology (**position 16 & 17**).

Objective 3: Augment and replace analytical equipment to improve and increase the capabilities of research staff.

Goal 2. Identify and quantify chemical and non-chemical stressors and understand their accumulation, distribution, interaction, and effects on biota and habitats.

Objective 1: Provide the scientific basis for assessment and understanding of the damage sustained by contaminated habitats and the biota they sustain.

Objective 2: Identify emerging contaminant issues and evaluate their significance (exposure, accumulation, effects) in biota.

Objective 3: Continue the development and analysis of molecular, biochemical and physiological indicators for understanding and determining the extent and mechanisms of toxicity in target species.

Objective 4: Conduct retrospective analyses of extant ecotoxicological information to identify significant trends and data gaps.

Objective 5: Continue to provide scientific information in support of the Natural Resource Damage Assessment and Restoration (NRDAR) Program, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, and other sites of concern to our client agencies.

Goal 3. Fulfill the short-term scientific and technical assistance needs of our client agencies.

Objective 1: Provide technical assistance to our client agencies through such efforts as analysis of established biomarkers, assessment and interpretation of monitoring data or assays, and design and implementation of studies in support of risk assessments.

Objective 2: Produce synoptic reviews of chemical and non-chemical stressors and provide scientific information in support of our clients' management needs.

Achievements since the 2003 Strategic Science Plan

The Contaminants Program has made considerable progress on many of the Goals and Objectives set forth in 2003. Valuable empirical data have been generated to address Goal 2 (identification of emerging contaminant issues). An investigation of the toxicity of the non-steroidal anti-inflammatory drug diclofenac to New World vultures was recently initiated. Comparative embryo toxicity studies have been conducted in chickens (*Gallus gallus*), mallards (*Anas platyrhynchos*), and American kestrels (*Falco sparverius*), which established biochemical, teratogenic and lethality toxicity thresholds for polybrominated diphenyl ether flame retardants, a contemporary contaminant of international concern. 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.

The development of molecular methods as outlined under Goal 3 is in its initial stages. A new scientist has been hired with expertise in this area. Objective 1 of Goal 3 (identification of performance criteria for evaluating the success of restored or remediated habitats based on wildlife population structure) has been addressed by a number of studies. 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.

Multiple studies have specifically addressed Objective 2 of Goal 4 (identification of threshold values for biomonitoring). 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 (*F. 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.

Systematic monitoring of contaminant biological effects (Goal 5) is an integral part of the Contaminants Group's research program. Three recent studies have involved the development or testing of methods (Goal 5, Objective 1) 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 (large-scale field investigations) has been addressed in several recent studies. 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.

Creation of widely-used internet-accessible ecotoxicological databases directly addressed Objective 3 (retrospective analyses of extant ecotoxicological information): 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. 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. This project specifically addressed Objective 4 (evaluation of biomonitoring methods for contaminant effects for monitoring and assessments of federal lands).

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 support 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.

The North American Bird Banding Laboratory (BBL) hosts a massive database of bandings and recoveries that have broad application for modeling demographic patterns of bird species. The BBL databases, along with data from the population monitoring programs, provide a treasure trove of data that are used extensively by analytical population ecologists at PWRC

Future Directions. PWRC will continue to be an institution composed of scientists and support 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. We plan to increase the use of the BBL database as a source of data for modeling trends in bird populations. 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 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 warblers 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 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 two new principal investigators (**position 18 &19**) with expertise in structured decision making and adaptive management.

Objective 5: Develop and secure funding for a post-doctoral 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 post-doctoral associates, through on-site courses, partnership with the National Conservation Training Center, and sabbaticals in academic settings.

Objective 7: Develop expertise through hiring a research scientist (**position 20**), with expertise in incorporating dimensions of human behavior into methods of decision analysis.

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 22**), and a Vertebrate Ecologist (**position 23**) 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 24**)

Achievements and summary of past performance

Goal 1: A PI was hired in 2005. 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 PIs.

Goal 2: PWRC has provided highly visible leadership within the Department of Interior to advance structured decision making and adaptive resource management as best practices throughout the agencies of DOI. PWRC scientists contributed extensively to the DOI Technical Guide on Adaptive Management and have briefed the highest executive levels of DOI and USGS on developing institutional capacity for applying decision methods. PWRC scientists have cooperated with numerous colleagues and stakeholders within and outside of DOI to develop tools and to communicate technical aspects of decision analysis in three primary areas of application: harvest management of migratory birds, recovery of imperiled species, and management of habitats in the USFWS National Wildlife Refuges system. Through the many training workshops, technical presentations, and scientific publications resulting from these efforts, PWRC is widely recognized as a leader in the application of decision theory for natural resource management, and the counsel of PWRC scientists is often sought by federal, state, local, and international agencies.

Goal 3: Species level work yielded great successes, including:

- whooping crane recover, which took a big step forward with the successful initial introduction of an eastern flock of migratory cranes;
- long term population studies on Roseate terns, which allowed an evaluation seasonal band long-term impacts of the April 2003 Bouchard Barge Oil Spill in Buzzards Bay;
- studies on Diamondback terrapins in Chesapeake Bay which yielded excellent population data, and was, in part, responsible for greater attention to this species by the MD DNR and a ban on harvest in MD;
- work in support of U.S. Fish and Wildlife Service through the North American Waterfowl Management Joint Ventures and the FWS Regional Offices which has informed the management of several bird species and habitats; notable is the research affecting management of Mississippi Alluvial Valley lands for game and non-game birds, and research evaluating the effects of wind power development on resident and migrating bird species.

Information Science

Background: PWRC is well known for its extensive databases associated with the Bird Banding Laboratory and the Breeding Bird Survey. Until recently these databases were managed internally and were not directly available to the public. BBL data requests were handled as batch jobs on a minicomputer and printouts were mailed to users. BBS data were handled similarly until trend analyses were delivered over the web in the late 1990s. About the same time, acquisition of higher-capacity servers, adoption of a client-server model, and a restructuring of the BBS database enabled web-based data-entry and retrieval of raw data.

This transition began a new era at PWRC in which the Internet has played an increasing role, both for delivering scientific data and products to users and for receiving data into databases managed at the Center. The transition has not been an easy one. Significant new programming talent had to be acquired and biologists needed to become more conversant in the language of relational databases, software, hardware, and the web. The simultaneous development of Oracle (BBL) and MS SQL (BBS and others) platforms presented additional challenges. However, the gradual expansion of capability enabled PWRC to develop new monitoring programs, such as the North American Amphibian Monitoring Program (NAAMP), to provide database services to the conservation community (e.g., national breeding bird atlas and point count database), and development of on-line software applications for managing and analyzing data that were unthinkable less than a decade ago (e.g., BBS trend web pages). Although BBL has lagged behind, it completed its conversion from a hierarchal to a relational database in 2006 and on the verge of greatly expanded web-based functionality.

A result of this rapid evolution is a small group of biologists producing, storing, and delivering scientific information in new ways with the assistance of IT programmers and database managers. The collective capabilities for design and management of large biological databases, for assuring their scientific quality, for delivering them to the right users, and for expanding their utility through on-line software applications make PWRC unique among the USGS science centers. Biological information science at PWRC has grown into a critical component of PWRC's own operational monitoring programs, a cross-programmatic support function, and a public service to outside scientists and resource management agencies.

Current Program

Large Web-accessible Databases. The **Bird Banding Lab (BBL) Infobase** stores information for more than 60 million birds banded by an extensive network of largely volunteer banders, whose banding activities are regulated under permit from either the BBL or the Canadian Bird Banding Office (BBO). The BBL Infobase holds information about the bands, band orders, banding permits, species, auxiliary markings (including RF tracking devices), and encounters with banded/marked birds. Enhancements to the Bandit stand-alone band management program for banders are being developed. PWRC and NBII plan to share delivery of the BBL database on line.

The **BBS database** supports most aspects of the operation of the North American Breeding Bird Survey. BBS has a diverse set of methods for capturing survey data: web-based entry

(by volunteers or by in-house seasonal staff), "scannable" forms, and a Filemaker Pro-based desktop program is in the works. Quality control and other operational tasks occur through a variety of tools (e.g. web-based tools, database procedures, GIS visualization) prior to annual raw data release via the website and FTP site. Trend analyses and map visualizations are not stored in the database but are presented via the PWRC web site as well. A major conversion to a fully relational database was recently completed, while development of new web-based data retrieval and management tools are nearing completion.

The **NAAMP database** includes amphibian calling survey data, location information, observer and coordinator contact information, and associated data. The NAAMP database is delivered to users by several web-applications, including Public Access (open to all for downloading data), Volunteer Access (data entry portal for participants), Coordinator Access (state program management site for state coordinators), and Frog Quiz (open access and login site). NAAMP also stores a series of frog quiz tables so that observers can be required to take auditory quizzes based on their assignments via the Frog Quiz.

Breeding bird atlases are the most comprehensive distributional studies available, and you can search over 30 published state and provincial atlases (and 7 current projects) via the **Breeding Bird Atlas Explorer**. Unlike BBS and NAAMP programs, coordination of these detailed distribution projects is by a state-based partner, with PWRC advising on scientific and other aspects of atlases, and acting to foster communication among atlas projects. Results are provided in both tabular and map format via the web.

The **Bird Point Count Database** handles data from a variety of small and large-scale research and monitoring projects, each using a variation of the point count method. For example, nearly all of the avian point counts from refuges in Region 5 of the Fish and Wildlife Service are managed here, as well as a four-state survey for eastern Painted Buntings and secretive Marsh Bird surveys of a National Marsh Bird Monitoring Protocol.

The **Colonial Waterbird Database** is a central repository for state or regional colony counts of waterbirds in North American and the Caribbean. Colony counts come from the Cornell Waterbird Registry, the US Fish and Wildlife Service-sponsored Great Lakes Surveys, state waterbird atlases, and other published sources. Data are delivered via a website and mapping tool.

The **National Amphibian Atlas** stores distribution information for amphibians of the United States. Most records are county-based, but in some cases more detailed location information is tracked. Records include references and whether data are based on museum specimens or other information. Delivery to users is by a web-application. A more dynamic mapping application is under development that will decrease staff time for updates and allow users to display dynamic species maps and download data, references, images, and GIS layers.

The following table compares and contrasts these monitoring databases:

Database	Sample design/ scale	Nature of Data	Number of sampling units	Years spanned
BBS	yes/continental	USGS research, avian roadside point counts	4000 routes	1966-present
NAAMP	yes/eastern US	USGS research, amphibian roadside point count	900 routes	2001-present
BBA	yes/national (participating states, NGOs)	State or NGO-supported programs involving non-constrained area searches	> 50K grid cells sampled	1976 – present (5-year spans)
Point Counts	yes/refuge or park scale, with some work spanning regional scale	FWS refuges, forests, state management areas: avian point counts	22K points surveyed	1990s – Present; Avg. 3-4 years each
CWB	“complete” counts/ regional or State	demographic parameters from literature and agency files	~15K colonies	~1960 thru 1990s; for majority of data
National Amphibian Atlas	none/national	presence/absence, by county	all US counties & some further subdivisions, as reported in literature	historic to present

For biologists seeking information on avian population trends at the state, regional, or continental scale, the **Breeding Bird Survey Trend Analysis** website provides state-of-the-art analytical output in map, graphical, and tabular formats. Like the CEE-TV database below, this site makes USGS research results available to the public in an easy-to-digest format.

The **Contaminant Exposure and Effects - Terrestrial Vertebrates (CEE-TV) database** contains over 18,000 records on more than 500 species (collections from 1884 to present) that reside in estuarine and coastal habitats of the United States. Most records describe exposure to halogenated compounds, pesticides, economic poisons, metals, and petroleum hydrocarbons, while about 10% of the records contain biomarker or adverse effects data. Also served through this site are biological and ecotoxicological summary information on 50 species commonly used in contaminant monitoring studies, a program that ranks the vulnerability of various species to contaminants, and educational tools describing the contaminant influences on wildlife. In addition, a database on contaminants as a factor contributing to species decline is served at PWRC.

Information Resource Infrastructure. The PWRC information resource infrastructure consists of a cadre of midrange servers running both enterprise relational database management systems and one-off databases with web-based graphical user interfaces. These servers are managed under the secure umbrella of Active Directory Services via a high speed network. Except for our contingent of public web and ftp servers, the servers are protected from unauthorized access via firewall, encryption and user access lists. PWRC possesses technical acumen in the design, development, testing, and implementation of Oracle, MS SQL Server, and FileMaker database applications.

Continuity of Operations Plan. The “COO” plan details the redeployment of human and IT assets from the Laurel campus to an alternate work site in case of electrical failure or other disaster. A generator is available for back-up power. Detailed procedures assure minimum down time for web and production servers, so that access by web-based customers is only minimally interrupted.

Modes of Data Capture. We have evolved from sole reliance on data entry staff to the use of scanning technology (“scannable” data forms) and web-based entry. BBL provides data-entry software on CDs to banders, eliminating the need for scanning or hand-transcription of data. Such efficiencies now allow capture of greater amounts of data than in the past. For example, data from all 50 stops on a BBS route are now stored instead of summaries for every 10 stops.

Future Directions: The special needs for information science at PWRC need to be recognized and the capability supported, so that it can continue to meet the growing information needs and expectations of the wildlife conservation and scientific communities. The future of information science at PWRC will largely be determined by policy decisions in BBL and the monitoring programs, and by the needs of specific research initiatives. Conversely, simply having information science capability available presents opportunities that can influence those policy decisions and research direction.

Goals and 5-Year Objectives

Goal 1. Continue to grow, manage and make available databases from high priority programs.

Objective 1: Maintain existing databases, data management systems, and data retrieval pages on current versions of software to ensure their online accessibility. Ensure that systems are backed up to meet the appropriate disaster recovery strategy.

Objective 2. Maintain metadata following FGDC standards for future interoperability, and publish SOPs for data-handling procedures to enable users to better understand and appropriately use the data.

Objective 3: Develop and maintain online mapping applications to provide access to data sets in appropriate geospatial contexts.

Objective 4: Conduct periodic reviews of each system to conform to USGS peer review standards and receive regular input from user communities for recommendations to improve the functionality and content of these systems.

Objective 5: Develop a centralized portal for accessing wildlife contaminant databases housed in various other government agencies, academic institutions, and conservation organizations.

Goal 2: Develop criteria/guidelines for expanding scientific database management services and taking on or developing new, database-intensive programs.

Objective 1: Identify current and future research activities that are likely to generate datasets of significance to the biological science community.

Objective 2: Assess the current and future data and information needs of Patuxent research partners.

Objective 3: Identify opportunities to work collaboratively with partner dataset owners to form linkages between similar datasets.

Goal 3. Improve biological information science capability through strategic hiring, deployment, and training.

Objective 1: Recruit and hire on temporary appointments college graduates with natural science backgrounds and strong IT skills to develop and maintain science datasets housed within relational database management systems.

Objective 2: Recruit and hire an experienced web designer/programmer to replace the PWRC webmaster, who is expected to retire within one year. **(position 25)**

Objective 3: Hire an additional permanent programmer in IRM to be deployed to support BBS, NAAMP, and similar population databases. **(position 26)**

Objective 4: Recruit and hire a trainee IT specialist to replace the computer assistant who is expected to retire within eighteen months. **(position 27)**

Objective 5: Redeploy and/or detail persons with strong web development, database, and system administration skills to assist in the design, development and maintenance of new science applications.

Objective 6: Require existing IT staff to attend formal classroom training annually to maintain their high skill level.

Goal 4. Continue to develop technological capabilities for managing bands, banding data, and banders.

Objective 1: Provide periodic enhancements to Bandit.

Objective 2: Make banding databases and analytical applications available to the public on the web.

Objective 3: Make continuous improvements to Oracle database functionality.

Objective 4: Create the ability to integrate banding databases with other databases for research, educational, conservation, or management purposes

Goal 5. Develop and implement a plan, including budgeting, for cyclical upgrading of development and production servers to state-of-the-art capability and for acquiring new software or renewing software licensing agreements.

Objective 1: Replace production servers on a 3-5-year basis, depending upon the immediacy of need for greater processing power. Replace expired development servers with legacy production servers.

Objective 2: Update application software to take advantage of state-of-the-art capabilities of new upgrades, to remedy flaws in current product, or when current versions are insufficient to meet requirements.

Achievements and Progress since the 2003 Plan

The 2003 plan provided no specific baseline for information science capability at PWRC. But PWRC's capability in this field has advanced substantially during the period, because of the rapid development of technology (server capacity and software applications), conversion to relational databases, training of existing personnel, and dedication of a small cadre of biologists to web-delivery of important data. Conversion of the BBS database to a more, flexible, fully relational structure has been completed, as has the BBS Methodology Training program for participants. Development of the point count, bird atlas, and NAAMP databases have all taken place since 2003, as has development of on-line mapping applications for bird databases through the NBII Bird Conservation Node. The "Frog Quiz," a program for training participants in frog surveys to recognize frog vocalizations and improve their skills was developed and implemented.

Conversion of the BBL databases to an Oracle-based relational database system was completed in 2007 and included a web-based user-interface front-end, a mapping server for entering and viewing encounter and banding locations, and a transaction processing subsystem. Personnel have been hired within IRM in an effort to institutionalize Oracle programming and database management support within PWRC. Other important developments in BBL include (1) a new and improved band-reporting web page that includes immediate feedback to the reporter and the option of sending certificates of appreciation electronically, and (2) a new, stand-alone banding data management software program for banders (Bandit), replacing BandManager.

Table 1.

Positions planned for hire and current SCEP students at Patuxent Wildlife Research Center. (Wildlife (W), Biodiversity (B), Contaminants (C), or Ecosystems (E); taken from PWRC Workforce Plan.)

Principal Investigators

- 21 - Coastal Wetland Ecologist (E)
- 8 - Community Ecologist / Ecosystem modeler (E)
- 9 - Freshwater Ecologist (E)
- 18, 19 - Wildlife biologist / Adaptive Management Scientist - (*need 2*) (W)
- 12, 13 - Wildlife Toxicologist/ecotoxicologists (*need 2*) (C)
- 14 - Toxicologist/Biochemist (C)
- 15 - Immunotoxicologist (C)
- 1 - Herpetologist (B)
- 3 - Ichthyologist (B)
- 22 - Avian Ecologist – GCC (W)
- 6 - Wildlife Biologist/Ornithologist (B)
- 20 - Human Dimensions-Decisions Analyst (W)
- 23 - Vertebrate Ecologist- GCC (W)
- 24 - Avian Disease Ecologist – GCC (W)

Research Support

- Library clerk
- Outreach specialist
- 26 - Programmer (BBS)
- 7 - GIS specialist
- 25 - Web Designer/Programmer
- 27 - IT Specialist

Technical Support

- 2 - Molecular systematics technician (B)
- 5 - Biological/Ornithological Technician (B)
- 4 - Fish systematics technician (B)
- 10- Coastal biological technician (E)
- 11- Ecology (freshwater) technician (E)
- 16, 17 - Contaminants Laboratory Technicians (*need 2*) (C)

SCEP students

- Avian influenza ecology
- Sea duck ecology
- Herpetology
- Wildlife toxicology

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DRAFT

Appendix 1. Science Management

Quality of Science

Peer review is the accepted and expected mechanism for evaluating the quality of research and maintaining high standards for scientific work. Like all USGS entities, PWRC requires peer review of project plans and final publications or other forms of information delivery to ensure the high quality of individual projects. The Research Grade Evaluation Guide and panel reviews evaluate overall scientific performance of individual scientists and the impact of that science on our mission.

Peer Review of Science Task Plans. PWRC has rigorous, independent, and anonymous peer review standards, which are summarized in PWRC Standard Operating Procedures (SOP) 21 - *Development and Review of Science Study Plans* (see Appendix 2). SOP 21 codifies the procedure for development, review, and approval of science task plans. Scientists initiate the peer review process by submitting documents to their Research Manager, along with names of potential reviewers. Reviews are solicited and provided to the scientist and changes made as warranted, to the satisfaction of the Research Manager, before work begins on that task.

Peer Review of Professional Expression. Like all USGS entities, PWRC requires peer review of manuscripts, reports, and other forms of dissemination of scientific information before dissemination. PWRC manages that review in accordance with PWRC SOP 11 - *Review Requirements and Process for Professional Expression*. After reviews are solicited and provided to the scientist, changes made as warranted, to the satisfaction of the Research Manager, documentation of the outcome of the review is sent to the Eastern Regional Office for further review, and to determine that there is no entanglement with the establishment of policy in the product. After certification a manuscript may be disseminated (e.g. sent to a journal for publication or served on the web). (See the section below on Managing External Communication of Science.)

Programmatic Peer Review. Certain categories of PWRC's science, such as long-term population surveys and endangered species recovery programs, encompass a variety of science and operational components. It is PWRC policy to subject such programs to peer review at 5-year intervals. Since 1996 programmatic peer reviews have been conducted for the Bird Banding Laboratory, the Breeding Bird Survey, the North American Amphibian Monitoring Program, and the Whooping Crane Program.

Programmatic peer reviews are conducted by panels of experts representing not only the scientific community but also the user community, such as resource managers from partner agencies. Panelists are provided a specific charge with clear objectives, including the requirement to prepare a consensus report with recommendations. Panels are provided extensive briefing materials and convened on site for up to three days for presentations by staff, detailed inquiry of scientific and management staff, and closed panel deliberation.

Science Scope and Focus

Although the scientists lead in science planning activities, a crucial role for management is to ensure that the ideas proposed are feasible and practical and align with Departmental and Bureau mission and policy statements, USGS/BRD Program goals, Regional priorities, partner needs, and current PWRC capabilities. Collectively, these factors, particularly those external to PWRC, define the “relevance” of PWRC science. Also, PWRC managers and scientists have opportunities to help shape USGS Science plans or Program plans, and an important responsibility of PWRC management is to participate personally, and to encourage scientist participation in USGS strategic planning at regional and national levels.

Budgetary Influences on Science Planning. The budget, the base, cyclical, and reimbursable funding available to PWRC, has a profound influence on the stability of the science program and direction of PWRC science. The profound shift from support of operations from substantially base funds, largely reimbursable funds generally constrains long-term, strategic science. It is the responsibility of management to seek a healthy balance of funding sources, beginning with assurance of base funding for all permanent staff salaries and a healthy base salary/operating ratio. Seeking long-term enhancements to base funding through Bureau budget initiatives is an extremely important element of PWRC’s budget planning strategy. PWRC science managers will take the lead in positioning PWRC for effective engagement in this process. Enhancements to operational funding will be sought continually through cyclical or reimbursable outside funding mechanisms, to support projects that are within the scope out PWRC mission.

External Communication of Science

The manner in which the results of PWRC’s science are communicated is a critical determinant of PWRC’s value to the scientific and resource management communities. Various forms of scientific expression are expected of PWRC scientists. Science managers and outreach staff play an important role in assisting the scientist with communications to the resource management community and in tailoring reports of science results and, in some cases, science plans or proposals, for various agency and Departmental reporting documents.

Publications. Written reports in the peer-reviewed scientific literature are essential for establishing the results of scientific research. They also are the most important means whereby the scientific community can evaluate both the productivity and quality of work by individual scientists. In compliance with RGE, PWRC 4-factor scientists are typically expected to publish at least two peer-reviewed papers in a nationally or internationally recognized journal every year.

Open File Reports. Sometimes written reports designed to get research results into the hands of land managers rapidly or larger final reports to other agencies under reimbursable agreements are not published in peer-reviewed outlets. These reports are still subject to internal USGS and PWRC peer and policy review. Generally such products carry less weight in the RGE process and time spent on such reports by 4-factor scientists has to be evaluated tactically in support of partners.

Professional Meetings. Participation in scientific meetings is essential for practicing scientists to remain abreast of new developments in their area of specialty. Such meetings

provide both the opportunity for learning and a venue for rapid dissemination of scientific findings. To comply with the guidance of RGE, all PWRC 4-factor scientists are expected to provide at least one platform or poster presentation at a nationally or internationally recognized scientific meeting every other year. Active participation in scientific societies is strongly encouraged.

Technical Assistance. PWRC scientists are expected to respond to requests for assistance from partner agencies, when possible. Care will be exercised by both the scientist and the research manager to ensure that the assistance provided is beneficial to the needs of partners, to the PWRC mission, and to the career of the PWRC scientist, i.e., has value in the RGE process. The assistance provided should be defined clearly, based on the active research expertise of the scientist, and produce measurable effects for the user.

Data Files and Databases. The initial products of any scientific investigation are data. Per PWRC SOP021, each scientist is expected to document data archiving procedures in the study plan so as to maintain data in a recognizable, easy-to-access spreadsheet format, with back-up copies updated frequently and stored at a separate location for safety. The information obtained by government scientists is public domain. Large databases are the primary product of some science activities like some of the major population survey programs. These will be developed in a way to make them readily usable by partners, with emphasis on web delivery.

Web Sites. Web sites have become a popular and easily accessible means of providing information to the public. Such web sites are currently in use by PWRC and some of its field stations. The Web Committee is expected to develop and maintain PWRC web standards, protocols and architecture. *SOP 25 Website and Web Server Policies and Procedures*, provides guidance for making PWRC materials available on the Web and provides policy and procedures for establishing, maintaining, and administering Web servers. These protocols are intended to: (1) implement agency guidelines to achieve the missions of the USGS and PWRC in the use of the WWW to disseminate information; (2) ensure that PWRC's Web material undergoes scientific, policy, and ethics reviews prior to release to the public; (3) provide a clear and consistent mechanism for adding, maintaining, and removing Web page information; (4) ensure a seamless Web presence for all PWRC servers; and (5) provide guidelines for Web server establishment, maintenance, and administration.

Science Briefs. Various forms of brief science task summaries will be used to meet communication needs with partners, the general public, and managers at higher levels of the agency and the Department. These include fact sheets, news releases, and posters. The outreach coordinator will have primary responsibility for such communiqués but will require the assistance of scientists to varying degrees, depending on the nature of the topic. Scientists are encouraged to work with the outreach staff to produce descriptive and attractive capsule summaries of their ongoing research. PWRC scientists also are encouraged to give public lectures, and to cooperate with the news media on items of broad public interest, in accordance with public expression policies.

Communication among Scientists and Managers

PWRC's philosophy is to harness the collective energy and spirit of its scientists and managers by promoting open communication that breeds mutual understanding, appreciation, and cooperation. The purpose of this section is to describe an operational framework designed to facilitate such a working environment.

The Research Manager – Scientist Interaction. An important component of the science planning process is dialogue between the scientist and the research manager, especially in the initial stages. It is incumbent upon each PWRC scientist to assume a primary role in developing his/her research direction and in seeking financial, supervisory, and partner support. 4-factor scientists will develop vision statements of their research programs, to be reviewed and updated in consultation with their Research Manager at 4-year intervals in conjunction with developing Research Grade Evaluation (RGE) Panel packages. This vision will be based on the scientists' creative abilities and knowledge of the field in which they work and reflected in Factor 3 ("Guidelines and Originality") of the RGEG. Study plans for individual tasks will be consistent with the overall vision. Research Managers must ensure that the vision and individual science task pre-proposals, as defined in the Science Planning SOP, meet relevance criteria and fit within the general context of the PWRC's Science Plan. The Research Manager will be available for consultation with scientists on issues related to the substance of their science programs, including desirable course corrections to accommodate changes in the relevance or funding environment.

Bi-Monthly PWRC Meetings. Meetings for all PWRC staff will be held bi-monthly. Field stations will be connected by speaker-phone. The meetings will be hosted by the Center Director and provide opportunities for information exchange on a wide variety of topics of interest to scientists and support staff. Special presentations by outside speakers on issues of broad relevance to staff may be scheduled in association with these meetings.

Bi-Annual Science Meetings. The tradition of Science Meetings designed to cultivate and reinforce partnership arrangements, by linking PWRC scientists and managers with current and future partners, will be continued on a bi-annual basis, normally in January or February at a venue near the Laurel campus. The next Science Meeting will be in FY 2004. A broad spectrum of current and future partners will be invited to hear presentations by scientists that demonstrate PWRC's potential value to the resource management community. Ample opportunity will be provided for regularly recurring meetings with long-term partners as well as for ad hoc meetings to discuss new applied science partnerships. Part of each meeting will be reserved for internal discussion of USGS issues at the center, regional, and national levels. The Science Meetings are an important mechanism for establishing connections than can have positive, long-term ramifications for PWRC science. They will be especially crucial during periods of greater dependency on outside support. Attendance at Science Meetings will be required of all professional staff, from both Laurel and field locations.

The Management Team (MT). The Management Team consists of the PWRC Center Director, three Research Managers, the Research Support Manager, and a Management Assistant (Appendix 3). The Research Managers provide management and supervision across PWRC's scientists and field stations, as well as liaison with primary DOI partner agencies. The Research Support Manager supervises administrative, information technology, and

facility support services. The Management Assistant provides analytical and technical input to support the MT.

Roles of the Management Team. The MT provides a forum for senior managers to discuss important PWRC-wide issues, to bring issues raised by scientists through supervisory channels to the attention of the Center Director, and to receive important information from the Center Director for conveyance to staff. It is a forum for discussing and finalizing decisions related to staffing and budget allocation. PWRC-wide policies are discussed by the MT. Policies important to the science program, such as many of the Standard Operating Procedures (SOPs) are drafted by the MT and vetted through the Science Council (see below), revised and issued by the Center Director. Appendix 4 lists the current science-related PWRC SOPs, which are readily available to all staff through the local intranet.

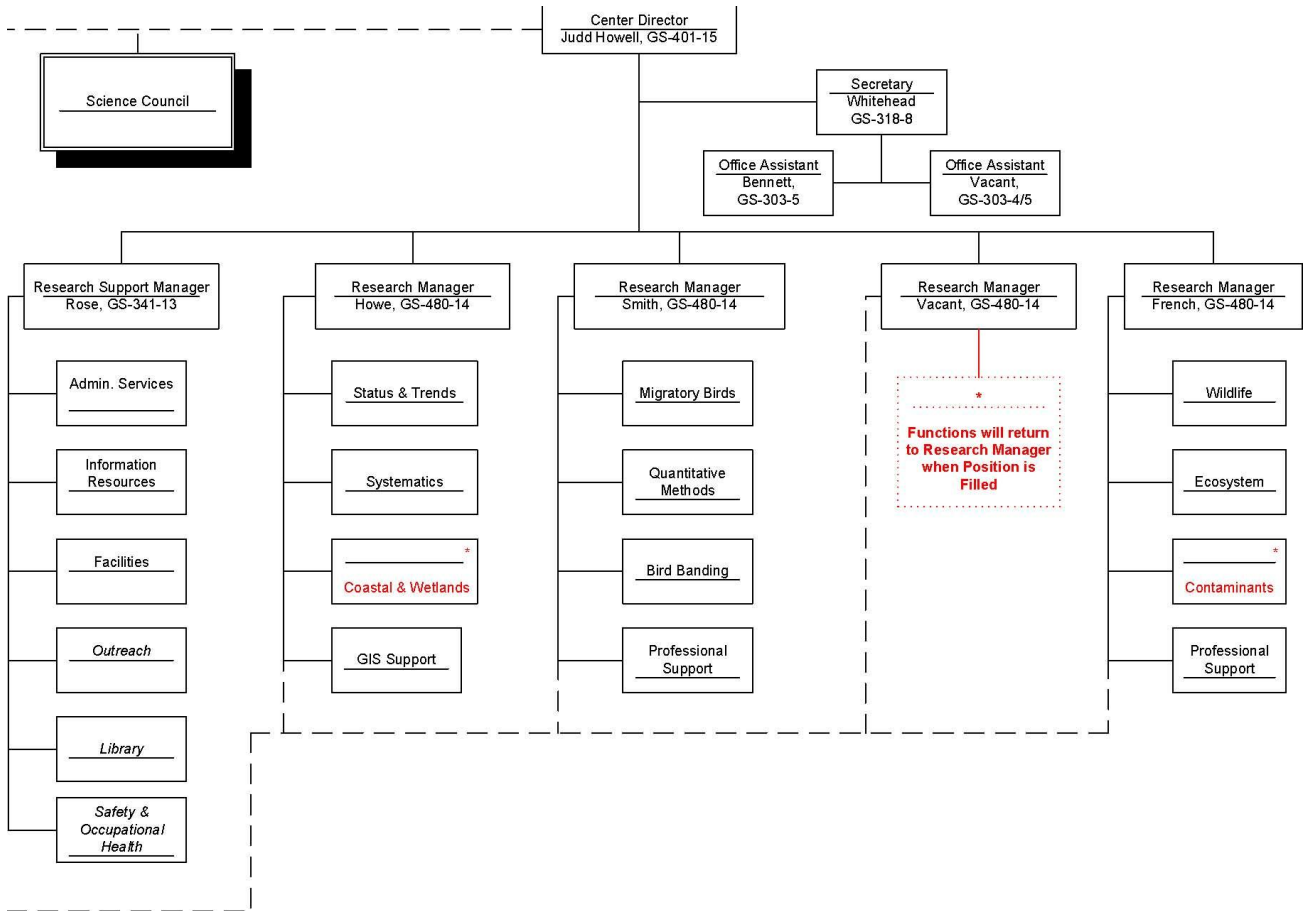
The Science Council (SC). The Science Council consists of five 4-factor scientists and one 9-factor scientist appointed by the Center Director to staggered 2-year terms. Under normal circumstances, three members of the SC are replaced annually on March 1. An effort is made to ensure that all areas of science emphasis at PWRC are represented in SC membership.

Roles of Science Council. The SC is a science advisory body to the Center Director. It provides an alternative mechanism for scientists to weigh in on issues of broad concern to the science staff and to influence management decisions. The SC is charged with primary responsibility for drafting comprehensive science strategies, such as the science focus areas in this Science Plan. The members of the SC select a Chair each time new members are added. The SC may establish committees (e.g., discipline-based and cross-discipline teams) that may include scientists not also on the SC.

Appendix 2. List of USGS Patuxent Wildlife Research Center Standard Operating Procedures

- SOP 7 - Animal Care and Use Policy
- SOP 8 - Correspondence/Communication Tracking System
- SOP 9 - Employee Exit Clearance Procedures :
 - Employee Clearance Form
 - Clearance for Non-Controlled (Non-Accountable) Property
- SOP 11 - Review Requirements and Process for Professional Expression *Recently Updated!*
- SOP 11A - Professional Expression Tracking Form (Word Format)
- SOP 12.3 - Coordination-proposed Refuge Activities-Research
- SOP 14 - Freedom of Information Act
- SOP 17 - Animal Quarantine Policy
- SOP 18 - Snow Emergency Protocol for Animal Colonies *Recently Updated!*
- SOP 20 - Scientific Achievement Awards
- SOP 21 - Development and Review of Science Study Plans *Recently Updated!*
- SOP 23 - Safety and Health: Responsibilities of the PWRC Safety and Health Committee, Supervisors, and Staff
- SOP 24 - Property Management Policy
- SOP 25 - Website and Web Server Policies and Procedures
- SOP 26 - Use of Firearms for Specimen Collection
 - Memorandum: Disqualification for Misdemeanor Convictions for Domestic Violence
 - Certificate of Need for Issuance of a Firearm for Official Use
- SOP 28 - Use of Volunteers
 - Individual Volunteer Services Agreement, Form 9-2080
- SOP 30 - Research Associates and Collaborators of the Center
- SOP 32 - Library: Purchasing books and subscriptions

Appendix 3 - USGS Patuxent Wildlife Research Center Management Organization



Appendix 4 - USGS Patuxent Wildlife Research Center Field Stations

