Recommendations to Implement a Biological Data Management System For National Wildlife Refuges

Prepared by:

Fulfilling the Promise
Inventory and Monitoring Database Team
WH 9.1

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Cover illustration courtesy of Dale Crawford, U.S. Geological Survey, Fort Collins Science Center

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Fulfilling the Promise
Inventory and Monitoring Database Team

Charter

Purpose To evaluate existing national and regional databases and recommend appropriate data storage approaches for the National Wildlife Refuge System.

Team is empowered to To evaluate existing regional and national databases for applicability in storing most frequently gathered inventory and monitoring data for species and habitats on units of the National Wildlife Refuge System and to recommend approaches to standardizing the way inventory and monitoring data are archived.

Participants The Team consists of representatives of each Region and the Washington Office, Division of Refuges.

Process Assemble a list of existing database systems for common species and habitats occurring on refuges.

Evaluate databases to see which are appropriate for most common types of data.

Develop or adopt protocols for archiving data in appropriate databases.

Products and Services The team will develop a recommendation for review by the Promises Team and present a progress report at the refuge biologists' meeting in May 2000.

Reporting Relationships The team reports to the Promises Team, chaired by the Chief, National Wildlife Refuge System.

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Chief, National Wildlife Refuge System Date

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Executive Summary

The National Wildlife Refuge System Improvement Act (NWRSIA) mandates that refuges *"...monitor the status and trends of fish, wildlife, and plants on each refuge."* The purpose of these monitoring activities is to evaluate whether or not wildlife and habitat objectives are being met through wildlife and habitat management actions on refuges. The appropriate and timely use of refuge data on management actions, abiotic and biotic surveys, and biological inventories is critical to science-based management. This initiative arose from the *Fulfilling the Promise* recommendation WH.9 to "Design or use existing database systems to store, analyze, and archive inventory and monitoring data to evaluate management practices on individual refuges, as well as link with System, flyway and ecosystem databases."

Biotic and abiotic inventory and monitoring activities are conducted by refuge staff, contractors, and/or volunteers on refuges throughout the National Wildlife Refuge System (NWRS). A questionnaire (Appendix A) developed and distributed to all refuges requested information on current wildlife and habitat monitoring procedures and how the data are collected, stored, and managed. The results (Appendix B) indicate that some refuges collect and archive monitoring data in file drawers without any analyses or interpretation of results. In contrast, most refuges (70%) store some information in refuge-specific databases, but there is no post-collection data processing. Less than one-third (30%) of the refuges use database software to analyze and interpret results for assessing whether or not management actions meet refuge wildlife and habitat objectives. Consequently, there is limited application and utilization of these data relative to wildlife and habitat management decisions on refuges.

Individual refuges are creating their own computer databases and applications to store biological inventory and monitoring data. These independent systems have resulted in duplication of effort as well as an inability to exchange and summarize data among refuges. As described in *Fulfilling the Promise*, the NWRS is supposed to be a national and international leader in habitat management and a center for excellence, where science and technology are used for wildlife conservation. Without an effective data management system for biological inventory and monitoring data, it is not possible to effectively implement the science-based, adaptive management and 'wildlife first' principles specified in the NWRSIA.

A national data management system will facilitate efficient data analyses for making and defending refuge wildlife and habitat management decisions and enable the NWRS to manage its biological inventory and monitoring data more effectively. At the same time, individual refuges will be able to efficiently use their data to support adaptive management decisions. Regional analysis may be conducted to determine the contribution of the NWRS within the larger landscape and alter priorities to meet the dynamic needs of trust resources.

The WH9.1 Inventory and Monitoring Database Team (Team) was chartered to evaluate existing national and regional databases and recommend data storage approaches for the NWRS. To effectively accomplish its stated mission, the Team determined that a variety of important information would be needed from refuges. A 3-page questionnaire (Appendix A) was developed

and distributed to all refuges, requesting information on current wildlife and habitat monitoring procedures and how the data are collected, stored and managed.

The questionnaire was completed by 219 refuges. Results (Appendix B) indicate that refuges conduct over 1,977 distinct biological surveys, using more than 186 different procedures. Because no single data management system can meet all the data storage needs of refuges, the recommendations in this report focus on a strategy to manage biological inventory and monitoring data that will facilitate science-based management on refuges. Results also indicate that biological data management is needed within the NWRS. The lack of a national system is attributed to the fact that there is no formal 'process' within the NWRS to address current or future biological data management needs.

Numerous refuges are collecting similar data and using the same data collection protocols. Examples of these protocols include Robel pole readings in grasslands, shorebird numbers using International Shorebird Survey protocols, and breeding landbird point count data. Each refuge may be collecting this data using a different sample design to answer a variety of refuge-specific questions. Using different sample designs to collect the data results in a refuge-specific monitoring program rather than a larger-scale monitoring program. To improve NWRS efficiency, the WH9.1 Team is proposing the design and development of individual data management modules (applications) for specific data collection protocols used by a large number of refuges. The Team recognizes that some refuges collect data that is very unique; in these instances, it is the responsibility of the refuge staffs to manage and maintain the data in an appropriate manner.

The difference between a NWRS inventory and monitoring program and the provision of biological database tools to meet existing refuge data management needs is of considerable importance. A national inventory and monitoring program involves specific questions that need to be answered for the refuge system as a whole, including consistent sample design, data collection protocols, and data management applications for efficient data use and storage.

Presently, the NWRS does not administer a national inventory and monitoring program. Implementing recommendations in this report will result in a biological data management framework by which the NWRS may efficiently develop a large-scale inventory and monitoring program in the future. More importantly, it will meet short-term data management needs by providing a framework for refuges that do not currently have sufficient staff expertise to fully utilize and manage their biological data.

The Team recognized that if specific recommendations were made to use existing applications for certain biological data, the benefits would be short-lived. Implementing one-time or relatively inexpensive recommendations will not materially improve the situation. On the contrary, organizational and system changes are necessary to show a lasting benefit. As a result, the Team focused its efforts on recommending a 'process' by which biological data management can be improved and 'institutionalized' to address both current and future needs.

This report describes ten recommendations and associated implementation tasks that will help the Service develop a national data management system to store and manage biological inventory and monitoring data to accomplish NWRS mission and unit-specific wildlife and habitat objectives. The Team's specific recommendations are the following:

1. Establish positions within the NWRS to develop, maintain, coordinate, and administer a NWRS biological data management system.

2. Design and develop a national biological data management system to store inventory and monitoring data collected by the Service, especially on refuges.

3. Develop a process to integrate refuge-specific monitoring activities into the biological inventory and monitoring data management system.

4. Develop a process to evaluate existing biological and abiotic data management applications that may be utilized as is, or adapted to meet refuge needs.

5. Adhere to existing Service policy and guidance on information and data management resources (i.e., computer hardware and software, data architecture, browsers, standards, and applications development) that are relevant to NWRS inventory and monitoring activities. Establish a formal process for developing standards, procedures, protocols, and applications that support NWRS inventory and monitoring activities.

6. Develop a uniform set of NWRS guidelines to systematically collect, store, and manage inventory and monitoring data on refuges.

7. Identify the commercial off-the shelf (COTS) desktop software tools to be used for storing, analyzing, summarizing, and presenting biological inventory and monitoring data. These desktop software tools will be made available to every refuge, associated field station, and regional NWRS office for use in managing biological data downloaded from the national database or collected in refuge-specific databases.

8. Adopt standard taxonomic nomenclature and codes to represent species of plants, fish, invertebrates, and wildlife.

9. Establish a process to catalog, document, and store existing and historical biological data and information resources.

10. Develop the NWRS administrative structure to utilize biological data from other agencies and organizations to improve refuge wildlife and habitat management decisions.

Introduction

The NWRSIA mandates that refuges *"...monitor the status and trends of fish, wildlife, and plants on each refuge."* The purpose of inventory and monitoring activities on refuges is to evaluate whether or not wildlife and habitat objectives are being met through management actions. The appropriate and timely use of refuge data on management actions, abiotic and biotic surveys, and biological inventories is critical to science-based management. In accordance with the *Fish and Wildlife Service Manual* (701 FW 2.8), biological inventory and monitoring data should be stored and managed in a computer database to facilitate its effective analyses and use with regard to wildlife and habitat management decisions on refuges; however, the current policy does not provide detailed specifications regarding database structure. Moreover, there is a general consensus within the Service that scientific data must be used effectively to provide justification and support for sound land and resource management decisions.

Biotic and abiotic monitoring activities are conducted by refuge staff, contractors, and/or volunteers on refuges throughout the NWRS. A questionnaire (Appendix A) was distributed throughout the NWRS to obtain information on current wildlife and habitat monitoring procedures and how the data are collected, stored, and managed. Information on the management and storage of data for 1977 monitoring activities was reported on questionnaires received from 219 refuges throughout the NWRS. While questionnaire results (Appendix B) indicate that some of these refuges collect monitoring data at great expense and archive it in file drawers without any analyses or interpretation of results, most refuges (70%) store some information in refuge-specific databases. In either case, there is no post-collection data processing. Less than one-third (30%) of the responding refuges use database software to analyze and interpret results for assessing whether or not management actions meet refuge wildlife and habitat objectives. Apparently, there is limited application and utilization of these data relative to wildlife and habitat management decisions on refuges. If a data management system was available to store biological data, it is likely that more refuges would electronically store and subsequently analyze data relative to wildlife and habitat objectives.

Individual refuges are creating their own computer databases and applications to store biological inventory and monitoring data. These independent systems result in duplication of effort, as well as an inability to exchange and summarize data among refuges, other Service divisions, and non-Service partners (e.g., state/federal agencies and private conservation organizations). The refuge data stored in these independent systems and databases frequently become outdated and are not converted to new file formats and media types (e.g., 9-track tapes and 5.25-inch diskettes are now outmoded). In addition, data are lost, misplaced, or forgotten when refuge staff transfer and new employees are not aware of the databases created for specific monitoring purposes. As described in *Fulfilling the Promise*, the Service is supposed to be a national and international leader in habitat management and a center for excellence, where science and technology are used for wildlife conservation. Without a national data management system to store the biological inventory and monitoring data collected by refuges, it is not possible to effectively implement the adaptive management and 'wildlife first' principles specified in the NWRSIA.

A national data management system will enable the NWRS to manage its inventory and monitoring data more effectively and, in turn, facilitate efficient data analyses for making and defending refuge wildlife and habitat management decisions. Regional analysis may be conducted to determine the contribution of the NWRS within the larger landscape and alter priorities to meet the dynamic needs of trust resources. Developing a central data repository will facilitate the data analyses needed to support important resource management decisions. A national, Web-based system will provide the mechanism needed to develop NWRS management objectives and plans for biological resources; improve wildlife resource management at local (refuge), regional, and national scales; defend the Service's management decisions to the public; and respond to inquiries from individuals, private organizations, or court litigation.

The Team recognizes that Internet connectivity and access to Web-based applications are important issues. Some refuges are still unable to access the Internet, and several others have minimal capabilities that prevent or severely limit any practical use of Web-based applications. Despite these obstacles, there are justifiable reasons for developing a Web-based system: secure access to the same data sets for all refuge staff; centralized data administration; data (and metadata) storage and maintenance; technical support for hardware and software; user-friendly functionality and features; and availability of training and help documentation. In addition, the Department of Interior (DOI) and Office of Management and Budget (OMB) have strict guidelines and security requirements for national systems. The Team also recommends and supports the use of desktop software tools for performing local analysis, and possibly for data entry tasks, but only if they are compatible with the national system and associated standards. Tools for uploading and downloading data will facilitate both local analysis and maintenance of current and available national data sets.

This report identifies recommendations and associated implementation tasks that will help the Service develop a national data management system to store and manage biological inventory and monitoring data to accomplish refuge-specific objectives and the NWRS mission.

Team Approach and Findings

This Team was chartered to evaluate existing national and regional databases and recommend data storage approaches for the NWRS. To effectively accomplish its stated mission, the Team determined that a variety of important information would be needed from refuges. A 3-page questionnaire (Appendix A) was developed and distributed to all refuges, requesting information on current wildlife and habitat monitoring procedures and how the data are collected, stored and managed.

The questionnaire was completed by 219 refuges. Results (Appendix B) indicate that refuges conduct over 1,977 distinct biological surveys, using more than 186 different procedures. Because no single data management system can meet all these refuge needs, the recommendations in this report focus on a strategy to manage biological inventory and monitoring data that will facilitate science-based management on refuges. Results also indicate that biological data management is needed within the NWRS. The lack of a national system is

attributed to the fact that there is no formal 'process' within the NWRS to address current or future biological data management needs.

The Team recognized that if specific recommendations were made to use existing applications for certain biological data, the benefits would be short-lived. Implementing one-time or relatively inexpensive recommendations will not materially improve the situation. In the long term, organizational and system changes are necessary to show a lasting benefit to the NWRS. As a result, the Team focused its efforts on recommending a 'process' by which biological data management can be improved and 'institutionalized' to address both current and future needs, and previously collected data will not be lost when software is upgraded.

Team members assessed 14 data management systems (Appendix C) for use or modification by the NWRS. The majority of these applications were designed and developed for specific wildlife or plant inventories and monitoring activities. Because they were not developed to meet the wide variety of data management needs across refuges, it became apparent that a process is needed to guide future evaluations of existing database applications, as well as new development efforts for specific NWRS applications. Towards this end, the Team identified a set of basic principles that should be used as the foundation for developing a biological data management system:

1. The system should be designed to support science-based wildlife and habitat management decisions at the refuge, ecosystem, regional, or national level.

2. The system should be modular in design to incorporate new monitoring activities.

3. The system should be readily accessible and user friendly, with appropriate levels of information access for various audiences.

4. The system should permit the efficient and local entry of biological inventory and monitoring data by refuge personnel, and the storage and retrieval of these data into a central repository. All data should be available via Internet technology.

5. The system should be dynamic, in order to keep pace with changing technological developments, new biological procedures, and upgrades to computer hardware and application software.

6. The system should be developed using an effective database design that is based on sound software engineering principles.

7. For purposes of efficiency, the computer software needed to manipulate biological data from the system to meet specific program objectives and reporting requirements for inventory and monitoring activities should be readily available to all refuges and NWRS offices.

8. Data should be properly stored, documented, and archived to protect against loss.

9. The NWRS should implement and adhere to a common set of data standards to assure data consistency, improved data quality, and a common data structure for exchanging information and making sound management decisions on a local, regional, or national scale.

10. Species codes and nomenclature should be standardized in all NWRS biological databases, regardless of database origin.

11. The system will facilitate the storage of unit-specific data to meet wildlife and habitat objectives at the refuge level. In these instances, relevant policies, procedures, and standards on species codes, biological data elements, and database structure will be strictly adhered to throughout the design and development process.

12. A process should be developed to convey current DOI, Service, and NWRS policies and procedures on biological data management to new staff.

13. To properly develop a NWRS biological database application, coordination must occur among numerous groups within the refuge program to ensure that all biological data needs are met. Presently, it must be a priority to coordinate with other *Fulfilling the Promise* Teams, specifically WH123 Wildlife/Habitat Objectives, WH7 Invasive Species, and WH8 Baseline Inventory/Monitoring, and WH10 Habitat Monitoring. During the planning stages for the various elements of a national data management system, there must be involvement by refuge staff, Regional Refuge Biologists, regional planners, and other Service program staffs (e.g., Migratory Birds) who have a need to use the data for making decisions.

Recommendations

Recommendation 1 Establish positions within the NWRS to develop, maintain, coordinate, and administer a NWRS biological data management system.

The inability of the NWRS to adequately address biological data management stems from the fact that there is no organizational entity that is responsible for this activity. The NWRS has a structure in place to administer national maintenance, operations, and budget systems, such as the Refuge Management Information System. This type of structure is also required for biological data, which are not only critical to the NWRS mission, but far more complex and numerous than the data contained in all NWRS administrative data sets. Without a formal structure and process for managing biological data, the potential benefits of any recommendations made by this Team will be short-lived. For this reason, a National Biological Data Management (NBDM) Team should be established with a minimum staffing level of one full-time Biological Data Manager in the Washington Office (WO), and one full-time Regional Office (RO) Biological Data Manager in each of the seven Regions of the Service.

Tasks:

1. Create permanent, federal positions for one full-time WO Biological Data Manager and one full-time RO Biological Data Manager in each of the seven Regions of the Service. Collectively, these eight positions will comprise the NBDM Team.

    A. Develop position descriptions for the WO and RO Biological Data Managers, as well as explicit and concise summaries of the knowledge, skills, and abilities required for the positions. Use the same position description to describe the major duties and responsibilities of the seven RO Biological Data Managers.

    B. Advertise the eight positions simultaneously, and hire the WO and RO Biological Data Managers. Place these positions within the NWRS organization, where they will be the most effective and accessible to refuge staff (i.e., place the RO positions in the Division of Natural Resources). Regardless of where these positions are located within the program, the WO and RO Biological Data Managers will need to closely coordinate with the Office of Information Technology and Management (OIM) and all other divisions and branches of the NWRS.

    C. Empower the WO and RO Biological Data Managers with the authority to implement and administer the recommendations in this report.

2. Delegate the overall administration of NWRS biological databases developed for inventory and monitoring activities to the WO and RO Biological Data Managers. This includes implementing the recommendations in this report; keeping abreast of new developments in data management and geographic information systems (GIS); providing training in database design and management; seeking out and reviewing the needs for

national level or regional level applications; determining where the system and database should be located and managed; and refereeing issues arising from requests for data from outside the Service. The WO and RO Biological Data Managers will perform the duties identified below:

A. Administer and facilitate compliance with existing policies, standards, procedures, and protocols that support NWRS inventory and monitoring activities, including DOI and Service policies and standards.

B. Participate in refuge wildlife and habitat management reviews, as well as reviews of data management practices identified in Comprehensive Conservation Plans and associated step-down plans (e.g., Habitat Management Plans).

C. Identify the extent of need for biological data management applications that accommodate specific types of refuge data (e.g., an application module for managing data collected on piping plover nesting success). At present, the questionnaire results in Appendix B serve this purpose, but refuge needs will continue to change over time.

D. If a high priority need for a biological data management application exists at numerous refuges, the NBDM Team will have the authority to recommend the formation of a User Acceptance Team of experts (i.e., subject matter specialists with technical expertise) who will determine if a new module is required, or if an existing application can be modified to meet the needs of refuges and ensure data compatibility with the national system. For example, a special User Acceptance Team is convened to determine if the Pacific Seabird Database should be used by all refuges that collect these data.

E. Develop and maintain a Web-based catalog of computer applications and databases that are 'required use' by refuges when collecting and manipulating biological data to meet inventory and monitoring objectives. Coordinate with the Division of Information Technology Management (ITM) to reference and link this site to the Service's "Catalog of Automated Information Systems (CAIS)" at http://sii.fws.gov/r9data/systems/cais.htm.

F. Summarize refuge data at landscape scales (i.e., ecosystem, regional, national) for use in making sound management decisions and setting resource priorities.

G. Review refuge compliance to policy, standards, and procedures contained in Part 701, Population Management at Fields Stations (specifically 701 FW 2, Inventory and Monitoring of Populations, and associated references and exhibits). Update *Fish and Wildlife Service Manual* chapters whenever policy, standards, and procedures are revised or developed for inventory and monitoring activities.

H. Ensure that the planning, budgeting, staffing, acquisition, development, implementation, and maintenance of NWRS inventory and monitoring systems are in compliance with OMB Circular A-11, Section 300, Planning, Budgeting, Acquisition and Management of Capital Assets; OMB Circular A-130, Management of Federal Information Resources; and applicable chapters in the *Fish and Wildlife Service Manual*, Part 270, ITM Program Management.

I. In accordance with *Fish and Wildlife Service Manual*, 282 FW 4, Electronic Records, develop a national plan for the permanent storage, maintenance, and archival of all biological data contained in the national system and other computer applications and databases used to support NWRS inventory and monitoring activities.

J. Serve as the primary point of contact for refuges on all biological data issues and requests pertaining to the development of data and systems, as well as the sharing and exchange of data and information with other Government agencies, private organizations, universities, and the general public.

Recommendation 2 Design and develop a national biological data management system to store inventory and monitoring data collected by the Service, especially on refuges.

The Team recommends the design and development of a customized, Web-based data management system for the NWRS that utilizes existing applications that can be modified to meet refuge needs. With this objective in mind, the Team assessed a variety of automated computer applications (Appendix C) being used within the Service and other federal bureaus to determine their overall utility for storing biological inventory and monitoring data collected by individual refuges. The Team found that Service applications were developed independently for a specific program (e.g., monitoring shorebirds or waterfowl, accessing threatened and endangered species information) and usually for a specific geographic area. As a result, these systems are not immediately suitable for storing and managing the wide variety of biological data collected throughout the NWRS. The computer applications developed by the National Park Service (NPS) and U.S. Geological Survey (USGS) have much to offer but require modification to meet the needs of the NWRS and other Service programs. The other applications evaluated by the Team are either not supported or lack sufficient capabilities to meet the needs of refuges.

While some of these existing applications have high potential for use by the NWRS, particularly the USGS LandBird Point Count Database and the NPSpecies Database, the Team recommends that a functional requirements analysis be conducted for each inventory or major monitoring activity (i.e., landbird counts, waterfowl surveys, shorebird surveys, large mammals survey, etc.) conducted on refuges. This analysis will identify the specific requirements for each activity that need to be met by a new or existing application. A more detailed explanation of the analysis process is provided in Recommendation 4.

Numerous refuges are collecting similar data and using the same data collection protocols. Examples of these protocols include Robel pole readings in grasslands, shorebird numbers using International Shorebird Survey protocols, and breeding landbird point count data. Each refuge may be collecting this data using a different sample design to answer a variety of refuge-specific questions. Using different sample designs to collect the data results in a refuge-specific monitoring program rather than a larger-scale monitoring program. To improve NWRS efficiency, the WH9.1 Team is proposing the design and development of individual data management modules (applications) for specific data collection protocols used by a large number of refuges. The Team recognizes that some refuges collect data that is very unique; in these instances, it is the responsibility of the refuge staffs to manage and maintain the data in an appropriate manner.

The difference between a NWRS inventory and monitoring program and the provision of biological database tools to meet existing refuge data management needs is of considerable importance. A national inventory and monitoring program involves specific questions that need to be answered for the refuge system as a whole, including consistent sample design, data collection protocols, and data management applications for efficient data use and storage.

Presently, the NWRS does not administer a national inventory and monitoring program. Implementing recommendations in this report will result in a biological data management framework by which the NWRS may efficiently develop a large-scale inventory and monitoring program in the future. More importantly, it will meet short-term data management needs by providing a framework for refuges that do not have sufficient staff expertise to fully utilize and manage their biological data.

The proposed data management system should satisfy the most common needs of the NWRS and allow for expansion to meet additional and future biological inventory and monitoring data management needs. Therefore, the Team has proposed the development of a modular system, where each module (application) represents an inventory or major monitoring activity. The strategy is to develop one module at a time and integrate the monitoring data with management actions by linking each module to the refuge management components. The development process will follow Service and ITM policy and guidelines for automated systems development and include a functional requirements analysis for each module and associated refuge management components.

The primary purpose of the proposed data management system is to facilitate adaptive management of refuge lands. In addition to inventory and monitoring data for wildlife species and habitat, the system should include detailed information on wildlife and habitat management actions. The system should allow refuge staff to evaluate wildlife, habitat, and environmental responses to management actions or other factors so adaptive management strategies may be used to achieve refuge wildlife and habitat management objectives that are tied to refuge purposes.

The biological inventory and monitoring programs across the NWRS poses a challenge to develop a national data management system. As shown by responses to the Team's questionnaire, refuges currently use many different monitoring protocols for a wide variety of habitats and wildlife species. Nevertheless, some monitoring activities (e.g., mid-winter or monthly waterfowl counts) are conducted on a large number of refuges using standardized protocols. The national system should begin with the most common wildlife, habitat, and environmental monitoring activities conducted on refuges to evaluate wildlife and habitat objectives. To allow for adaptive management, the data management system should provide the ability to relate wildlife and/or habitat management actions conducted on specific land units and the associated wildlife, habitat, and environmental responses to these actions. Therefore, the data management system should be designed to incorporate the following three inter-related modules:

1. Unit Characteristics. Land management activities (e.g., water level management, riparian restoration, crop lands, and prescribed burns) conducted to meet wildlife and habitat objectives occur on distinct management units within refuges. The data management system will store updated information about management units (e.g., Canvasback wetland) on a refuge that can be georeferenced in a GIS to facilitate spatial analyses of biological inventory and monitoring data. A *Fulfilling the Promise* GIS Coordination Team is currently assessing GIS data acquisition, data delivery, and data management issues for refuges.

Refuge management actions often require combining or splitting management units to accomplish certain objectives or test various manipulations. GIS technology can be used to manipulate the management unit boundaries. There are also situations where treatment of habitat (e.g., prescribed burn, pesticide application), surveys (distribution of invasive species), or other management activities are not linked to specific management unit boundaries. The survey may be completed for an entire refuge (e.g., distribution of vernal ponds). Under these circumstances, a consistent naming convention may be used (i.e., unique names used in a Management Unit field), but dynamic spatial boundaries are delineated in a GIS.

Because adaptive management requires refuge staffs to assess changes over time, date information associated with management unit changes also will be required. Additional information within this module should include acreage, habitat type(s), and geographic coordinates (e.g., GIS shape files). All this information will need to be considered when developing data standards for information pertaining to a management unit.

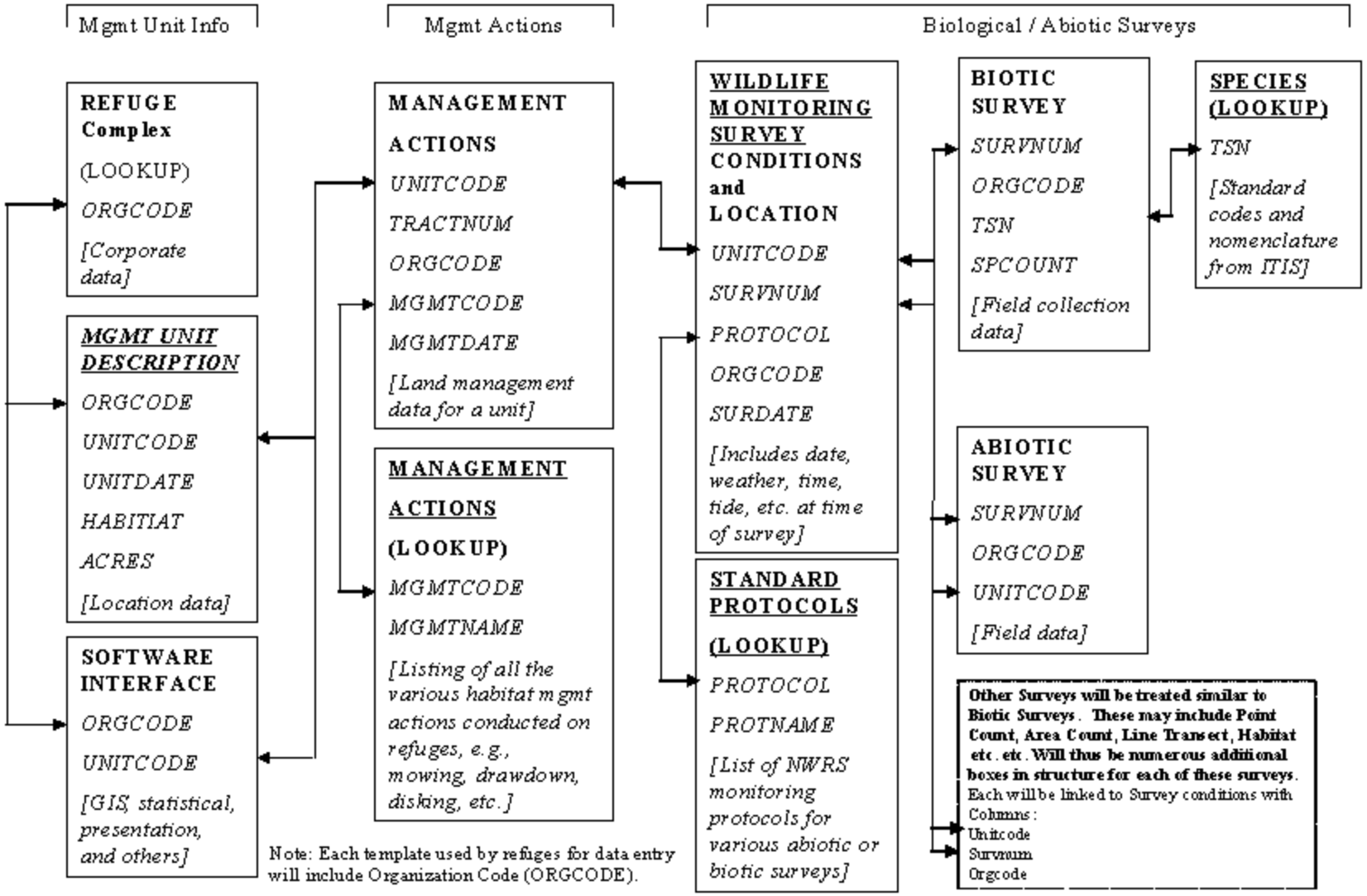
2. Management Actions. This module will be comprised of submodules that store detailed information about management actions (prescriptions) conducted on each management unit on a refuge. If needed, the level of detail captured within these submodules will be adequate to replicate the management action(s) in the future. The date of each management action will also be captured so that multiple management actions can be identified for any unit during the same year and, in turn, related to wildlife and habitat responses to assess progress toward achieving refuge objectives.

3. Inventory and Monitoring. This module will be comprised of submodules that store biological data (e.g., numbers of wildlife observed) along with the date, environmental conditions at the time of data collection, and all other parameters required for specific inventory and monitoring protocols.

Figure 1 illustrates the relationships among these three proposed modules of the biological data management system. The data elements identified in the illustration are described in Appendix D. Ultimately, there will be separate submodules for the wide variety of inventory and monitoring data collected on refuges, including wildlife (e.g., landbird point counts), habitat (e.g., vegetation transects), and environmental (e.g., water levels and quality) surveys; wildlife and habitat management actions; and refuge unit characteristics.

When addressing refuge-specific questions, the biological monitoring data needs to be related to refuge management units and management actions. In this case, the biological data module (e.g., landbirds) must contain one or more key fields to establish a relationship to the refuge management module. If the key fields are properly constructed, the data can be analyzed to assess whether or not wildlife and habitat objectives are achieved through management actions on

Figure 1. Table Relationships of the Biological Data Management System.



refuges. Although the data management system directly facilitates these assessments through storage and data export functions, it does not perform the data analyses.

Because there are numerous refuge-specific inventory and monitoring activities that cannot be standardized for the NWRS, the data management system will allow for integration monitoring methods at the refuge level. It will also permit modification of existing standardized protocols (e.g., landbird point count) to address refuge-specific needs.

Proper design of the national biological data management system is critical to its success. A well-designed structure will allow refuges to efficiently store data, evaluate habitat, wildlife, and environmental responses to a variety of variables, and easily exchange data among refuges and other organizations. It will also enable the system to be dynamic in order to meet current and future refuge-specific needs.

The development of a Web-based data management system for biological inventory and monitoring data represents a significant undertaking for the Service. Nevertheless, policies for planning and managing a national system of this magnitude are well defined in *Fish and Wildlife Service Manual*, Part 270, ITM Program Management. Adherence to Service policies and requirements will assure a well-structured design that accounts for program needs and business processes. It will also ensure that the biological inventory and monitoring data collected by refuges is stored in formats that allow not only its full use during the present, but the ability to make future changes and additions to the data structure that ensures its compatibility with future technology.

Implementation of a Web-based data management system for the NWRS will require a clear vision, well-defined goals, and strategic guidelines. Strong management commitment will be necessary, as well as the active involvement and understanding of field staff. A team comprised of representatives from all Regions and the WO will provide the leadership and focus for this effort.

Tasks:

1. Establish and implement a national biological inventory and monitoring program for the NWRS.

2. Authorize the NBDM Team (Recommendation 1) to create a Charter for the national data management system and maintain the information necessary to coordinate with the Regions and establish priorities, including:

    A. A list of the high priority monitoring activities and associated database needs identified by refuges (Appendix B).

    B. Current monitoring protocols and biological databases, including descriptions of how the data are used to facilitate adaptive management on refuges.

C. Data standards for variables collected for the high priority monitoring activities on refuges.

D. Any other data issues that are important factors in the design and implementation of a national biological inventory and monitoring program.

2. The NBDM Team will create User Acceptance Teams composed of Service biologists who collect and use the data; non-Service biologists (e.g., university and USGS scientists) with recognized expertise in specific inventory and monitoring activities, WO and RO staff who will utilize the data for reporting purposes and system-wide analysis; and information technology (IT) specialists with expertise in the design, development, and administration of Web-based applications for data entry, storage, retrieval, and analysis.

The User Acceptance Teams will perform the following steps to develop submodules for storing the high priority inventory and monitoring data collected on refuges:

A. Identify a standardized protocol that represents the core data collection methodology for an inventory or monitoring activity that will be consistent for refuges throughout the NWRS or Region(s). The standardized protocol represents data entry fields from the protocol within an Inventory and Monitoring submodule of the data management system. Data entry fields will be based on the biological data elements collected for recording management actions on units of refuges, as well as the habitat, wildlife, and environmental responses within those same units.

B. Based upon the data entry fields, develop data dictionaries that describe the biological data elements to be entered, stored, queried, and downloaded from the initial modules.

C. Develop specifications to ensure that the application modules can be used by refuge personnel to enter and store biological data collected within specific areas of a refuge for high priority monitoring activities (e.g., waterfowl counts, shorebird counts). These modules must also have the capability to easily and efficiently import biological data that is created in refuge-specific applications and databases.

D. Contact the Division of ITM for up-to-date information on Service policies, procedures, and approvals for planning and managing information system projects. Ensure compliance with all DOI and Service policies and requirements pertaining to the design and development of information systems, as described in *Fish and Wildlife Service Manual* 270 FW 1, Service Information and Technology Architecture (Appendix E.1), and 270 FW 2, Automated Information Systems Capital Planning and Management (Appendix E.2).

E. When all IT requirements and approvals for developing and funding the initial system are fully met, contact the Division of Contracting and Facilities Management (CFM) to determine the best method available for procuring the

technical support services required to design the overall structure of the data management system and develop the initial application modules.

F. Based on the guidance provided by the Division of CFM, prepare a Scope of Work (SOW) that can be used to procure the technical support services required to design[1] and develop the initial Web-based system and database components.

G. Develop a project schedule that specifies milestones and due dates for each product deliverable.

H. Identify and describe interim and final products to be developed and delivered for inspection and acceptance by the Service.

3. The NBDM Team, in conjunction with a User Acceptance Team, will serve as the official technical review committee to evaluate and accept interim and final products in accordance with the SOW and established milestones in the project schedule.

4. Upon the successful completion of the initial application modules, the NBDM Team will identify the next module for development using the list of high priority data management needs identified by refuges.

5. Ensure that the application architecture fully complies with the DOI's common requirements, conceptual architecture principles, domain architectures, and draft principles documents (http://sii.fws.gov/r9data/DOIArch/Update.htm); the Service policies and requirements described in *Fish and Wildlife Service Manual*, 270 FW 1, Service Information and Technology Architecture (Appendix E.1), and 270 FW 2, Automated Information Systems Capital Planning and Management (Appendix E.2); SITA requirements (http://sii.fws.gov/r9data/sita/sita.htm#APPLICATION); and those pertaining to open database connectivity and Section 508 of the Rehabilitation Act of 1973, as amended.

[1] The Team evaluated the Service's Region 5 Census Database, which has been implemented and used effectively for a number of biological data collection needs within Region 5. This application was developed using an older DOS-based software package (Rbase) and is not suitable for implementation on a national level. However, the SOW should include a requirement to evaluate the Service's Region 5 Census Database as a model for developing the first application module of the national system.

Recommendation 3 Develop a process to integrate refuge-specific monitoring activities into the biological inventory and monitoring data management system.

Questionnaire results (Appendix B) indicate that a myriad of monitoring activities are conducted on refuges for adaptive management. Although some are common to numerous refuges (e.g., breeding pairs for waterfowl, moist-soil monitoring), many monitoring activities are refuge specific.

The national data management system will contain submodules to store core data for standardized inventory and monitoring activities conducted by numerous refuges. However, the data management system also must allow individual refuges to modify these standardized protocols as well as store their unique inventory and monitoring data. This flexibility will ensure that NWRS biological data management needs are met at all geographic scales. Refuge-specific data that are not collected by other refuges can be used at the local level to make science-based management decisions. Biological data collected at numerous refuges with a regional or national standardized protocol and sample design can be summarized or analyzed to address ecosystem, regional, or national priorities, as well as refuge-specific management needs.

Individual refuges will be required to develop their own monitoring program for specific biological data needs that are not common to other refuges. To improve the efficiency of the NWRS and maximize use of all refuge data, these refuge-specific protocols must be incorporated into the data management system in a fashion similar to the standardized national and regional monitoring activities. Consequently, a process must be developed so that individual refuges can store their monitoring data in a standard format that does not compromise the functional integrity of the Web-based system. This will ensure that refuge-specific data can be uploaded and used in the national data management system. In addition, refuges may need to modify a standard protocol to meet unique objectives.

The integration of a refuge-specific biological monitoring activity into the data management system involves the following steps: developing a protocol; identifying data entry fields; developing a data dictionary; and developing an Inventory and Monitoring submodule to store the data. Strategies for establishing standardized protocols for wildlife and habitat monitoring on refuges are being developed by *Fulfilling the Promise* Teams WH7, 8, and 10, in accordance with Service policy (701 FW 2, Inventory and Monitoring of Populations).

The successful integration of national or refuge-specific monitoring data into Inventory and Monitoring submodules will require an understanding of the database structure; adherence to applicable data standards; a data dictionary (Appendix D) that represents the data elements associated with a monitoring protocol; and incorporation of these data elements into the national data management system. The data dictionary will describe the important attributes or characteristics of each data element, such as name, definition, length, and type. For example, if staff gauge readings in wetland units of a refuge are monitored, there will be corresponding data elements for wetland unit, date, and the water level reading(s).

The data dictionary will also include the key field(s) needed to maintain structural integrity and effectively relate (link) biotic (wildlife and habitat) and abiotic responses to refuge management actions. The same key field(s) will be used for all monitoring activities that are incorporated into refuge-specific databases or the national data management system. To ensure data compatibility, standard templates will be provided to refuges that include the core data elements needed to store and utilize refuge-specific monitoring data in the national system.

For example, a refuge may use a national standard protocol to collect the following check station data for harvested deer: harvest date, sex, age, weight, antler measurements, and a specimen identification code. In addition, the refuge will need specific data regarding kidney weight and marrow fat index data from each harvested deer to address refuge-specific management issues. Because the national system will not include fields for refuge-specific data, a standard template will be used to add these data elements to both the refuge and national data management systems.

Table 1 is an example of a standard template that contains the core data elements (**Orgcode** and **Specimen ID**) plus additional fields for other deer harvest data elements. Table 2 includes the core data elements (**Orgcode and Specimen ID**), as well as the refuge-specific data elements needed to link kidney weight or marrow index to other data collected on the individual deer (**Specimen ID**) and analyze kidney weight of male versus female deer, analyze data according to animal weight, or numerous other combinations.

Table 1. Standard template with the core and other deer harvest data elements.

Orgcode	TSN	Date	**Specimen ID**	Sex	Age (Yr)	Weight (kg)
52510	180699	11/05/2002	1	M	1.5	100
52510	180699	11/05/2002	2	M	2.5	140
52510	180699	11/05/2002	3	F	1.5	85
52510	180699	11/07/2002	4	M	1.5	110

Table 2. Standard template with the core and refuge-specific data elements.

Required Data Elements		Refuge-Specific Data Elements	
Orgcode	**Specimen ID**	Kidney Weight	Marrow Index
52510	1	15.23	3.4
52510	2	17.45	4.6
52510	3	14.20	5.0
52510	4	15.35	5.2

Tasks:

1. Identify monitoring activities for which standardized protocols may be developed for the NWRS. Prioritize these monitoring activities for integration into the national data management system.

2. For the biological/abiotic monitoring activities not identified in Task 1, identify procedures to integrate refuge-specific monitoring activities into the data management system at the refuge level.

3. Develop a standard format for data dictionaries along with essential data elements (key fields) that must be used in order to integrate a monitoring protocol into the refuge-specific and national data management systems.

4. Develop a variety of templates to efficiently incorporate biological data into the refuge-specific data management system for a host of monitoring activities including data collected on individual animals, monitoring numbers of animals within a census unit, and additional environmental variables at a refuge for standard surveys.

5. Require the submission of data dictionaries to the appropriate National or Regional Inventory and Monitoring Coordinator for review and approval before the data elements are incorporated into the refuge-specific data management system.

Recommendation 4 Develop a process to evaluate existing biological and abiotic data management applications that may be utilized as is, or adapted to meet refuge needs.

The NWRS has unique biological and abiotic data management needs which require the development of a NWRS biological data management system. However, for some types of data, existing applications developed by other organizations may meet NWRS needs. While the adoption and use of an existing application should be beneficial to the Service, in terms of both time and cost, a thorough evaluation must be performed to determine its suitability for meeting a particular need. It is also likely that any existing application of interest to the NWRS would require some modifications to adequately address data management issues, such as the inclusion of organization code, specific census unit codes, species codes from the Integrated Taxonomic Information System (ITIS), or other items necessary to create linkages to other refuge data in the national system.

The implementation actions are presented for the purpose of proposing a process to formally evaluate existing and future biological data management applications for use by the NWRS. This evaluation process, which is proposed to be the responsibility of the NBDM Team, will (1) identify existing applications with high potential for refuge-wide use and (2) create a User Acceptance Team with the appropriate level and mix of knowledge and expertise in the particular subject to conduct the evaluations. User Acceptance Team members should have experience with data management systems, as well as specialized knowledge and expertise in collecting and using the data which the application is designed to store.

Once a User Acceptance Team determines that an existing application is suitable for refuge-wide use, there must be an administrative structure in place to make the application available to refuges; assist in training staff; install and maintain upgrades; perform backups of the data; and ensure that all versions of the application and data are properly stored and archived.

Tasks:

1. Existing applications that demonstrate the potential to meet specific refuge data management needs will be proposed for evaluation by the NWRS. Any NWRS staff person may recommend an existing application to the NBDM Team for evaluation.

2. The NBDM Team will maintain a list of the applications proposed for evaluation, review staff recommendations, and determine if an existing NWRS module or adopted application already meets the specific data management need. If so, this information will be provided to the individual who made the proposal.

3. If there is no existing NWRS module or adopted application, the NBDM Team will create a User Acceptance Team to evaluate the proposed data management application. The User Acceptance Team will be comprised of at least one member of the NBDM Team, several refuge staff members with particular expertise in the biological procedure which

the database addresses, and several NWRS staff with expertise in relational data management.

4. The User Acceptance Team will:

   A. Identify the need for the particular data and how this data will be used by the NWRS for decision making.

   B. Evaluate the proposed application and determine if the structure will accommodate the specific uses of the data to be stored.

   C. Compare the structure of the proposed application with the structure of other Service and NWRS biological data modules.

   D. Review the proposed application for user-friendly input/output, data administration, archiving, data exchange, and other data management issues.

   E. Recommend the adoption or rejection of the proposed application to the NBDM Team.

   F. If adoption of the proposed application is recommended, identify the modifications required to meet NWRS needs and to maintain relational linkages with other refuge data, consistency in species codes, and ease of data import/export.

5. When a recommendation is made to adopt an existing application, contingent upon the required modifications, the NBDM Team will contact the developing bureau or organization to determine the best method for incorporating the modifications. A member of the NBDM Team will be designated as the steward for both the application and the protocol by which the data is collected. This individual will coordinate the development work; provide technical direction on database structure, specifications, and other requirements to meet refuge needs; monitor progress; and determine final acceptance. The NBDM Team will enlist the services of appropriate personnel in the NWRS OIM and Divisions of CFM and ITM to provide the technical assistance and support necessary to complete this development effort in a timely, cost-efficient, and professional manner.

6. Upon completion and acceptance of the application for NWRS use, schedule and conduct a "train the trainers" course at the National Conservation Training Center (NCTC). The staff who developed the application will train the WO and RO Inventory and Monitoring Coordinators, and at least one Service employee from each Region will serve as the primary liaison and refuge point of contact for help in using a new application.

7. Publish the availability of the new module in appropriate sections of the *Fish and Wildlife Service Manual*, Part 701, Population Management at Fields Stations (specifically, 701 FW 2, Inventory and Monitoring of Populations), and the proposed guidelines described in Recommendation 6.

In accordance with the process outlined above, the WH9.1 Team recommends an evaluation of three biological data management applications developed by other DOI Bureaus:

Landbird Point Count Database: Web-based application designed and developed by the USGS Patuxent Wildlife Research Center (PWRC) for the specific purpose of storing and sharing data collected during breeding landbird point counts across the country. A significant amount of time and effort was expended during its development to insure that the appropriate variables are being collected for landbird surveys. A variety of options are available for exporting the data into other software packages for analysis, which contributes to the efficient exchange of data among the numerous organizations using this database.

Managing breeding landbird point count data was identified as the second highest need of the NWRS (Appendix B), second only to waterfowl surveys. The developers of the Landird Point Count Database are willing to incorporate modifications that will meet both the specific needs of refuges and the database structure requirements described in Recommendation 2. The WH9.1 Team recommends that the NWRS work closely with USGS-PWRC personnel to ensure that this database can be adapted or modified to meet the specific needs of refuges. The adoption of this database by the NWRS will allow refuges to contribute to a national program and assess habitat management actions (e.g., riparian restoration). Refuges will be able to combine their own data with local data collected by others and identify their contribution to breeding landbirds within a larger landscape context.

NPSpecies Database: Developed by the NPS as a Bureau-wide inventory program to document the occurrence of vertebrates, invertebrates, and vascular plants in national park units with significant natural resources. The database contains a documented checklist of vertebrates, invertebrates, and vascular plants for 270 parks, lists distribution and abundance of priority species (threatened and endangered and exotics), and contains baseline information for long-term monitoring.

The Team evaluated a number of species applications (Appendix C) developed by other agencies and organizations and developed a capabilities matrix (Appendix F) to determine the strengths and weaknesses of each application. The results clearly indicate that the NPSpecies Database has the most potential for meeting the needs of refuges. This user-friendly application is based on the ITIS species codes, with unique Taxonomic Serial Numbers (TSN) that never change. If a species name changes, a new TSN is assigned. The database is supported by an established program, including a training course, handbook, data dictionary, and core funding for technical support, updates, operations, and maintenance. Moreover, the NPSpecies data elements are consistent with those described in the WH8 Baseline Inventory Team report.

The NPS has agreed to allow use of its database application by the NWRS and has offered to provide guidance to the Service in converting the NPSpecies Database to meet refuge needs. A great deal of time, energy, and funding would be saved by adopting and modifying the NPSpecies Database. The Service would also benefit in other ways that are less tangible, such as learning from the NPS about mistakes and unforeseen circumstances or issues that hindered or delayed the development process. Obvious modifications to the NPS database include substituting the name of a National Park and associated Park number with the name of a National Wildlife Refuge and associated organization code. Because the Service and NPS have overlapping biological and ecological resources issues at the local and national levels, these associated species databases would be a substantial help in establishing partnerships for information exchange.

North American Amphibian Monitoring Program (NAAMP): Developed by the USGS to monitor amphibian populations throughout the eastern half of the United States by using a calling survey. Information is being collected to monitor populations of amphibians, many of which have declined in recent years. Data is also used to monitor the environmental health of wetlands, for which amphibians are excellent indicators. Numerous refuges in Regions 3, 4, and 5 are collecting this data and making it available to the USGS for the above-mentioned purposes. In addition, data are being collected at the refuge-specific level to measure amphibian responses to certain wetland management actions.

The USGS has expressed a willingness to alter the NAAMP application to address NWRS needs. Initial discussions have already identified the need to include organization codes, census unit identifiers, and other variables that will allow refuges to use the data for local decision making purposes.

Recommendation 5 Adhere to existing Service policy and guidance on information and data management resources (i.e., computer hardware and software, data architecture, browsers, standards, and applications development) that are relevant to NWRS inventory and monitoring activities. Establish a formal process for developing standards, procedures, protocols, and applications that support NWRS inventory and monitoring activities.

The Service's information management strategy, *A Strategy for Sharing Corporate Information* (August 18, 1999), outlines several initiatives for implementing a progressive strategy for sharing information and data within and outside the Service. Significant progress has been made on several of these initiatives:

Data Standards: To date, over 50 data standards have been adopted for specific data elements, data layers, data sets, and procedures that cross all programs of the Service. Each adopted Service standard identifies a designated data steward who is a subject matter specialist for the data described in the standard. This individual prepares the initial draft standard, provides advice and instructions on the proper use of the standard, reviews and incorporates comments during the formal review process, makes electronic copies of the data if appropriate, and modifies and maintains the standard to ensure its continued utility and accuracy. The *Fish and Wildlife Service Manual* 270 FW 6, Data Management and Standards, defines data management practices within the Service and the process for establishing data standards.

The Corporate Master Table (CMT) System (http://cmt.fws.gov): *Fish and Wildlife Service Manual* 270 FW 6, Section 6.4.F, states that the CMT is "the official repository of administrative data on Service organizations"and "its use is mandatory when officially publishing or sharing Service information that uses this data." The CMT data includes, but is not limited to, official organization codes and names, organization name abbreviations, ecosystems, mailing and physical/shipping addresses, telephone, TTY and fax numbers as well as location information on states, counties, and congressional districts. This organizational information is updated and maintained by designated data stewards and Regional representatives, who coordinate and conduct semi-annual verifications to keep the data current.

SITA (http://sii.fws.gov/r9data/sita/sita.htm): *Fish and Wildlife Service Manual* 270 FW 1, Service Information and Technology Architecture (Appendix E.1), provides developers with a standard infrastructure for data, security, hardware, and software as a basis for managing information and developing and maintaining information systems. For an information system to be SITA-compliant, it must conform with the set of standards, policies, and procedures that align information technology with the Service's mission and goals.

Corporate Information Center Web Site (http://sii.fws.gov/r9data/): Provides links to the Service's CMT System, SITA, Data Standards, the DOI Enterprise Architecture effort (http://sii.fws.gov/r9data/DOIArch/Update.htm), spatial data resources pertaining to GIS and the Interactive Map and Data Server, and information on systems development services.

Awareness of, and accessibility to, the Service's information and data management resources varies greatly throughout the NWRS. The vast majority of refuge staffs are not familiar with the Service's CMT System, SITA requirements, DOI Enterprise Architecture effort, and Division of ITM Web sites that provide Service data standards, spatial data resources, and associated mapping applications. Those who are may attach little, if any, importance to using these resources to accomplish their inventory and monitoring activities. There appears to be no established or consistent method within the NWRS for disseminating or responding to information resource requests at the national, regional, or field office level. This has been evident in two separate, yet related, review processes: the formal review of proposed data standards for adoption by the Service; and the semi-annual review and verification of organizational information in the CMT. Memoranda and electronic mail messages on these periodic reviews are not being routed to the appropriate NWRS personnel in the Regional and field offices. A consolidated response from the NWRS on a proposed Service data standard from either a program or regional perspective is the exception rather than the norm.

At the present time, there is no single reference that describes the policy, procedures, and guidance necessary to ensure that the inventory and monitoring data collected by a refuge can be shared with other refuges, other programs, and with partners and clients outside the Service; or that the database system used to store this information is accessible for data analyses. The NWRS must ensure that database managers, system developers, and users can access and reference the same policy, procedures, and guidance when decisions are being made on collecting, creating, or updating inventory and monitoring data, improving existing information systems, and developing new information systems and applications to meet refuge-specific needs.

Tasks:

1. Appoint the WO Inventory and Monitoring Coordinator to lead a Service team[2] of refuge biologists and information/data specialists to:

   A. Develop and implement the NWRS policy and guidance needed to develop and disseminate standards, procedures, protocols, templates, software macros, and applications that support the entry, analysis, and storage of inventory and monitoring data collected by refuges.

   B. Using the Service's formal *Process for Establishing Data Standards* as the model (http://sii.fws.gov/r9data/standards/process.html), develop a process to identify,

[2] To include a Service employee in the NWRS Office of Information Technology and Management (OIM) and at least one Regional Refuge Biologist.

develop, review, and adopt standards that describe the biological data elements collected to meet NWRS inventory and monitoring objectives. Enlist the services of personnel in the Division of ITM's Branch of Data Systems and Services to help the team formulate a data standards process that will meet NWRS needs and identify common data elements that may be suitable candidates for Service data standards. Members of the NBDM Team will serve as the final review board for all proposed NWRS policy and guidance.

C. Establish data security guidelines that address data-sensitive issues, such as the location of threatened or endangered species and data to be used in publications.

D. Identify and designate data stewards who have a thorough knowledge of the data collected for inventory and monitoring activities. These individuals will have responsibilities that are the same or similar to those described in the Service's formal *Process for Establishing Data Standards*.

E. Empower the data stewards to develop data standards[3] for the common data elements in accordance with the formal process established by the NWRS. At a minimum, standards will include the following information: data element description, data type, syntax, recommended field name, data values, data source, references, and use instructions.

F. Develop a data dictionary (Appendix D) for each module of the proposed Web-based application that fully describes the biological data elements collected for the specified inventory and monitoring activity. Each data element should include, at a minimum, the attributes or characteristics provided in Service data standards (i.e., data element name, description, type, syntax or format, recommended field name, data values, source, references, use instructions, etc.). Additional data characteristics may be identified by the data steward. Each data dictionary will be a stand-alone document, referenced and linked in appropriate sections of the *Fish and Wildlife Service Manual*, Part 701, Population Management at Fields Stations (specifically 701 FW 2, Inventory and Monitoring of Populations); and the proposed guidelines described in Recommendation 6.

G. Ensure compliance with existing policy and guidance on data and information resources that are relevant to refuge inventory and monitoring activities, specifically SITA requirements, the mandatory use of Federal standards (e.g., Federal Information Processing Standards [FIPS] and Federal Geographic Data Committee [FGDC] standards, Service standards, and the CMT) when applicable.

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[3] Data standards developed for the common data elements (fields) collected in refuge inventory and monitoring activities may apply solely to the NWRS ; however, each designated data steward will determine if a particular standard is applicable to other programs of the Service. In these cases, the designated data steward will follow the Service's *Process for Establishing National Data Standards.*

H. Provide assistance to other teams created for the specific purpose of developing the initial application modules and proposed guidelines described in separate recommendations.

3. Assign a qualified Service/NWRS employee to design and develop a national Web site to easily locate and access information and data management resources that pertain to refuge inventory and monitoring activities, including standard procedures, protocols, templates, software macros, and refuge-specific databases and applications. This site shall include links to applicable sections of the *Fish and Wildlife Service Manual*, such as Part 701, Population Management at Field Stations, and Part 270, ITM Program Management; Division of ITM Web sites that provide or link to Service policy, guidance, standards, and technical information related to the CMT, SITA, spatial data resources, and systems development services; Web sites on national data standards, such as FIPS and FGDC; handbooks, including the proposed guidelines described in Recommendation 6; literature reviews of the best available biological information; standard survey, inventory, and monitoring protocols; database systems developed by other agencies to collect, store, and manage biological data (e.g., the USGS-PWRC Landbird Point Count Database); and other sites that have information relevant to refuge inventory and monitoring activities.

4. Incorporate presentations and/or training sessions on DOI, Service, and NWRS policies and guidance into formal NWRS workshops, such as the annual Regional Refuge Biologists Workshop and Project Leaders Meeting, NCTC training classes and workshops, the Refuge Academy, and biological reviews conducted at individual refuges.

5. Assign a Service/NWRS employee to develop a user-friendly training tool that provides a comprehensive overview of DOI, Service, and NWRS policies and guidance on information and data management resources, including the requirements for compliance with each documented policy. This should be a Web-based training tool, to guarantee accessibility to all employees at individual refuges and NWRS offices, and allow ease of use at appropriate Service meetings, workshops, and NCTC classes.

6. Incorporate adherence to DOI, Service, and NWRS data management policies into the wildlife and habitat management review process.

Recommendation 6 Develop a uniform set of NWRS guidelines to systematically collect, store, and manage inventory and monitoring data on refuges.

The proposed NWRS biological data management system will provide a way for refuges to collect and manage monitoring data for refuge-specific purposes as well as for ecosystem, regional and national purposes. Because the effectiveness of a national system will be entirely dependent upon the information collected and entered at the refuge level, training and guidelines on using and customizing the system to meet specific refuge needs is crucial. A national data management system and uniform set of NWRS guidelines for collecting, storing, and managing data will not only facilitate training new biologists but also improve consistency throughout the refuge system by enabling new or transferring biologists to utilize the same database, policy, and procedures at every refuge. One mechanism for providing these guidelines and training to all NWRS staff is the Service Internal Internet.

The NWRS guidelines will serve as the single point of reference for up-to-date information on policy, procedures, standards, and protocols for collecting, storing, analyzing, and managing refuge inventory and monitoring data. As such, these guidelines will become the necessary link between established and evolving inventory and monitoring policy and on-the-ground implementation.

The identification, development, and incorporation of standard protocols and data dictionaries into application modules of the Web-based system will be a long-term process. It will take several years to develop application modules for the high priority monitoring activities, and many of the refuge-specific monitoring activities will never be incorporated as separate modules or submodules. Consequently, guidelines must be developed in the form of a "how to" guidebook for biologists to incorporate their refuge-specific monitoring data into a refuge-level data management system. In order to respond to rapidly changing technology and techniques, the guidebook should be developed and published as a Web document, and organized in a format that can be quickly and easily updated. Rather than a handbook that takes several years to develop, and/or one that is cumbersome to update, this Team envisions a product that will be published on the NWRS Intranet site, and one that can be readily accessed and changed on a daily basis if needed.

The proposed guidebook will provide up-to-date training tools and information on the NWRS biological data management system, as well as policy, procedures, standards, and protocols for collecting, storing, analyzing, and managing refuge monitoring data. The guidebook will also include quality assurance guidelines to ensure that the data are checked and verified for completeness and accuracy before they are incorporated into the national system. Quality assurance should also be performed during data analysis, through production of reports and internal/external reviews of the data.

A draft outline of the guidebook may be:

Database design and structure
Data dictionary

Applications for specific biological surveys
Data standards
Data collection protocols
Metadata
Data access (including access to sensitive or restricted information)
Data storage and archiving
Tools available for data analysis (e.g., GIS, statistical software, etc.)

- Links to related Web sites

NOTE: Topics may be changed or expanded by the Service team assigned to this task.

Tasks:

1. Charter a Service team[4] of 5-6 persons with expertise in IT, database utilization, and biological survey, inventory and monitoring methods to develop and write the content of the initial draft guidebook within one calendar year of the official assignment date. The initial content of the guidebook shall include, but not be limited to, the data topics outlined in the preceding section of this recommendation. The one-year time frame for completing the draft guidebook assumes a significant time commitment by team members.

2. Assign a qualified Service/NWRS employee to design, develop, and publish the initial draft guidebook on the NWRS Intranet site, in accordance with Service and NWRS publishing plans and policies. The Service's Web Publishing Guide, including mandatory requirements and official guidance, is available at the following Intranet site: http://sii.fws.gov/webpublish/styleguide.htm

3. This team will work closely with the NBDM Team and the appropriate user acceptance teams to ensure that information and instructions on using the application modules are accurate, up-to-date, and user friendly.

4. The NWRS guidebook will be developed as a Web document for access on the Service Intranet, with chapters and sections organized and structured in a format that can be easily updated in a timely manner.

5. The guidebook will be referenced in, and linked to, the applicable chapters and sections of the *Fish and Wildlife Service Manual*, Part 701, Population Management at Fields Stations (specifically 701 FW 2, Inventory and Monitoring of Populations), and Part 270, ITM Program Management, which includes the Service's policy, guidance, and technical information on data standards, SITA, and the CMT.

[4] WO staff are revising the 701 FW 2 policy on inventory and monitoring populations. These staff members, along with representatives from the various Promise Teams chartered to address these issues, may form a good core for this team.

Recommendation 7 Identify the commercial off-the shelf (COTS) desktop software tools to be used for storing, analyzing, summarizing, and presenting biological inventory and monitoring data. These desktop software tools will be made available to every refuge, associated field station, and regional NWRS office for use in managing biological data downloaded from the national database or collected in refuge-specific databases.

In accordance with 701 FW 2, inventory and monitoring data "should be stored and managed using some form of a computer database." To meet this requirement, many refuges have developed, and will continue to develop, refuge-specific databases for their own inventory and monitoring activities. There will be a continuing need for such databases, even after development of the Web-based system, since application modules cannot be developed for every inventory and monitoring activity conducted on a refuge. The majority of these individual databases have been developed using a variety of COTS software, such as Microsoft (MS) Access®, MS Excel®, Corel Quattro Pro®, Visual dBase®, FileMaker Pro®, etc.

The Team's initial recommendation identified specific procedures and tasks for evaluating and selecting COTS desktop software tools to be used by all refuges for biological data management, analysis, and storage. The following actions by the DOI render such a recommendation unnecessary:

On September 13, 2002, the Assistant Secretary for Policy, Management, and Budget signed a Findings and Determination document that requires DOI to standardize on Microsoft products on a Department-wide basis. The DOI Microsoft Enterprise Agreement (MEA) with Dell Corporation, a reseller of Microsoft products, allows all DOI Bureaus to access to an array of Microsoft software products as well as certified services and training.

On December 23, 2002, the USGS modified the existing DOI Blanket Purchase Agreement (BPA) with the Environmental Systems Research Institute, Inc. (ESRI) to incorporate an Enterprise Licensing Agreement for the ArcGIS suite of GIS software products and a limited number of other ESRI GIS products and services. The ESRI BPA is currently used by all eight DOI Bureaus.

Information on these and other DOI enterprise licensing agreements and contracts can be found on the DOI Office of the Chief Information Officer Web site at http://www.doi.gov/ocio/erm/.

Recommendation 8 Adopt standard nomenclature and codes to represent species of plants, fish, invertebrates, and wildlife.

A standard list of species, especially standard species codes, is critical for sharing data among refuges and regions and summarizing wildlife trends throughout ecosystems, regions, and the NWRS. For example, if refuges identify the "American Wigeon" by various names (Wigeon, Widgeon, Am. Widgeon, Baldpate, etc.), a computer summary of the data will treat each name as a separate species. This makes it difficult to determine the total number of American Wigeon which may occur within an ecosystem, region, or the NWRS during a specific time period.

The Bird Banding Laboratory (BBL) and the Breeding Bird Survey (BBS) have attempted to rectify this problem by using either American Ornithological Union (AOU) numbers for birds or 4-character alpha codes. However, not all birds have been assigned alpha codes and not all species are birds. The Service requires an electronic list of all species (plants, fish and wildlife, including invertebrates which the Service monitors) with a unique code assigned to each species. This list should reside with the applicable data standard on the Service's Intranet and Internet sites. It should also be available in an electronic format so that the standard species names and codes are used whenever a biological database is developed by the Service. This list must be updated on a regular basis to add new species that are identified and/or monitored by the Service or to rename existing species.

The Team recommends that the NWRS adopt the Web-based ITIS (http://www.itis.usda.gov/) as the NWRS standard for all botanical and zoological nomenclature. The ITIS is the result of a partnership of federal agencies formed to satisfy their mutual needs for scientifically credible taxonomic information. The original ITIS partners include:

Department of Commerce
- National Oceanic and Atmospheric Administration

Department of Interior
- U.S. Geological Survey
- National Park Service
- National Biological Information Infrastructure

Environmental Protection Agency

Department of Agriculture
- Agriculture Research Service
- Natural Resources Conservation Service

Smithsonian Institution
- National Museum of Natural History

Canadian Government Agencies

Mexican Government Agencies

These agencies signed a Memorandum of Understanding and have formed a Steering Committee that directs two technical work groups: the Database Work Group (DWG) and the Taxonomy Work Group (TWG). The DWG is responsible for the database design and overseeing development of the system to meet the requirements of the ITIS partners. The TWG is

responsible for the quality and integrity of the database information. In addition to the database, the working groups have created "Taxonomic Workbench" software designed for easy entry and manipulation of taxonomic data.

The ITIS brings into one place the most current nomenclature for the majority of species of interest to refuge biologists and managers. Taxonomic groups important to refuge management and completed for the United States, Canada, or the world include: vascular plants, mammals, birds, reptiles, amphibians, bony and cartilaginous fish, mollusks, and some insects. It is a dynamic system that has crosswalks to most major systems including endangered species. While any nomenclature system adopted by the NWRS will have limitations and difficulties integrating with partners and other entities, the ITIS appears to have the most potential for providing consistent nomenclature across agencies, programs, and institutions.

The ITIS vascular plants database is based on the Biota of North America Program and the PLANTS database (http://plants.usda.gov). The birds database is based on modifications and updates of Sibley and Monroe's *Distribution and Taxonomy of Birds of the World* and reflects as faithfully as possible the AOU's Checklist of North American Birds, 7th ed., 1988.

Tasks:

1. Adopt the ITIS as the NWRS standard for all botanical and zoological nomenclature.

2. Use the ITIS as the primary source of species codes and nomenclature in the NWRS Biological Data management System, as well as all databases and applications developed by individual refuges.

3. Once adopted, issue a mandate that all NWRS data collection systems will utilize the ITIS TSN species codes and nomenclature.

4. Include the mandate to use the ITIS as the NWRS standard for species codes and nomenclature in *Fish and Wildlife Service Manual*, 701 FW 2, Inventory and Monitoring of Populations, and proposed guidelines described in Recommendation 6.

5. Periodically download current ITIS lists for all species of concern to refuges, and make the list accessible to refuge personnel via an internal Web site.

6. In addition to the ITIS species list, provide a crosswalk that contains well known and/or frequently used species codes from other coding systems or classification schemes. For example, the ITS TSN code for mallard is "175063," the BBL alpha code is "MALL," and the AOU number is "1320." A crosswalk between the ITIS and other species codes will greatly facilitate the exchange of biological data between the NWRS, its partners and cooperators, and other organizations. However, all internal coding of species within NWRS biological databases will utilize the ITIS species codes.

7. Investigate the opportunities and requirements for FWS to join the ITIS partnership.

Recommendation 9 Establish a process to catalog, document, and store existing and historical data and information resources.

Data and information resources are collected and acquired by refuges in a variety of formats that include paper files, electronic files, digital files, maps, photographs, videos, images, etc. Refuge personnel need an efficient process to catalog and document all types of data and information resources to ensure their long-term utility and availability; to minimize the loss of data and institutional knowledge that occurs with staff turnover; to protect the cost and resources associated with collecting and acquiring the data and information; and to comply with Federal policies on managing and documenting Government data information resources (specifically, OMB Circulars A-16, *Coordination of Surveying, Mapping, and Related Spatial Data Activities*, and A-130, *Management of Federal Information Resources*; and Executive Order 12906, *Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure*).

With all of the different types of data and information resources that currently exist, there may be a need for different types of catalogs ranging from an electronic inventory to an electronic library of information. An electronic inventory would provide a list of information resources in a COTS package such as MS Access®, while an electronic library would actually contain the documents, photographs, maps, etc. using a COTS package such as Folio Views®.

In addition, these different types of data and information resources may require different levels of documentation. For example, metadata (or data about data) describe the content, quality, condition, and other characteristics of data. An original biological data set or digital file of spatial information produced by a refuge may need to be documented in a manner that complies with the applicable FGDC metadata standard. Spatial data acquired from other sources (e.g., Digital Raster Graphic, Digital Line Graph, Digital Orthophoto Quad, etc.) should already have metadata, which would require updating only if the data were modified by the refuge. Photographs, maps, or scanned documents at a refuge may require a minimal level of documentation to catalog the basic product information (e.g., description, spatial domain or geographic extent, lineage, source, scale, use constraints, date, etc.).

Legacy (historical) data is another important aspect of data management that needs to be addressed by refuges. Large volumes of legacy data reside in unique databases, spreadsheets, word processing documents, publications, and paper file cabinets. Identifying, organizing, and importing legacy data will be a monumental task. The Team recommends cataloging legacy data in an electronic format to provide a searchable directory to the information. The NPS has dealt with this issue by devoting considerable effort at each Park to catalog monitoring data and eventually enter this information into a new system. At this stage, the Team is not advocating a nationwide effort to catalog legacy data; however, there are various tools available that can assist with this process, such as the Data Catalog and other desktop software tools developed by the NPS. As the NWRS I&M Program grows, so should the ability of refuges to recognize the advantage of incorporating and maintaining both current and historical data in a national system.

Much of the data mining associated with implementation of Recommendation 9 would not be applicable to a national system but would be very useful at the refuge and regional levels. It will take additional time and resources to convert existing paper and computer systems to a new format. The cost or level of effort will depend on the type of process and system adopted, the type of survey activity, and the tools and training necessary to enable field staff to conduct data mining and data conversion.

Tasks:

1. Identify each type and medium of existing and historic data and information that should be cataloged and documented by refuges, as well as the level of documentation required for each. Develop guidelines that clearly describe how each type of data and information resource should be cataloged and documented, and provide at least one example of the documentation required for each one. Include the guidelines and examples in the proposed guidebook described in Recommendation 6.

2. Using a COTS software package, such as MS Access ®, design and develop the tools (macros, data entry forms or screens, etc.) needed by refuge personnel to catalog and document existing and historic data and information resources.

3. Develop data entry forms (screens) that identify the required elements for each level of documentation, including:

   A. Metadata entry forms (or screens) that contain all the required data elements for full compliance with the FGDC metadata standards for documenting spatial and nonspatial (i.e., biological) data sets:

      Content Standard for Digital Geospatial Metadata (CSDGM), Version 2, FGDC-STD-001-1998 (http://www.fgdc.gov/metadata/contstan.html).

      Biological Profile of the CSDGM, Part I, FGDC-STD-001.1-1999 (http://www.fgdc.gov/standards/status/sub5_2.html).

      NOTE: The Biological Data Profile of the CSDGM includes all the elements in the geospatial metadata standard, as well as additional elements to describe biological data sets. The Service's procedural standards for using the FGDC geospatial and biological metadata standards can be found at http://sii.fws.gov/r9data/standards/standards.html and http://www.fws.gov/stand/.

   B. Data entry forms that include a subset of the FGDC metadata elements needed to catalog basic information on documents and data products acquired or purchased by a refuge. These types of information resources need to be cataloged, but will not require the level of detail mandated by the FGDC metadata standards.

4. Research, recommend and acquire COTS software packages for scanning, indexing, and retrieving text, images, video, and/or sound files, as well as the conversion of historical data that was archived in electronic file formats that are now outmoded and no longer supported. Document indexing and retrieval software should be capable of storing diverse file formats regardless of size. It should also be fully searchable both by record/document and by information within the record/document, and capable of providing access to the information by Intranet, Internet, and CD-ROM.

   NOTE: Folio Views® is one example of a COTS software package that can be used to develop and maintain large databases of text, video, images, sound files, etc. (often referred to as "infobases").

5. Work with personnel in the Service's Division of ITM, Branch of Data and Systems Services, to investigate the mechanisms and procedures for obtaining funds to document existing and historical data collected on refuges. The FGDC encourages federal, state, local, and tribal governments, academia, the private sector, and nonprofit organizations to work together within a geographic area to make important data sets available to all. The FGDC provides seed money to regional consortia through the National Spatial Data Infrastructure (NSDI) Cooperative Agreements Program (CAP). Detailed information on the NSDI and CAP is available at http://www.fgdc.gov/funding/funding.html.

Recommendation 10 Develop the NWRS administrative structure to utilize data from other agencies and organizations to improve refuge management decisions.

Numerous organizations and agencies monitor a wide variety of biological and abiotic components of the environment. Examples of these monitoring programs include national scale land cover types (similar data layers are land use and vegetation), breeding bird surveys, mid-winter waterfowl inventories, water elevations in river systems, weather, State heritage programs, etc. Standard GIS data layers are also included in this category, and these are defined in the WH8 Team report on Baseline Inventory Data Layers (e.g., digital orthophotography, soils, hydrography). Oftentimes, these data are readily available to other organizations free of charge or for a nominal fee. The NWRS seldom takes advantage of opportunities to obtain free or low cost information on a system-wide scale. By not obtaining available data from the primary source, the NWRS contributes to the negative portrait of federal and state agencies that is often observed by the public: duplication of effort, lack of coordination, and loss of information from data integration. These national and regional data sets provide a broader ecological context for biological resources found on a refuge. Rather than be managed in isolation, refuges should determine their contribution toward biological resources within the context of larger landscapes, from ecosystem to continental scales, to establish refuge resource objectives.

Unfortunately, there is no process or institutional structure within the NWRS to actively seek and use data produced by other organizations, or to contribute its own data resources. Until a formalized structure exists, the NWRS will continue to miss opportunities to incorporate and use data that would improve refuge management decisions and the establishment of appropriate resource priorities.

On a local scale, some refuges provide excellent examples of how data from other sources can be used to improve refuge-specific management decisions. This is usually because a refuge staff member is familiar with the data and its availability. Data collected by other organizations can greatly benefit individual refuge management efforts, by helping to explain processes that influence refuge resources, identify threats to the refuge, and improve refuge efficiency by avoiding the collection of duplicate data. When data are combined with data sets produced by other organizations, the end result is often referred to as a "value added" product. Another term is "data synergy," when the value of the secondary data product exceeds the value of all the data sets taken individually.

The Team recommends the development of a process or institutional framework to make better use of data collected by other agencies and organizations. The catalyst for this recommendation was a presentation to the Team by Dr. Thomas Stohlgren, USGS Fort Collins Science Center (FORT), National Institute of Invasive Species Science, that demonstrated the added value obtained from combining information from several different data sources. Using value-added data can improve the ability of the NWRS to manage refuges as individual entities and as a System. One example of using value-added data at a refuge scale may be the Invasive Species Database being compiled by personnel at the USGS FORT, National Institute of Invasive Species Science. Once this database is developed and available, individual refuges could inventory invasive species found at the refuge, compare the refuge-specific data to other data collected at a

county or state scale, and identify invasive species not detected during the refuge survey or species of concern that are in close proximity to the refuge.

On a larger landscape scale, the refuge program in Region 5 is developing a Strategic Resource Plan that identifies the relative contribution of different portions of the Region to various wildlife species. For example, the relative distribution of migrating and wintering black ducks within Region 5 was developed from band return data administered by the Migratory Bird Management Office. This information will be combined with refuge-specific data on habitat availability and waterfowl populations at each Region 5 refuge. The results of this analysis will identify which refuges should address black duck management within their Comprehensive Conservation Plans at specified times of the year.

Tasks:

1. Create a team of 2-3 staff biologists whose primary responsibility is the proactive incorporation of biological and abiotic data from other organizations into the national system.

2. The team of staff biologists will:

    A. Serve as an interface between the NBDM Team and refuge staff, planners, and other users of refuge data.

    B. Identify priority data needs.

    C. Catalog the wide variety of "value added" data available for use by all levels of the NWRS, and identify the suitability of each data set for establishing NWRS priorities and making management decisions on a local (refuge), regional, and national level.

    D. Provide the catalog to all NWRS staff on an Internal Web site to avoid duplicate data acquisition efforts.

    E. Acquire, interpret, and maintain digital copies of the commonly used and/or value added data sets produced by the Service and other organizations in a format that is readily available and easily used by personnel at all levels of the NWRS.

    F. If necessary, convert or reformat digital data sets to meet specific reporting requirements and/ or to increase use by NWRS staff.

    G. Manipulate data sets to include the appropriate key variables needed to link to the relational database structure within the national system.

    H. Work with the NBDM Team to make refuge data available to Service programs, NWRS partners and cooperators, other agencies and organizations, and the general

public. Provide the information (i.e., metadata) needed to locate, evaluate, and access refuge data on Service/NWRS Web sites and/or the NBII Metadata Clearinghouse (http://www.nbii.gov/search/clearinghouse/about.html).

I. Perform the tasks needed to ensure the quality of refuge data provided to the NWRS user community, and compliance to federal standards that apply to all metadata provided on the NBII clearinghouse nodes.

J. Analyze and summarize refuge data with other data sets to provide value added data that can help the NWRS identify priorities and significant contributions of the refuge system to biological resource management.

Cost Estimates to Implement Recommendations

The process of developing a national biological data management system for the NWRS will be an iterative process. Some of the Team's recommendations must be initiated first; as expertise and initial projects are developed, additional aspects of the data management system can be addressed. The cost estimates provided below are minimal costs. These estimates are based upon discussions with NPS, U.S. Forest Service (USFS), and USGS personnel, all of whom have taken on development efforts that are similar in scope to the proposed national system for the NWRS. However, these Bureaus have developed data management systems to meet a specific need, and their cost estimates can not be strictly applied to the NWRS.

Another important consideration is the mechanism used to develop a national data management system. Some Bureaus and organizations have acquired the necessary hardware/software and computer programming expertise to develop their data management systems in-house; whereas other Bureaus have hired a private contractor to acquire the necessary technical support services to develop the system. Depending on the size and scope of the project, equipment and development costs can range between several hundred thousand dollars and several million dollars.

It should also be remembered that the design and development of the national system is not the entire cost. There will always be recurring costs for hardware/software upgrades, system and database maintenance, data conversion, user training, etc. For these reasons, the cost figures presented below are for initial development of the national system.

Recommendation 1: Establish positions within the NWRS to develop, maintain, coordinate, and administer a NWRS biological data management system.

> $150,000 per position (GS-13), **per year**, for salary, travel, equipment, etc. $300,000 **per year** for personnel and travel costs associated with the various ad hoc teams identified in this report. These teams are critical, since they will be the subject matter experts for many aspects of NWRS data collection and management needs.

Recommendation 2: Design and develop a national biological data management system to store inventory and monitoring data collected by the Service, especially on refuges.

> $500,000 to begin design and development of the National Biological Data Management System.
>
> This estimate is the minimum amount of "seed" money needed to initiate development of a national system. Once the NBDM Team is hired and on board, these individuals will perform the numerous tasks associated with actual design and development of the national system, including the preparation of detailed cost estimates. The Promise Implementation Team should anticipate development costs of several million dollars over a period of several years, plus the costs

associated with hardware/software upgrades, system and database administration, annual maintenance, software enhancements, user training, etc. Projected costs for the hardware, software, and technical support options needed to implement two common architectures are provided in Appendices G and H. These cost projections are based on an industry analysis[5] conducted in February 2002.

Recommendation 3: Develop a process to integrate refuge-specific monitoring activities into the biological inventory and monitoring data management system.

The cost to implement this recommendation is included in the cost estimate for Recommendation 2.

Recommendation 4: Develop a process to evaluate existing biological and abiotic data management applications that may be utilized as is, or adapted to meet refuge needs.

The cost to implement this recommendation is included in the cost estimate for Recommendation 1 (i.e., funding for the various ad hoc teams).

Recommendation 5: Adhere to existing Service policy and guidance on information and data management resources (i.e., computer hardware and software, data architecture, browsers, standards, and applications development) that are relevant to NWRS inventory and monitoring activities. Establish a formal process for developing standards, procedures, protocols, and applications that support NWRS inventory and monitoring activities.

The cost to implement this recommendation is included in the cost estimate for Recommendation 1 (i.e., funding for the various ad hoc teams).

Recommendation 6: Develop a uniform set of NWRS guidelines to systematically collect, store, and manage inventory and monitoring data on refuges.

The cost to implement this recommendation is included in the cost estimate for Recommendation 1 (i.e., funding for the various ad hoc teams).

Recommendation 7: Identify the commercial off-the shelf (COTS) desktop software tools to be used for storing, analyzing, summarizing, and presenting biological inventory and monitoring data. These desktop software tools will be made available to every refuge, associated field station, and regional NWRS office for use in managing biological data downloaded from the national database or collected in refuge-specific databases.

This recommendation is no longer relevant due to the DOI's Enterprise Licensing Agreements for Microsoft and ESRI software products, services, and training.

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[5] Based on "Cost Analysis of Sun/Oracle and Unisys/Microsoft for a BI Solution in a VLDB Environment," February 2002; prepared by the Walklett Group (http://www.walklett.com/news/Whitepapers.htm).

Recommendation 8: Adopt standard nomenclature and codes to represent species of plants, fish, invertebrates, and wildlife.

> The cost to implement this recommendation is included in the cost estimate for Recommendation 1. Implementation will require a small amount of coordination and administrative time of the WO and/or one RO Data Manager.

Recommendation 9: Establish a process to catalog, document, and store existing and historical data and information resources.

> The cost to implement this recommendation is included in the cost estimate for Recommendation 1.

Recommendation 10: Develop the NWRS administrative structure to utilize data from other agencies and organizations to improve refuge management decisions.

> $500,000 **per year** for three national biologist positions (GS-13), including salary, travel, equipment, etc.

Appendix A: NWRS Biological Data Questionnaire

Fulfilling the Promise - Recommendation WH9.1

Orgcode: _____ Date: _____

Refuge: _____

1. Please identify each survey procedure you conduct on the refuge which is biological or habitat oriented. Include procedures to measure numbers of wildlife, habitat, or abiotic factors which influence habitat. Record your responses on the attached questionnaire.

2. Please identify all data management software being used at the Refuge for management or storage of your biological data (examples of software are Microsoft Access, Foxpro, FileMaker Pro, etc):

   _____ _____
   _____ _____
   _____ _____
   _____ _____

3. Are you aware of biological database Applications which the *Promises* WH9.1 Implementation Team should consider for use by the NWRS? An Application is a data management system that is created using software such as Microsoft Access. The Application is a set of data entry screens, output, menu system, etc). Please list any Applications you feel the Team should evaluate for NWRS use:

   _____ _____
   _____ _____
   _____ _____

4. Please describe the types of training or technical support you may require to improve your use and management of biological data at the refuge (such as relational database use, Geographic Information Systems (GIS), and/or others):

5. Please identify your 5 highest priority biological data sets and list how many past years data is available (Example, Winter Waterfowl Census, 20 years):

Priority	Survey	Years of Data
1		
2		
3		
4		
5		

6. If the refuge is using Electronic Data Storage for biological data, where and how is that data being stored at the present time? For example, does this data reside on a computer hard drive within the refuge office, is it permanently archived using some other media? Also, is the data accessible to others?

7. Please provide any comments/feedback you wish the Promises WH9.1 implementation team to consider in evaluating various database applications to manage refuge biological information:

Orgcode:

Refuge:

Group/Species/Habitat [A]	Method [B]	Season [C]	Data Storage [D]	Application / Software [E]	Data Used ? [F]	Statistics [G]	GIS [H]	GPS[I]

[A] Identify survey procedure, such as waterfowl, wintering waterfowl, waterfowl brood survey, or single species such as bald eagle. (Include habitat surveys, such as noxious weeds, cattail encroachment, or other abiotic measurements such as water levels, etc).

[B] Identify method of survey, ie. Point Count, Transect, Area Survey (count of birds within impoundment, etc), quadrat, point intercept,

[C] Identify all seasons of year survey is conducted, ie. 1 = Winter, 2 = Spring, 3 = Summer, 4 = Fall, 12 = Winter, Spring, 123 = Winter, Spring, Summer, etc

[D] Identify Data Storage, P = Paper Files, E = Electronic, K = Key Sort Cards, X = Other.

[E] If electronic storage, identify database or spreadsheet software used (ie, Microsoft Access), and Application used (if a application has been created). Example may be RBASE (software) / CENSUS (application)

[F] Is the data used to improve refuge management decisions? Yes / No, if the answer is Yes identify what decisions are made from the data. (You may include a supplemental sheet with this information).

[G] Is the data statistically analyzed to improve reliability of decisions ? Yes / No

[H] Is the data available for importing into a GIS ? Yes/ No / Do not know.

[I] Is Global Positioning System (GPS) used in your data collection efforts? Yes/No

Appendix B: Findings of a Questionnaire Regarding Monitoring Activities on National Wildlife Refuges Throughout the National Wildlife Refuge System

Prepared by

Fulfilling the Promise
Inventory and Monitoring Database Team
WH 9.1

March 2002

Introduction

A critical element of adaptive management on national wildlife refuges is biotic and abiotic monitoring to determine whether wildlife and/or habitat management actions have met refuge-priority goals and objectives. In order for monitoring data to be analyzed and assessed relative to refuge objectives, the data first must be stored and managed in a way to facilitate its use and interpretation. Although many refuges collect monitoring data, there is no standardized approach for storage/management of these data. Consequently, there is disparity regarding the application and utilization of these data relative to management decisions on refuges throughout the National Wildlife Refuge System. In some cases, monitoring data are collected and then simply archived in file drawers without any analyses or interpretation of results. In contrast, some refuges store the information in databases, but there is no post collection data processing. Other refuges utilize monitoring by storing/managing data in database software that facilitates data analyses and subsequent interpretation of results to assess whether management actions meet refuge goals and objectives. In accordance with 701 FW 2.1, monitoring data are to be stored and managed in a database to facilitate their effective use with regard to management decisions on refuges.

Questionnaire

A 3-page questionnaire (Appendix A) was distributed to all project leaders/refuge managers within the National Wildlife Refuge System during fall 2000 regarding biotic and abiotic monitoring activities (surveys) conducted on refuges to guide adaptive management. One questionnaire was sent to each complex, but the staffs at each satellite refuge were requested to complete it for their respective unit(s). The questionnaire included a series of 7 questions regarding software and hardware used to store data associated with monitoring activities on refuges. Specific information was requested regarding storage, management, analyses, and use of data for each monitoring activity conducted on a refuge. Respondents also were requested to prioritize the top 5 monitoring activities for their refuge(s).

Information regarding the management/storage of data for 1977 monitoring activities was reported on questionnaires received from 219 refuges throughout the National Wildlife Refuge System (Table 1). Monitoring activities on refuges involved birds (54% [1063/1977]), habitat (15% [310/1977]), mammals (11% [217/1977]), amphibians and reptiles (7% [134/1977]), abiotic (environmental) conditions (6% [112/1977]), and invertebrates and fish (3% [69/1977]). The following are the 15 most frequently conducted monitoring activities on refuges reported on the questionnaire: birds - waterfowl counts, breeding landbirds, bald eagles, waterbirds, shorebirds, marsh and wading birds, waterfowl production, Christmas bird count, and grassland birds; habitat - vegetative community, invasive plants, and moist-soil vegetation; mammals - big game; amphibians and reptiles - breeding frogs and toads; and abiotic monitoring - water gauges. The 15 highest priority (ranked) biotic and abiotic monitoring activities on refuges were the following: waterfowl counts, vegetative community, breeding landbirds, waterfowl production, waterbirds, shorebirds, marsh and wading birds, bald eagles, water gauge readings, grassland birds, invasive plants, deer, brown bears, moist-soil vegetation, and raptors (Table 2). Of the 15 highest ranked monitoring activities on refuges, 9 involved birds. Waterfowl counts was the highest ranked monitoring activity on refuges throughout the National Wildlife Refuge System.

Most of the monitoring activities on refuges throughout the National Wildlife Refuge System involved a limited number of survey techniques. For the 1855 monitoring activities on refuges for which methods were reported by respondents, there were only 46 different survey techniques (Table 3). Area counts, point counts, transects, and aerial surveys were used for 73% of all monitoring activities reported by questionnaire

respondents. The most frequently reported survey technique was area counting which was used for a variety of biotic monitoring activities.

Of the 219 respondents to the questionnaire, 189 (86%) electronically stored their refuge monitoring data on a computer hard drive (Table 4). In addition to computer hard drives, some respondents also back-up monitoring data using other electronic media such as a floppy disk, Zip disk, CD-ROM, back-up tape, and/or server/network/LAN. Sixteen respondents (7%) stored data as data-entry sheets filed at the refuge without any electronic storage. Another 13 respondents (4%) had refuge monitoring data stored by another agency.

Questionnaire respondents used a variety of software for electronic storage/management of monitoring data collected on refuges. Of the 613 questionnaire responses regarding data management/storage software, 42% (259/613) identified relational databases (Table 5): Rbase (83), Access (68), FileMaker Pro (61), Dbase (33), Paradox (13), and Fox Pro (1). Forty-one percent (250/613) of the responses reported monitoring activities on refuges were electronically stored using non-relational (flat file) database software: Excel (141), Quattro Pro (81), and Lotus 123 (28). Seventy (11%) responses identified GIS programs (primarily ArcView) as data management/storage software. There were 14 (2%) responses that identified statistical programs (SAS, SPSS, SigmaStat, SysStat) as management/storage software. Seventeen responses (3%; 6 of 7 regions with ≥ 1) identified word processing programs (primarily WordPerfect) as management/storage software for monitoring data. Two responses (<1%) identified graphical software (Harvard Graphics and Power Point) as management/storage software for monitoring data. In accordance with the preference to use of database software for storage/management of monitoring data, many respondents recommended the use of Excel, FileMaker Pro, and Access for future development of specific applications to store/manage data for refuge monitoring (Table 6). Respondents also wanted databases to be user friendly and easily interface with GIS and statistical software.

Although questionnaire respondents indicated that most monitoring activities on refuges were used to make management decisions, computer programs were not frequently employed to analyze these data. Respondents indicated 74% (1286/1737) of the monitoring activities on refuges were used to make management decisions (Table 7); however, only 30% (514/1701) of the data for monitoring activities reported on the questionnaire were analyzed statistically, ranging from summary statistics (e.g., range, mean, standard deviation and error) to comparative tests (e.g., multivariate and factorial analyses of variance, t-test, regression). Respondents indicated 41% (692/1674) of the data for monitoring activities could be imported into GIS for data analyses. Similarly, 38% (662/1732) of the data for monitoring activities on refuges was geo-referenced through the use of GPS.

The questionnaire also inquired about software and hardware training needs for refuge staff responsible for collecting, storing, and analyzing data for biotic and abiotic monitoring on refuges. Most respondents (131/289 [45%]) identified the need for GIS training (Table 8). Associated with GIS, some respondents (31/289 [11%]) indicated the need for GPS training. Another 27% (78/289) and 15% (43/289) identified the need for training in the use of databases (particularly relational programs such as FileMaker Pro and Access) or statistical software, respectively. A small number of respondents wanted training for metadata documentation and management (3/289) or population modeling (3/289).

Summary and Recommendations

Refuges throughout the National Wildlife Refuge System collect monitoring data to evaluate wildlife and habitat management actions. However, only a minority of refuges actually analyze these data on computers using database, statistical, and GIS software. Inappropriate or uneffective methods for storage/management of these data likely results in infrequent computer data analyses. For example, some refuges use graphical and word processing software for management/storage of monitoring data. Some refuges store/manage monitoring data in non-relational databases that do not facilitate effective assessment of relationships between management actions and wildlife and/or habitat responses. In contrast, relational databases can effectively store/manage monitoring data with linkages to facilitate assessment of these relationships. Although only a minority of refuges throughout the National Wildlife Refuge System use relational databases to store/manage their monitoring data, most of them successfully evaluate wildlife and habitat responses relative to management actions.

In addition, questionnaire results indicate many monitoring activities are similar throughout the National Wildlife Refuge System and they utilize a limited number of survey techniques. Consequently, we recommend development of a Refuge Monitoring Data Management System to accomplish the following:

> Improve the use of monitoring data to make wildlife and habitat management decisions;
> improve efficiency of the National Wildlife Refuge System by eliminating the need for each refuge to develop its own data management system;
> facilitate analyses and summarization of biological data at the regional and national levels to aid in identifying management priorities, setting refuge system biological objectives, and improving the contribution of the National Wildlife Refuge System to biological resources; and
> facilitate exchange biological data with other organizations.

This data management system would address the storage/management of numerous types of data collected for monitoring activities on refuges. It would group biotic and abiotic monitoring data and information regarding management actions into modules with relational structure to create linkages amongst them in order to evaluate the response of wildlife and/or habitat to refuge management activities.

Table 1. Frequencies of biotic and abiotic monitoring activities (n = 186) conducted on refuges throughout the National Wildlife Refuge System.

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
BIRDS (75 different monitoring activities)								
Waterfowl counts (1)[a]	27	17	28	43	24	23	10	172
Breeding landbirds (2)	14	12	9	18	32	17	6	108
Bald eagle (4)	7	7	7	27	9	6	2	65
Waterbirds (6)	9	2	13	22	9	7	0	62
Shorebirds (7)	2	9	7	12	14	9	2	55
Marsh and wading birds (9)	1	5	14	4	19	3	0	46
Waterfowl production (11)	11	1	10	0	8	5	5	40
Christmas bird count (12)	0	7	7	7	6	8	4	39
Grassland birds (14)	0	3	8	0	14	11	0	36
Wood duck box	1	1	8	16	5	0	0	31
Raptors	5	7	4	1	5	6	2	30
Canada geese	5	1	5	4	1	4	4	24
Gulls and terns	0	4	5	4	9	1	0	23
All birds	3	3	5	0	3	5	2	21
Seabirds	16	0	0	1	1	0	1	19
Woodcock	0	0	4	0	13	0	0	17
Turkey	0	1	2	12	2	0	0	17
Ruffed grouse /mourning dove	5	2	4	0	1	4	0	16
Piping plovers	0	0	1	3	8	4	0	16
Bluebird box use	0	1	6	0	6	2	0	15
Waterfowl nests	0	0	0	0	0	13	0	13
MAPS banding	0	2	1	3	2	1	3	12

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
RCW-roost, spring tree, survey	0	0	0	11	0	0	0	11
Waterfowl pair counts	0	0	0	0	0	11	0	11
Geese	7	0	0	4	0	0	0	11
Swans	6	0	0	1	0	0	3	10
Osprey production	0	0	1	4	4	0	0	9
Goose, brant, swan production	0	0	1	2	1	5	0	9
Pheasants	1	1	0	0	0	6	0	8
Sage grouse	6	0	0	0	0	2	0	8
Canada goose broods	0	0	2	0	1	0	3	6
May bird count	0	0	4	0	2	0	0	6
Wood duck	0	0	4	1	1	0	0	6
Clapper rails	3	3	0	0	0	0	0	6
Quail	0	3	0	1	1	0	0	5
Banding	0	0	0	2	0	3	0	5
Sea bird colonies	0	0	0	0	0	0	4	4
Botulism	0	0	0	0	0	4	0	4
Brant	4	0	0	0	0	0	0	4
Black tern	0	0	3	0	1	0	0	4
Snow goose	0	0	2	0	1	0	1	4
Peregrine falcon	2	0	0	0	1	0	1	4
Snowy plover	4	0	0	0	0	0	0	4
Owls	1	2	0	0	0	0	1	4
Harlequin duck	0	0	0	0	0	0	3	3
White-faced ibis	0	1	0	0	0	2	0	3
Eiders	0	0	0	0	0	0	3	3
Loons	0	0	0	0	0	0	2	2
Sedge wren	0	0	1	0	1	0	0	2

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Saltmarsh sparrow	0	0	0	0	2	0	0	2
Nesting shorebirds	0	0	1	0	1	0	0	2
Ibis	1	1	0	0	0	0	0	2
Corvids	2	0	0	0	0	0	0	2
Schaus swallowtail	0	0	0	1	0	0	0	1
Birds on wastewater	0	0	0	1	0	0	0	1
Bayfront shorebirds	0	0	0	0	1	0	0	1
Purple martin	0	0	0	0	1	0	0	1
Prothonotary warbler	0	0	0	0	1	0	0	1
Snail kite	0	0	0	1	0	0	0	1
Scrub jay	0	0	0	1	0	0	0	1
Saw-whet owl	0	0	0	0	1	0	0	1
Northern harrier	0	0	0	0	1	0	0	1
Whipporwill	0	0	0	0	1	0	0	1
Forest birds	1	0	0	0	0	0	0	1
Tri-color blackbirds	1	0	0	0	0	0	0	1
Puffins	1	0	0	0	0	0	0	1
Band-tail pigeon	1	0	0	0	0	0	0	1
California gnatcatcher	1	0	0	0	0	0	0	1
Murres	0	0	0	0	0	0	1	1
Cormorants	0	0	0	0	0	0	1	1
Kittiwake	0	0	0	0	0	0	1	1
White-fronted goose	0	0	0	0	0	0	1	1
Henslow sparrow	0	0	0	1	0	0	0	1
Cliff swallow	0	0	0	1	0	0	0	1
OMWM monitoring	0	0	0	0	1	0	0	1
Bird Subtotal	148	96	167	209	215	162	66	1063

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
MAMMALS (34 different monitoring activities)								
Big game (8)	6	0	6	12	8	18	0	50
Small mammals	7	4	1	0	3	4	4	23
Mule deer	2	14	0	0	0	0	0	16
Predators	1	0	4	0	3	5	0	13
Black bear	1	0	0	6	1	0	3	11
Furbearers	0	0	3	2	4	0	2	11
Beaver	0	1	3	3	1	1	0	9
Pronghorn	3	5	0	0	0	0	0	8
Caribou	0	0	0	0	0	0	8	8
Bats	1	2	1	0	1	1	1	7
Moose	0	0	0	0	0	0	7	7
Prairie dog	0	1	0	0	0	5	0	6
Brown bear	0	0	0	0	0	0	6	6
Bighorn sheep	1	5	0	0	0	0	0	6
Feral horses/burros/hogs	1	3	0	0	0	0	0	4
Delmarva fox squirrel	0	0	1	0	3	0	0	4
Muskrat	1	0	0	1	0	1	0	3
Marine mammals	2	0	0	2	0	0	0	4
Wolf	0	0	0	0	0	0	2	2
Coyotes	2	0	0	0	0	0	0	2
Muskox	0	0	0	0	0	0	2	2
Elk	1	1	0	0	0	0	0	2
Northern flying squirrel	0	0	1	0	1	0	0	2
Water buffalo	1	0	0	0	0	0	0	1
Ungulates	1	0	0	0	0	0	0	1
Scrub vertebrates	0	0	0	1	0	0	0	1

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Lynx	0	0	0	0	0	0	1	1
Dall sheep	0	0	0	0	0	0	1	1
Black-footed ferret	0	0	0	0	0	1	0	1
Red wolf	0	0	0	1	0	0	0	1
Walrus	0	0	0	0	0	0	1	1
Seals	0	0	0	0	0	0	1	1
Key Largo woodrat/c.mouse	0	0	0	1	0	0	0	1
Beach mouse	0	0	0	1	0	0	0	1
Subtotal	31	36	20	30	25	36	39	217
AMPHIBIANS & REPTILES (15 different monitoring activities)								
Breeding frogs and toads (10)	0	1	6	5	27	4	1	44
Reptiles	0	0	1	19	1	0	0	21
Herptiles	6	7	3	0	2	0	0	18
Terrestrial amphibians	8	0	2	0	2	0	0	12
Amphibians	8	1	0	1	0	0	0	10
Sea turtles	0	0	0	9	1	0	0	10
Deformed frogs	0	1	5	0	2	0	0	8
Bog turtle	0	0	0	0	2	0	0	2
Cheat mountain salamander	0	0	0	0	1	0	0	1
Blue-spotted salamander	0	0	0	0	1	0	0	1
Turtles	0	1	1	0	1	0	0	3
Plymouth red-bellied turtle	0	0	0	0	1	0	0	1
Box turtle	0	0	0	1	0	0	0	1
Gopher tortoise	0	0	0	1	0	0	0	1
American crocodile nests	0	0	0	1	0	0	0	1
Subtotal	22	11	18	37	41	4	1	134
INVERTEBRATES (10 different monitoring activities)								

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Insects	0	1	4	0	4	2	0	11
Butterflies	1	0	3	1	3	3	0	11
Freshwater mussels	0	0	3	0	1	0	0	4
Monarch butterfly	0	1	1	0	1	0	0	3
Terrestrial invertebrates	3	0	0	0	0	0	0	3
Horseshoe crab	0	0	0	0	2	0	0	2
Gypsy moth egg mass	0	0	0	1	1	0	0	2
Aquatic invertebrates	1	0	0	0	0	0	1	2
Stock Island tree snail	0	0	0	1	0	0	0	1
Zebra mussels	0	0	0	1	0	0	0	1
Subtotal	5	2	11	4	12	5	1	40
FISH (3 different monitoring activities)								
Fish	3	4	6	6	3	2	3	27
Carp	1	0	0	0	0	0	0	1
Robust redhorse sucker	0	0	0	1	0	0	0	1
Subtotal	4	4	6	7	3	2	3	29
HABITAT (34 different monitoring activities)								
Vegetative community (3)	11	21	9	15	13	34	4	107
Invasive plants (12)	8	5	6	5	1	14	0	39
Moist-soil vegetation (14)	4	2	5	14	8	3	0	36
Grassland habitat	0	2	6	0	5	5	0	18
Purple loosestrife	3	0	6	0	6	0	0	15
Habitat mapping	1	0	8	0	1	0	4	14
Plant inventory	0	1	5	0	1	0	6	13
Exclosures	0	1	2	0	2	3	0	8
Rare plants	7	1	0	0	0	0	0	8
Fuel loads	0	0	1	0	1	3	2	7

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Plant seed yield	0	3	3	0	1	0	0	7
Deciduous shrubs	1	0	0	0	0	5	0	6
Wetland basin survey	0	0	0	0	0	5	0	5
Phragmites	0	0	2	1	1	0	0	4
Saltmarsh vegetation	0	0	0	0	2	0	0	2
Fire history	0	0	0	0	0	0	2	2
Beach profile	0	1	0	0	1	0	0	2
Herbaceous plants	1	0	0	0	0	0	0	1
Emergent vegetation	1	0	0	0	0	0	0	1
American gingseng	0	0	0	0	1	0	0	1
Cheat mtn. salamander habitat	0	0	0	0	1	0	0	1
Balsam wooly adelgid	0	0	0	0	1	0	0	1
Vespula	1	0	0	0	0	0	0	1
Snag	1	0	0	0	0	0	0	1
Tree mortality	1	0	0	0	0	0	0	1
San Diego ambrosia	1	0	0	0	0	0	0	1
Otay tarplant	1	0	0	0	0	0	0	1
Crow nests sites	0	0	0	0	0	1	0	1
Bird habitat preference	0	0	0	0	0	1	0	1
Aquatic vegetation	0	0	0	0	0	0	1	1
Tropical curly grass fern	0	0	0	1	0	0	0	1
Key tree cactus	0	0	0	1	0	0	0	1
Sea beach amaranth	0	0	0	1	0	0	0	1
Erosion	0	0	0	1	0	0	0	1
Subtotal	42	37	53	39	46	74	19	310
ABIOTIC FACTORS (9 different monitoring activities)								
Water gauges (5)	7	5	10	11	16	13	1	63

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Water quality	3	4	5	3	3	3	1	22
Water salinity	0	0	0	8	1	0	0	9
Weather	0	0	0	5	0	2	0	7
Snow depth	0	0	0	0	0	0	4	4
Air quality	0	0	0	3	0	1	0	4
Sea surface temperature	0	0	0	0	0	0	1	1
Permafrost depth and temperature	0	0	0	0	0	0	1	1
Soil salinity	0	0	0	0	1	0	0	1
Subtotal	10	9	15	30	21	19	8	112
OTHER (6 different monitoring activities)								
Hunter check station	0	0	8	14	2	2	1	27
Species of concern	0	12	0	0	0	5	0	17
Public use activity	0	1	4	2	1	0	3	11
Species list	0	0	8	0	1	2	0	11
All wildlife sightings	0	1	2	0	1	0	0	4
Biodiversity measurement	0	0	1	0	1	0	0	2
Subtotal	0	14	23	16	6	9	4	72
Grand total	262	209	313	372	369	311	141	1977
Number of refuges responding	29	38	35	43	37	25	12	219

[a]Number in parentheses represents one of the top 15 monitoring activities based upon total frequency of a monitoring activity.

Table 2. Rankings[a] for biotic and abiotic monitoring activities conducted on refuges throughout the National Wildlife Refuge System.

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Waterfowl counts	1.59	1.63	1.58	3.07	1.54	2.32	2.25	13.98
Vegetative community	0.59	0.97	2.58	0.65	0.81	2.52	0.92	9.04
Breeding landbirds	0.97	0.61	1.25	0.81	2.11	0.40	1.67	7.82
Waterfowl production	0.55	0.00	2.00	0.56	0.24	0.92	0.00	4.27
Waterbirds	1.38	0.13	1.25	0.53	0.49	0.28	0.00	4.06
Shorebirds	0.10	0.63	1.33	0.72	0.50	0.40	0.00	3.68
Marsh and wading birds	0.10	0.26	1.70	0.30	0.70	0.20	0.00	3.26
Bald eagle	0.07	0.11	1.25	0.91	0.16	0.16	0.50	3.16
Water gauge readings	0.07	0.18	1.25	0.23	0.51	0.40	0.00	2.64
Grassland birds	0.00	0.13	1.75	0.00	0.43	0.32	0.00	2.63
Invasive plants	0.31	0.16	1.58	0.19	0.14	0.00	0.00	2.38
Deer	0.38	0.58	1.16	0.02	0.14	0.00	0.00	2.28
Brown bear	0.00	0.00	0.00	0.00	0.00	0.00	2.08	2.08
Moist-soil vegetation	0.28	0.00	0.92	0.60	0.24	0.00	0.00	2.04
Raptors	0.10	0.42	0.67	0.00	0.16	0.16	0.25	1.76
Fish	0.00	0.03	0.43	0.14	0.03	0.00	1.08	1.71
Sensitive species	0.00	1.42	0.00	0.00	0.00	0.28	0.00	1.70
Breeding frogs and toads	0.00	0.05	0.92	0.00	0.65	0.00	0.00	1.62
Moose	0.00	0.00	0.00	0.00	0.00	0.00	1.58	1.58
MAPS banding	0.00	0.08	0.17	0.09	0.19	0.16	0.67	1.36
Piping plovers	0.00	0.00	0.00	0.19	0.78	0.36	0.00	1.33
Woodcock	0.00	0.00	0.92	0.00	0.38	0.00	0.00	1.30
Swans	0.31	0.00	0.00	0.00	0.00	0.00	0.92	1.23

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Caribou	0.00	0.00	0.00	0.00	0.00	0.00	1.17	1.17
Goose	0.00	0.00	0.00	0.14	0.00	0.00	1.00	1.14
Seabirds	0.62	0.00	0.00	0.07	0.11	0.00	0.33	1.13
Cranes	0.10	0.63	0.00	0.35	0.00	0.00	0.00	1.08
Terns	0.00	0.03	0.50	0.23	0.24	0.00	0.00	1.00
All birds	0.00	0.26	0.42	0.07	0.24	0.00	0.00	0.99
Waterfowl nesting	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.92
Furbearers	0.00	0.00	0.29	0.05	0.05	0.00	0.42	0.81
Great blue heron	0.00	0.00	0.58	0.00	0.16	0.00	0.00	0.74
Red-cockaded woodpecker	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.72
Small mammals	0.07	0.00	0.00	0.21	0.00	0.08	0.33	0.69
Wolf	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.67
Mourning dove	0.00	0.63	0.00	0.00	0.00	0.04	0.00	0.67
Invertebrates	0.00	0.00	0.37	0.14	0.11	0.04	0.00	0.66
Brant	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Pronghorn	0.28	0.32	0.00	0.00	0.00	0.00	0.00	0.60
Eider	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.58
Clapper rails	0.28	0.29	0.00	0.00	0.00	0.00	0.00	0.57
Elk	0.00	0.08	0.00	0.00	0.00	0.48	0.00	0.56
Hunter check station	0.00	0.00	0.20	0.26	0.05	0.00	0.00	0.51
Gulls and terns	0.00	0.18	0.23	0.00	0.08	0.00	0.00	0.49
Freshwater mussels	0.00	0.00	0.34	0.00	0.14	0.00	0.00	0.48
Waterfowl pair counts	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.48
Bighorn sheep	0.07	0.39	0.00	0.00	0.00	0.00	0.00	0.46
Heptiles	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Snowy plover	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.45

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Waterfowl banding	0.00	0.05	0.00	0.14	0.00	0.24	0.00	0.43
Rare plants	0.38	0.00	0.00	0.05	0.00	0.00	0.00	0.43
Sea turtles	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.42
Christmas Bird Count	0.00	0.18	0.00	0.12	0.00	0.12	0.00	0.42
Black bear	0.00	0.00	0.00	0.09	0.08	0.00	0.25	0.42
Water quality	0.07	0.05	0.00	0.26	0.00	0.00	0.00	0.38
Canada goose	0.28	0.00	0.00	0.09	0.00	0.00	0.00	0.37
Reptiles	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.37
Sage grouse	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Plant inventory	0.00	0.00	0.31	0.00	0.03	0.00	0.00	0.34
Muskox	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33
Fire history	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33
Marine mammals	0.17	0.00	0.00	0.14	0.00	0.00	0.00	0.31
Snow goose	0.00	0.00	0.11	0.00	0.03	0.00	0.17	0.31
Monarch butterfly	0.00	0.00	0.03	0.00	0.08	0.20	0.00	0.31
Terrestrial invertebrates	0.14	0.00	0.00	0.16	0.00	0.00	0.00	0.30
Forest birds	0.17	0.00	0.00	0.12	0.00	0.00	0.00	0.29
Herptiles	0.00	0.26	0.00	0.00	0.03	0.00	0.00	0.29
Harlequin duck	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.29
Quail	0.00	0.11	0.00	0.09	0.03	0.00	0.00	0.23
Bats	0.00	0.11	0.09	0.00	0.03	0.00	0.00	0.23
Terrestrial amphibians	0.00	0.00	0.14	0.02	0.05	0.00	0.00	0.21
Migrating songbirds	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.19
Water buffalo	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.17
White-fronted goose	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.17
Loon	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.17
Turkey	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.14

Monitoring Activity	Region							
	1	2	3	4	5	6	7	Total
Cheat mtn. salamander	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14
Ungulates	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Coyotes	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Delmarva fox squirrel	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14
Northern flying squirrel	0.00	0.00	0.03	0.00	0.11	0.00	0.00	0.14
Gopher tortoise	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.14
Raptors	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Scrub jays	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.09
Salinity	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.09
Bog turtle	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.08
Prairie dogs	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.08
Weather	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.07
Aquatic invertebrates	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Osprey production	0.00	0.00	0.00	0.02	0.05	0.00	0.00	0.07
Erosion	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.07
Snail kite nesting	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05
Beach disposal	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05
Saltmarsh sparrows	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05
Restoration survey	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04
Horseshoe crab	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.03
Scrub vertebrates	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02

[a]Rankings are calculated by dividing the sum of ranks for a monitoring activity (questionnaire #5) by the total number of refuges responding to the questionnaire.

Table 3. Frequencies of survey types (n = 46) used for monitoring activities conducted on refuges throughout the National Wildlife Refuge System.

Survey Method	Region							
	1	2	3	4	5	6	7	Total
Area count	113	97	34	142	137	141	40	704
Point count	23	27	13	35	135	43	28	304
Transect	32	45	11	55	30	39	14	226
Aerial survey	22	20	4	17	5	0	46	114
Visual encounter	0	3	8	28	3	8	17	67
Nest survey	9	5	5	27	6	0	15	67
Quadrat survey	5	8	4	6	17	0	11	51
Box checks	1	3	7	15	16	0	0	42
Call survey	2	16	8	2	1	0	0	29
Ground survey	4	2	10	6	1	0	4	27
Harvest survey	3	3	4	6	4	0	0	20
Banding	1	2	7	2	4	0	3	19
Mist net	3	4	1	3	3	0	3	17
Boat survey	1	4	5	0	1	0	5	16
Water gauges	7	0	0	7	0	0	0	14
Pitfall traps	5	3	2	0	2	0	0	12
Aerial photos	1	0	6	0	1	0	1	9
Spotlight survey	0	3	4	1	1	0	0	9
Fixed plots	0	0	0	9	0	0	0	9
Live trapping	6	0	0	3	0	0	0	9
Radio telemetry	0	2	0	1	0	0	5	8
Check station	0	0	0	7	0	0	1	8
Census	8	0	0	0	0	0	0	8

Fish trap	1	0	0	2	0	0	4	7
Grid	0	0	0	0	2	2	3	7
Drift fence	0	2	2	1	1	0	0	6
Point intercept	1	0	0	3	0	0	0	4
Photo points	1	2	0	0	0	1	0	4
Mark/resight	4	0	0	0	0	0	0	4
Nets and traps	0	0	0	2	0	0	2	4
Weirs	0	0	0	0	0	0	4	4
Disease	3	0	0	0	0	0	0	3
Index	0	0	2	0	1	0	0	3
Neck collars	3	0	0	0	0	0	0	3
Random plots	0	0	0	3	0	0	0	3
Routes	0	0	0	0	0	0	3	3
Spot mapping	2	0	0	0	0	0	0	2
Interview	0	0	0	0	0	0	2	2
Sweep nets	1	0	0	0	0	0	0	1
Fur seals	0	0	0	0	0	0	1	1
Electro fishing	1	0	0	0	0	0	0	1
Trail indicator	1	0	0	0	0	0	0	1
Hook and line	0	0	0	0	0	0	1	1
Harvest ticket	0	0	0	0	0	0	1	1
Cover board	0	0	0	0	1	0	0	1
Total	264	251	137	383	372	234	214	1855

Table 4. Storage and management of data from monitoring activities on refuges throughout the National Wildlife Refuge System.

Storage/management	Region							
	1	2	3	4	5	6	7	Total
ELECTRONIC								
Hard drive	25	23	26	34	43	30	8	189
Floppy disk	3	7	0	15	4	6	7	42
Zip disk	8	3	1	6	8	3	5	34
CD-ROM	3	1	0	4	4	2	5	19
Server/network/LAN	9	3	0	2	0	0	5	19
Tape	2	3	0	0	2	3	3	13
NON-ELECTRONIC								
Paper files	0	14	8	20	0	4	3	49
No electronic storage	0	4	0	7	0	5	0	16
OTHER								
Stored by other agency	2	2	0	7	0	2	0	13
Grand Total	52	60	35	95	61	55	36	394

Table 5. Software for storage and management of data from monitoring activities on refuges throughout the National Wildlife Refuge System.

Software	Region							
	1	2	3	4	5	6	7	Total
RELATIONAL DATABASES								
Rbase	15	2	22	1	42	0	1	83
Access	32	6	3	7	8	6	6	68
FileMaker	2	8	26	8	9	5	3	61
Dbase	10	4	2	3	1	8	5	33
Paradox	0	1	1	2	1	3	5	13
FoxPro	0	0	0	1	0	0	0	1
Subtotal	59	21	54	22	61	22	20	259
NON-RELATIONAL DATABASES								
Excel	53	13	12	18	19	16	10	141
Quattro Pro	43	8	6	7	4	9	4	81
Lotus 123	3	6	2	1	3	8	5	28
Subtotal	99	27	20	26	26	33	19	250
GIS								
ArcView	13	3	8	11	13	9	6	63
MapInfo	0	0	0	3	0	0	0	3
ArcInfo	0	0	0	0	0	1	1	2
Topo Scout	0	0	0	0	1	0	0	1
MIPS	0	0	0	0	0	1	0	1
MAPS	0	0	0	1	0	0	0	1
Subtotal	13	3	8	15	14	11	7	71
WORD PROCESSING								
WordPerfect	0	7	3	2	2	0	1	15

Software	Region							
	1	2	3	4	5	6	7	Total
Word	0	1	0	0	0	1	0	2
Subtotal	0	8	3	2	2	1	1	17
STATISTICAL								
SigmaStat	0	0	0	0	1	0	1	2
Systat	0	0	0	1	0	0	0	1
Statgraphics	1	0	0	0	0	0	0	1
Subtotal	1	0	0	1	1	0	1	4
GRAPHICS								
Harvard Graphics	0	0	0	0	0	1	0	1
PowerPoint	0	0	0	1	0	0	0	1
Subtotal	0	0	0	1	0	1	0	2
Grand total	173	63	88	70	111	70	50	613

Table 6. Questionnaire comments received regarding the storage/management of data from monitoring activities on refuges throughout the National Wildlife Refuge System.

Comments	Region							
	1	2	3	4	5	6	7	Total
Create database which is simple, easy to use for new staff, volunteers, and interns	1	1	2	2	5	8	1	20
Create database which integrates with GIS and statistics	2	1	2	3	6	2	2	18
Develop generic /dynamic application to address numerous procedures	0	6	3	1	3	0	0	13
The core issue still is that data entry, data analysis, and report writing are lacking at the individual biologist level due to excessive work loads, shifting priorities, and employee turnover	0	5	0	0	0	0	1	6
Provide technical support for developed databases	3	1	0	2	0	0	0	6
Develop application in widely used software.	2	0	0	0	2	0	1	5
No Corel products	0	0	0	4	0	0	0	4
If you choose to focus on one desktop data management system, we recommend that you select Microsoft Access or Corel Paradox. Please do not select FileMaker Pro; it is a poor software package with many disadvantages	0	0	0	1	0	0	2	3
Create a windows based census program	0	0	0	0	2	0	0	2

Use ESRI software	0	0	0	1	0	0	1	2
Use SAS or other satistics software	0	0	0	1	0	0	1	2
Develop some standardized database applications and data structures to be used on data sets that are generally similar among several refuges.	0	0	0	1	0	0	1	2
At a minimum, the Service should develop a “data vault”system accessible via the Intranet to store refuge biological data in a centralized permanent file archival	0	0	0	1	0	0	1	2
Many field stations, especially those with 20+ years of data, would benefit from having a database manager at the field station	0	0	0	1	0	0	1	2
Database flexibility to meet individual refuge needs	1	0	0	1	0	0	0	2
Provide field with software for databases	1	0	0	1	0	0	0	2
The Service should serve a centralized ProCite bibliographic database over the Intranet to document all published and unpublished refuge reports and data sets, including contact information for viewers to request the data from the original source	0	0	0	0	0	0	1	1
Some surveys are already standardized (e.g. BBS, MAPS, goose molting counts)	0	0	0	0	0	0	1	1
Create application which addresses non-traditional wildlife	0	0	0	0	1	0	0	1
All databases provided Service-wide or to the public should be well documented with metadata viewable by the user	0	0	0	0	0	0	1	1

Don't go overboard trying to standardize too many surveys. Databases should be user friendly and compatible with major statistical programs (such as SPSS, SAS, S+) and GIS software. More emphasis should go to getting biologists on refuges than spending to standardize software which is constantly changing	0	0	0	0	0	0	1	1
Use MicroSoft software	0	0	0	1	0	0	0	1
Window applications	0	0	0	1	0	0	0	1
Standardize database at least at ecosystem level and preferably at NWRS level	0	0	0	1	0	0	0	1
Standardize vegetation monitoring to evaluate mgmt.	0	0	0	1	0	0	0	1
Total	10	14	7	24	19	10	16	100

Table 7. Analyses and use of data from monitoring activities on refuges throughout the National Wildlife Refuge System.

Region	Is data used for mgmt. decisions?	Are statistics used to analyze data?	Is data available to import into GIS?	Is GPS used in data collection efforts?
	Y/N	Y/N	Y/N	Y/N
1	202 / 46	60 / 177	83 / 148	69 / 176
2	196 / 42	102 / 131	44 / 157	66 / 160
3	23 / 11	6 / 16	11 / 23	10 / 24
4	205/123	68/253	109/220	128/205
5	245 / 127	65 / 307	148 / 224	157 / 215
6	254 / 57	104 / 196	133 / 165	99 / 210
7	161 / 45	109 / 107	164 / 45	133 / 80
Total	1286/451 (74%)[a]	514/1187 (30%)	692/982 (41%)	662/1070 (38%)

[a]Value in parentheses represents the percentage of positive responses to a question.

Table 8. Training needs of refuge staffs associated with biotic and abiotic monitoring activities on refuges throughout the National Wildlife Refuge System.

	Region							
	1	2	3	4	5	6	7	Total
GIS	22	21	15	23	27	15	8	131
Databases	20	5	4	20	18	7	4	78
Statistics	12	5	0	10	10	5	1	43
GPS	3	9	0	12	3	4	0	31
Population modeling	0	0	0	2	0	0	1	3
Metadata documentation & mgt	0	0	0	1	0	1	1	3
Total	57	40	19	68	58	32	15	289

Appendix C: Computer Applications Evaluated by the WH9.1 Team

Monitoring Applications:

BIRDBASE: Microsoft Access® desktop application developed by the USFS. Application includes three modules for collecting bird observations, vegetation, and stand activity at the "point." [Presentation by Jorge Coppen, Edwin B. Forsythe NWR, Region 5, Oceanville, NJ]

Bird Point Count Database for Partners in Flight: Complete database management system developed by the USGS PWRC for point count data. Control access, quality control, updating, etc. are built into the system. Information on each refuge is tied to a refuge code, and a refuge biologist is in charge of data quality. Established program includes base funding for technical support and maintenance. [Presentation by Mark Wimer, PWRC, USGS, Laurel, MD]

Canada Goose and Field/Wetland Monitoring Relational Database: FileMakerPro database with three components: (1) Field/Wetland Characteristics (annual); (2) Field/Wetland Monitoring (bi-weekly); and (3) Canada Goose Monitoring (weekly). Developed for the Oregon refuges (i.e., Oregon Coast NWR Complex and Willapa NWR). A similar computer application called the **Hawaiian Islands Aquatic Resources Relational Database System** was also described. [Presentation by Kevin Kilbride, Assistant Regional Refuge Biologist, FWS Region 1, Vancouver, WA]

Census Database (Version 2.0) for Region 5: Based on input from field personnel, this application was going to be developed as the Wildlife Inventory Module for the Refuge Management Information System (RMIS). The module is written in Rbase (DOS system), and a run-time version is available for distribution to other Service users. Region 5 has been using this database application since 1994. There are a number of standardized protocols in place for data collection, and refuges are funded for tasks if they follow these procedures and use the wildlife inventory module. [Presentation by Hal Laskowski, Regional Refuge Biologist, Prime Hook NWR, FWS Region 5, Milton, DE]

North American Amphibian Monitoring Program (NAAMP): Application developed by the USGS to monitor amphibian populations throughout the eastern half of the United States by using a calling survey. Information is being collected to monitor populations of amphibians, many of which have declined in recent years. Data is also used to monitor the environmental health of wetlands, for which amphibians are excellent indicators. Numerous refuges in Regions 3, 4, and 5 are collecting this data and making it available to the USGS for the above-mentioned purposes. In addition, data are being collected at the refuge-specific level to measure amphibian responses to certain wetland management actions. [Application reviewed and evaluated by Hal Laskowski, Regional Refuge Biologist, Prime Hook NWR, FWS Region 5, Milton, DE]

Refuge Management Information System (RMIS): The RMIS is a collection of databases containing a wide variety of information of national scope needed to properly manage the NWRS. Provides access to the Maintenance Management System (MMS) and Real Property Inventory

(RPI) data. The RMIS application uses FilemakerPro as a flat file and, therefore, is not a true relational database management system. [Presentation by Mary Mixon, NWRS, FWS Region 9]

Sacramento National Wildlife Refuge Complex Biological and Habitat Management Database: Microsoft Access® application contains data entry forms for Unit Management Planned, Disease Pick-up Data, Wildlife Survey, and Incidental Wildlife Sightings. This application is somewhat unique as the refuge complex has about 200 impoundments and uses it for specific management purposes. In other words, it's not a biological monitoring tool and is "hardwired" for specific species. [Presentation by Hal Laskowski, Regional Refuge Biologist, Prime Hook NWR, Region 5, Milton, DE; application provided by Kirk Lambert, FWS Region 1, Portland, OR]

South Atlantic Migratory Bird Initiative: Web-based data entry system for refuges along the coast of Virginia, North Carolina, South Carolina, and Georgia. The primary objective is to capture waterfowl and shorebird survey results in a common database to determine movements of the two groups of birds during migration and winter for use in coordinating management among the various refuges. The database is user-friendly and well suited for its intended purpose. The database does not allow the capture of information on other groups of wildlife, nor does it allow refuges to evaluate waterfowl or shorebird response to specific habitat management actions within specified management units. In addition, the database is not a relational DBMS but rather a collection of text files, which precludes detailed use and analysis of the data with other refuge management information. However, the database is an excellent example of a grassroots effort to standardize data collection and coordinate management among refuges. [Application reviewed and evaluated by Hal Laskowski, Regional Refuge Biologist, Prime Hook NWR, FWS Region 5, Milton, DE]

Species Applications:

Biological Inventory Databases: Visual Basic application developed by the University of California-Davis has been used to produce several biological inventory databases. Clients include the U.S. and UNESCO's Man and the Biosphere Programs, the NPS, and The Nature Conservancy. Features include the automatic entry of the ITIS species code, a link to the ITIS web site, and an online tutorial that walks the novice user through the entire system. Users can enter any valid species name the system correlates the name with the current taxonomic name, even if the name is very old. As long as it was a valid published name at some point in time, the system will recognize it and crosswalk it to the new name. [Presentation by Robert Meese, Director, Biodiversity Group, Information Center for the Environment, University of California-Davis]

Environmental Conservation Online System (ECOS): Modular, Web-based system that provides access to endangered species, environmental contaminants, and habitat conservation data systems. ECOS provides a central access point for data queries, generating reports and summaries, data editing, spatial analysis tools, map generation, and data export. Developed and supported by the Service's Division of Endangered Species. [Presentation by Tim Hall, Division of Endangered Species, FWS Region 9, Washington, DC]

Fauna Module of the Natural Resource Inventory System (NRIS): Agency standard database and computer application that integrates with the other four NRIS modules and serves the terrestrial wildlife specialist community. The major components of Fuana are Data Entry (surveys and

observations, features), GIS Core Layers (automatic - provided to every forest), Basic Reports/BE Assistant, and Data Migration (database conversion). Each forest can customize its own local species list. The USFS has active partnerships with other federal agencies, including the Bureau of Land Management's National Integrated Lands System (NILS), and the Service's Breeding Bird Survey. [Presentation by Chris Frye, NRIS Fauna Module Leader, USFS, Gainesville, GA]

Nationwide Invasive Species Survey: The USGS Fort Collins Science Center is establishing the National Institute of Invasive Species Science and the new NBII Invasive Species Information Node. The National Invasive Species Survey was designed as a two-year project: Phase 1 (funded) includes the questionnaire and survey database. The Internet survey writes data directly to a relational database. Web site and results are in development. Species codes don't match Natural Resources Conservation Service or other classification schemes such as ITIS; however, quality control is being done to correct spelling and crosswalk species codes to other coding schemes.

Phase 2 (contingent on funding) will include nested-intensity field work, modeling, and tools development. The current multi-scale database design includes a relational database, a geospatial component (i.e., GIS database), and Web-based interface. If the proposed database becomes a reality, national data sets from adjacent landscapes could be linked spatially to provide lists for early detection and/or species not detected on the refuge. For example, county plant data (Biota of North America, University of NC), watershed aquatic species data (USGS Non-Indigenous Aquatic Species Database), and county disease data (USGS National Wildlife Health Center) could be combined and overlaid with refuge data to identify the gaps and prioritize field work. [Presentation by Tom Stohlgren, Fort Collins Science Center, National Institute of Invasive Species Science, USGS, Fort Collins, CO]

NPSpecies Database: This application is a documented checklist of species for each park and park status, abundance, residency, nativity, cultivation, and weedy. A needs assessment was done to identify these data elements and design the original data structure (i.e., data elements, field names, definitions, descriptions, etc.). Oracle® is the relational database management system used for the master Web-based data repository. Microsoft Access® was used to develop the desktop application and is used by the individual parks for initial data entry and subsequent data modifications. The NPS has adopted the ITIS species codes and taxonomy and have established procedures in place for requesting a new species code (i.e., TSN). [Presentation by Mark Wotawa, Biological Inventory Coordinator, Inventory and Monitoring Program, Natural Resource Information Division, NPS.

Information Technology (IT) Management Applications:

Corporate Master Table (CMT) System: Web-based application on the FWS Intranet that contains administrative data on Service organizations with official organization codes. Data stored in the CMT can be accessed and downloaded by all FWS employees for use in a variety of COTS software packages (e.g., Microsoft Access®, Microsoft Excel®, FileMakerPro, etc.). [Presentation by Barb White, National Data Administrator, Division of ITM, FWS Region 9, Lakewood, CO]

Folio Views® 4.11: Info-based system/tool allows user to search, bookmark, and note literally hundreds of textual documents. [Presentation by Ken Rice, Chief, Refuge Planning, FWS Region 7, Anchorage, AK]

Appendix D: Data Dictionary of Data Elements (Figure 1)

The recommended field name, field type, field size, and field description is identified for each data element in Figure 1. This information is followed by definitions of the field types.

DATA ELEMENT NAME	RECOMMENDED FIELD NAME	FIELD TYPE	FIELD SIZE	FIELD DESCRIPTION
ACRES	ACRES	Numeric		Acreage of the tract of land identified by UNITCODE.
HABITAT	NVCSCODE	Character	20	National Vegetation Classification System (NVCS) code for the habitat type found at a specific management unit.
MANAGEMENT CODE	MGMTCODE	Character	8	Unique code that identifies the specific type of management action (e.g., prescribed burning, flooding, drawdown, cutting, mowing, discing, ditching, etc.).
MANAGEMENT DATE	MGMTDATE	Integer	8	Date a specific management action is conducted.
MANAGEMENT NAME	MGMTNAME	Character	30	Name of a specific management action.
ORGANIZATION CODE	ORGCODE	Integer	5	Unique five-digit code assigned to a Service organization where personnel are assigned, an unstaffed land management unit, or to meet an administrative requirement.
PROTOCOL	PROTOCOL	Character	10	Unique code that identifies the specific type of biotic or abiotic survey conducted on a management unit (e.g., BBS).
PROTOCOL NAME	PROTNAME	Character	45	Name of the specific abiotic or biotic survey conducted (e.g., Breeding Bird Survey).
SPECIES CODE	TSN	Integer	6	Unique ITIS TSN for each individual species being counted.
SPECIES COUNTED	SPCOUNT	Numeric		The number of individuals of a species which are counted during a survey.
SURVEY DATE	SURDATE	Integer	8	Date of the actual survey.

DATA ELEMENT NAME	RECOMMENDED FIELD NAME	FIELD TYPE	FIELD SIZE	FIELD DESCRIPTION
SURVEY NUMBER	SURNUM	Numeric		Number assigned to a particular survey and used to link the single row of environmental data for a survey with the multiple rows of each species counted during the survey.
TRACT NUMBER	TRACTNUM	Character	10	Unique code that identifies a tract of land that contains individual land units that can be combined.
UNIT CODE	UNITCODE	Character	10	Unique code assigned to a tract of land or water that is managed as a distinct unit by the refuge.
UNIT DATE	UNITDATE	Integer	8	Date a particular management unit is identified or created. A single management unit may be split into 2 units, or 2 separate units may be combined into a single unit. The date entry is the date the unit was created or when it was combined or split.

Definitions of the field types used in this data dictionary are provided below.

Character: Items in this field type can include any of the ASCII characters, such as letters of the alphabet, numbers, punctuation markings, etc.

Integer: A subset of numeric, where decimal places are not used (i.e., a whole number).

Numeric: All items in this field type are numeric digits or items relating to numeric digits, such as a plus sign (+), minus sign (-), or decimal place (.) marker.

Appendix E.1: 270 FW 1, Service Information and Technology Architecture

1.1 What is the purpose of this chapter? This chapter describes the U.S. Fish and Wildlife Service (Service) Information Technology Architecture (SITA).

1.2 What is an information technology (IT) architecture? An IT architecture is an integrated framework that provides developers with a standard infrastructure for data, security, hardware, and software as a basis for managing information and developing and maintaining information systems. The aim is to improve the productivity, efficiency, and effectiveness of the Service by aligning information resources with the business of the Service to achieve the strategic goals and information resources management goals.

1.3 Why do we have an IT architecture? Federal and Departmental policies mandate the establishment of an IT architecture program in the Service. The most important ones are:

A. Information Technology Management Reform Act of 1996 (ITMRA or Clinger-Cohen).

B. OMB Circular A-11, Part 3 , Planning, Budgeting, and Acquisition of Capital Assets.

C. OMB Circular A-130 , Management of Federal Information Resources.

1.4 To whom does this chapter apply? This chapter applies to all Service Regions and programs that acquire, manage, and use information resources.

1.5 What is the Service policy on architecture?

A. Managers will ensure that their acquisition, management, and use of information resources comply with SITA. Exceptions must be reported as part of project management documentation required by 270 FW 2.

B. SITA will be consistent with and support the Department's IT architecture.

1.6 Where can SITA standards be found? We publish SITA standards on the Service Intranet.

1.7 How can new standards be nominated for inclusion in SITA? The SITA document defines the process for making changes.

1.8 Who is responsible for implementing the provisions of this chapter?

A. Assistant Directors and Regional Directors will ensure that their staffs implement these policies and procedures.

B. The **Chief Technology Officer** (CTO) will:

(1) Appoint the Service's Chief IT Architect.

(2) Ensure that SITA supports Service and Departmental mission goals.

C. The **Chief IT Architect** will:

(1) Maintain and update SITA to assure that it reflects the most current, secure, and efficient technology for supporting Service mission goals.

(2) Ensure that information system owners and Regional CTOs have the opportunity to review and comment on proposed modifications to SITA.

(3) Communicate changes in SITA to Regional and program managers, system owners, Regional CTOs, and IT coordinators.

(4) Advise information system owners on opportunities for data integration and sharing.

(5) Certify that information systems are SITA-compliant.

(6) Coordinate with the Department to ensure that SITA supports the Department's IT architecture, and resolve conflicts.

D. Information system owners will ensure that information systems under their management are in compliance with SITA.

E. Regional CTOs and IT Coordinators will:

(1) Support the implementation of SITA standards within their areas of responsibility.

(2) Coordinate with programs to communicate the SITA standards within their areas of responsibility.

(3) Identify priorities in their areas of responsibility for consideration in the development and revisions of SITA.

1.9 What terms do I need to know?

A. Chief Technology Officer (CTO). The official responsible for coordinating IT issues on a Servicewide basis and for ensuring that information resources support the Service's strategic missions. The CTO is the Chief, Division of Information Technology Management - Washington Office.

B. Information System. A discrete set of information and IT organized for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information. Information systems include local and wide area networks, telecommunications systems, electronic mail systems, geographic information system (GIS) projects, data creation projects, databases, and radio projects.

C. Information System Owner. The manager who makes the decision to fund the information system and who is responsible for development, acquisition, operation and maintenance of the system.

D. Information Technology (IT). Any equipment or interconnected system or subsystem of equipment used in the automatic acquisition, storage, manipulation, management, movement,

control, display, switching, interchange, transmission, or reception of data or information. Typically, IT includes hardware and software pertaining to computers, telecommunications, networks, and radio equipment.

E. IT Coordinator. A person designated by a program or office to coordinate IT issues between that program or office and the cognizant CTO.

F. Service Information and Technology Architecture (SITA). The set of Service standards, policies, and procedures that align IT with the Service's mission and goals and guide information system owners and developers so they know the IT infrastructure that is supported in the Service.

G. Regional CTO. The person designated by each Region to coordinate IT issues between that Region and the Division of ITM.

Appendix E.2: 270 FW 2, Automated Information Systems Capital Planning and Management

2.1 What is the purpose of this chapter? This chapter defines Fish and Wildlife Service (Service) policies for planning and managing investments in information technology (IT) and automated information systems (AIS). The goal is to ensure that Service investments in IT and AIS are made, managed, and documented on a sound business basis, reflect strategic goals of the Service, and comply with applicable Service, Departmental, and Federal policies. The aim is to improve the productivity, efficiency, and effectiveness of Service programs by ensuring that investments in IT and AIS are linked to mission and budget and are managed in accordance with validated business processes.

2.2 To whom does this chapter apply? This chapter applies to Regions, California/Nevada Operations Office (CNO), and all Service offices that initiate and fund IT and AIS, or deploy IT in support of Department of the Interior mandated AIS.

2.3 How does this chapter relate to other Service policies? This chapter deals with the general requirements for initiating and funding an AIS to become part of the Service's IT investment portfolio and for managing its life cycle. 270 FW 1 states policy on IT architecture with which Service systems must conform. 270 FW 4 articulates the requirements to integrate periodic reviews into the life cycle. 270 FW 7 focuses on specific IT security requirements that are a critical part of a system's life cycle.

2.4 What is our authority for taking this action? There are several Federal and Departmental laws and guidelines that mandate the establishment of an IT capital planning program in the Service. The most important ones are:

A. Government Performance and Results Act (GPRA) of 1993, Pub. L.103-62**.**

B. Information Technology Management Reform Act of 1996 (ITMRA or the Clinger-Cohen Act)**.**

C. OMB Circular A-11, Parts 2, 6, and 7.

D. OMB Circular A-130

2.5 What is the Service's policy on IT planning and management?

A. Every Service major application (MA) and general support system (GSS), as defined in paragraph 2.7, must be properly documented by a project charter and tracked in the Service's Catalog of Automated Information Systems (CAIS) (see paragraph 2.8).

B. Annual multi-year funding information for every MA and GSS must be tracked in the Service's IT Investment Portfolio (OMB Circular A-11, Exhibit 53). Information must include the annual costs of development, modernization, enhancement, maintenance, and other related activities. This requirement also pertains to Service deployment of IT in support of Departmentally mandated AIS.

C. Major IT investments, as defined in paragraph 2.7, must be documented and kept up to date by a Capital Asset Plan and Business Case in the format of OMB Circular A11, Exhibit 300. All other

MA and GSS must be documented and kept up to date by a Project Profile in the format of Exhibit 300-1 (“300 lite”).

D. Project documentation for MA and GSS described in 2.5A and 2.5C must be circulated to the Chief Technology Officer (CTO) Council for review, and the Service CTO will review and approve projects (see paragraph 2.6).

E. All MA and GSS will follow a documented life cycle methodology (see paragraph 2.10).

2.6 Who is responsible for implementing the provisions of this chapter?

A. Regional Directors; Manager, CNO; Chief, Law Enforcement; and Assistant Directors are responsible for ensuring that their staffs implement these policies and procedures.

B. The **Service IT Capital Planner** is responsible for:

(1) Gathering and maintaining information for the Service's IT investment portfolio and the CAIS to reflect new and updated information on MA and GSS on an annual basis.

(2) Reviewing and circulating project charters to Regional/CNO and Program CTO’’s for review and comments, incorporating comments, and preparing the project package for approval by the Service CTO.

(3) Providing updates to the Department's IT Investment Portfolio (reported in OMB Circular A-11, Exhibit 53).

(4) Coordinating the submission and updates of Business Cases (Exhibit 300) and Project Profiles (Exhibit 300-1) for the Service’’s major applications and GSS to the Department.

C. The **Service Chief Technology Officer** is responsible for:

(1) Designating Service AIS as major applications and GSS.

(2) Designating whether or not an MA or GSS is a major investment.

(3) Advising AIS owners on compliance with Service IT standards and architecture and opportunities for data integration and sharing.

(4) Elevating to the CTO Council for resolution issues that raise questions about proceeding with development.

D. AIS Owners and Project Managers are responsible for:

(1) Ensuring that the planning, budgeting, staffing, acquisition, development, implementation, and maintenance of AIS under their management are in compliance with OMB Circular A-11, Section 300; OMB Circular A-130; 270 FW 7; 270 FW 1; and 270 FW 4 .

(2) Ensuring that project charters are prepared (see paragraph 2.8) and kept up to date for all of their systems.

(3) Ensuring that Business Cases in the format of OMB Circular A-11, Exhibit 300 are prepared for their major IT investments and kept up to date.

(4) Ensuring that Project Profiles in the format of Exhibit 300-1 (“300 lite”) are prepared for their non-major IT investments and kept up to date.

(5) Ensuring that project charters for new MA and GSS and their Capital Asset Plans or Project profiles are submitted to the Service’’s IT capital planner for review (see paragraph 2.9).

(6) Following a life cycle methodology for their MA and GSS (see paragraph 2.10).

(7) Providing (generally on an annual basis) funding information and updated copies of Capital Asset Plans and/or Project Profiles to the Service IT capital planner to update the Service's IT investment portfolio. Documenting whether funding sources of increased AIS expenditures are from existing base budgets or are reflected in new budget requests.

(8) Ensuring that their MA and GSS are accurately described in the CAIS by providing the Service CTO with an updated description annually.

(9) Ensuring that their AIS incorporate the IT security provisions described in 270 FW 7, including the requirement that MA and GSS have system security plans and are properly certified and accredited.

E. Regional/CNO and Program CTO’’s are responsible for:

(1) Commenting on project charters circulated for review by the Service CTO.

(2) Supporting the implementation of chartered AIS within their Region/CNO or Program.

F. The **CTO Council** will:

(1) Review Capital Asset Plans prior to submission to the Department.

(2) Resolve issues that raise questions about proceeding with development, such as the classification of a system as a major IT investment, or compliance with Service IT standards and architecture.

(3) Review and approve major IT investments, other than Departmentally mandated systems, on the basis that the investment serves Service goals in a cost effective manner.

G. User Acceptance Teams are responsible for:

(1) Defining and developing functional requirements.

(2) Participating in the evaluation and testing of the system.

(3) Recommending to the AIS owner whether or not to accept the system.

2.7 What special terms do I need to know?

A. Automated Information System (AIS). A discrete set of information and IT organized for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information. AIS’’s include, but are not restricted to, local and wide area networks, telecommunications systems, electronic mail systems, geographic information system (GIS) projects, data creation projects, databases, and radio projects. See the definitions of “major application” and “general support system”” for two important kinds of AIS.

B. AIS Life Cycle. The period of time from the conception of an AIS through implementation, operations, and maintenance to retirement.

C. AIS Life Cycle Costs. The total cost expended for an AIS over all stages of its life cycle, including equipment, salaries, contracts, training, etc.

D. AIS Project Manager. The person appointed by the AIS owner who is responsible for direct management of all aspects of the system's development and life cycle.

E. AIS Owner. The senior management official having overall functional responsibility for the program or activity in which a specific AIS is conceived, planned, funded, developed, acquired, operated and maintained. The AIS owner is at least one supervisory level above those who are responsible for system development.

F. Catalog of Automated Information Systems (CAIS). A database describing AIS owned by the Service. The CAIS is available to Service personnel to enable them to learn what systems exist in the Service and to avoid duplicating systems and data.

G. Chief Technology Officers (CTO) Council. The group that will fulfill oversight requirements of the Clinger-Cohen Act and OMB Circular A-11 and which is comprised of the Service CTO, Regional/CNO CTO''s, and Program CTO''s, as well as a rotating member from the Deputies Group (Deputy Assistant Directors and Deputy Regional/CNO Directors) and a rotating member who is an Assistant Regional Director Budge t and Administration. The CTO Council reviews and advises the Directorate on proposed AIS, and makes budgetary and deployment recommendations to the AIS owner and the Director based upon overall Service priorities and requirements.

H. Financial System. An AIS used for any of the following:

(1) Collecting, processing, maintaining, transmitting, and reporting data about financial events.

(2) Supporting financial planning or budgeting activities.

(3) Accumulating and reporting cost information.

(4) Supporting the preparation of financial statements.

I. General Support System (GSS). Term from OMB Circular A-130, Appendix III, meaning an interconnected set of information resources under the same direct management control that shares common functionality and normally includes hardware, software, information, data, applications, communications, and people. Examples are local and wide area networks, telecommunications systems, and electronic mail systems.

J. Information Technology (IT). Any equipment or interconnected system or subsystem of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information. Typically, IT includes hardware and software pertaining to computers, telecommunications, networks, and radio equipment.

K. IT Capital Asset Plan. A formal plan in the format of OMB Circular A-11, Exhibit 300, that documents the information that will be used to design a major IT investment, to assess the benefits and risks of alternative solutions, and to establish realistic cost, schedule and performance goals.

L. IT Investment Portfolio . An inventory of existing MA and GSS that captures annual costs of development, modernization, enhancement and maintenance. The Service reports its IT Investment Portfolio to the Department in Exhibit 53 of OMB Circular A-11.

M. IT Project Profile . A formal description of an IT Project in the form of Exhibit 300-1 ("300 lite") used by the Department to document non-major IT investments.

N. Major Application (MA). Term from OMB Circular A-130, Appendix III, meaning an application that requires special attention to security due to the risk and magnitude of the harm resulting from the loss, misuse, or unauthorized access to or modification of the information in the application. Do not confuse this term with the term "major IT investment" defined below to designate certain levels of capital investment for a system. Applications that meet any of the following criteria will be considered by the Service to be MA:

(1) Runs over a Service or Departmental network.

(2) Is shared by more than one Region/CNO or Program.

(3) Requires user authentication for access.

(4) Is a financial system.

(5) Access to data could benefit someone financially.

(6) Is a personnel/payroll system.

(7) Contains privacy data.

(8) Contains Indian trust data.

(9) Total life cycle costs exceed $1M.

(10) Interfaces with other Federal, State, or local governments.

(11) Supports critical Federal activities like law enforcement or fire management.

O. Major IT Investment . As defined by OMB Circular A-11, an AIS that requires special management attention because of its (1) importance to a Service mission; (2) high development, operating or maintenance costs; or (3) high risk systems that have a significant role in the administration of Service programs, finances, property, or other resources. A system will meet criterion (2) if its total life cycle costs (development, operating, and maintenance) exceed $35M (or annual cost of $500,000 for financial systems). Do not confuse this term with "major application" defined above.

P. Program Chief Technology Officer (Program CTO). A person designated by a Program or office to coordinate IT issues between that Program or office and the Division of ITM.

Q. Regional/CNO Chief Technology Officer (Regional CTO). The person designated by each Region/CNO to coordinate IT issues between that Region/CNO and the Division of ITM.

R. Service Chief Technology Officer (Service CTO). The official who is responsible for coordinating IT issues on a Servicewide basis and for ensuring that information resources support

the Service's strategic missions. The Service CTO is the Chief of the Division of Information Resources and Technology Management - Washington Office.

S. Service Information Technology Capital Planner. The person designated by the Service CTO to be responsible for IT capital planning and investment control coordination in the Service, as required by OMB Circular A-11 and the Department.

T. User Acceptance Team. Team comprised of representatives from the user community that have the appropriate expertise to define and assess functional requirements for an AIS.

2.8 What is a project charter? A project charter must be prepared for all MA and GSS using FWS Form 3-2230 (Project Charter). Charters are also recommended for other systems. The charter ensures that the AIS owner has a thorough understanding of the system before investing resources in development. The project charter is also used to communicate plans for the system within the Service IT community to avoid duplication, to facilitate partnerships, and to ensure a thorough understanding within the IT community of the proposed system's impact on existing Servicewide and Regional network infrastructures. A charter provides the raw material for creating the initial description of the system in the CAIS. This document is also a vehicle for the Service Chief Technical Officer to communicate any concerns or issues concerning the system to the owner. Finally, it is the vehicle whereby the Service CTO will certify the compliance of the system with Service and Departmental IT standards and architecture as well as recommend whether the system should be considered a major IT investment. Project charters are not static documents and need to be updated as systems change.

2.9 What is the process for reviewing project charters?

A. The owner of an MA or GSS will submit a project charter to the Service''s IT capital planner in the Division of Information Technology Management. If it is a major IT investment as defined in paragraph 2.7, the owner must attach a Capital Asset Plan in the format of OMB Circular A-11, Exhibit 300 and any pertinent supporting documentation, such as Federal Register notices, Privacy Act notices, supporting laws, etc. All others must have a Project Profile in the format of Exhibit 300-1 ("300 lite") attached.

B. The Service''s IT capital planner will circulate the charter and accompanying documentation by electronic mail to the Regional/CNO and Program CTO''s for review and comments for a period of 10 working days. Major IT investments may require additional time for review, but the period will not exceed 30 calendar days.

C. The Service''s IT capital planner will consolidate comments on the charter and submit it to the Service CTO for approval.

D. The Service CTO will recommend whether to proceed with the project as described, to proceed with recommended changes, or to terminate the project.

E. After CTO signature, the IT capital planner will return the charter with comments and recommendations to the system owner and enter project information into the CAIS.

F. If the Service CTO has an unresolved disagreement with the system owner on an issue that raises a question about proceeding with development, the system owner may document the disagreement and ask the CTO to submit the charter to the CTO Council for resolution.

2.10 What is the Service's Life Cycle Management policy? System owners should use an evolutionary methodology that reflects current information technologies such as the Internet, that can accommodate changes in information needs and technologies during the development and operation of a system, and that supports rapid prototyping. The following sequence describes the minimal requirements for development of any MA or GSS. All stages must be well documented.

A. Identify the problem or need, based on plans and priorities of a Service office or Program.

B. Review the AIS in the CAIS before beginning development of a new system in order to avoid duplicating an existing system or a system under development.

C. Appoint a project manager and a user acceptance team. The project manager should be trained in Systems Development Life Cycle Methodology. In order to achieve a broad range of feedback, the user acceptance team should be comprised of technical staff, end users, program personnel, and management. General SDLC guidance for IT systems can be found in the Service SDLC Guidebook.

D. Clearly define what results are required to satisfy the need, and what resources (staff/funding) are available.

E. Create a project charter for the system (and a Capital Asset Plan for major IT investments) using FWS Form 3-2230 (see paragraph 2.8) and submit it for review per paragraph 2.9. Revise the charter if necessary. Documentation should include, where appropriate, items that address the following:

(1) Privacy and records management to ensure that the system has effective security controls and authentication tools to protect privacy and that the processing of personal information is in compliance with the Privacy Act of 1974 and other relevant Government wide and agency policies.

(2) The Government Paperwork Elimination Act (GPRA) to ensure considered feasibility of an option to conduct those transactions electronically and to maintain electronic records of the transactions.

(3) Section 508 of the Rehabilitation Act Amendments of 1998, which require that information technology be accessible to disabled employees as much as practicable.

F. Define performance measures that allow comparison of actual performance to expected results.

G. Define control processes that will be used to assure that project budget, schedule, and quality are met.

H. Evaluate alternative solutions and select an appropriate one.

I. Establish a project plan by documenting the schedule and strategies for design, development, acquisition, testing, training, deployment, and maintenance. Include all relevant phases and milestones, including hardware and software to be procured, and applications to be developed. For each phase/milestone, describe the criteria of success that will be used to evaluate progress and to justify funding the next phase/milestone. Determine costs of each phase. Plan and budget for IT security (see 270 FW 7).

J. Build and acquire a system that will produce the results described in the project charter and other project documentation.

K. Develop IT security documentation as required by 270 FW 7 .

L. Test the system and its security features to make sure it works, based on feedback from the user acceptance team.

M. Formally certify and accredit the system in accordance with Service and Departmental requirements.

N. Implement the system and train employees to use it properly.

O. Review the system and its documentation periodically to ensure that they are kept current, measure actual performance against performance goals, and make changes as necessary based on feedback from the user acceptance team. Provide updates to the Service CTO to reflect changes for the CAIS.

P. Perform periodic independent reviews or audits of IT security controls in the system security plan (see 270 FW 7) at least every 3 years or when significant changes are made to the system. See 270 FW 4 and NIST Special Publication 800-26, "Security Self-Assessment Guide for Information Technology Systems," for further information.

Appendix F: Comparison of Capabilities Between Species Applications

Y denotes capability exists **L** denotes limited capability **U** denotes unknown or uncertain
***** denotes in progress " **blank**" field denotes no capability

Capability	**UC-Davis Species**	**NPSpecies**	**FS NRIS Fauna**	**FWS ECOS**	**USGS Invasive Species** [1]
"auto fill" (data entry)	Y				
"automated" data upload			Y	Y	
baseline data provided to field			Y		
bibliographic module		Y			
data entry template	Y		Y	*	
data acquisition process		Y			
data migration/mgt. tools		Y	Y		
desktop application	Y	Y	Y		
DOI bureau		Y		Y	Y
easily applied to FWS NWRS		Y			
established program/funding		Y	Y	Y	
export formats	U	L*	L	L	
habitat component	Y	*	Y	Y	
historical data		L	L	Y	
international scope	Y				
I&M tool	Y	Y	Y		
ITIS species codes (TSN)	Y	Y	Y	Y [2]	
links to other species databases	Y	L	Y		

[1] Invasive Species database is in the conceptual design phase.

[2] ECOS maintains crosswalk with ITIS codes, which are utilized for all non-T&E species.

Application Functions/ Capabilities (continued)	**UC-Davis Species**	**NPSpecies**	**FS NRIS Fauna**	**FWS ECOS**	**USGS Invasive Species**[3]
links to other data/information	Y	Y	Y	Y	
metadata	U	Y	Y	Y	
modular design		Y	Y	Y	
national roll-up/summary		Y			
online application		Y	Y	Y	
online tutorial			Y		
public domain		Y	Y	Y	
quality control process		Y	Y	Y	
query tools			Y	Y	
references	Y	Y	L		
relational DBMS	U	Y	Y	Y	
reporting capability		Y	Y	Y	
spatial component	L	Y	Y	Y	
species modifiers	Y	L			
species status	Y	?	Y		
standard data collection protocols			L		
support and maintenance		Y	Y	Y	
species documentation	Y	Y		Y	
system documentation		Y	Y	Y	
update process	L	Y	Y	L	
user friendly	Y	Y	L	L	
value added		L	Y	Y	Y
Web-based delivery tool		Y	Y	Y	

[3] USGS Invasive Species database is in the conceptual design phase.

Appendix G: Projected Costs for Sun/Oracle Solution (5-Year Period)[1]

Cost Category	Year 1	Year 2	Year 3	Year 4	Year 5
Hardware	787,245	0	0	0	0
Hardware Maintenance	15,708	15,708	15,708	15,708	15,708
DBMS (Oracle)	640,000	0	0	0	0
Multi-Dimensional Database (MDDB)	384,000	0	0	0	0
Data Mining	320,000	0	0	0	0
Oracle DBMS/Solaris Operating System (OS) Maintenance/Update Agreement	352,000	352,000	352,000	352,000	352,000
Application Developer	70,907	70,907	70,907	70,907	70,907
OS Administrator	117,217	117,217	117,217	117,217	117,217
Data Base Administrator	211,306	211,306	380,351	380,351	380,351
Total Cost Per Year	2,898,383	767,138	936,183	936,183	936,183
Grand Total All Years					**6,474,070**

Hardware:

Initial equipment costs based on Sun Workstation with Solaris 8 OS. Additional hardware costs (not shown) would include a separate server for the business intelligence solution (e.g., Cold Fusion, Java, or ASP) and sufficient disk storage (estimate 6 terabytes, i.e., 1000 gigabytes).

Software:

DBMS (Oracle) - Initial software cost and 5 years of annual maintenance (including update/maintenance costs for Solaris OS. Cost estimates reflect commercial market price, which may be different from Government purchase/maintenance agreements.
MDDB - Tool that stores data in predefined summaries for scheduled data transfers to database users.
Data Mining - Process of analyzing data to identify unknown or unsuspected trends and established business patterns. This technology is more suited for biological research.

Application Developer: Ongoing cost for system/application development, database creation, enhancements, maintenance, etc.

OS Administrator: Ongoing cost for systems administration (software installation, OS upgrades, patches, security, etc.).

Database Administrator: Ongoing cost for database administration (table creation, updates and maintenance, data backups, data retrieval, etc.).

[1] Based on "Cost Analysis of Sun/Oracle and Unisys/Microsoft for a BI Solution in a VLDB Environment," February 2002; prepared by the Walklett Group (http://www.walklett.com/news/Whitepapers.htm).

Appendix H: Projected Costs for Unisys/Microsoft Solution (5-Year Period)[1]

Cost Category	Year 1	Year 2	Year 3	Year 4	Year 5
Hardware	406,925	0	0	0	0
Hardware Maintenance	12,480	12,480	12,480	12,480	12,480
DBMS (MS SQL Server 2000); includes Multi-Dimensional Database (MDDB) and Data Mining	319,984	0	0	0	0
MS Operating System (OS) Maintenance/Update Agreement	31,044	31,044	31,044	31,044	31,044
MS SQL Server 2000 Maintenance/Update Agreement	158,904	5,880	158,904	5,880	158,904
Application Developer	77,407	77,407	77,407	77,407	77,407
OS Administrator	108,920	108,920	108,920	108,920	108,920
Data Base Administrator	120,784	120,784	120,784	120,784	120,784
Total Cost Per Year	1,236,448	356,515	590,061	437,037	590,061
Grand Total All Years					3,210,122

Hardware:

Initial equipment costs based on a Unisys Enterprise Server running MS Windows 2000 Datacenter Server as its OS. Additional hardware costs (not shown) would include a separate server for the business intelligence solution (e.g., Cold Fusion, Java, or ASP) and sufficient disk storage (estimate 6 terabytes, i.e., 1000 gigabytes).

Software:

DBMS (MS SQL Server 2000) - Initial software cost and 5 years of annual maintenance. Cost estimates reflect commercial market price, which may be different from Government purchase/maintenance agreements.
MDDB - Tool that stores data in predefined summaries for scheduled data transfers to database users.
Data Mining - Process of analyzing data to identify unknown or unsuspected trends and established business patterns. This technology is more suited for biological research.

Application Developer: Ongoing cost for system/application development, database creation, enhancements, maintenance, etc.

OS Administrator: Ongoing cost for systems administration (software installation, OS upgrades, patches, security, etc.).

Database Administrator: Ongoing cost for database administration (table creation, updates and maintenance, data backups, data retrieval, etc.).

[1] Based on "Cost Analysis of Sun/Oracle and Unisys/Microsoft for a BI Solution in a VLDB Environment," February 2002; prepared by the Walklett Group (http://www.walklett.com/news/Whitepapers.htm).

Glossary of Acronyms

AOU	American Ornithological Union
BBL	Bird Banding Laboratory
BBS	Breeding Bird Survey
CAIS	Catalog of Automated Information Systems
CAP	Cooperative Agreements Program
CFM	Contracting and Financial Management
CMT	Corporate Master Table
COTS	Commercial-off-the-shelf
CSDGM	Content Standard for Digital Geospatial Metadata
DOI	Department of the Interior
FGDC	Federal Geographic Data Committee
FIPS	Federal Information Processing Standards
GIS	Geographic Information Systems
IT	Information Technology
ITIS	Integrated Taxonomic Information System
ITM	Information Technology Management
NBII	National Biological Information Infrastructure
NCTC	National Conservation Training Center
NPS	National Park Service
NSDI	National Spatial Data Infrastructure
NWRS	National Wildlife Refuge System
NWRSIA	National Wildlife Refuge System Improvement Act
ODBC	Open Database Connectivity
OIM	Office of Information Management and Technology
OMB	Office of Management and Budget
PWRC	Patuxent Wildlife Research Center
RMIS	Refuge Management Information System
RO	Regional Office
SITA	Service Information and Technology Architecture
SOW	Scope of Work
TSN	Taxonomic Serial Number
TWG	Taxonomy Work Group
USGS	U.S. Geological Survey
WO	Washington Office

Abiotic: Non-living thing. Usually refers to the physical and chemical components of an organism's environment.

Adaptive Management: Systematic process for continually improving management policies and practices by learning from the outcomes of operational programs.

Application: A program or group of programs designed for end users, such as database programs, word processors, and spreadsheets. Figuratively speaking, application software sits on top of systems software because it is unable to run without the operating system and system utilities.

Biological: Of, pertaining to, caused by, or affecting life or living organisms.

Biotic: Referring to life or specific life conditions.

Commercial-off-the-shelf (COTS): Describes software or hardware products that are ready-made and available for sale to the general public. COTS products are designed to be implemented easily into existing systems without the need for customization.

Corporate Information Center: Intranet web site for Service employees to locate information on spatial and tabular data, policy, guidance, technical information, systems development, contracts, and geographic information system Internet and Intranet resources.

Corporate Master Table (CMT): Official repository of administrative data on Service organizations. Information in the CMT includes, but is not limited to, organization codes and names, organization name abbreviations, ecosystems, mailing and physical/shipping addresses, telephone, TTY, and fax numbers, as well as information on States, counties, and congressional districts. Use of the CMT is mandatory when officially publishing or sharing this information.

Data architecture: Overall structure of a data resource that provides a consistent foundation across organization boundaries to provide easily identifiable, readily available, high-quality data to support the information demand.

Data characteristic: Individual characteristic or attribute that describes a data entity, data subject, or data file.

Data dictionary: A tool to aid the design, administration, and maintenance of a database management system. The dictionary can be consulted to obtain information relevant to any name used to describe a data element in the system. When elements for a data dictionary are standardized, information is collected consistently and can be compiled, integrated, and analyzed across all units that are using the system.

Data element: Item that contains data values. A data element can be an individual field in a data record, a data column in a relational database management system, a column in a flat file, an attribute used to describe spatial data, or a row or column in a spreadsheet.

Data quality: The quality, or accuracy, of the data values.

Data set: One or more data elements and associated data values. Examples of data sets are a database containing a mailing list or a flat file containing taxonomic names.

Data standard: A definition or format that has been approved or adopted for the purpose of sharing data between organizations. A standard is commonly used and accepted as an authority.

Data steward: The person responsible for a data standard and associated data. In this role, a data Steward is charged by management to develop and maintain the data standard and associated data, and to counsel Service personnel on the proper use of both. This individual must have a thorough knowledge of the subject matter of the standard, provide accurate and current electronic copies of data relevant to the standard, and weigh the pros and cons of comments received during the review process.

Data structure: Representation of the arrangement, relationship, and contents of data subjects, data entities, and data files in the common data architecture. In simple terms, a scheme for organizing related pieces of information.

Data table: A physical file of data in a relational database management system.

Data type: Describes the data values of a data element. Different types of data values include character, date, integer, time, real, etc.; definitions for these data types are provided below.

Alpha - items in this field type are letters of the alphabet; no other ASCII characters are included..
Character - items in this field type can include all ASCII characters, such as letters of the alphabet, numbers, punctuation markings, etc.
Integer - a subset of numeric (see below), where decimal places are not used: a whole number.
Numeric - items in this field type are numeric digits or items relating to numeric digits, such as a plus sign (+), minus sign (-), or decimal place(.) marker.
Real - a subset of numeric that requires decimal places. The number of places should be defined.

Data value: A single piece of information. Examples of data values are names, dates, or dollar amounts.

Database: A collection of information organized in such a way that a computer program can quickly select desired pieces of data.

Database management system (DBMS): A collection of programs that enables the end user to store, modify, and extract information from a database. The terms relational, network, flat, and hierarchical all refer to the way a DBMS organizes information internally.

Ecosystem: An ecological community together with its physical environment, considered as a unit.

Federal Geographic Data Committee (FGDC): A federal level committee mandated by OMB Circular A-16 to oversee data standards at the federal level, and to implement the National Spatial Data Infrastructure.

Functional requirements: The services, tasks, or functions that a software system or product is required to perform. In product development, it is useful to distinguish between the "baseline functionality" necessary for any system to complete in that product domain, and "features" that differentiate the system from competitors' products, and from variants in the company's own product line. Features may be additional functionality, or differ from the basic functionality along some quality attribute, such as performance or memory utilization.

Geographic information system (GIS): A computerized system for analyzing and displaying map-related information (spatial data).

Information system: A discrete set of information and technology organized for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information. Information systems include local and wide area networks, telecommunications systems, electronic mail systems, geographic information system projects, data creation projects, databases, and radio projects.

Information technology (IT): Any equipment or interconnected system or subsystem of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information. Typically, IT includes hardware and software pertaining to computers, telecommunications, networks, and radio equipment.

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.

Intranet: A network (based on a suite of communications protocols used to connect computer systems on the Internet) belonging to an organization and accessible only by the organization's members, employees, or others with authorization. An intranet's Web sites look and act just like any other Web sites, but the firewall surrounding an intranet prohibits unauthorized access.

Inventory: Determines the presence, relative abundance, and/or distribution of species at a particular time.

Metadata: Documentation about the data resource (i.e., its content, quality, format, condition, history, availability, and other characteristics), and is essential for understanding information stored in data warehouses, such as the National Spatial Data Infrastructure (NSDI). The creation of metadata and the format used are mandated by Executive Order 12906 and the FGDC Content Standard for Digital Geospatial Metadata.

Module: In software, a module is a part of a program. Programs are composed of one or more independently developed modules that are not combined until the program is linked.

Monitoring: Determines the status and/or demographics of species over time.

National Spatial Data Infrastructure (NSDI): A clearinghouse mandated by OMB Circular A-16 for the discovery and sharing of spatial data on the Internet, designed to reduce duplication of effort, to speed data access, and to distribute spatial data collected by Federal agencies to the public.

Open database connectivity (ODBC): A standard database access method developed by Microsoft Corporation. The goal of ODBC is to make it possible to access any data from any application, regardless of which DBMS is handling the data. ODBC manages this by inserting a middle layer, called a database driver, between an application and the DBMS. The purpose of this layer is to translate the application's data queries into commands that the DBMS understands.

Query, report writing, and database access tools: Software programs used to query and retrieve data from existing databases and write reports. These tools can be COTS products or integrated with customized applications. Examples of these tools are Microsoft Access, Microsoft Excel, Lotus 1-2-3, and custom-written programs using ODBC and Structured Query Language (SQL).

Relational database management system (RDBMS): A database management system designed to store and manage in the form of related tables. Relational databases are powerful because they require few assumptions about how data is related or how it will be extracted from the database. As a result, the same database can be viewed in many different ways. An important feature of relational systems is that a single database can be spread across several tables.

Scope of Work (SOW): A document that identifies the work that must be accomplished under a contract, establishes a basis for evaluating proposals from private companies and vendors, forms the core of any resulting contract, and describes the standards of performance for determining if the requirements have been met.

Service Information and Technology Architecture (SITA): The set of Service standards, policies, and procedures that align IT with the Service's mission and goals and guide information system owners and developers so they know the IT infrastructure that is supported in the Service.

Software: Computer instructions or data. Anything that can be stored electronically is software. Software can be divided into two general classes: systems software and applications software. Systems software consists of low-level programs that interact with the computer at a very basic level. This includes operating systems compilers, and utilities for managing computer resources.

Structured Query Language (SQL): A specialized language used to query and retrieve data from relational databases. SQL drivers are implemented by each RDBMS vendor to enable database access to its proprietary database. Vendors may add extensions to the SQL language for their proprietary databases.

Syntax: A systematic arrangement of letters, numbers, and/or characters that describes the coding scheme for a data value.

Web-based: Accessible from an Internet connection.