Operational Blueprint for Inventory and Monitoring on National Wildlife Refuges:

Adapting to Environmental Change

U.S. Fish and Wildlife Service, National Wildlife Refuge System

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CONTENTS

I. INTRODUCTION

OVERVIEW

The *Operational Blueprint for Inventorying and Monitoring on National Wildlife Refuges – Adapting to Environmental Change (Operational Blueprint)* describes how the National Wildlife Refuge System (NWRS or Refuge System) will initially implement a nationally coordinated program to support inventorying and monitoring (I&M program) at refuge, landscape, regional, and national scales. The purpose of this effort is to collect and synthesize information that supports management at multiple geographic scales and informs decisions at all organizational levels. The I&M program is designed to address the Refuge System's critical information needs and to help plan and evaluate the effectiveness of conservation strategies implemented by the U.S. Fish and Wildlife Service (Service) and conservation partners in the face of accelerating climate change and growing threats from other environmental stressors. This *Operational Blueprint* establishes the initial structure of the I&M program and identifies priority tasks to be initiated in Phase 1 (Fiscal Years 2010 and 2011). A companion *Strategic Plan* provides more background and rationale for the I&M program and the initial priority tasks outlined in this document, presents factors needing consideration as various aspects of the program are initiated, identifies key partnership opportunities inside and outside the Service, and identifies components that should be considered for implementation in 2012 and beyond (Phase 2). Program organization, administration, and staffing are addressed in a separate *Addendum to the Strategic Plan (Addendum).* These plans are the result of a focused, five-month effort by two teams of Refuge System staff, representing all U.S. Service regions, the I&M Core Team (Core Team) and an Executive Oversight Committee (EOC).

The Service recently issued *Rising to the Challenge: Strategic Plan for Responding to Accelerating Climate Change* and a five-year action plan to implement the strategic plan (USFWS 2009). The plans call for organizing conservation planning and modeling capacity within *Landscape Conservation Cooperatives* (LCCs) to provide scientific leadership and work with partners within landscape units or geographic areas. LCC staff will work with other agency and conservation partners to plan, design, and evaluate landscape-scale conservation in the face of climate change and other stressors, using the principles of adaptive management, scientific inquiry, and a process the Service calls Strategic Habitat Conservation (SHC). The I&M program is being designed to integrate with and support the Service's landscape conservation efforts.

The Core Team and the EOC first met in August 2009 to define a vision for the program and set broad programmatic goals and priorities. From that foundation, the *Strategic Plan* and *Operational Blueprint* were developed by the Core Team, with review and input from the EOC. Through this process, the following emerged as Refuge System-wide priorities in the context of its legislated mission and mandates. These priorities are particularly relevant in the face of accelerating climate change, and will support and complement the Service's landscape conservation efforts and response to climate change:

- Inventories of abiotic resources and physical features (supported by assessing and utilizing existing geospatial data as appropriate);
- Baseline inventories of biota, including vegetation (supported by assessing and utilizing legacy data on species occurrence on Service lands as appropriate);
- Status and trends of priority fish and wildlife species;

- Assessment of natural disturbance regimes, with initial emphasis on fire;
- Reconnaissance-level inventories and assessments of water resources including water quality and quantity;
- Status and trends of invasive species;
- Support of adaptive management at refuge and landscape scales; and
- Assessment of vulnerability to climate change, with initial emphasis on sea-level rise modeling for coastal refuges.

While recognizing the scope and complexity involved in addressing these priorities, the *Operational Blueprint re*commends initiation of several tasks during Phase 1, or as soon as practicable. The I&M program's Phase 1 budget is expected to be $12 million in FY 2010 and $20 million in FY2011; these budget estimates were assumed for planning purposes. The first administrative tasks for Phase 1 are hiring staff, refining priorities, and initiating the priority tasks identified in the *Operational Blueprint*. Most recommended tasks will be initiated during Phase I. I&M program staff will be responsible for refinement of priorities and timelines; some tasks may be deferred to Phase II. The *Operational Blueprint* recommends several "pilot" approaches that, if implemented in Phase 1, will inform important programmatic decisions and help frame future monitoring needs and approaches.

The *Operational Blueprint* is intended to provide enough information to guide the establishment of the national I&M program office and initiate hiring of key staff at national, regional, geographic area/LCCs, and field stations. The I&M program will need staff that have diverse technical as well as administrative skills, including skills in adaptive management, modeling, biometrics, structured decision-making (decision analysis), hydrology, invasive species, remote sensing, and a variety of taxonomic and ecosystem expertise such as wetland ecology, ornithology, forest ecology, grassland ecology, and fire ecology. Similarly, data managers at all levels should possess a variety of technical IT/data management skills such as programming, database design, GIS, and modeling. Some of this expertise already resides within the Service and the Refuge System; leadership will consider how best to fill the I&M program positions to fully integrate with and complement existing capacities and expertise.

The I&M program will evolve as staff are hired, implementation begins, and integration with monitoring priorities identified by field stations and the LCCs occurs. The *Strategic Plan* and *Operational Blueprint* focus primarily on Refuge System-wide priorities broadly shared by all the regions of the Service; we anticipate that each region and/or geographic area will also have inventory and monitoring priorities tailored to the needs of local managers. We anticipate that the I&M program will evolve to provide technical and data management support for long-term (surveillance) monitoring components (e.g., water resources) as well as targeted monitoring conducted under adaptive management (e.g. invasive species, fire effects) and other species or habitat-specific priorities defined by field stations, LCCs, or the regions and our partners. The I&M program is expected to provide coordination and technical support for inventorying and monitoring on refuges at multiple spatial scales: national, regional, and local. The I&M program will work hand in hand with existing refuge and regional staff to address these needs.

The direction of I&M program evolution over time will be determined by management priorities. The *Strategic Plan* provides a wealth of information about possible future directions for the Refuge System I&M program. A nationally coordinated I&M program for refuges will require setting priorities, clarifying the questions we want to answer, defining the spatial and temporal scale of the questions, and defining the accuracy and precision of the information we need. Priority-setting will be an ongoing process for the Refuge System I&M program. The *Operational Blueprint* calls for a needs assessment process, which will

involve broad input from the field, LCCs, the regions, and partners. A process will be developed to review the results of this needs assessment on a regular basis and revisit program priorities, based on this information. Refuge System leadership will remain engaged in guiding program priorities.

WHAT'S THE PROBLEM?

The National Wildlife Refuge System Administration Act (16 U.S.C. 668dd–668ee), as amended by the 1997 National Wildlife Refuge System Improvement Act (NWRSIA, Public Law 105-57), established the Refuge System's mission: "*to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans*." The NWRSIA was the Refuge System's first true organic legislation. Under it, the Secretary of the Interior is charged with specific responsibilities, including the following biological directives:

- *Provide for the conservation of fish, wildlife, and plants and their habitats;*
- *Ensure the biological integrity, diversity, and environmental health of the System are maintained for the benefit of present and future generations of Americans;*
- *Plan for the continued growth of the System;*
- *Assist in the maintenance of adequate water quantity and quality to fulfill the mission of the System and the purposes of refuges;*
- *Acquire, under state law, water rights that are needed for refuge purposes; and*
- *Monitor the status and trends of fish, wildlife, and plants in each refuge.*

Inventorying and monitoring play critical roles in implementing these directives and are critical to effective planning and management of refuges and the Refuge System. However, the NWRS does not currently have a nationally coordinated approach to inventorying and monitoring, unlike other federal land management agencies such as the National Park Service (whose inventory and monitoring program is described at http://science.nature.nps.gov/im/index.cfm) , and the U.S. Forest Service (whose monitoring program is described at http://fhm.fs.fed.us/). Inventorying and monitoring comprise a large part of the work done on stations of the NWRS, but these efforts are largely uncoordinated among refuges and regions. Duplication of effort, weak linkages between monitoring and management decisions, and inadequate documentation, data management, sampling designs, and data analysis are a few of the problems that result. In addition, no synthesis of the information and lessons learned from these disparate efforts is currently available to NWRS regional or Washington Office managers or to Congress. The Refuge System needs a much stronger, coordinated inventory and monitoring program to prepare for and address the major threat of climate change as well as to address other ongoing threats and stressors.

Concern about the conservation of species and ecosystems in the face of shrinking and degraded habitats is widespread (Sutherland *et al.* 2009). Climate change is predicted to have pervasive effects on lands managed for conservation, including changes in water quality and quantity; shifts in biomes and the species associated with those biomes; changes in ecosystem disturbances such as fire, storm frequency, and insect pathogens; and major effects on arid, coastal, and marine environments (CCSP 2009; Karl et al. 2009; Scott et al. 2009; U.S. Department of the Interior 2009). Climate change is predicted to magnify the threat and greatly increase species extinction rates across the globe (McLaughlin et al. 2002; Massot et al. 2008; Sekercioglu et al. 2008). However, many other stressors such as urbanization, invasive species, habitat fragmentation, land use changes, contaminants, and disease are having an immediate effect on NWRS resources.

HOW WILL THE SERVICE AND THE NWRS RESPOND?

Facilitating the adaptation of fish, wildlife, and plants to rapid climate change is a huge undertaking and represents an enormous intellectual and ecological challenge to the Service, the Refuge System, and the conservation community as a whole. The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as "*the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities.*" A recent review summarized the adaptation strategies available for sustaining wildlife and biodiversity in the face of climate change by major types of actions (Mawdsley et al. 2009),(Table 1). The conservation community has experience with some of the strategies; others will require new tools and approaches; none are simple. Many of the strategies do not lend themselves to experimentation. They involve landscape-scale efforts that are difficult to replicate in a controlled setting. A number of the adaptation options involve reducing non-climate stressors and improving ecosystem resilience, representation and redundancy; this is a low-risk approach and one we should be doing anyway.

Table 1. Climate change adaptation strategies available to land managers (Mawdsley et al. 2009).

Type	**Strategy**
Land and water protection	Increase extent of protected areas
	Improve representation and replication within protected-area networks
	Improve management and restoration of existing protected areas to facilitate resilience
	Design new natural areas and restoration sites to maximize resilience
	Protect movement corridors, stepping stones, and refugia
	Manage and restore ecosystem function rather than focusing on specific components (species or assemblages)
	Improve the matrix by increasing landscape permeability to species movement
Direct species management	Focus conservation resources on species that might become extinct
	Translocate species at risk of extinction
	Establish captive populations of species that would otherwise go extinct
	Reduce pressures on species from sources other than climate change
Monitoring and planning	Evaluate and enhance monitoring programs for wildlife and ecosystems
	Incorporate predicted climate-change impacts into species and land-management plans, programs, and activities
	Develop dynamic landscape conservation plans
	Ensure wildlife and biodiversity needs are considered as part of the broader societal adaptation process
Law and policy	Review and modify existing laws, regulations, and policies regarding wildlife and natural resource management

The I&M program is being designed to provide the long-term data that the NWRS needs to meet refuge purposes, fulfill the Refuge System's legislated mission and mandates, support the Service's landscape approach to conservation, and respond to climate change. The I&M program will play a key role in informing the development and evaluation of climate adaptation strategies.

The I&M program will address long-standing information needs in support of planning and management of refuges at the local scale. At a minimum, the I&M program will honor the recommendations of the WH8.1 Baseline Inventory Team (Byrd et al. 2004) that all refuges should have basic information on biotic and

abiotic resources. This information includes inventories, maps, and geospatial databases of topography, hydrography, soils, boundaries, man-made structures, vegetation communities, vertebrate fauna, and vascular flora. In addition to supporting SHC, the I&M program will help refuges evaluate the full spectrum of management decisions and actions they make. New and untested adaptation strategies will be needed to address the threat of climate change and other stressors (Mawdsley et al. 2009; Scott et al. 2009); each of these strategies will require evaluation through targeted monitoring and adaptive management.

The I&M program will serve a key role in support of the LCCs by focusing on evaluation of landscape-scale conservation delivery, providing and managing data on species occurrence on refuges, quantifying impacts of non-climate stressors, and working cooperatively with other LCC staff and the USGS Climate Change Response Centers on vulnerability assessments and modeling of present and projected species distributions. This landscape context is critical for conservation design, biological planning, and, ultimately, conservation delivery because refuges constitute only five percent of the contiguous United States, and many stressors originate from outside refuge boundaries. In particular, as we consider strategic growth of the Refuge System, species translocations, habitat restoration and creation, and other tools for facilitating adaptation to climate change, it will be critical that this program be developed in a way that it contributes to understanding ecological change within the Refuge System in a regional, national, and even continental context.

The I&M program's primary role under SHC will be monitoring the effects of management on populations and habitats on refuges and, with other conservation partners, across the landscape. The I&M program will also provide leadership in designing and implementing surveys to assess the current state of species populations and identify limiting factors (*Biological Planning*). Major components of the I&M program are directed at assessing status and trends of limiting factors already identified as important across the NWRS (water quality, quantity, and invasive species). I&M program staff will engage as participants in other elements in the SHC process and provide leadership for monitoring at broader spatial scales beyond refuge boundaries.

The I&M program will be coordinated nationally by Washington Office staff based in Fort Collins, Colorado, to ensure that inventorying and monitoring addresses national needs. Data management, data access, and product delivery will be significant components of this office. Data management capacity will constitute approximately one-third of the annual budget for the overall Refuge System I&M program. I&M staff in regional offices, associated with LCCs, and assigned to field stations will work collectively to meet the information needs unique to refuges within geographic areas and required by the LCCs. Data will be collected and summarized by geographic areas. Refuge System I&M coordinators will work with LCCs to ensure that information collected contributes to conservation design and biological planning at landscape scales. Refuge System I&M data managers will ensure that data standards and data management systems integrate well with those of the LCCs, while nesting within the I&M program's national-level data management infrastructure. I&M program staff assigned to field stations will provide additional coordination of program initiatives, including facilitation of monitoring to support both local and regionally scaled adaptive management projects.

Recognizing that potential partnerships vary across the country and at different scales, we propose an I&M program that is nationally coordinated but allows for regional variance to address issues that may be more significant in one part of the country than another. This operational flexibility fits with the operating history and strong regional structure of the Refuge System. But successful implementation of the I&M program will also require strong cooperation and communication among the national, regional, LCC, and field-level I&M staff. It will require successful integration and leveraging of existing biological and

technical capacity within the Refuge System, the Service, and conservation partners. A nationally coordinated program will require good communication, adoption of standard operating procedures and data standards, an integrated data management structure, and consistent reporting requirements.

The I&M program will ensure that all survey design, data storage and analysis, and reporting is consistent with the draft 701FW2 Inventory and Monitoring Policy (U.S. Fish and Wildlife Service 2009). This policy provides guidance for developing an inventory and monitoring plan for a station of the NWRS. However, it accommodates all levels of natural resource surveys from the station level on up to participation in national and international survey programs, both inside and outside the Service. Such surveys may include long-term monitoring programs (e.g., sea-level rise, climate change, biological integrity, diversity, and environmental health of refuges) of regional, national, or international scale, and implement protocols developed by other Service programs or conservation partners. Overall, this policy promotes consistency in the planning and implementation of inventorying and monitoring throughout the Refuge System.

II. VISION, GOALS AND OBJECTIVES

I&M PROGRAM VISION

A nationally coordinated program of inventory and monitoring on the National Wildlife Refuge System will generate information critical to ensuring the Refuge System's ongoing contributions to the conservation of the nation's fish, wildlife, and plant resources in the face of climate change and other environmental stressors. Collaboration with other Service programs and State, Federal, and private partners will lead to the effective integration of inventory and monitoring data needed to advance conservation at landscape scales.

The inventory and monitoring program will document the status of, assesses the condition of, and detect changes in the Refuge System's diverse fish, wildlife, and plant communities, as well as physical resources including water, air and soils, and ecological processes in order to support science-based conservation planning and management at multiple spatial scales. The information generated will be scientifically credible, relevant, and valued by the Service, its partners in the conservation community, and the public. I&M program protocols and standards provide the basis for consistent data collection and data management throughout the Refuge System, ensuring the timeliness, availability, and long-term integrity of the information collected.

I&M PROGRAM GOALS

1. Meet the Refuge System's legal mandate to monitor the status and trends of fish, wildlife, and plant populations on refuges, and collect and manage information needed to maintain biological integrity, biological diversity, and environmental health, and preserve the character of designated wilderness within the System.

2. Advance fish and wildlife conservation at the refuge scale and broader landscape scales in an adaptive management cycle by providing scientific information that supports conservation planning and design, guides learning through evaluation of conservation delivery, and offers a basis for assumption-driven research.

3. Implement monitoring of fish, wildlife, and plants; physical resources; and ecological processes to reduce uncertainty related to impacts of climate change and other stressors; provide early warning of changing conditions; and guide development of management actions that facilitate adaptation to climate change.

4. Synthesize, interpret, and report on the condition of fish, wildlife, plants, and habitats conserved by the Refuge System in a manner that documents the contributions of the Refuge System within the context of the larger conservation estate and clearly communicates its value to the American public.

5. Enhance effectiveness and reduce costs by coordinating and integrating monitoring of natural resources at landscape scales through collaboration with other Service programs, agencies, and organizations.

I&M PROGRAM INITIAL OBJECTIVES

1. Collect, synthesize, and manage information needed to increase the resilience of existing protected areas by informing refuge planning and management and the future growth of the Refuge System. Support and evaluate adaptation strategies at multiple spatial scales.

2. Collect, synthesize, and manage information needed to assess the vulnerability of the NWRS related to broad-scale climate and non-climate stressors: water shortages, changes in precipitation and disturbance patterns, changes in fire risk, contaminants, and land use changes. Support and evaluate adaptation strategies at multiple spatial scales.

3. Collect, synthesize, and manage information needed to assess the vulnerability of the NWRS to increases in weed species and changes in insect pests and disease pathogens. Support and evaluate adaptation strategies at multiple spatial scales.

4. Collect, synthesize, and manage information needed to detect shifts in biomes and species ranges, elevated extinction rates, and changes in the timing of migrations and other phenological phenomena. Support and evaluate adaptation strategies at multiple spatial scales.

5. Collect, synthesize, and manage information needed to assess the vulnerability of the NWRS coastal and marine resources to sea level rise, rising ocean temperatures, and ocean acidification. Support and evaluate adaptation strategies at multiple spatial scales

6. Collect, synthesize, and manage information needed to assess the vulnerability of the NWRS Arctic and other high-latitude resources, including ice-dependent species. Support and evaluate adaptation strategies at multiple spatial scales

III. PHASE 1 TASKS – FISCAL YEARS 2010 AND 2011

Phase 1 of the I&M program, implemented in Fiscal Years 2010 and 2011, will undertake a series of tasks that will serve to launch the program and lay the foundation for program evolution. These tasks are described below. Some general tasks that transcend program objectives are described first, followed by tasks associated with the objectives above. General considerations include fully engaging Refuge System staff, other Service programs, and conservation partners to fully define needs and ensure effective

leveraging of resources. The I&M program must also build a strong data management infrastructure to ensure that data collection is properly planned and that the data are analyzed, reported, and managed so as to provide the greatest value to the Refuge System and our partners. Specific data management tasks are outlined in Section IV below.

The objectives-driven tasks involve assembling baseline inventory data and designing pilot projects that will test protocols, sampling designs, and databases and pave the way for replication nationwide in the future. Fact sheets with more specifics regarding each task are found in Appendix A. A list of information needs representing initial priorities for data acquisition, some of which will be obtained by working with other Service programs, interagency agreements, and/or contracting are listed in Appendix B.

The following criteria were also used to identify priority tasks:

- Address information needs common to all or much of the NWRS, which will have immediate and direct benefit to field level planning and management, and when "rolled up" will have direct benefit in supporting national-level priority setting and budget formulation for the NWRS.
- Address information needs (data gaps) critical to developing adaptation strategies for climate change with wide application to the Refuge System.
- Avoid adding to the workload of the field stations.

GENERAL TASKS

a) Task**: Information needs assessment**

Managers at all levels of the NWRS have emerging information needs associated with the challenges of managing in the face of climate change and other stressors, such as habitat fragmentation and contaminants. The Refuge System I&M program will develop and implement a process for identifying these emerging needs through a "functional analysis" that will seek the input of Refuge System staff at all levels. The managers for the Ecology and Technical Team will work with the regional I&M Coordinators, regional refuge biologists, LCCs, and field positions to plan and implement the needs assessment and report the results. The FWINS (Fish and Wildlife Information Needs Assessment) database is available for managing the data associated with the needs assessment.

b) Task: **Coordinate with existing NWRS and Service leadership.**

I&M program staff funded under this initiative will coordinate with existing NWRS and Service leadership, biological, planning, and technical staff, and programs to help develop priorities and approaches and to leverage resources to increase effectiveness and efficiency. This work will include coordination with regional refuge chiefs, refuge supervisors and project leaders, regional refuge biologists, Land Management and Research Demonstration biologists, refuge biologists, and Fire, Water Resources, Invasive Species and Information Technology staff and programs. In some regions, the Division of Natural Resources may provide an organizational "home" for the regional I&M staff.

c) Task: **Collaborate and build partnerships with other Service programs, the LCCs, and other agencies and conservation partners.**

Managers at all levels of the NWRS have a long history of collaboration with other Service programs including Migratory Birds, Partners for Fish and Wildlife and Coastal programs, Fisheries, Endangered Species, Contaminants, USGS Wildlife Health Center (wildlife diseases), as well as with State and Federal agencies, conservation organizations, and private landowners. These collaborative relationships will be enhanced by directing I&M staff to coordinate monitoring activities within the Service and among our partners. The I&M program will work at the national level to expand our partnerships with the National Park Service "Vital Signs" Inventory and Monitoring Program, the U.S. Geological Survey, the Bureau of Land Managerment, U.S. Forest Service, National Ecological Observatory Network (NEON; http://neoninc.org/), and the National Oceanic and Atmospheric Administration. Coordination at this level is critical for addressing conservation needs of resources for which climate adaptation strategies must be developed at national and continental scales. Similarly, I&M program staff at the regional and field levels will work through the LCCs and locally to expand existing partnerships and develop new ones supporting inventory and monitoring needs.

INITIAL OBJECTIVES AND TASKS

1. *Objective: Collect, synthesize, and manage information needed to increase the resilience of existing protected areas by informing refuge planning and management and the future growth of the Refuge System. Support and evaluate adaptation strategies at multiple spatial scales.*

   a) Task: **Assemble existing abiotic data sets needed by NWRS managers to set management objectives through the Comprehensive Conservation Plan (CCP) process.**

Abiotic baseline data are essential for refuge management and are assembled by refuges during the CCP planning process. Abiotic factors such as soils, hydrology, and geomorphology provide the foundation for ecological processes and ecosystem restoration. The value of assembling abiotic data layers was identified as part of the *Fulfilling the Promises* initiative (WH 8.1 2004) (U.S. Fish and Wildlife Service 1999). However, some refuges still lack access to the baseline data identified in the *Promises* document, and there is no central location for storing this information so that it is available to regional or national NWRS managers. Delineating a core set of abiotic data layers for all refuges will help define how the NWRS responds to existing environmental stressors and future climate change. A central data library that builds a catalog of available abiotic data sets, along with interpretation of how this information can be used by managers, is needed for the entire NWRS. The regions need to identify additional abiotic data sets that are region-specific and cooperate with the National office to catalog this information. The priority will be to develop a process for assembling the data layers, then a timeline for implementing the task across the Refuge System; refuges that have immediate use for this information for CCPs are priorities.

b) Task: **Complete baseline hydrogeomorphic (HGM) analyses at selected NWRS stations.**

Hydrogeomorphic analysis (HGM) is a method of assessing ecosystem condition and ecological processes at a site to evaluate departure from historic conditions, identify restoration and management options, and identify ecological attributes needed to restore specific habitats. Note that the term "HGM" as used here refers to an analysis tool in a management context and differs from the related Hydrogeomorphic (HGM) Approach used to assess and classify wetland function in a regulatory framework. HGM determines historic condition and ecological processes (soils hydrology, topography, geomorphology, vegetation). Next, HGM identifies changes to physical condition and ecological process. Finally, the HGM process

generates restoration options for a given landscape. Restoration options will need to be informed by climate models; restoration of ecosystem function may be more feasible than restoration of specific plant communities. An HGM analysis helps refuge stations clarify their management objectives and respond to climate change by creating a better understanding of the potential for a refuge to support wildlife and plant communities. HGM provides a science-based approach to understanding the physical and ecological attributes of landscapes and specific areas within them, such as NWRs. HGM helps us view individual refuges within the functions and values of the larger geographical scale ecosystem. HGM will use information generated by water resource inventories and assessments described below. Therefore, coordination is needed to maximize the value of both efforts.

c) Task: **Design and implement a strategic plan for compiling, organizing, interpreting, and serving legacy data within the NWRS for the purpose of documenting historic and current occurrences of species.**

Floral and faunal inventories are critical for benchmarking extant species assemblages before accelerated climate change and non-climate stressors cause extinctions, species redistributions, and novel assemblages. Inventories also set the stage for reasoned and deliberate development of monitoring objectives and a well-designed monitoring program. New data resulting from comprehensive inventories may also redirect current management priorities and assist with assessments of species vulnerability to climate change. The first step in documenting species occurrences is to review the existing data; i.e., legacy data. Legacy data include existing data sets, annual narratives, reports, theses, museum voucher specimens, and species checklists. Most refuge bird checklists are compiled from legacy data. The National Park Service has developed several databases and protocols for inventorying legacy data, compiling legacy data on species occurrence within the National Parks in a national database (*NP_Species* database) and other legacy data into a natural resource bibliography database for each park. In a world with rapid climate change, legacy data represent only historic, not necessarily current, species occurrence. However, they can serve as benchmarks against which future changes can be compared. As a caution, these data sources often have serious limitations; the value of the information must be weighed against the cost of acquisition and compilation before proceeding.

d) Task: **Design and implement at least four pilot studies across the NWRS to contrast approaches for inventorying the occurrence of vertebrates, vascular plants, and a subset of invertebrates.**

The WH8 Baseline Inventory Team and the Service Climate Change Strategic Plan recommend complete inventories of vascular plants, vertebrate species, and a subset of invertebrate species on all refuge lands. The inherent value of knowing which species occur on a refuge is predicated on the certainty of that knowledge, the rigor with which data were collected, and the spatial distribution of the sampling efforts. These attributes dictate the potential for using inventory data as baseline values for subsequent plot-based monitoring, for input into spatial modeling at local scales including the development of vegetation and wildlife species distribution maps, for developing statistical models of species-habitat relationships, for ground-truthing remote-sensed data, or as validation data sets for spatially explicit models. The trade-off is that even as the collateral benefits grow with increasing statistical rigor and spatial comprehensiveness, so does the financial cost of conducting the inventory. Designs for inventorying biodiversity range from species lists derived from aspatial legacy data (*e.g.,* museum voucher specimens); to geo-referenced but spatially incomplete data produced by rapid ecological assessments; to multiple taxon-specific surveys that may be on mutually exclusive sample frames; and, finally, to spatially comprehensive sample frames that estimate species occupancy. The scientific, fiscal, and logistical trade-offs of taking one inventory approach

versus another are based, to a very great extent, on considerations about the subsequent monitoring design. Consequently, the collateral benefits of partnering with national programs such as the Forest Service's Forest Inventory and Analysis (FIA), the Environmental Protection Agency's National Aquatic Resource Surveys (NARS), and the Natural Resource Conservation Service's Natural Resource Inventory (NRI) will be actively explored. The priority in Phase 1 is to focus on exploring partnerships, designing the pilot studies, and garnering input from across the NWRS and key partners. Implementation will not occur until Phase 2.

e) Task: **Design, fund, and implement a strategic process for completing vegetative inventories and cover mapping, using the National Vegetation Classification Standard on all refuges.**

Vegetation species and communities are unique from refuge to refuge. The inventory of these resources helps refuge managers conserve plant biodiversity; manage challenges such as exotic species, urbanization, insect outbreaks, and diseases; and understand resources and processes such as wildlife-habitat relationships and wildland fires. Establishing baseline vegetative cover maps using the National Vegetation Classification Standard (NVCS) sets the stage for conducting change detection analyses for monitoring and quantifying shifts in habitat. Comprehensive vegetative cover maps of refuge landscapes and surrounding areas will allow us to determine suitable sites for restorations and acquisitions to facilitate the establishment of extensive protected areas connected by biological corridors. As a baseline, standardized cover maps will help us set biodiversity conservation targets and track changes in extent and composition of communities following short-term events such as fire and longer-term events such as climate change. These products will provide LCCs an integral dataset used in conservation design.

f) Task: **Support monitoring for adaptive management by providing guidance, coordination, data management, and documentation of monitoring within an adaptive management framework.**

Technical support and guidance are needed across the NWRS for implementation of both passive and active adaptive management (AM). A large proportion of existing monitoring on refuges is targeted monitoring. Currently, the NWRS has little infrastructure for supporting stations engaged in targeted monitoring and AM. Work by the regional refuge biologists, staff from the various Joint Ventures, national air and water quality specialists, and regional fire ecologists to help stations identify priority CCP and HMP objectives has laid the foundation for AM across the Refuge System. Partner and interagency programs (e.g. interagency fire community, NPS Vital Signs Network, NRCS CP33 program, etc.) have AM tools and resources to share, but these are underutilized by most field stations. A fundamental need at the field station level is monitoring support for passive AM. The I&M program should support the monitoring component of AM on NWRS units as well as summarize and report how the NWRS and partners are using AM to help species and ecosystems adapt to the threat of climate change and other stressors. In addition, several large AM projects, developed in cooperation with USGS under the Refuge Cooperative Research Program (RCRP) and several smaller AM consultancy projects are ongoing. Some of these projects involve multiple regions. Monitoring under AM requires careful planning, a variety of technical skills, and a dedicated coordinator to lead the project. All of these resources are currently scarce at both regional and field station levels. I&M program staff at the LCC and field station levels could provide the coordination and technical skills to support both passive and active AM. Because AM incorporates a process for periodic reevaluation of projects, there is a mechanism for sun-setting projects that have achieved their objectives, thus freeing up staff for future projects.

2. *Objective: Collect, synthesize, and manage information needed to assess the vulnerability of the NWRS related to broad-scale climate and non-climate stressors: water shortages, changes in precipitation and disturbance patterns, changes in fire risk, contaminants, and land use changes. Support and evaluate adaptation strategies at multiple spatial scales.*

a) Task: **Complete a baseline, reconnaissance-level inventory of water resources, including an assessment of water quality, at all refuges.**

Climate change will likely alter the timing, availability, and demand for water among competing interests, including the NWRS. Conflicts over water will increase as burgeoning population centers look to tap more surface and groundwater sources, and as domestic energy development --biofuels, solar, nuclear and hydro-electric expansion -- and climate change increases the variability of and demand for water supply. Refuges depend on the availability and timing of surface and groundwater sources of sufficient quality to meet their management goals, yet the Service does not have a comprehensive inventory of its waters or an assessment of present and future sources, needs, and uses. For refuges nationwide, there is a pressing need for water resource inventories and assessments, due to a widespread lack of data about water resource supplies, needs, and quality as they relate to the management of refuges and hatcheries, the recovery of federally listed species, and the avoidance of listing new species. The water resource inventories and assessments will be initiated during FY2010, but will take approximately five years to complete for all refuges.

b) Task: **Fire Regimes - Scope an approach for establishing and reporting standard reference points for measuring long-term, landscape-scale, fire regime shift under climate change and other stressors.**

Altered fire regimes pose a serious threat to biodiversity. Their restoration is dependent on understanding the natural ecological range of variability in fire frequency and severity and vegetation composition and structure. However, determining natural ranges of variability in fire regimes and vegetation can be difficult, given the lack of reference landscapes to use as benchmarks. A procedure to model reference conditions for all vegetation types across the U.S. is currently being applied via the LANDFIRE (LF) project by the USDA Forest Service, Department of the Interior and The Nature Conservancy. Historic and current benchmark or reference points are needed for the NWRS to calculate future rates and relative departure in fire and other disturbance regime attributes expected under a changing climate. Key fire regime attributes will be recalculated and trends reported for the NWRS at 10- to 20-year intervals as measured against the historic benchmarks and 2010 benchmarks. LCC and refuges will use finer-scale analysis and benchmarking and will construct linkages with focal wildlife species-habitat relationships, climate change-sea level rise, and other fuels/fire decision-support tools developed through PROGRAM pilot projects. Nearly all key datasets currently exist and are available through LANDFIRE, but we need an automated process to customize these datasets to NWRS 'fire-scapes' to develop system-wide benchmarks applicable to the NWRS. Once the initial process is completed and documented, it can be periodically replicated for recalculating trends at long-term intervals.

3. *Objective: Collect, synthesize, and manage information needed to assess the vulnerability of the NWRS to increases in weed species and changes in insect pests and disease pathogens. Support and evaluate adaptation strategies at multiple spatial scales.*

a) Task: **Develop pilot projects focused on mapping and monitoring invasive plants in at least two regions, with a long-term vision of supporting an integrated landscape approach to the management of invasive species across the Refuge System.**

Invasive species are one of the most pervasive threats to habitat management in the National Wildlife Refuge System. Invasive species are the most frequently reported problem affecting habitat trends. A large proportion of refuge managers (78 percent) report that invasive plants are a moderate to large problem at their stations (GAO 2008). In addition, invasive plant management actions have increased more in cost than any other management actions. Climate change will exacerbate the already huge threat of invasive species. The number of invasive species and the spread of these species are predicted to increase under climate change.

In general, refuges have not had the resources to strategically plan management actions for invasive species. Very few refuges have thorough inventory data. Without inventory data, managers do not know what the problem is or where it is, and they do not understand patterns of spread. As a result, management priorities are often defined by political pressures or crisis management. Commonly, efforts are focused on control of the biggest and densest patches; smaller patches are widely ignored, which is the opposite of what the NWRS Invasive Species Strategic Plan advises (U.S Fish and Wildlife Service 2003).

A standardized I&M approach is critical to improving our understanding of the invasive species threat and our ability to deter it. Without inventory data, we do not know what the problem is, where it is, and we do not understand patterns of spread. At a refuge scale, we need to be able to quantify the extent of the problem. Inventory and monitoring data at a larger landscape scale or watershed scale are critical for working with partners to control invasive species; they are also especially crucial for the early detection of new invaders on NWRS lands. It will be necessary to share I&M protocols and databases with sister agencies and non-governmental partners through LCCs or other collaborative data sharing platforms or venues. We also recommend building upon the work that strike teams have begun. The strike teams have developed protocols and guidelines for how to collect data in their regions. These methods need to be evaluated for flexibility and the appropriateness for other areas. For Phase 1, we recommend beginning with a pilot project in two regions that will create a strategic, landscape-scale approach to inventory and monitoring of invasive species across the Refuge System, including the development of standardized protocols and databases. In this first phase of the I&M program, we also recommend creating at least one early detection network, using volunteers or other partners in each region.

Our vision is to address information needs in support of invasive species management through the I&M program, working closely with partners to provide real-time, science-based inventory and monitoring data and models at multiple spatial and temporal scales that improve our understanding of the spread and distribution of invasive species and help guide management decisions on refuges and adjacent lands. This will require a national conversation with staff throughout the NWRS and with partners to determine long-term objectives.

4. *Objective: Collect, synthesize, and manage information needed to detect shifts in biomes and species ranges, elevated extinction rates, and changes in timing of migrations and other phenological phenomenon. Support and evaluate adaptation strategies at multiple spatial scales.*

a) Task: **Prioritize geographic areas and species based on ecosystem vulnerability.**

Ecosystem vulnerability to climate change depends on the rate of climatic change and the resilience of the system. Climate change rates and resilience vary spatially at both regional and local scales. In order to minimize species extinctions in a rapidly changing climate, managers will need to facilitate adaptation in vulnerable ecosystems. Many management actions, both reactive (based on historic conditions) and anticipatory (based on future conditions), have been suggested to facilitate adaptation. Deciding whether a reactive, an anticipatory, or a blended adaptation strategy is most appropriate requires an understanding of the ecosystem vulnerability of the geographic area. In addition, adaptation actions will need to be strategically coordinated based on the larger landscape context and local-scale variability of both climate change and resilience. Geographic areas with rapidly changing climates and low resilience will also be more likely to experience unexpected or surprising changes to current ecological relationships. Therefore, accurately documenting current conditions, detecting early change, and using adaptive management to implement adaptation strategies will be critical in these areas. Finally, species with constricted or fragmented distributions, and distributions in highly vulnerable ecosystems, will also need to be prioritized for adaptation planning and monitoring. Currently, many refuges do not have access to species distribution maps with a resolution appropriate to identify vulnerable species or document range expansions or contractions. Species distribution models provide a methodology to accurately predict multi-species distributions and to forecast distributions based on future climate scenarios. These products are also useful for prioritizing species and areas for adaption planning.

b) Task: **Partner with the USA National Phenology Network by developing a landing page or portal for the NWRS on the USA-NPN web page.**

The inventory of current phenology and monitoring temporal changes that result from climate change can serve as critical components of an "early warning system" for threats to both species occurrence and abundance (i.e., species vulnerability). Recent literature indicates that species that show relatively great phenological change are more resilient and therefore less likely to be locally extirpated as climate changes. Phenological data are also critical for understanding some of the underlying proximate mechanisms (e.g., trophic mismatch, parasite-host relationships, or growing season) that may be driving species redistributions, population extirpations, and species extinctions in a world with rapid climate change. The USGS launched the USA National Phenology Network (NPN) in March 2009 with the goal of having 100,000 observation locations across the country that are monitored by citizens, universities, agencies, and organizations. The NWRS needs to develop a portal on the NPN web page and identify key taxa that should be monitored in collaboration with the NPN.

c) Task: **Coordinate bird monitoring with Migratory Birds and other partners.**

Management of birds and their habitats is a major focus for the NWRS. Bird monitoring on refuges needs to be coordinated across the landscape with other Service programs (Migratory Birds) and our Partners (USGS, States, NGOs). There are a number of national bird surveys that the Refuge System participates in, including the North American Breeding Bird Survey, Woodcock Singing Ground Counts, four-square-mile surveys, and the Mid-Winter Waterfowl Survey. Therefore, the NWRS should take a leadership role, in partnership with Migratory Birds, regarding coordinated bird monitoring across the nation. A national I&M program bird monitoring coordinator could begin to address continental/national scale coordination of bird monitoring on refuges, especially during the migration period. Coordination of monitoring across regions is important for all stages of bird life cycles, but especially during migration when the timing and availability of habitat for birds is critical. Migration is also the most difficult life stage for land managers to engage in coordinated monitoring because of the short time frames and very large landscapes involved. One project that is attempting to deal with the complexities of migration monitoring

is the Integrated Waterbird Project (http://www.acjv.org/waterbird_project.htm) that involves Regions 3, 4, and 5. This project is an example of Strategic Habitat Conservation and adaptive management applied at the scale of two flyways (Atlantic and Mississippi flyways) and several bird taxa (waterfowl, shorebirds, marsh birds), with a focus on providing high-quality migration habitat. There may be projects in other regions with similar goals. A NWRS national I&M program bird monitoring coordinator could play an important role in promoting monitoring coordination across flyways and regions, working with Migratory Birds to engage all the regions in addressing migration habitat needs for many different bird taxa, including seabirds.

5. *Objective: Collect, synthesize, and manage information needed to assess the vulnerability of the NWRS coastal and marine resources to sea level rise, temperature rise, and ocean acidification. Support and evaluate adaptation strategies at multiple spatial scales.*

a) Task: **Coordinate with science partners (federal agencies, academia) to understand the relevance of models and predictions of changes in ocean temperature, acidification, and other oceanographic variables for refuge management; gather information needed to plan and evaluate adaptation strategies.**

Much of the NWRS is marine-influenced, encompassing about 30,000 coastal miles across 61 million coastal land acres. This puts 66 percent of the NWRS's land acres in the coastal zone[1] of the United States. In addition, refuge ocean holdings include two 1,000-mile-long archipelagos and expansive estuarine systems from above the Arctic Circle to remote, coral reefs and tropical lagoons below the Equator. Coral reef ecosystems alone within the NWRS total almost 5 million acres. In total, the FWS co-manages 89 million acres of marine habitats in the Papahānaumokuākea Marine National Monument in Hawaii and the recently designated Pacific Remote Islands, Rose Atoll, and Marianas Trench Marine National Monuments, which cover 53 million acres of submerged lands in the Central and Western Pacific.

Climate-induced changes in ocean temperatures, pH, and oceanographic variables, such as currents, gyres, and upwelling regimes will all affect ocean and coastal refuge species and habitats. Academic institutions, NOAA, and other agencies monitor these variables and gather data. The oceans and the NWRS marine resources are so immense that the NWRS will need to partner with these agencies to gather data needed for models and predictions. In addition, these agencies will help the NWRS understand the relevance of predicted and potential impacts to management and long-term planning for the Refuge System as a whole.

b) Task: **Complete initial sea-level rise modeling for coastal refuges**.

Sea-level rise is one of the most pressing climate change issues facing coastal refuges (Defeo et al. 2009). Sea levels in the next 100 years are estimated to rise 0.18 to 0.59 meters above current levels (IPCC 2007). Given the significance of NWRS's coastal lands, rising sea levels present a geographically ubiquitous threat. Understanding the potential impacts of sea-level rise to coastal and estuarine habitats is essential to management and long-term planning for the affected refuges, and for the Refuge System as a whole. The Sea Levels Affecting Marshes Model (SLAMM) was developed to help predict the possible effects of various levels of sea rise on coastal marshes and adjacent lowland areas. This model uses National Wetlands Inventory data plus information on

[1] "Coastal zone" as defined by NOAA's Coastal Change and Analysis Planning Boundary.

local topography, accretion and erosion rates, dikes, and development in making these predictions. SLAMM has been run for a few large estuaries including Puget Sound, Chesapeake Bay, and Delaware Bay and for numerous refuges along the Atlantic, Gulf, and Pacific Coasts. This modeling needs to be completed for coastal refuges where rising seas could impact coastal and estuarine wetland habitats. Data gaps that must be filled include obtaining digital elevation data and updating the NWI.

6. *Objective: Collect, synthesize, and manage information needed to assess the vulnerability of the NWRS Arctic and other high-latitude resources, including ice-dependent species. Support and evaluate adaptation strategies at multiple spatial scales.*

a) Task: **Coordinate with science partners (federal agencies, academia) to understand the relevance of models and predictions of changes in Arctic and high-latitude environmental changes for refuge management; gather information needed to plan and evaluate adaptation strategies.**

The 16 refuges in Alaska comprise 87 percent of the land base within the NWRS, ranging in size from 1 to 22 million acres; Congressionally designated wilderness makes up 20 percent of refuge lands, most of which is in Alaska. The median area of refuges in Alaska is 2.7 million acres. Even as climate change is dramatically impacting the high Arctic and subarctic Alaska, the logistical and fiscal costs of inventorying and monitoring continue to be significantly greater in Alaska than elsewhere in the country. The loss of the cryosphere will have significant effects on animal and plant life in Alaska. Warmer temperatures have already reduced sea ice used by seals and walruses to rest between searches for fish and mussels. Polar bears in some Arctic regions appear to be experiencing shorter feeding periods and decreased accessibility to the seals they hunt because of reduced sea ice. The melting cryosphere will also impact native populations and subsistence hunting. It is reported that sea ice off the Arctic coast of Alaska is thawing and retreating, having widespread affects on marine ecosystems, human settlements, and subsistence activities. Finally, loss of permafrost is already having profound effects on localized ecosystems and threatening much more. All these things put the management and ecological integrity of Alaskan refuges at risk. Academic institutions, USGS, NOAA, and other agencies monitor these variables and gather data. The Arctic region is so immense that the NWRS will need to partner with these agencies to gather data needed for models and predictions. In addition, these agencies will help the NWRS understand the relevance of predicted and potential impacts to management and long-term planning for the Refuge System as a whole.

PILOT PROJECTS ARE CENTRAL TO THE SUCCESS OF PHASE 1

Several of the priority tasks (Section III, Appendix A) require a pilot phase during which protocols, sampling designs, databases, and reporting methods will be tested and refined (water inventories, invasive species, biotic inventories, adaptive management). Pilot testing for some of these components may occur in only a few regions during Phase 1, while methods are being developed; other components will benefit from testing at a few stations in many or all regions. The regions will work cooperatively to design methods and tools with the ultimate goal of expanding their use nationwide; in Phase 2, some of these pilot efforts will be revised, refined, and expanded to more regions or nationwide. *It is essential that the regions work together to identify which regions will assume leadership roles for these pilot projects. This is necessary to ensure that all pilot projects are tested and that staff hired have the necessary technical skills for the pilot projects adopted by that region.* For example, Regions 6 and 4 may want to cooperate to develop the tools and methods for inventories, mapping, and monitoring of invasive species, since they have Strike Teams

and existing staff heavily engaged in invasive species management. These regions may want to hire staff with expertise in invasive species ecology and adaptive management. As another example, we would like to test the water resources inventories in at least one of the Eastern regions. Regions testing water inventory methods may want to hire people with water quality/hydrology expertise. We need to test biotic inventory methods in several regions outside Alaska. Several regions have ongoing multi-refuge adaptive management projects. Those regions may consider dedicating one FTE to coordination of these large projects; such a coordinator needs expertise in adaptive management.

IV. DATA AND INFORMATION MANAGEMENT

The I&M program will make a strong commitment to data management and provide the necessary resources to ensure our data is synthesized and turned into useful information for our managers and partners. Our information will be shared and leveraged in as many ways as possible to maximize its value while diminishing its overall cost. Scalability and flexibility in system design will be important requirements as the I&M program will certainly evolve. We will ensure our systems are maintainable, expandable, and interoperable.

Performance and cost efficiencies will be achieved through centralized management of our infrastructure. We will identify and procure infrastructure for the I&M program in Phase 1 and establish our primary servers at the Denver Federal Center. This site includes common physical and system security controls resulting in streamlined security certification and accreditation (C&A). The C&A process is required for evaluating, describing, testing, and authorizing information systems. By centralizing management of servers, data management personnel at the national office and geographic areas will be able to devote more time to data design, quality control, documentation, and providing support to the field. Support agreements will be established with the Division of Information Resources & Technology Management (IRTM) to maintain the hardware and assist with streamlining the C&A process.

The national office in collaboration with regional I&M staff will establish which data collection efforts are to be conducted Refuge System-wide. The national office will be responsible for providing the framework, standards, and guidelines for geographic areas to contribute to these efforts. Flexibility in data collection mechanisms will be given to geographic areas to promote creativity. The national office will focus on designing systems, delivering dynamic data services, and facilitating data sharing practices. We recommend formal collaboration from the onset with the NPS Inventory and Monitoring Program in Fort Collins.

Geographic areas will have the capacity to pursue, design, and manage I&M project data tailored for their landscape-level needs. However, a set of core attributes will be established by the national office to ensure the essential "who, when, what, how and where" details are consistently applied in each geographic area. The geographic areas will be heavily involved with data collection, quality control, and aggregation of data.

Standardized field data collection protocols and quality control procedures will be developed before any extensive I&M data collection efforts begin. Protocols, standards, and procedures for capturing and managing enterprise level data will be developed by a National I&M Data Standards Team. This team will be led by the national office data management staff and will include all geographic area data managers and the National GIS Coordinator or designee. A Data Governance Team with representation from NWRS leadership and at least one biometrician will also be formed to establish a "chain of accountability" and

process to ensure our data assets are consistent, accurate, complete, accessible, protected, and efficiently managed.

DATA MANAGEMENT TASKS

1. Task: **Determine the data, information, and functional requirements for Phase 1 I&M priority tasks.**

National data management staff will lead the effort to determine the data, information, and functional requirements for Phase 1 I&M priority tasks. This detailed planning phase will identify stakeholders and answer important questions such as what data is to be produced, who will produce it, how it will be used, and by whom. Determining these requirements is integral to ensure database products generated by the I&M program are thoughtfully designed and meet the needs of the NWRS.

2. Task: **Assess existing Service IT infrastructure capacity and draft technical specifications to procure hardware/software and establish IT agreements/contracts.**

A few of the I&M tasks identified in Phase 1 could potentially be addressed using existing infrastructure through collaboration and agreements with the Service IRTM - Branch of Data Systems Services (BDSS) or other contracts. However, the I&M program will ultimately require additional servers, peripherals, support, and software licensing to successfully implement an enterprise data management system. An assessment of national, regional, and LCC infrastructure will be conducted to determine existing capacities and identify potential leveraging opportunities. This assessment along with the data, information, and functional requirements determined in *Task 1* above must be considered before major procurement and/or contracting decisions are made.

3. Task: **Investigate, establish and maintain an easily accessible centralized repository for I&M related documents.**

Numerous documents will be generated by the I&M program due to the multitude of projects being initiated in Phase 1. It will be crucial for I&M staff at all levels to have a "one-stop shop" for accessing the most current version of I&M user guides, policy, guidance, data standards, work plans, and field protocols. The I&M program will investigate the document repository used by the National Conservation Training Center (NCTC) library and work to find a common solution with the National Climate Change Data Team, which has also identified a need for centralized document management.

4. Task: **Develop and maintain web site for the I&M program and provide standards, templates, and procedures for geographic areas to maintain individual pages.**

Communication to the field will be vital for early success. The Internet will be one of the primary communication tools for the I&M program. Establishing a consistent look for all I&M program web pages will allow users to find information quickly. Geographic area and regional I&M and biological program web sites will be linked from the home I&M page. The NWRS web design standards will be used.

5. Task: **Establish mechanisms to support refuges biologists to efficiently manage refuge specific monitoring data as identified in the draft NWRS I&M policy.**

The new draft I&M policy requires individual field stations to comply with data management procedures for survey plans, reports, data and field notes for all surveys of plants, fish, wildlife, habitats, abiotic

components and vegetation communities. Specifically, each station must ensure these data comply with Service data standards and are created, maintained, and archived in accordance with Service policy on electronic records (282 FW4). The national office data management staff will work with regional staff to develop a mechanism for stations to consistently produce, document, and centrally archive their final packaged datasets to ensure consistency and long-term safeguarding.

6. Task: **Collaborate with IRTM and system owners to streamline the capability of the Corporate Master Table (CMT) and other applicable Service database products so they can be easily integrated with the I&M data management system.**

The Corporate Master Table (CMT) is the official source for Service organizational information (orgcode, station name, address, etc.). These data must be seamlessly integrated with the I&M data management system. Enhancements are needed to make CMT compatible with Service-Oriented Architecture (SOA). Essentially, SOA is an application development design philosophy recommended by the DOI that allows disparate database products to efficiently communicate with each other using standard industry protocols. Depending on functional requirements determined in *Task 1*, other Service database products may require integration and the national office data management staff will work with applicable system owners to ensure interoperability.

7. Task: **Assemble the national I&M Data Standards and Data Governance teams to begin the process of identifying data standards and establishing workflow processes for Phase 1 priority I&M tasks.**

Nearly all of the data management tasks outlined above will require the development of standardized operating procedures and data standards. The management of data and information is common to all elements of the I&M program. It will be advantageous to form functional teams in order to establish consistent approaches across all geographic areas so we can demonstrate early success and build the capacity to support field stations and LCCs. These two teams will provide the framework necessary to promote confidence in the use of our data for decision-making purposes.

8. Task: **Assess the existing land bird/marsh bird monitoring database applications maintained by the USGS and develop a long-term strategy for supporting land bird/marsh bird monitoring by refuges.**

The United States Geological Survey - Patuxent Wildlife Research Center (USGS-PWRC) maintains a centralized database application used by the NWRS and others to store and retrieve bird monitoring data. The database is populated by refuge users via an online web interface. The database supports numerous monitoring protocols for land birds and one standardized protocol for monitoring secretive marsh birds. There are approximately 92 national wildlife refuges throughout seven USFWS administrative regions that are actively using the database. The database is extensively used by field stations in the Northeast (R5), with moderate use occurring in the Midwest (R3), and Southeast (R4). The remaining regions (R1, R2, R6, R7, R8) use the database minimally. There is currently no official agreement between the USFWS and USGS-PWRC regarding the long-term maintenance of this database. The I&M program will assess the current application and develop a long-term strategy for supporting land bird/marsh bird monitoring by refuges.

9. Task: **Establish formal working agreements with appropriate external and internal IT development teams that present opportunities for information sharing and/or technology exchange.**

By strategically locating the national I&M data management staff in Fort Collins near the National Park Service's *Vital Signs* program office, the Service's *Environmental Conservation Online System* (ECOS) development team, and the IRTM Denver office, we will have tremendous opportunities to learn, share, and adopt best practices for application development. For example, the NPS has been conducting I&M activities in their parks for nearly a decade and are actively employing SOA concepts in their systems development and design. The national I&M data management staff will identify and establish appropriate working agreements with others to facilitate information sharing and technology exchange.

10. Task: **Determine data management staffing and contracting strategies for application and systems development in Phase 2.**

After the initial information and functional requirements have been identified for Phase 1 priority tasks, the national data management staff will assess existing capacity and develop a staffing and contracting strategy to accomplish the scope of work being proposed. Depending on the number of projects actively being pursued by the I&M program, additional business analyst positions may be required along with contracting or hiring other skills such as application developers, web developers, and programmers. Accomplishing the data management goals identified in the strategic plan is a huge undertaking and it will require an efficient, highly skilled team of information technology professionals.

V. I&M PROGRAM ROLES AND RESPONSIBILITIES

The initial staffing framework for the I&M program will include a national office in Fort Collins, Colorado, (15 FTEs), regional offices (regional I&M coordinator), a presence within each LCC established (I&M coordinator and I&M database manager), and a minimum of three field positions located at stations served by the LCC. The *Addendum to the Strategic Plan* provides a detailed description of program organization and administration. The I&M program will be nationally coordinated, but integrated with refuge management. This *Operational Blueprint* focuses primarily on the roles and responsibilities of the national office and the regional coordinators; the roles of the I&M program staff at the LCCs and field stations will evolve as the program matures (Figure 1). It is likely that the roles of these staff will vary, based on the priority monitoring needs in different geographic areas and the technical skills of existing permanent staff. This operational flexibility fits with the operating history and strong regional structure of the NWRS, but also requires strong cooperation and communication among the regions. A nationally coordinated I&M program will benefit from good communication; adoption of a set of standard operating procedures and data standards; a strong, unified data management structure; and reporting requirements.

NWRS station managers (project leaders) have long expressed concern that biological staffing levels on the ground are inadequate to meet habitat management and monitoring needs. Why are we creating a national I&M program office when we need more FTEs on the ground? We believe that national leadership and infrastructure are needed to promote NWRS cohesiveness, maximize efficiency, and ensure inventory and monitoring efforts have a solid biological and scientific basis. Access to peer-reviewed monitoring protocols and data management, in particular, are strong needs across the NWRS. Many regions lack adequate technical expertise to meet station needs in the areas of data management, biometrics, remote sensing, modeling, and hydrology. National and regional managers need biological information

summarized in a variety of ways to inform strategic decisions and meet specific reporting needs. The I&M program, as it evolves, will identify additional deficits in our technical expertise and our capacity on the ground to collect biological information needed to inform important management decisions. Strategies will be developed to address these deficits.

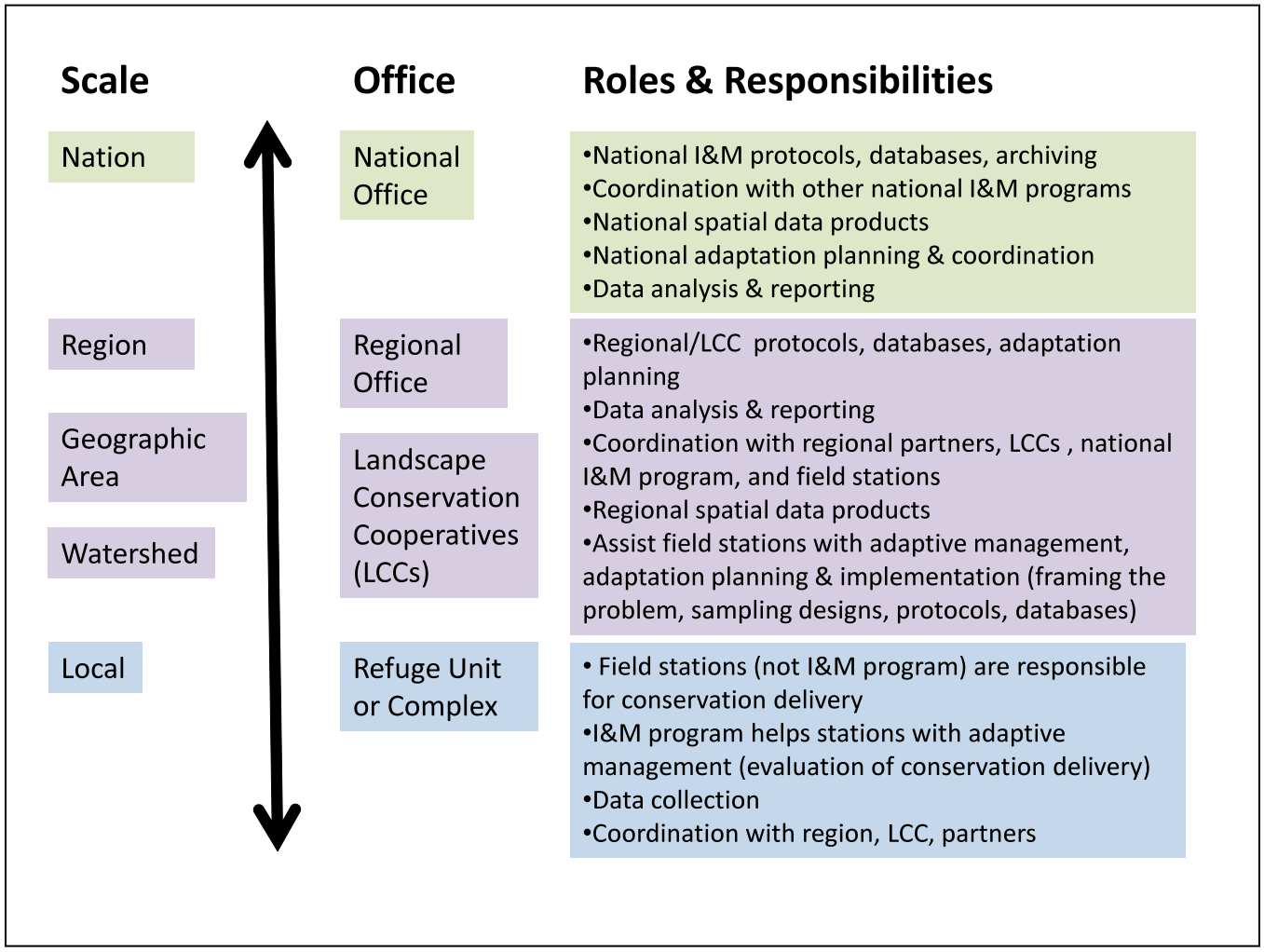

Figure 1. Roles and responsibilities of the I&M program at the national, regional, LCC, and field station levels.

NATIONAL I&M OFFICE

A national-level I&M office will be established in Fort Collins, Colorado (Figure 2, Table 1). The national staff will work with the regional I&M coordinators and NWRS leadership to refine program goals, set priorities, and develop detailed work plans to address the highest priority program goals and objectives.

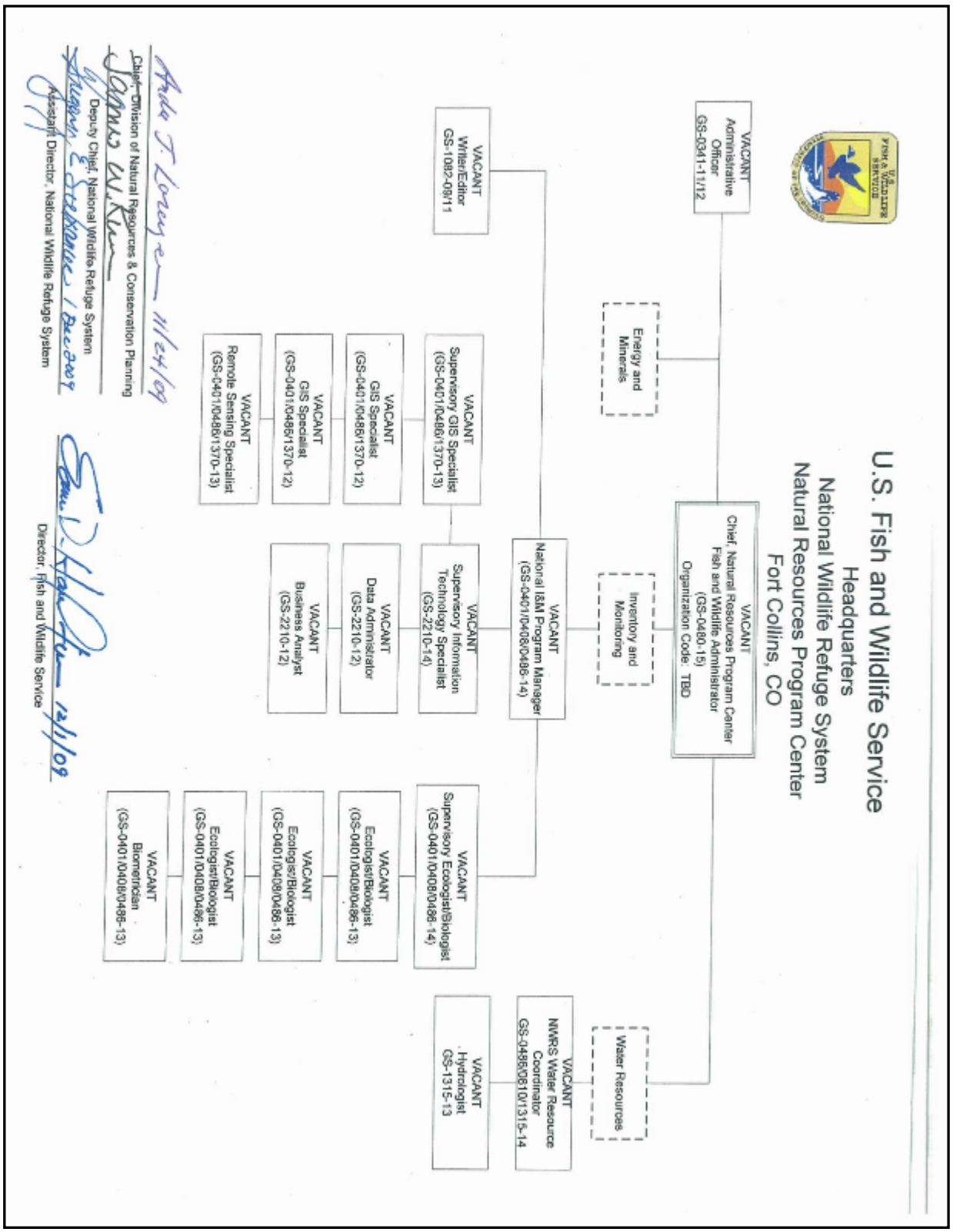

Figure 2. Organization of the Refuge System Inventory and Monitoring Program National Office in Fort Collins, Colorado.

Table 1. National I&M program positions and functions (supervisory positions in bold).

Title	Function
National I&M Program Manager	Overall supervisory and administrative responsibility for the I&M program. Reports to the Chief, Natural Resources Program Center, also located in Fort Collins, Colorado.
Writer/Editor	Manages, edits, and publishes all external I&M program communications in the form of reports, fact sheets, web sites, etc.
Supervisory Ecologist / Biologist	Supervises Ecology Team, lead ecologist/biologist
Ecologist/Biologist Inventories	Coordinates biological inventories. Data analysis and reporting.
Ecologist/Biologist Invasive Species	Coordinates invasive species inventory and monitoring activities. Data analysis and reporting.
Ecologist/Biologist Bird Monitoring	Coordinates bird monitoring on NWRS, in cooperation with FWS Migratory Birds and partners. Data analysis and reporting.
Biometrician	Consultation regarding sampling designs, data analysis, reporting for all aspects of I&M program. Data analysis and reporting.
Supervisory Information Technology Specialist	Supervises Data Management Team, lead IT Specialist.
Data Administrator	Systems design, database development and maintenance.
Business Analyst	Performs functional analysis and project coordination.
Supervisory GIS Specialist	Supervises GIS Team. Systems design and geospatial project management.
Remote Sensing Specialist	Coordinates development of new vegetation/land use maps.
GIS Specialist (2)	Report to national GIS coordinator; assess, acquire, and assemble abiotic data layers.
NWRS Water Resources Coordinator & Hydrologist (not part of I&M Program)	Coordinates water inventories, plans monitoring. Data analysis and reporting.

REGIONAL OFFICES

The regional office will have a regional Refuge System I&M program coordinator (1 FTE); this position reports to the ARD for refuges (or designee). The regional I&M program coordinators will work cooperatively with each other, the national office, the regional refuge biologists, the LCCs, and the field to create and sustain a nationally coordinated I&M program. The regional I&M program coordinator will have overall responsibility for the content, quality, and effectiveness of the I&M program in that region. The regional I&M program coordinator has the flexibility to hire staff at the LCC and field level to meet local, regional, and national I&M program needs. The regional I&M program coordinator will work with the regional refuge biologists, refuge supervisors, and the ARD for refuges to plan staffing at the field level needed to support inventory and monitoring priorities at multiple spatial scales and ensure that the staff hired have skills complementary to those already represented.

VI. PLAN CONTRIBUTORS

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Facilitation: Mark Chase, Patricia Heglund, Steve Morey.

VII. ADDITIONAL INFORMATION

The I&M Core Team produced draft white papers fully describing the rationale, need, and specific recommendations for several tasks identified in the *Operational Blueprint* (the topics include invasive species; water, abiotic, and biotic inventories; fire ecology; spatial modeling; adaptive management; and data management). These white papers are available to those interested in more information and team recommendations regarding these tasks.

VIII. GLOSSARY

Term	**Definition**
Adaptation	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2007).
Adaptive management (AM)	Adaptive Management is a decision process that promotes flexible, informed decision-making and that allows adjustment as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself,

[2] Environmental Protection Agency

[3] National Aeronautics and Space Administration

[4] USA National Phenology Network

Term	Definition
	but rather a means to more effective decision-making, more efficient management, and other enhanced benefits. It helps meet environmental, social, and economic goals; increases scientific knowledge; and reduces tensions among stakeholders (Williams et al. 2007).
Adaptive management, active	Active adaptive management is an approach whereby managers, when faced with uncertainty, implement more than one alternative to see which will best meet management objectives. It is characterized by "actively probing" the system in order to distinguish between competing hypotheses (where the different hypotheses suggest different "optimal" actions) (Walters 1986).
Adaptive management, passive	Passive adaptive management is an approach whereby managers, when faced with uncertainty, implement the alternative they think is 'best' with respect to meeting management objectives, and then monitor to see if they were right, making adjustments if desired objectives are not in fact met (Walters 1986).
Comprehensive Conservation Plan (CCP)	A document that describes the desired future conditions of a refuge or planning unit and provides long-range guidance and management direction to achieve the purposes of the refuge; helps fulfill the mission of the Refuge System; maintains and, where appropriate, restores the ecological integrity of each refuge and the Refuge System; helps achieve the goals of the National Wilderness Preservation System; and meets other mandates (602 FW 1, 603 FW 2, 620 FW 1).
Functional analysis	The process of identifying stakeholders, interviewing users, documenting user information needs and translating those needs into the specific requirements a system needs to meet.
Hydrogeomorphic Analysis (HGM)	A method of assessing ecosystem condition and ecological processes at a site to evaluate departure from historic conditions, identify restoration and management options, and identify ecological attributes needed to restore specific habitats.
Integrated Taxonomic Information System (ITIS)	Easily accessible database with reliable information on species names and their hierarchical classification. The database is reviewed periodically to ensure high quality with valid classifications, revisions, and additions of newly described species. The ITIS includes documented taxonomic information of flora and fauna from both aquatic and terrestrial habitats
Invasive Species	Alien species whose introduction does or is likely to cause economic or environmental harm, or harm to human health. Alien species, or non-indigenous species, are species that are not native to a particular ecosystem. The Refuge System is prohibited by Executive Order, law, and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere (620 FW 1).
Inventory	A survey that documents the presence, relative abundance, status, and/or distribution of abiotic resources, species, habitats, or ecological communities at a particular time (U.S. Fish and Wildlife Service 2009).
Monitoring	A survey repeated through time to determine changes in the status and/or demographics of abiotic resources, wildlife or plants, habitats, or ecological communities. Two major types of monitoring are surveillance monitoring and targeted monitoring; they address different kinds

Term	Definition
	of management objectives (U.S. Fish and Wildlife Service 2009).
Monitoring, surveillance	Monitoring that is not tied to specific predictions of how a resource will respond to management or environmental stressors but rather is designed to document the status or change over time of a station resource. Examples include monitoring climatic parameters, species population trend over time, disease incidence, contaminants, or wilderness character (U.S. Fish and Wildlife Service 2009).
Monitoring, targeted	Monitoring to assess whether a natural resource responds to a specific management action or system stressor in a previously specified manner ('target'). This type of monitoring involves defining the expected response, then surveying to measure the response or a closely related indicator. Comparing monitoring results with target values identified in the management objectives may indicate the need for a further management response. In this policy, it generally means monitoring in an adaptive management context to improve management or evaluate progress towards achievement of management objectives (U.S. Fish and Wildlife Service 2009).
Priority species	Species that are the focus of management and conservation by the NWRS. These may be species identified in laws or policies (trust species) or species identified through the Strategic Habitat Conservation framework (U.S. Fish and Wildlife Service 2006, 2008).
Resilience	The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change (IPCC 2007).
Station or Refuge	Any unit of the National Wildlife Refuge System, including wetland management districts and waterfowl production areas, other than coordination areas.
Strategic Habitat Conservation (SHC)	An approach to habitat conservation focused on providing landscapes capable of sustaining trust species populations at prescribed levels. This approach is founded on a science-based, adaptive, iterative process of biological planning, conservation design, conservation delivery, and monitoring and research (U.S. Fish and Wildlife Service 2006, 2008).
Structured decision making (SDM)	An approach to decomposing and analyzing decisions to identify solutions that achieve the desired objectives, in a manner that is explicit and transparent. Based in decision theory and risk analysis, SDM is a concept that encompasses a very broad set of methods, not a prescription for a rigid approach for problem solving. SDM provides clear roles for stakeholders and scientists when working on problems at the interface of science and policy. Key SDM concepts include making decisions based on clearly articulated fundamental objectives, dealing explicitly with uncertainty, and responding transparently to legal mandates and public preferences or values in decision making; thus, SDM integrates science and policy explicitly.
Survey protocol	A description of the survey method sufficiently detailed to allow someone unfamiliar with the protocol to learn why the survey is being done, what personnel and technical skills are needed to implement the survey, the timing and nature of the data collection procedures, and how the data will be analyzed, reported, and interpreted. Survey protocols assure continuity of quality data collection techniques for both the duration of the survey and

Term	Definition
	between similar surveys on different stations (U.S. Fish and Wildlife Service 2009).
Vulnerability	The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and it adaptive capacity (IPCC 2007).

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APPENDIX A. TASK DESCRIPTIONS

OBJECTIVE: INCREASE RESILIENCE OF PROTECTED AREAS, SUPPORT REFUGE MANAGEMENT AND LANDSCAPE CONSERVATION
TASK 1A: ASSEMBLE EXISTING ABIOTIC DATASETS FOR NWRS LANDS
Rationale & Desired Outcomes
Abiotic baseline data are essential for refuge management and are assembled by refuges during the CCP planning process. Abiotic factors such as soils, hydrology, and geomorphology provide the foundation for ecological processes and ecosystem restoration. The value of assembling abiotic data layers was identified as part of the *Fulfilling the Promises* initiative (WH 8.1 2004). However, some Refuges still lack access to the baseline data identified in the Promises document and there is no central location for storing this information so that it is available to regional or national NWRS managers. Delineating a core set of abiotic data layers for all refuges will help to define how the NWRS responds to existing environmental stressors and future climate change. A central data library that catalogs available abiotic data sets, along with interpretation of how this information can be used by managers, is needed for the entire NWRS. The regions need to identify additional abiotic data sets that are region-specific and cooperate with the national office to catalog this information. We anticipate this task will be completed in 5 years.
Task Description
• The FWS National GIS Coordinator (existing FWS position) will collaborate with the I&M program to determine priority abiotic data sets for the NWRS, determine which are accessible, and identify gaps in key data sets for refuges. • LCCs assist in accessing some of the datasets necessary to fulfill abiotic inventory on Refuges. • National Geospatial Manager hires term positions to access much of the abiotic information from existing data sources (USDA/NRCS, USGS, state agencies, etc.) • National GIS Coordinator will supervise GIS Technicians engaged in developing a data library of abiotic data sets. • The Regional I&M program Coordinators will identify additional abiotic data layers that are region-specific and work with the National GIS Coordinator to assemble and catalog this information.
Contracts And Agreements
• MOA with National GIS Coordinator • Base cartographic data for all refuges • Current aerial photos for all refuges • Soils inventory for Alaska refuges
Products
• A report identifying the status of other priority data sets. • Mechanism for distributing existing data layers: 1) a searchable interactive web location that provides information on existing data layers to refuges; and 2) for remote refuges with slow internet, an option for information to be provided on DVD. • Assess whether missing data could be obtained through short term Contracts and Agreements or assignments and what resources would be needed to obtain fill these gaps.
Staffing
• National Office: Geospatial Manager and FWS National GIS Coordinator • Regional I&M program Coordinators identify priority abiotic data for their regions
Collaboration & Partnerships
• USDA (NRCS) leads soil survey • USGS Gauging station data for stream hydrographs • NOAA National Weather Service for historical climate data • State Geological Survey offices for geomorphology and subsurface hydrology information • Landscape Conservation Cooperatives

OBJECTIVE: INCREASE RESILIENCE OF PROTECTED AREAS, SUPPORT REFUGE MANAGEMENT AND LANDSCAPE CONSERVATION
TASK 1B: CONDUCT HYDROGEOMORPHIC ANALYSES OF REFUGE LANDS
Rationale & Desired Outcomes
Hydrogeomorphic analysis (HGM) is a method of assessing ecosystem condition and ecological processes at a site to evaluate departure from historic conditions, identify restoration and management options, and identify ecological attributes needed to restore specific habitats. HGM provides a science-based approach to understanding the physical and ecological attributes of landscapes and specific areas within them, such as refuges. HGM utilizes historic condition and ecological processes (soils hydrology, topography, geomorphology, vegetation), identifies changes to physical condition and ecological process, and generates restoration options for a given landscape. An HGM analysis helps refuge stations clarify their management objectives and respond to climate change by creating a better understanding of the potential for a refuge to support wildlife and plant communities. Restoration options will need to be informed by climate models; for example, restoration of ecosystem function may be more feasible than restoration of specific plant communities. HGM will use information generated by water inventories and assessments described below, therefore, coordination is needed to maximize the value of both efforts.
Task Description
• Regions identify priority refuges for conducting HGM. • HGM has been implemented on Refuges in Regions 6 and 3, as well as several areas managed by state wildlife agencies. See www.greenbrierwetland.com for examples of completed HGM reports. The Ouray NWR document offers a comprehensive Executive Summary of the products. • National office develops contracts for conducting HGM analysis for priority refuges
Contracts And Agreements
Develop contract to conduct HGM analysis for priority stations (identified by regions) (estimate: ~$70K /station). Contract should include scoping for the most cost-effective method for conducting these assessments in the future.
Products
• HGM Reports for individual refuges or landscapes within a region • Synthesis of abiotic data layers • Identification of how restoration can restore ecosystem function and value, including connectivity on both public and private lands. • Prioritization of restoration options based upon departure from historical ecosystem function and process.
Staffing
• National Office: Hydrologist and Geospatial Manager develop contracts for HGM analyses. • Regional I&M program Coordinators identify priority refuges for their regions
Collaboration & Partnerships
• NWRS regions currently conducting or contracting HGM Analysis (Regions 3 & 6). • Leigh Fredrickson and Mickey Heitmeyer • Rob Jacobson, USGS Columbia Environmental Research Center

OBJECTIVE: INCREASE RESILIENCE OF PROTECTED AREAS, SUPPORT REFUGE MANAGEMENT AND LANDSCAPE CONSERVATION
TASK 1C: DESIGN AND IMPLEMENT A STRATEGIC PLAN FOR COMPILING, ORGANIZING, AND SERVING LEGACY DATA FOR THE PURPOSE OF DOCUMENTING HISTORIC AND CURRENT OCCURRENCES OF SPECIES
Rationale & Desired Outcomes
Floral and faunal inventories are critical for benchmarking extant species assemblages and functional groups before accelerated climate change and non-climate stressors cause extinctions, species redistributions, and novel assemblages. Inventories also set the stage for reasoned and deliberate development of monitoring objectives and a well-designed monitoring program. New data resulting from comprehensive inventories may also redirect current management priorities and assist with assessments of species vulnerability to climate change. The first step in documenting species occurrences is to review the existing data; i.e., legacy data. Legacy data include existing data sets, annual narratives, reports, theses, museum voucher specimens, and species checklists. Most refuge bird checklists are compiled from legacy data. The National Park Service has developed several databases and protocols for inventorying legacy data, including the compilation of legacy data into a *NP Species* database which documents species occurrence for each park (NPS 2009). In a world with rapid climate change, legacy data really only represent historic, not necessarily current species occurrence. However, they can serve as a benchmark against which future changes can be contrasted. As a caution, these data sources often have serious limitations; the value of the information must be weighed against the cost of acquisition and compilation before proceeding.
Task Description
• Consult with NPS about existing database templates and collection procedures. Review existing refuge species checklists. • Compile preliminary metadata by contacting each refuge unit in advance to identify existing data sources including any checklists or other compilation of species records • Contract NatureServe to provide all species occurrence records from the NWS; consider contracting NatureServe to develop an online database that can serve the NWRS. • Search museum collections for vouchered specimens from NWRs. • Develop an overall strategy (inhouse? outsourced?) for extracting species occurrence data from information sources and database development (NPS NP_species database as a model).
Contracts And Agreements
Exact details to be determined but will likely involve NatureServe and regional museums and other sources of archived biological material. (estimate = $500K)
Products
• In the near term, database that itemizes information sources housed at each refuge, in museums or in NatureServe. • In the medium term, begin populating the Refuge Taxonomic Database (developed at Kenai NWR). • In the longer term, GIS products such as maps, geodatabases, and metadata; and summary reports for each refuge.
Staffing
• National Office: I&M program Lead for Biotic Inventories will serve as lead • Regional I&M program Coordinators will facilitate communication with each refuge
Collaboration & Partnerships
NatureServe, National Park Service, regional museums, State Natural Heritage I&M programs, Service Ecological Services (T&E species, rare species) Landscape Conservation Cooperatives

OBJECTIVE: INCREASE RESILIENCE OF PROTECTED AREAS, SUPPORT REFUGE MANAGEMENT AND LANDSCAPE CONSERVATION

TASK 1D: DESIGN AND IMPLEMENT AT LEAST FOUR PILOT STUDIES ACROSS THE NWRS TO CONTRAST APPROACHES FOR INVENTORYING THE OCCURRENCE OF VERTEBRATE, VASCULAR PLANT AND A SUBSET OF INVERTEBRATE SPECIES.

Rationale & Desired Outcomes

The WH8 Baseline Inventory Team and the Service Climate Change Strategic Plan recommend complete inventories of vascular plants, vertebrate, and a subset of invertebrate species on all refuge lands. The inherent value of knowing which species occur on a refuge is predicated on the certainty of that knowledge, the rigor with which data were collected, and the spatial distribution of the sampling efforts. These attributes dictate the potential for using inventory data as baseline values for subsequent plot-based monitoring, for input into spatial modeling at local scales including the development of vegetation and wildlife species distribution maps, for developing statistical models of species-habitat relationships, for ground-truthing remote-sensed data, or as validation data sets for spatially-explicit models. Designs for inventorying biodiversity range from species lists derived from aspatial legacy data (*e.g.,* museum voucher); to geo-referenced but spatially-incomplete data produced by rapid ecological assessments; to multiple taxon-specific surveys which may be on mutually-exclusive sample frames; and, finally, to spatially-comprehensive sample frames that estimate species occupancy. The scientific, fiscal and logistical trade-offs of doing one inventory approach versus another are based, to a very great extent, on considerations about the subsequent monitoring design. Consequently, the collateral benefits of partnering with national programs such as the FIA, NARS, and NRI would be actively explored. The priority in Phase 1 is to focus on designing the pilot studies, garnering input from across the NWRS and key partners. Implementation will not occur until Phase 2.

Task Description

- The WO team will develop the study design in consultation with potential partners such as FIA, NARS, and NRI. Design elements to be considered include pairing rapid ecological assessment and grid-based designs at each study site to assess cost-benefits; selecting refuges which represent the range of climate risk, logistics, spatial scale, and different taxonomic diversity; and investigating the details of the metrics (e.g., carbon, fuel loads) monitored by other agency programs to better understand their relevancy to the NWRS.
- Each refuge pilot study will produce a final report; the WO will develop a final report that makes recommendations for inventorying at the national scale.
- Develop agreements and vouchering protocols with regional museums and other potential repositories for archived material.
- Develop agreements and methods for developing a genetic library to facilitate subsequent monitoring (regardless of inventory design) using DNA barcoding.
- Develop appropriate methods, databases, and products for retrieving, managing, and using inventory data.
- Develop QCA protocols to ensure credible data collection and management from field to lab to databases.
- Develop temporary agreements with our partners at the local level that could serve as templates for interagency MOUs at the WO level. Develop survey protocols for taxa which exist in different parts of the U.S.

Contracts And Agreements

To be determined.

Products

Hire WO and regional staff in FY10. Design study in FY11. Implement in FY12.

Staffing

- It is critical that the WO oversees the design and implementation of these pilot studies to ensure that the outcome of these efforts answer questions about inventorying and monitoring at a national scale. However, actual implementation will be accomplished by temporary field staff supervised by one of the six regional I&M staff, in consultation with staff from the refuges which are selected.
- Hire 3-6 biologists/technicians for each study site. With the exception of very large refuges (>1 million acres), field sampling will likely only take one field season.
- Identify and contract taxonomic experts to process samples. Curation and identification of samples requires more time (1-2 years) than the actual field sampling (1 season).

Collaboration & Partnerships

EPA-NARS, NRCS-NRI,USDA-FIA, Landscape Conservation Cooperatives

Museums, universities, state agencies will provide taxonomic expertise
Statistical assistance with sampling designs and review of proposed protocols and sampling designs.

OBJECTIVE: INCREASE RESILIENCE OF PROTECTED AREAS, SUPPORT REFUGE MANAGEMENT AND LANDSCAPE CONSERVATION

TASK 1E: DEVELOP STANDARDIZED VEGETATIVE COVER MAPS FOR REFUGE LANDSCAPES

Rationale & Desired Outcomes

Vegetation species and communities are unique from refuge to refuge. The inventory of these resources helps refuge managers conserve plant biodiversity, manage challenges such as exotic species, urbanization, insect outbreaks, and diseases, and understand resources and processes such as wildlife-habitat relationships and wildland fires. By establishing baseline vegetative cover maps using the National Vegetation Classification Standard (NVCS), it sets the stage for conducting change detection analyses for monitoring and quantifying shifts in habitat. Comprehensive vegetative cover maps of refuge landscapes and surrounding areas will allow us to determine suitable sites for restorations and acquisitions to facilitate the establishment of extensive protected areas connected by biological corridors. As a baseline, standardized cover maps will help us set biodiversity conservation targets and track changes in extent and composition of communities following short and longer term events such as fire and climate change. These products will provide LCCs an integral dataset used in conservation design. This task is expected to take 10-15 years to complete.

Task Description

- Regions identify priority refuges which require vegetative cover maps in Phase 1.
- The Geospatial Manager will assess existing approaches currently employed throughout the NWRS. Region 2 has been moderately successful in implementing a regional vegetation mapping program, completing 25 percent of their field stations to a floristic level following the National Vegetation Classification Standard (NVCS). Region 2 has transferred some of this capacity to Region 6, supporting a number of vegetation mapping projects in Southern Colorado, Kansas and Nebraska. In 2006, Region 2 developed and published the *NWR Spatial Vegetation Inventory and Monitoring Handbook* (Donnelly, 2006) which documented the remote sensing methods, field protocol, sample design and statistical analysis used in mapping procedures.
- A Remote Sensing Specialist will prepare guidance documentation for conducting and contracting vegetation mapping projects (protocols/specifications/requirements/list of contractors).
- National office provides resources to generate vegetative cover maps for priority refuges.

Contracts And Agreements

To be determined by National office and regions

Products

- Report assessing existing vegetation mapping approaches being employed throughout the NWRS
- Guidance document to assist regions with contracting and conducting vegetation mapping projects
- Detailed vegetation reports for Phase 1 refuges completed
- Digital vegetation maps for Phase 1 refuges completed
- Accuracy assessment data & analysis for Phase 1 refuges completed
- Assessment of Phase 1vegetation mapping projects initiated
- Priority list and cost estimates for Phase 2 vegetative cover mapping projects

Staffing

- National Office: Geospatial Manager and Remote Sensing Specialist (assess current regional approaches, develops vegetation mapping guidance, technical consultant for image acquisitions, assists LCCs on landscape analysis projects)
- Regional I&M program Coordinators identify priority refuges for their regions

Collaboration & Partnerships

- NWRS regions currently conducting or contracting vegetation mapping
- USGS - UMESC (Jennifer Dieck, Branch Chief for the Geospatial Sciences and Technologies Branch 608-781-6382)
- NPS (Karl Brown – NPS Vegetation Inventory Coordinator (970) 225-3591)
- NatureServe
- Landscape Conservation Cooperatives

OBJECTIVE: INCREASE RESILIENCE OF PROTECTED AREAS, SUPPORT REFUGE MANAGEMENT AND LANDSCAPE CONSERVATION

TASK 1F: SUPPORT MONITORING FOR ADAPTIVE MANAGEMENT ON REFUGES

Rationale & Desired Outcomes

Technical support and guidance are needed across the NWRS for implementation of both passive and active adaptive management (AM). Stations have identified priority CCP and HMP objectives, laying the foundation for AM across the Refuge System. The I&M program will support the monitoring component of AM on NWRS units as well as summarize and report how the NWRS and Partners are using AM to help species and ecosystems adapt to the threat of climate change and other stressors. Monitoring under AM requires careful planning, a variety of technical skills, and a strong coordinator to lead the project. All of these resources are currently scarce at both regional and field station levels. I&M program staff at the LCC and field station levels could provide the coordination and technical skills to support both passive and active AM. (See the Adaptive Management Chapter for more details.)

Task Description

- The I&M program will provide technical support and guidance for both passive and active AM. At a minimum, the I&M program should support passive AM. In addition, several large, multi-refuge active AM projects, developed in cooperation with USGS, are ongoing in Regions 3, 5, and 6. The regional/LCC I&M staff could identify 1 FTE to coordinate each of these projects. In addition, the regional/LCC I&M staff need to provide database support for the monitoring component of the AM projects.
- The I&M program will work primarily with refuges, but also in partnership with the LCCs and USGS Climate Change Response Centers on monitoring the outcomes of conservation delivery under Strategic Habitat Conservation. (See Adaptive Management Chapter for more details.)
- Report how the NWRS and Partners are using AM to help species and ecosystems adapt to the threat of climate change and other stressors. Work with the RAPP coordinator to evaluate and revise RAPP to report the outcomes of both passive and active AM projects.
- Work with the National Conservation Training Center to support training in structured decision making, modeling, monitoring, and adaptive management for NWRS staff and Partners.

Contracts And Agreements

- Continue development of databases for passive adaptive management projects. $100K
- Continue development of adaptive management training courses (in cooperation with NCTC) $100K
- Contracting needs will arise once AM projects are through the scoping phase.

Products

- Passive AM information will be documented in a standardized database. The Refuge Habitat Management Database (RHMD), developed by Region 1 may be useful in this regard.
- Structured decision making (SDM) and AM will become standard operating practices for evaluating conservation delivery under SHC, progress towards meeting refuge CCP and HMP objectives, and the success of climate change adaptation strategies.
- Work with others to develop handbooks and guidance for implementing SDM, AM, and monitoring for use by field stations.

Staffing

- National Office: Work with the RAPP coordinator in the Washington Office.
- Regional I&M Coordinators will work with the Regional Refuge Biologists, LMRDs, and the LCCs to identify high priority AM projects in each region/LCC. Selected Coordinators will work with the RAPP coordinator to revise RAPP to report outcomes of AM projects.
- LCC/field I&M staff will provide coordination, monitoring, and database support for specific AM projects.

Collaboration & Partnerships

- Structure Decision Making Community of Practice (coordinated by NCTC)
- USGS (Mike Runge, Clint Moore, Jim Nichols)
- NCTC (Donna Brewer)
- Lincoln Park Zoo (Eric Lonsdorf)
- Migratory Birds (Jim Lyons, Mark Seamans, Tim Jones, Emily Silverman)
- Performance Planning (Noah Kahn)
- Fisheries (Ken Newman)
- Independent contractors: Tony Starfield, Jean Cochrane
- Landscape Conservation Cooperatives

OBJECTIVE: ASSESS VULNERABILITY TO BROAD-SCALE STRESSORS: WATER AVAILABILITY, DROUGHT AND FIRE RISKS

TASK 2A: CONDUCT WATER RESOURCE INVENTORIES AND ASSESSMENTS OF REFUGE LANDS.

Rationale & Desired Outcomes

Climate change will likely alter the timing, availability, and demand for water among competing interests, including the NWRS. Conflicts over water will increase as burgeoning population centers look to tap more surface and groundwater sources, domestic energy development—biofuels, solar, nuclear and hydro-electric—expand, and climate change increases the variability, timing of, and demand for water supply. Refuges depend on the availability and timing of surface and groundwater sources of sufficient quality to meet their management goals, yet the Service does not have a comprehensive inventory of its waters or an assessment of present and future sources, needs and uses. For refuges nationwide, there is a pressing need for water resource inventories and assessments (WRIAs), due to a widespread lack of data about water resource supplies, needs, and quality as they relate to the management of refuges and hatcheries, the recovery of federally-listed species, and the avoidance of listing new species.

Task Description

The initial focus of a water inventory and monitoring program will be to complete a baseline, reconnaissance-level inventory of water resources, including an assessment of water quality, at all refuges. This will take approximately 5 years to complete. We will collect standardized information on refuge water quantity and quality, including physical descriptions of surface water and groundwater features, water rights, infrastructure, and water quality issues. When this fact-based inventory is completed, a hydrologist and water quality specialist will review and provide a professional assessment of the station's water resource issues, current and future threats and needs, and make recommendations for management actions, including recommendations for more detailed assessments where appropriate.

Contracts And Agreements

- The NWRS will contract the Service's IRTM Systems Development Team to develop a draft national standardized relational geospatial database for spatial and non-spatial water rights and resource data ($150K).
- Contractors to collect existing water quality data ($200K/yr); Water assessments – contract with existing programs ($200K/yr)
- Hydro-techs for water resource assessments ($200K/yr); Purchase water monitoring equipment ($150K)

Products

- A database that contains standardized, accessible data on a refuge's water resources.
- For each completed water resource inventory, a professional assessment that details the issues, needs, and threats to the refuge's water resources, as well as recommended management actions.

Staffing

- National Office: NWRS National Water Resource Coordinator (Hydrologist or Water Resources Specialist), Database Administrator, Geospatial Manager, Business Analyst
- Regional/Program Administrative Unit Level Competencies*:
- Hydrologist: provides QA/QC of data, provides professional assessment of water resource inventory data
- Water Quality Specialist: collects existing WQ data and assesses refuge WQ issues and needs
- Database manager: manages regional/geographic area data; responsible for metadata, backups/archiving
- Geospatial Analyst: extracts hydro-related features; imports into geospatial database; provides training, QC of geospatial data, metadata
- Hydro-tech/Field Support Specialist: performs data input/update for inventory phase
- *These do not necessarily represent separate, full-time positions fully dedicated to this effort (e.g., one individual may have multiple competencies/responsibilities). However, more water resources inventories and assessments (WRIAs) will be completed with staff dedicated to the effort. Regions will have flexibility in how to best accomplish the task of completing the WRIAs by leveraging existing resources and competencies with additional I&M program support. Options for filling these competencies may include contracting, term positions, sharing technical positions with other I&M program efforts, sharing positions with other regions/programs.

Collaboration & Partnerships

FWS National Water Resources Team
Local watershed partnerships through the FWS National Fish Habitat Action Plan

OBJECTIVE: ASSESS VULNERABILITY TO BROAD-SCALE STRESSORS: WATER AVAILABILITY, DROUGHT AND FIRE RISKS
TASK 2B: DEVELOP BENCHMARKS FOR ASSESSMENT OF SHIFTS IN FIRE REGIMES.
Rationale & Desired Outcomes
Altered fire regimes pose a serious threat to biodiversity. Their restoration is dependent on understanding the natural ecological range of variability in fire frequency and severity and vegetation composition and structure. However, determining natural ranges of variability in fire regimes and vegetation can be difficult given the lack of reference landscapes to use as benchmarks. A procedure to model reference conditions for all vegetation types across the U.S. is currently being applied via the LANDFIRE (LF) project by the USDA Forest Service, Department of the Interior and The Nature Conservancy. Historic and current benchmark or reference points are needed for the NWRS to calculate future rates and relative departure in fire and other disturbance regime attributes expected under a changing climate. Key fire regime attributes will be recalculated and trends reported for the NWRS at 10-20 year intervals for the NWRS as measured against the historic and 2010 benchmarks. LCC and Refuges will use finer-scale analysis, benchmarking and construct linkages with focal wildlife species-habitat relationships, climate change-sea level rise, and other fuels/fire decision-support tools through I&M program pilot projects. Nearly all key datasets currently exist and are available through LANDFIRE but an automated process customized for NWRS is necessary to develop system-wide benchmarks applicable to the NWRS fire-scapes. Once the initial process is completed and documented, it can be replicated for periodically recalculating trends at long term intervals specified above.
Task Description
• Scope requirements for project using subject matter expert panels. • Determine and secure contracting and/or partnership needs for project. • Create portal/link for easy online access to benchmark data and report for FWS and partners.
Contracts And Agreements
• The LANDFIRE National and the Monitoring Trends in Burn Severity (MTBS) Projects both have existing contracts that could be leveraged to complete much of this work. Climate Center data are available for purchase. ($300K/yr for 2 years) • Contract to take fire and fuel data to species distribution models (need cost estimate) $350K/yr for 2 yrs for 2 pilot projects.
Products
• Report – Approaches for Assessing Fire Regime Shift Under a Changing Climate. • GIS Datasets (NWRS Boundaries w/ fire landscape buffer) • A Pre-European Settlement Fire Regime Landscape Benchmark dataset; • A Current Fire Regime Landscape Benchmark dataset; • A Current Departure from Historic Fire Regime Landscape “differenced” dataset • A Refuge System-wide Large Fire History-Burn Severity Atlas (Current Severity) • A Climate and Fire Weather data file for each LCC (22) and FWS Region (8) • Written Benchmark Assessment Report for NWRS • Easy-access portal for NWRS users and partners to assessment report and supporting, spatial data.
Staffing
• National Office: Geospatial Data Manager, Business Analyst • Regional: Available regional I&M program staff with fire expertise to serve on expert panel for scoping phase
Collaboration & Partnerships
• National Fire I&M program Staff (Explore short-term detail to assist with initial scoping) • Regional Fire I&M program or GIS Staff (Explore short-term detail to assist with initial scoping\GIS data development) • Landscape Conservation Cooperatives

OBJECTIVE: ASSESS WEEDS, PESTS, & PATHOGENS
TASK 3A: DEVELOP PILOT PROJECTS FOCUSED ON MAPPING AND MONITORING INVASIVE PLANTS.
Rationale & Desired Outcomes
Invasive species are one of the most pervasive threats to habitat management in the National Wildlife Refuge System; 78 percent of refuge managers reported invasive plants to be a moderate to large problem. Climate change will exacerbate the already huge threat of invasive species. In general, refuges have not had the resources to strategically plan management actions for invasive species. As a result, efforts are often focused on control of the biggest and densest patches and ignoring smaller patches, which is the opposite of what the NWRS Invasive Species Strategic Plan (2003) suggests. A standardized inventory and monitoring approach is critical to improving our understanding of, confronting, and deterring the invasive species threat. In addition, as invasive species do not respect property boundaries, invasive species require a landscape solution. Successful invasive species management will be based on partnerships. It will be necessary to share inventory and monitoring protocols and databases with sister agencies and non-governmental partners through Landscape Conservation Cooperatives (LCCs) or other collaborative data sharing platforms or venues. Our vision is to address information needs in support of invasive species management through the I&M program, working closely with partners, to provide real-time, science-based inventory and monitoring data and models at multiple spatial and temporal scales that improve our understanding of the spread and distribution of invasive species and help guide management decisions on refuges and adjacent lands. This will require a national conversation with staff throughout the NWRS and with partners to determine long-term objectives. For Phase I, we recommend beginning with a pilot project in two regions that will create a strategic, landscape-scale approach to the monitoring of invasive species across the refuge system including the development of standardized protocols and databases. In this first phase of the I&M program, we also recommend creating at least one early detection network using volunteers or other partners in each region. (See Invasive Species Chapter for more information.)
Task Description
• A team of dedicated people (national invasive species I&M coordinator and invasive species I&M experts in at least two regions) work together to develop pilot invasive species I&M projects, as a template for nation-wide application in the future. • At least two regions will volunteer for the pilot project (suggestion: Regions 4 and 6). We recommend that at least one of the regional/LCC/field positions in each of those regions hosting the pilot projects be invasive species ecologists. • Two invasive species specialists (term appointments) will lead the pilot project. A GIS/data analyst will assist the specialists. • The invasive species I&M team will identify critical climate change and landscape-level inventory and monitoring questions that must be answered in order to resolve invasive species management issues on refuges. • Database will be designed in FY11; Field data will be collected beginning in FY11. • At least one early detection network using volunteers or other partners will be created in each region
Contracts And Agreements
• Two invasive species specialists and one GIS/data analyst (term appointments) will be hired to lead the pilot projects. [$500K/yr] • Six biological technicians will be hired to collect pilot data [with travel and equipment; $150K/yr starting in FY11]. • Trainers and technical support for early detection networks. [$200K/yr]
Products
• White paper describing the pilot I&M program--outlining a strategic, landscape-scale approach to the monitoring of invasive species across the NWRS, including standardized protocols and databases. • Inventories and maps of invasive species on selected refuges and in surrounding landscapes in pilot regions. • At least one new early detection network per region established.
Staffing
• National Office: Invasive species coordinator, with expertise in adaptive management, as lead. • Regional invasive species coordinators work together with national coordinator.
Collaboration & Partnerships
• FWS National Invasive Species Coordinator (Jenny Ericson) • NPS Invasive Species Coordinator (Rita Beard 970-267-2165) • BLM Assessment, Inventory, and Monitoring Project Manager (Craig MacKinnon 202-912-7542) • FWS Region 6 Invasive Species and IPM Coordinator (Lindy Garner) • Landscape Conservation Cooperatives

OBJECTIVE: DETECT BIOME SHIFTS, SPECIES RANGE SHIFTS, CHANGES IN MIGRATION TIMING AND PHENOLOGY

TASK 4A: PRIORITZE GEOGRAPHIC AREAS AND SPECIES BASED ON ECOSYSTEM VULENERABILITY

Rationale & Desired Outcomes

Ecosystem vulnerability to climate change depends on the rate of climatic change and the resilience of the system. Climate change rates and resilience vary spatially at both regional and local scales. In order to minimize species extinctions in a rapidly changing climate, managers will need to facilitate adaptation in vulnerable ecosystems. Many management actions, both reactive (based on historic conditions) and anticipatory (based on future conditions), have been suggested to facilitate adaptation. Deciding whether a reactive, an anticipatory, or a blended adaptation strategy is most appropriate requires an understanding of the ecosystem vulnerability of the geographic area. Geographic areas with rapidly changing climates and low resilience will also be more likely to experience unexpected or surprising changes to current ecological relationships. Therefore, accurately documenting current conditions, early change detection, and using adaptive management to implement adaptation strategies will be critical in these areas. Finally, species with constricted distributions, fragmented distributions, and distributions in highly vulnerable ecosystems will also need to be prioritized for adaptation planning and monitoring. Currently, many refuges do not have access to species distribution maps with a resolution appropriate to identify vulnerable species or document range expansions or contractions. Predictive species distribution models provide a methodology to accurately predict multi-species distributions and to forecast distributions based on future climate scenarios and these products are also useful for prioritizing species and areas for adaption planning.

Task Description

- Compile currently available GIS layers of both current and future conditions for an ecosystem vulnerability assessment.
- Develop an index of ecosystem vulnerability to allow refuges to be ranked and compared in order to identify highly vulnerable geographic areas.
- Develop remotely sensed layers of current biotic and abiotic conditions to be used for change detection and as predictors in species distribution models.
- Develop databases and inventories of known species occurrences to be used in predictive species distribution models. Gaps and inconsistency in spatially referenced species occurrence data across the spatial extent of interest is the largest barrier to producing accurate predictive models of species distributions.
- Identify species with species occurrence information that is adequate to begin developing species distribution models.

Contracts And Agreements

Products

- Completed ecosystem vulnerability assessment of Refuge System lands that can be used to rank categorize refuges for inventory & monitoring development and adaptation planning.
- Web-delivered access to disseminate geospatial data and remote sensing products.
- Web-delivered access to spatially reference occurrence data.
- Distribution maps based on current and future climate conditions for species with currently available occurrence locations that are appropriate for predictive modeling efforts.

Staffing

National Office:

- Technical Team Manager and Ecologist/Manager will oversee data development for Refuge System-wide vulnerability assessment through the Geospatial Manager, Remote Sensing Analyst and Database Administrator.
- Technical Team Manager and National GIS Coordinator will develop database capacity to disseminate geospatial data and species occurrence data.
- Spatial Modeler will develop initial species distribution maps.

Collaboration & Partnerships

USGS, Landscape Conservation Cooperatives , NatureServe, National Park Service, regional museums, State Natural Heritage Programs, Service Ecological Services (T&E species, rare species)

OBJECTIVE: DETECT BIOME SHIFTS, SPECIES RANGE SHIFTS, CHANGES IN MIGRATION TIMING AND PHENOLOGY
TASK 4B: PARTNER WITH THE NATIONAL PHENOLOGY NETWORK.
Rationale & Desired Outcomes
The inventory of current phenology and monitoring temporal changes that result from climate change can serve as critical components of an "early warning system" for threats to both species occurrence and abundance (i.e., species vulnerability). Recent literature indicates that species which show relatively great phenological change are more resilient and therefore less likely to be locally extirpated as climate changes. Phenological data are also critical for understanding some of the underlying proximate mechanisms (e.g., trophic mismatch, parasite-host relationships, growing season) that may be driving species redistributions, population extirpations, and species extinctions in a world with rapid climate change. The USGS launched the USA National Phenology Network (NBN) in March 2009 with the goal of having 100,000 observation locations across the US that are monitored by citizens, universities, agencies, and other organizations. The NWRS needs to develop a portal on the NPN web page and identify taxa that could be monitored in collaboration with the NPN. NWRS leadership will set monitoring priorities.
Task Description
• Charter a team to work with NPN (via workshops and meeting) to identify lists of appropriate taxa for different geographic areas, identify and add species to NPN page/database not already on the NPN lists, identify appropriate intensities of monitoring, and facilitate/coordinate with other interagency phenology monitoring efforts on local to national scales • Develop a landing page or portal for the NWRS on the USA-NPN web page. This landing page would allow NWRS personnel to directly enter phenological data into the NPN, but ensure that these data are retrievable for use by the NWRS. The page would contain a description of the project, use FWS/NWRS friendly logos and images, list the NWRS contact people, list the refuges participating (as individual units or within the LCC or any other organizational unit), describe the levels of participation (sentinal, participating, optional), provide lists of taxa appropriate/recommended for monitoring, 'personalized' instructions (e.g., study design, methodologies, protocols, site registration, training), and provide links to the data entry/download/visualization user interface (with minor customization for NWRS as appropriate).
Contracts And Agreements
The I&M program lead for Biotic Inventories will contract to develop the NWRS portal to the NPN ($25K)
Products
• White paper describing the selection of additional species for tracking on NWRS lands for the NPN. • NWRS portal on the NPN web page.
Staffing
• National Office: I&M program Lead for Biotic Inventories will serve as lead. Work with NWRS leadership to set priorities for monitoring. • Regional Refuge Biologists will work with I&M program Lead to charter a team and develop a white paper.
Collaboration & Partnerships
This task represents a collaboration with the NPN Landscape Conservation Cooperatives

OBJECTIVE: DETECT BIOME SHIFTS, SPECIES RANGE SHIFTS, CHANGES IN MIGRATION TIMING AND PHENOLOGY

TASK 4C: COORDINATE BIRD MONITORING

Rationale & Desired Outcomes

Management of birds and their habitats is a major focus for the NWRS. Bird monitoring on refuges needs to be coordinated across the landscape with other Service Programs (Migratory Birds) and our Partners (USGS, States, NGO's). There are a number of national bird surveys that the Refuge System participates in, including the North American Breeding Bird Survey, Woodcock Singing Ground Counts, four-square-mile surveys, and the Mid-Winter Waterfowl Survey. Therefore, the NWRS should take a leadership role, in partnership with Migratory Birds, regarding coordinated bird monitoring across the nation. A National I&M program Bird Monitoring Coordinator could begin to address continental/national scale coordination of bird monitoring on refuges, especially during the migration period. Coordination of monitoring across regions is important for all stages of bird life cycles, but especially during migration when the timing and availability of habitat for birds is critical. It is also the most difficult life stage for land managers to engage in coordinated monitoring because of the short time frames and very large landscapes involved. One project that is attempting to deal with the complexities of migration monitoring is the Integrated Waterbird Project (http://www.acjv.org/waterbird_project.htm) that involves Regions 3, 4, and 5. This project is an example of Strategic Habitat Conservation (SHC) and adaptive management applied at the scale of two flyways (Atlantic and Mississippi flyways) and several bird taxa (waterfowl, shorebirds, marsh birds), with a focus on providing high quality migration habitat. There may be projects in other regions with similar goals. A NWRS national I&M program bird monitoring coordinator could play an important role in promoting monitoring coordination across flyways and regions, working with Migratory Birds to engage all the regions in addressing migration habitat needs for many different bird taxa, including seabirds.

Task Description

- The national bird monitoring coordinator would work with Migratory Birds, the Joint Ventures, and the Flyway Councils to identify monitoring needs and ensure good communication among regions regarding bird monitoring, especially during the migration period. For example, the coordinator could join the Steering Committee for the Integrated Waterbird Project and contribute to coordination of this and other similar projects, in cooperation with Migratory Birds, USGS, and other Partners. Critical needs associated with such coordination are data management, data analysis and reporting, development of protocols, sampling designs, and open channels of communication among land managers and others engaged in on-the-ground monitoring.
- The coordinator would also address continental/national coordination of other high priority bird monitoring (land birds & marsh birds during the breeding season) and conduct a needs assessment for strategic planning.

Contracts And Agreements

- Trainers and field support for pilot testing Waterbird monitoring protocols in fall 2010, spring 2011, and fall 2011. [$400 K/year for FY10-11]
- Develop centralized database to support the Integrated Waterbird Project. [$500K in FY2011]
- Identify technical support and data management needs for other similar regional, flyway, or continental bird monitoring initiatives.

Products

- Improved habitat management and allocation of resources, in the right places, at the right time for waterbirds using the Atlantic and Mississippi Flyways (Integrated Waterbird Project). Similar products for other initiatives.
- White paper summarizing a national strategy for addressing bird monitoring coordination needs from the perspective of the NWRS.
- White/journal paper reporting the results of the 'proof of concept' provided by the pilot phase of the Integrated Waterbird Project, with recommendations for future management of the Project.

Staffing

- National Office: Bird Monitoring Coordinator
- National Technical Team – scope database development

Collaboration & Partnerships

- Service Migratory Birds Program (James Lyons, Mark Seamans, Jorge Coppen, John Stanton, Katie Koch)
- USGS (Mike Runge, post-doc)
- Lincoln Park Zoo (modeling during pilot phase) (Eric Lonsdorf, Sarah Jacobi)
- States—Association of Fish and Wildlife Agencies (AFWA) (Debra Hahn)
- Joint Ventures – Prairie Pothole, Great Lakes, Atlantic, Lower Mississippi River (Tim Jones, Rex Johnson, Greg Soulliere, others)
- Flyway Councils; Landscape Conservation Cooperatives
- Region 3 Refuges (Pat Heglund, Socheata Lor)

OBJECTIVE: ASSESS THE VULNERABILITY OF THE NWRS TO SEA LEVEL RISE AND CHANGES IN MARINE RESOURCES
TASK 5A: COMPLETE INITIAL MODELING OF SEA LEVEL RISE ON COASTAL REFUGES.
Rationale & Desired Outcomes
Sea level rise is one of the most pressing climate change issues facing coastal National Wildlife Refuges. Sea levels in the next 100 years are estimated to rise 0.18-0.59 meters above current levels (IPCC 2007). The NWRS includes two 1,000-mile long archipelagos, expansive estuarine systems from above the Arctic Circle to remote, coral reefs and tropical lagoons below the Equator. Marine holdings include ~30,000 coastal miles across 30 million coastal acres, with tidally-influenced lands totaling 7 million acres. Coral reefs within the NWRS total almost 3 million acres, in addition to the 89-million acre Papahānaumokuākea Marine National Monument in Hawaii and the recently-designated Marianas Trench Marine National Monument with 60 million acres of submerged lands in the Western Pacific. Understanding the potential impacts of sea level rise to coastal and estuarine habitats is essential to management and long-term planning for the affected refuges, and for the Refuge System as a whole. The Sea Levels Affecting Marshes Model (SLAMM) was developed to help predict the possible effects of various levels of sea rise on coastal marshes and adjacent lowland areas. This model uses NWI data plus information on local topography, accretion and erosion rates, dikes, and development in making these predictions. SLAMM has been run for a few large estuaries including Puget Sound, Chesapeake Bay, and Delaware Bay and for numerous National Wildlife Refuges along the Atlantic, Gulf, and Pacific Coasts. This modeling needs to be completed for all coastal refuges where rising seas could impact coastal and estuarine wetland habitats.
Task Description
• Prioritize coastal NWRs for SLAMM modeling and assess model data needs for these stations. Complete initial modeling where adequate data are available. • Complete National Wetland Inventory mapping for all coastal zones on coastal refuges with the most recent imagery to facilitate SLAMM modeling (~$3.7 million). • Examine the need for more detailed elevation data (LIDAR) at selected coastal refuges.
Contracts And Agreements
The NWRS will contract with Service National Wetlands Inventory Program to begin revising and/or completing NWI maps for coastal zones within coastal refuges.
Products
• Regional I&M program coordinators identify priority refuges or areas of refuges that need NWI mapping in FY11. • Regional I&M program coordinators identify priority refuges or areas of refuges that may need high resolution DEMs.
Staffing
National Office: National GIS Coordinator and Geospatial Manager, lead
Collaboration & Partnerships
National Wildlife Federation, NOAA, EPA, USGS, Service-NWI Landscape Conservation Cooperatives

APPENDIX B. POTENTIAL AGREEMENTS, CONTRACTS AND/OR TEMPORARY STAFFING FOR I&M PROGRAM, PHASE 1.

TYPE	INFORMATION NEED	ESTIMATED COST	PRIORITY (PHASE 1)[a]
Abiotic	Hydrogeomorphic Analyses (HGM)	$70K/station	High
Abiotic	Base cartographic data	TBD	High
Abiotic	Current aerial photos for all refuges & buffers	TBD	Low
Abiotic	Soils mapping for Alaska	TBD	High
Abiotic	MOA with National GIS Coordinator--cartography	TBD	Essential
Abiotic	Contract for additional SLAMM (sea level) modeling	$150K	Essential
Abiotic	Data to support sea level modeling – National Wetlands Inventory and Digital Elevation Data	TBD	High
AM	Develop AM training course	$100K	High
AM	Continue development of databases for passive AM processes	$100K	HIgh
Biotic	Acquisition of species occurrence legacy data, including museums	TBD	Essential
Biotic	Contract for National Phenology Network portal	$25K	High
Birds	Database development for Integrated Waterbird Project (FY2011)	$500K	High
Birds	Integrated Waterbird Project field support techs	$400k/yr	High
Data	Maintain/enhance land bird & marsh bird database application	$50K	High
Data	Streamline capabilities of corporate master table (CMT)	$50K	High
Data	Acquire IT infrastructure and related contracts	$200K	Essential
Fire	Benchmark fire regime (historic and current)	$300K/yr for 2 yrs	Essential
Fire	Translate fire & fuel data to species-habitat & distrib. models	$175K/yr for 2 yrs	High
Invasives	Invasives early detection networks	$200K/yr	High
Invasives	Six biological technicians to collect pilot invasives data	$150K/yr	Essential
Invasives	Support for invasive species pilots	$500k/yr	Essential
Water	Collect existing water quality data--contract	$200K/yr	Essential
Water	Water assess.--contract w/ existing programs	$200K/yr	Essential
Water	Purchase water monitoring equipment	$150K	High
Water	Contract to develop water resource database	$150K	Essential
Water	Hydro-techs for water resource assessments	$200K/yr	Essential

[a]Essential: Deemed of highest priority by the Core Team; needed to implement one of the tasks identified in the *Operational Blueprint*. High: Deemed of high priority by the Core Team; associated with one or more tasks identified in the *Operational Blueprint*. Low: Deemed of lesser immediate importance than the other items by the Core Team.