
Chapter 9. Data Management, Storage, and Reporting

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9.1 Objective

Data collected for a habitat monitoring program must be managed and stored to be accessible for current and future use inside and outside the Forest Service. Information maintenance and dissemination are important to the Forest Service; they are part of the U.S. Department of Agriculture (USDA) guidelines for information quality (USDA 2002) under the Data Quality Act of 2001. These guidelines state that USDA agencies and offices will treat information quality as integral to every step in their development of information, including creation, collection, maintenance, and dissemination (USDA 2002). The purpose of this chapter is to describe procedures for managing and storing **legacy** and newly collected habitat data in the Forest Service data management system (the Natural Resource Manager [NRM] information system) and in **auxiliary databases** as needed. The chapter concludes by providing recommendations for reporting the results of habitat monitoring programs.

9.2 Key Concepts

9.2.1 Data Preservation

The Forest Service supports the concept of data preservation, whereby data are stored electronically for future accessibility beyond the current use and the local management unit. Decisions and performance accountability are enhanced when resource information is accessible in a standard **corporate database**. Moreover, preserving resource information in a central repository rather than on local servers makes resource data broadly available, easy to use, and relevant to making informed resource management decisions (Heuttmann 2005). For example, key management questions related to Forest Service business requirements and the strategic plan (USDA Forest Service 2007) can be quickly addressed using centralized data.

For wildlife habitat monitoring, data preservation is essential because the intervals between monitoring could be several years, and evaluation of monitoring results may not occur for a decade or more. In the interim, changes in personnel create challenges to maintaining a record of the data and associated **metadata** previously collected for

the monitoring program. Electronic data preservation is generally preferred over paper records because electronic data are easier to maintain, edit, and share with other users. Moreover, an electronic format facilitates standardized data entry (Heuttmann 2005, McComb et al. 2010). Using electronic data also increases the probability that a monitoring program can be maintained through time and through staffing changes. Electronic data can easily proliferate, so that timely and proactive electronic records management is critical (<http://www.nascio.org/publications/>).

9.2.2 Forest Service Corporate Data Structure

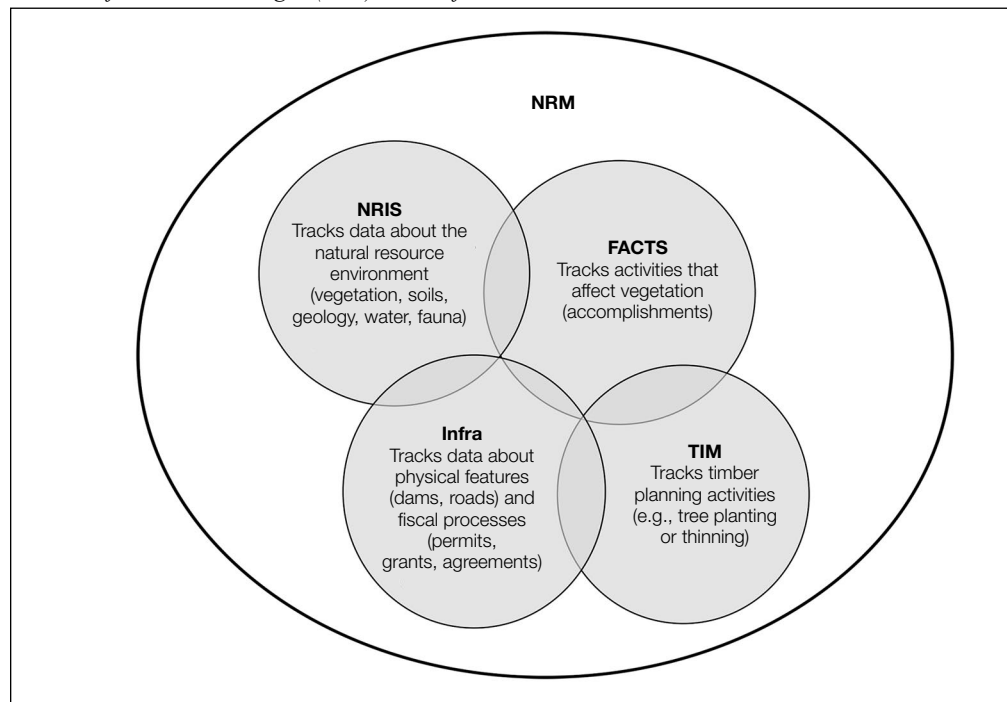
Natural Resource Manager (NRM) (<http://fsweb.nrm.fs.fed.us/>) is a national Forest Service organization responsible for the management and software development activities of four application groups whose data are accessible through the Enterprise Data Center at the Forest Service National Information Technology Center (FS-NITC) (<http://cdb.fs.usda.gov/content/dav/fs/Reference/FSWeb/BusOps/CIO/EGIS/documents/HowToFindData.pdf>). (This Web site and others beginning with “fsweb” are internal to the Forest Service and thus not available to outside users.). The principal functions of NRM are to (1) support nationally accepted data-collection protocols, (2) provide the ability to query data through output tools, and (3) store legacy and newly acquired data in editable feature classes called **transactional data**.

All NRM application groups share common components, such as a helpdesk, outputs, and training tools. NRM oversees database development and standardization, which enhances integration of information across resources. The Forest Service designed NRM applications to meet the unique business requirements of the agency, but the applications follow standards of the Federal Geographic Data Committee (FGDC) and are therefore compatible in metadata standards with data compiled by other Federal agencies that comply with FGDC standards (section 9.3.4).

The primary purpose of NRM is to coordinate numerous key application groups (figure 9.1).

- NRM contains the primary applications for habitat monitoring (section 9.3.1; also chapter 4, section 4.4.1) and is part of the corporate database system containing data and information, in conjunction with analysis tools.
- FACTS (Forest Service Activity Tracking System) contains accomplishment and treatment reporting; for example, it tracks and monitors National Environmental Policy Act (NEPA) decisions and invasive species treatments.
- TIM (Timber Information Manager) contains information about timber sales, stewardship contracts, and forest product permits.
- Infra contains information about engineering, heritage, range management, recreation sites, special use permits, grants and agreements, and real property.

Figure 9.1.—Interaction of the four application groups within Natural Resource Manager (NRM): Natural Resource Information System (NRIS); Forest Service Activity Tracking System (FACTS); Timber Information Manager (TIM); and Infra.



The Forest Service plans to make many types of data from NRM externally available through the Enterprise Data Warehouse (EDW). Moreover, the NRM platform allows for the use of other data; e.g., from NatureServe (<http://www.natureserve.org/>). The EDW also provides Forest Service users time-stamped copies of data compiled from external sources, such as Natural Resource Conservation Service (NRCS).

9.2.3 Auxiliary Databases

In some situations, data and map products from a habitat monitoring program may not easily fit in existing NRM applications, either because the applications do not contain the appropriate protocols or they do not have the data fields for entering specific habitat attribute data. The monitoring team may need to create an auxiliary database; if this database is created, first consult the business area manager, program managers, and database stewards at the national forest or grassland and regional office levels to (1) ensure that the proposed database does not already exist, (2) verify that it does not conflict with any existing databases, and (3) track new developments and new business requirements. Also, auxiliary databases may be a long-term management investment. If an auxiliary database is created, use codes and other features published in the corporate databases as much as possible to make them compatible with data supported in NRM.

An auxiliary database can be as simple as a spreadsheet or as complicated as a relational database or Geographic Information System (GIS) project. Whatever the final format for the data, using best data management practices and following FGDC data standards enhance the integrity of the data management, storage, and retrieval system. Martin and Ballard (2010) provide a comprehensive overview of best data management practices for biologists who collect and manage bird monitoring data, and they also provide a list of resources on best data management practices that are published or available on line. Borer et al. (2009) and McComb et al. (2010) provide simple guidelines for effective data management that we highly recommend to habitat monitoring teams.

A key element of best data management practices is documenting all decisions related to data fields through a **data dictionary** and user guide. The NRM *Threatened, Endangered, and Sensitive Plants-Invasive Species (TESP/IS) User Guide* is a good example ([http://fsweb.nrm.fs.fed.us/support/docs.php?module=Threatened, Endangered and Sensitive Plants—Invasive Species \(TESP/IS\)](http://fsweb.nrm.fs.fed.us/support/docs.php?module=Threatened,EndangeredandSensitivePlants—InvasiveSpecies(TESP/IS))). This guide can serve as a template for creating an effective user guide for an auxiliary database.

We recommend that Forest Service personnel use NRM applications to the extent possible and that they create auxiliary databases only when no other option is available within the Forest Service corporate database structure. Many NRM databases provide a dedicated field (Local ID) that can be used to link databases so that the monitoring team can begin using data in the NRM database and use the Local ID to link to the auxiliary data. In this way, the auxiliary data are directly linked to the corporate database, and the corporate database serves as the main repository for the data.

9.3 Data Management and Storage

Habitat monitoring information can include newly collected vegetation data (e.g., single attributes such as snag density or cover type associated with a particular emphasis species) or output from habitat models created from a formally defined interaction of several key habitat attributes (chapter 5). These data can be stored in NRM databases or in auxiliary databases, or both. Store data products created for habitat monitoring that do not readily fit in existing NRM applications, such as habitat quality maps for an emphasis species, in the appropriate project-level Forest Service electronic filing system (e.g., Content Database or Enterprise Drive).

9.3.1 Database Structure

We recommend that wildlife habitat monitoring be stored in the corporate database applications as much as possible. Wildlife habitat monitoring may require that data be maintained in auxiliary databases, however. Store auxiliary data in the appropriate project-level Forest Service electronic filing system structure. Wildlife monitoring may require data on thinning projects or prescribed burns that are stored in the FACTS database. These data could inform monitoring teams of changes in forest structure at fine

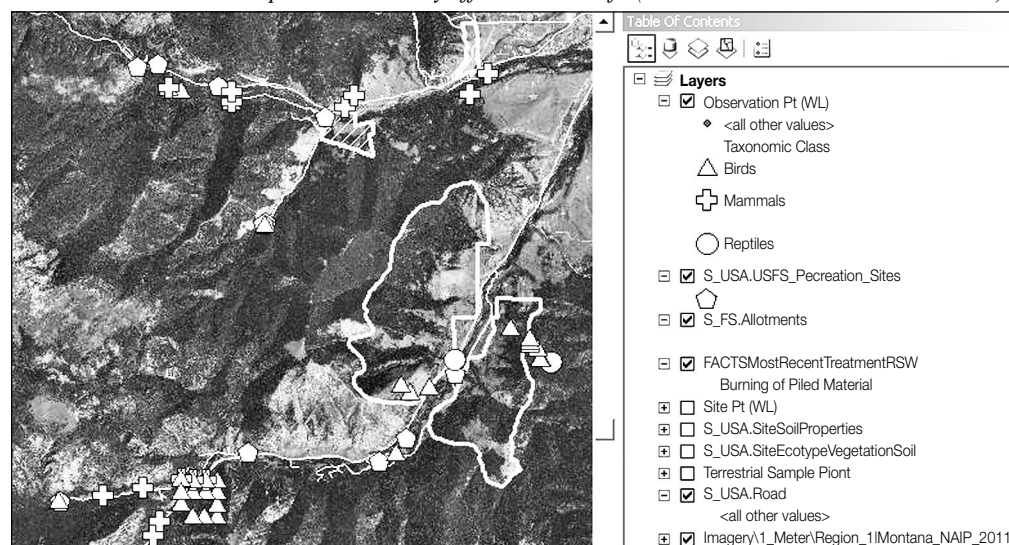
scales; similarly, overlaps of treatments, such as fuels reduction with wildlife observations, could be quantified (figure 9.2). In addition, NRM contains data on land use that could be useful for monitoring human disturbance agents described in chapter 7.

Use NRM corporate databases in habitat monitoring programs as a source of existing data and protocols and as a repository for newly collected data (chapter 4, section 4.4.1). For NRM, the goal is to create a common look and feel across all products. This architecture minimizes repetitive development, simplifies data structure, and provides the same interface across all applications. This streamlined approach to development and standards ultimately results in less user training and an increased comfort level for entering and exporting data (section 9.4.1).

Forest Service employees can access transactional data by requesting a role as either a data steward (for data entry) or a data editor (for data editing) for a specific management unit. Prospective users must have an eAuthentication account and specific user roles and organizational units. Employees can refer to the Quick Guide for an application to get assistance with this process (<http://fsweb.nrm.fs.fed.us/support/index.php>). The assigned roles enable the employee to edit and query data in NRM from the specific local management unit, through output tools such as the EDW (read-only), NRM **User Views**, and the **Geospatial Interface (GI)**.

Although transactional data are available only to Forest Service employees who have assigned roles, the eventual goal of NRM is to make certain types of data available to external parties as published data. When these data are available, interested parties will have access through the Internet and either query the data or download time-stamped data into external databases.

Figure 9.2.—Example of an ArcMap project incorporating data from several NRM applications (EDW, FACTS, and Wildlife). This map project could be used to examine land management treatments and Forest Service pasture boundary effects on wildlife (observations at the taxonomic level).



EDW = Enterprise Data Warehouse. FACTS = Forest Service Activity Tracking System. NRM = Natural Resource Manager.

Because of this future capability, any unit that is implementing a habitat monitoring program will need to assess whether monitoring products are ready for publication or should be retained as transactional data in anticipation of further refinement. For example, if a map of existing habitat is based on a regional vegetation-mapping product that the region intends to replace in the near future, it would be best to keep the habitat map transactional until the new regional vegetation data can be incorporated into the habitat map.

NRM Applications

Although an NRM application specifically for managing wildlife habitat data does not exist, similar attributes and sample designs exist in several NRM applications. Documentation for these applications can be found by following the Product links (<http://fsweb.nrm.fs.fed.us/products/>). In general, a documentation link exists for each application in which information on required fields, spatial standards, and other business rules may be obtained (<http://fsweb.nrm.fs.fed.us/support/index.php>).

TESP/IS. This application contains records on all taxa of threatened, endangered, and sensitive plant species and invasive species. It is used in planning invasive species surveys, storing field-collected survey and element occurrence data, and analyzing data for consideration in managing the land. It accommodates casual point and polygon observations with basic attributes, such as location, plant code, and observer, but its intended use is for formal, protocol- or program-driven inventories within defined survey areas. For habitat monitoring, one function of this application may be using the locations of threatened, endangered, or sensitive plants selected as emphasis species to help define the monitoring area boundaries, as well as for periodic population monitoring of the selected plant taxa. Another use of this application is the invasive species information, because the presence of invasive species is likely to affect the quality of wildlife habitat. For example, Japanese honeysuckle (*Lonicera japonica*) is an invasive vine that has spread through much of the Southeastern United States, replacing native flora with dense infestations (Miller 2003).

FSVeg. This application contains data about trees, fuels, down woody material, surface cover, and understory vegetation (chapter 4, section 4.4.1). FSVeg supports the business areas of common stand exams, fuels data collection, permanent grid inventories, and other vegetation inventory collection processes. It provides data-collection protocols, codes, entry forms, an Oracle database, and reports for forest vegetation. The application is based on stand polygons defined by local delineation criteria. A spatial application called FSVeg Spatial provides the polygon linkage. This application has high value for monitoring habitat of many species that use forest environments, such as northern goshawk (*Accipiter gentilis*) or flammulated owl (*Otus flammeolus*).

Inventory and Mapping. This application supports classification and mapping of Terrestrial Ecological Unit Inventory (TEUI), geology, non-National Cooperative Soil Survey (non-NCSS) soils, and Potential Natural Vegetation following nationally accepted protocols. Point and polygon features can be created. The application directs

the development of describable, repeatable map units such as ecological land units for a TEUI or potential vegetation map units. These map units can be used to interpret resource values for wildlife habitat on the landscape.

Rangeland Inventory and Monitoring. This application supports vegetation, ground cover, and soil **pedon** sampling using nationally accepted protocols. It accommodates point observations and many sample types. The intended use is for formal, protocol- or program-driven inventory and monitoring for defined projects. This application can be used to monitor vegetation and ground cover attributes in forested and nonforested vegetation communities that are directly related to hiding cover, forage, thermal cover, and other wildlife habitat requirements.

Aquatic Survey. This application is the agency standard for managing information about aquatic surveys. It encompasses data about fish, aquatic insects, reptiles, amphibians, aquatic invertebrates, riparian environment characteristics, and other aquatic features. NRM Aquatic Survey has high value for monitoring aquatic wildlife species.

Wildlife. The NRM Wildlife application supports information about locations of terrestrial wildlife on National Forest System lands, as well as other information about the observation (e.g., observed versus heard, nest sites versus foraging sites). Observations, Sites, and Surveys can be created, and habitat or other attributes can be associated with each. Observations (point or polygon) are either collected during a Visit to a Site or obtained opportunistically. Sites (point or polygon) are typically monitored for wildlife business requirements, including biological, administrative, or use areas. Surveys are searches for certain wildlife species conducted following a specific protocol. Sites and Observations are associated with Surveys. NRM Wildlife enables users to track multiyear surveys by associating the Surveys with specific Sites and entering data for each Visit to a Site. Users enter all survey outcomes, including surveys that did not result in any observations of the targeted species (i.e., negative surveys). Even for species with clearly defined habitat relationships, we recommend periodic monitoring of populations, to ensure that the species occurs in areas defined as habitat for habitat monitoring (chapter 1, section 1.3.2). For wildlife habitat monitoring, a primary value of this application may be using observations of an emphasis species to evaluate a habitat model (chapter 5, section 5.3.4) or for periodic monitoring of populations in conjunction with habitat monitoring to strengthen the relationships defined in the model (chapter 1, section 1.3.2). NRM Wildlife Observation data can be used to meet this need. Habitat monitoring data may be stored in more than one NRM application, or in a combination of NRM and auxiliary databases.

Navigating NRM

The NRM applications reside at the National Information Technology Center (NITC) in Kansas City, MO. Applications can be accessed using Citrix at the Enterprise Data Center. Each application has (1) a required list of roles for editing, (2) a positive spatial requirement (i.e., it must have a spatial feature), (3) an NRM Feature Inspector, (4) a Task

Assistant (specific for each business), (5) online Help, and (6) a set of Output tools. Each application uses ArcMap as a spatial interface and Oracle for tabular data storage. Users can access the applications by running ArcMap software loaded on their personal computers or by using Citrix software to launch ArcMap or the Data Exchange tool at the Enterprise Data Center.

Each NRM application also has its own set of business-related information. This information may contain supported protocols, data requirements, spatial feature datasets, software downloads, documentation about business rules, and lists of acceptable values. This detailed information can be found in the documentation for the specific application on the NRM Support page (<http://fsweb.nrm.fs.fed.us/support/index.php>).

Data summaries, analyses, reports, and map products are supported through NRM Output tools—EDW; GI; and User Views, Forms, and Reports. The EDW provides read-only, historical, and aggregated data using an Online Analytical Processing (OLAP) design that provides snapshots of the transactional (editable) data repository. Benefits of the EDW include availability of outputs for general use, significantly faster performance relative to the transactional database reports and queries, a variety of formats for data delivery (e.g., reports, maps, raw and summarized data), and data at national spatial extents. Users access the EDW through various database connection methods, including standard ArcMap, the GI, and, in the future, Web services. To display the EDW published feature datasets in ArcMap, users must create a one-time connection to the Citrix (Enterprise Data Center) environment using the SDE (ESRI Spatial Database Engine). The login tool for Forest Service employees is (http://fsweb.nrm.fs.fed.us/support/help/gis/Establish_a_Citrix_Connection.htm).

The GI is an ArcMap extension that NRM applications leverage to simplify loading data, accessing custom products for display, running queries that analyze data, and exporting data. The GI provides a way to load multiple sets of spatial data with or without the tabular data already attached. Presymbolized data can be set up so layers load with the same look for everyone. The GI can be used to run spatial processes like clip, intersect, and identity. The GI enables users to repeat standard analyses on data over and over.

User Views provide support for tabular data exports for specific business requirements. These customizable views allow for direct querying of data tables and provide tabular reports that can be exported to Microsoft (MS) Excel. These views are accessible through the I-Web interface main menu.

Raw data can be summarized using these output tools. Outputs contain various queries, maps, and views that help summarize data collected (1) at the Site, such as aspect, elevation, and slope (e.g., Site General data); (2) in fixed-area plots (e.g., ocular macroplot); (3) along transects (e.g., line intercept); and (4) in quadrats (e.g., cover frequency). Data summaries can include descriptive statistics (e.g., mean, minimum, maximum, count, frequency) for continuous and categorical variables as appropriate. Additional queries, maps, and views are continuously being developed as users' requests

are prioritized. The GI content enables users to create and export maps and tables in MS Excel, Word, and Access, or in text format. User Views generate Excel spreadsheets. These output data can then be imported into and analyzed using the Statistical Analysis System (SAS, available through a Forest Service license) or other statistical software, or a multivariate package such as PC-ORD (McCune and Grace 2002).

9.3.2 Data Quality

Data stewards can ensure data quality by designing and implementing a number of quality assurance and quality control (QA and QC) techniques during program design and execution. Application of principles of effective project management to the design and execution of inventory and monitoring programs can ensure appropriate quality assurance and quality controls are incorporated into all program phases. Data quality and assurance benefit not only from development of an inventory or monitoring plan but also from use of the techniques described in the following paragraphs.

Data Cleaning Methods

A simple checklist of questions can assist in the QA and QC of data. These exercises can be performed in the field and also automated to check data already in the corporate database. While in the field, we recommend you review data entry forms to check that individual land cover types will sum to the total monitoring area. Ensure that field personnel collecting data have the proper skills, adequate training, and periodic oversight, or the field data collected and analyses based on the data will be suspect. If proper skills are not available at the district or forest level, request assistance on project design and implementation, as well as training and oversight, from the regional or national level.

An important component of data quality assurance and control is oversight and monitoring of the collection crew's performance. This oversight may consist of resampling a proportion of sites or specific portions of data collection and error checking. Use of electronic field data recorders will minimize data recording and transferring errors.

Within the database, users can generate reports and maps to identify outliers or extremes that may need to be adjusted or dropped. Users can evaluate if attribute values are reasonable by visually inspecting the data using scatterplots, summarizing the data with simple statistics, or simply sorting the data in ascending or descending order (chapter 8, section 8.5). Some NRM applications include output tools to aid users in QA and QC of their data in the database. For example, the Range business area provides QA and QC visualization in the GI that identifies discrepancies between pasture areas entered in the Forest Service NRM Rangeland Management Unit forms and area calculated from spatial data. A percent difference in area is displayed to notify the specialist of the degree of discrepancy.

Field Data Recorders

Data from the field can be collected on paper forms or entered into a data recorder, depending on the application. In either situation, the user will follow the standards set in

the protocol field guides. These guides, designed for nationally accepted protocols, provide the requirements for data to be housed in the corporate database. NRM application development closely follows defined standards and does not support local modifications (chapter 4, section 4.4.1).

Field data recorder software for several NRM applications implements QA and QC of data through use of code sets and error checking. The validation includes notice of incorrect codes and missing required values. The software also validates measurement formats. Free-form text fields other than Comments and Remarks do not exist. Additional validation occurs when data are uploaded from a data recorder to the corporate database using the NRM Data Exchange (DX tools; <http://fsweb.nrm.fs.fed.us/products/nris/>).

The DX tool identifies values that are not supported by the lists found in the field guides or at the unit, thus providing a way to correct errors before entering data into the database. With paper forms, users can manually enter data into the DX Tools or the NRM application data entry forms. Both processes provide the same quality control steps, including lists of values and requirements. Other means for data validation include reviewing data on screen within the applications or using outputs such as the GI (section 9.3.1) or I-Web User Views to run reports and create export products, such as tables or maps.

9.3.3 Data Management

At its simplest, data management for habitat monitoring involves reporting on six basic descriptors of the data: (1) what attribute was estimated, (2) the attribute values, (3) where (location in space) the data were collected, (4) when they were collected, (5) how (protocols used) they were collected, and (6) who collected them (McComb et al. 2010). Data management encompasses a broad range of activities from the technical aspects of entering and cleaning data to administrative aspects such as defining user roles and providing for long-term storage. Adhere to best management practices in all aspects of data management (section 9.2.3).

The Forest Service Standard Data Management project is tasked with creating tools and guidance to manage inventory and monitoring data, based on clear standards to collect, manage, use, and report those data (<http://fsweb.wo.fs.fed.us/standarddatamanagement/>). The overall governance of the corporate database structure is by NRM staff and the directors. At the regional level, resource information coordinators implement and integrate NRM modules across the Forest Service. NRM data stewards oversee regional and local code table maintenance and application use. They may also regulate role assignment and perform data QA and QC. Users enter data and maintain data to meet national and local standards implemented within NRM databases (<http://fsweb.nrm.fs.fed.us/support/index.php>).

Change requests for software, application interface, and the databases are received throughout the year from users and Forest Service leadership; these requests may become part of the program of work (<http://fsweb.nrm.fs.fed.us/about/steeringteam/>). Enhancements

or updates to the applications go through the process of evaluation by various stakeholder groups. These requests for enhancements may include new attributes, new business rules, a new look for a form, or data migration. Proposals are submitted using a transparent process. The national program managers and NRM extended team are responsible for reviewing and selecting proposals for inclusion in the NRM program of work. Some enhancements create the potential to move legacy data into the national database. The scope of the need defines whether local, regional, or national programs fund the migration.

Local users may need to maintain auxiliary databases that have attributes that do not fit in the corporate database (section 9.2.3). Store these data, including habitat map products and model data, in a format and location that are accessible to those who need it. The likely repositories for these data are the forest or local management unit's project and program folders at the Data Center (T:\FS\NFS\Forest\Project\). Filing at this location greatly speeds data access, availability, and use with other NRM application data. A GIS analyst and a wildlife biologist will likely manage the auxiliary data. Evaluate archival information, such as maps and photos, attachments, reports, and other documents from the project record, for inclusion in the NRM database periodically.

Software updates, database structural changes, or new business rules may affect stored data. Although database structure or forms may change, data quality is maintained. To minimize impacts to permanently stored data, a thorough analysis is part of every proposal and is incorporated into development and testing cycles. Data protection is achieved through this measure as well as backup procedures.

Specify in the monitoring plan and all subsequent reports where data are stored and which agency, office, or organization is the primary steward. The primary steward is responsible for ensuring that data are transferred correctly as software or applications become obsolete.

9.3.4 Metadata Requirements

Metadata are information about the data (i.e., its history and changes) that are federally mandated by Executive Order 12906 (<http://www.archives.gov/federal-register/executive-orders/pdf/12906.pdf>). Metadata provide the information people need to understand, trust, and correctly use data. From defining attributes and accuracy to providing information on projection and coordinate systems, metadata provide answers to many questions. Metadata also help to avoid wasteful duplication of effort, direct people to the data they need, and determine how best to use it. The *Forest Service Metadata Users Guide* is designed to provide this information (<http://www.fs.fed.us/gac/metadata/step1.html>).

Implement the interagency FGDC data standards when creating and disposing of metadata. The Forest Service must archive and dispose of FGDC-compliant geospatial metadata in accordance with its records retention and disposal requirements and schedules as listed in Forest Service Handbook 6209.11 (USDA Forest Service 1996) and with direction issued by the FGDC Historical Records Working Group of the National Archives and Records Administration.

Specific applications enable users to create metadata; for example, the NRM FS Veg Spatial application has implemented a feature level metadata tool. Spatial metadata required by FGDC includes the location revision date (i.e., when the feature was compiled), location source (e.g., aerial photograph or Global Positioning System), and location accuracy. These three feature-level attributes are standard for regional and forest geospatial datasets, such as coverages or feature classes. NRM applications use SDE feature classes stored at NITC. Guidelines of the National Standard for Spatial Data Accuracy (FGDC 1998a, 1998b) and others (ASPRS 1990; U.S. Bureau of the Budget 1947) are followed for geolocational accuracy.

NRM protocols contain requirements for certain tabular and spatial metadata documentation. Some metadata may have to be maintained at the local level, working with the local data stewards. In the corporate database, the revision date and compilation date are maintained for each record. The accuracy of methods used to derive the spatial location is stored in the feature class, in the associated Oracle tables, or as part of the project record. Tabular metadata for the Cover Frequency protocol require that sample design data for transect and frame numbers and sizes be completed before frame-level data are entered.

9.4 Reporting

The monitoring plan will include a section on reporting that describes (1) the type of products the habitat monitoring program intends to produce and (2) the anticipated schedule for availability of these products. The reporting section is essential because the monitoring program can then be designed to efficiently produce these reports and other products. Moreover, by stating the intended outcomes of the monitoring program, the decisionmaking officials are informed about the types of products they can expect to see and when these products will be delivered. A clearly defined reporting plan will also assist in securing funds for creating the monitoring reports. Monitoring plans produced by the Forest Service under the auspices of the Northwest Forest Plan provide excellent examples for those creating habitat monitoring plans and reports (e.g., Hemstrom et al. 1998, Madsen et al. 1999).

9.4.1 Data Products

Tailor the data products specifically to the habitat monitoring questions addressed by the monitoring plan and present data in a style that is meaningful to decisionmakers. The primary data products will be a series of reports describing the monitoring program and its outcomes at different stages of implementation (e.g., 1 year, 5 years, and 10 years). Follow Vesely et al. (2006), section 3.5, for key elements of interim or final monitoring reports. When reporting data results, be sure to describe the sampling design and data quality protocols to provide context for the data. If data are not spatial, ensure that summary tables are uncluttered and interpretable (table 9.1). Consider using bar graphs or pie charts as visual tools for displaying monitoring results.

Wildlife habitat monitoring data will typically consist of spatial databases of habitat attributes and maps for the emphasis species that indicate the location of habitat by some category of quality, such as high, moderate, or low quality. Ensure that spatial products are in a format readily viewed outside of GIS environments (e.g., maps in various graphics formats, such as jpegs or tiffs) so that they are easily accessible to decisionmakers.

Several tools will help prepare habitat data for presentation in a monitoring report. For example, the NRM GI ArcMap extension helps resource specialists work efficiently with their data. It provides tools that simplify loading data and access to custom products for display, analysis, and export of data and maps (table 9.2, figure 9.3). The desired

Table 9.1.—An example report of sagebrush (*Artemisia spp.*) canopy cover classes for meeting landscape-scale monitoring objectives for greater sage-grouse (*Centrocercus urophasianus*) (chapter 10, sage-grouse case example).

Monitoring year	Percent total sagebrush by canopy cover class ^a				Total
	0–5	6–15	16–25	> 25	
Year 1	21	39	14	26	100
Year 5	18	32	29	21	100
Year 10	12	25	40	23	100
Goal	< 10	< 30	60 ^a	—	100

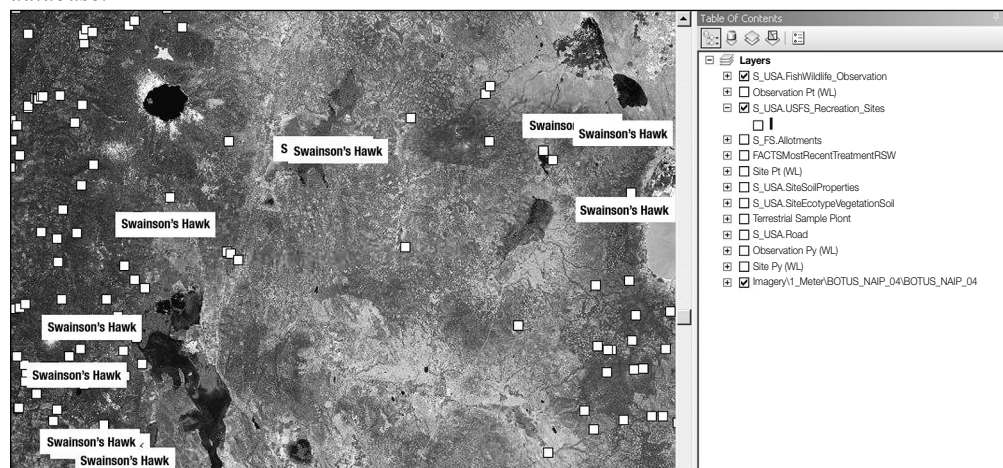
^a The overall goal is for at least 60 percent of the sagebrush to be either in the 16 to 25 percent or > 25 percent canopy cover classes.

Table 9.2.—Example of tabular output from the Geospatial Interface for Observations of Swainson's hawk (*Buteo regalis*).^a

Observer	Observation date and time	Observation date accuracy	Observation method	Reproductive status	Total detected	Age	Activity
K. Hauge (experienced)	6/20/1990 0:00	Day	Other	Unknown	2	Unknown	Unknown
E. Olmeso (experienced)	6/9/1997 0:00	Day	Camera Set	Unknown	1	Unknown	Moving
Unknown (unknown)	7/11/1974 0:00	Day	Other	Unknown	1	Adult	Unknown
S. High (experienced)	3/31/1995 7:25	Exact	Visual	Unknown	1	Adult	Unknown
S. High (experienced)	8/29/1995 10:00	Exact	Visual	Unknown	1	Adult	Unknown
J. McAlister (experienced)	9/22/1986 15:00	Exact	Visual	Unknown	1	Unknown	Incubating
S. High (experienced)	11/12/1996 0:00	Day	Other	Unknown	1	Adult	Unknown

^a Data were edited to fit the page.

Figure 9.3.—Observations of Swainson's hawk (*Buteo regalis*) from the NRM Wildlife observation database.



products can be preset and made available to all Forest Service users to apply with their local data, or the products can be specific to a Forest Service unit. Products can be easily reproduced over time, and maps and tables can be exported and delivered to cooperators. Tabular data can be exported in many formats: in MS Word, Access, and Excel or as text files.

The GI enables users to—

- Easily upload preset maps that include many features.
- Load layers using a different symbology (such as all roads as a solid black line rather than a different symbol for each road type).
- Combine tabular data with spatial layers.
- Run predefined queries and export maps or layouts to MS Word with a one-button click.
- Access data stored in various places on a local server as well as NITC.
- Run standard spatial analysis using processes such as clip, intersect, dissolve, and identity.

9.4.2 Reporting Schedule

When the habitat monitoring program is part of land management plan monitoring, the reporting schedule will reflect the forest plan reporting schedule. Other habitat monitoring reports may not be tied to the Forest Service planning process, but to specific conservation efforts (e.g., a multiagency monitoring program for a wide-ranging emphasis species). In these cases, the reporting schedule will be a function of the expected rate of change in the monitored attributes, the frequency of management actions affecting the monitoring area, and the anticipated response time. Milestones that could be listed in a reporting timetable include results of the pilot monitoring program and the first full year, subsequent annual reports, and 5- or 10-year reports.

9.4.3 Report Content

Organize reports produced for a habitat monitoring plan to address the specific objectives and the associated sampling design and methods of the monitoring program (McComb et al. 2010). For example, a monitoring objective could be estimating the number of vernal pools with salamanders present in the monitoring area (chapter 10, salamander case example). In this case, the monitoring report should clearly display the results of sampling (e.g., sample sizes, locations, dates) to estimate vernal pools, in either graphic or tabular format, or both. Similarly, objectives may include a threshold statement, such as—*After each monitoring period, any pool neighborhoods with a decline in neighborhood area greater than 15 percent will be evaluated for possible changes in vegetation and road management to prevent further declines or to restore neighborhood size, if*

feasible (chapter 10, section 10.2.4). In the monitoring report, describe the additional evaluation in areas exhibiting declines above the threshold and what management actions are planned to address these declines.

We recommend that reports include a section explicitly describing how the results from the habitat monitoring program can be used in resource management, either to improve current management or affirm current management direction. Report the results of implementing the habitat monitoring program in a separate section from a list of suggested management recommendations. Last, in the management recommendations section, be sure to link recommendations to the business requirements identified in the original monitoring plan.

9.5. Conclusions

It should be apparent that wildlife habitat monitoring data are at risk of being stored incorrectly and possibly lost without a well-designed system of data management including (1) data entry, (2) storage, (3) retrieval, (4) analysis, and (5) reporting. Because a tremendous investment of time and energy is typically made for sample design and data collection, it is critical that this very important last step, data management, is completed properly. The NRM applications provide a system that not only fosters data sharing but also ensures data integrity and transparency and defensible analysis and reports. This chapter provided guidance and links to resources that will help you properly manage the data you collect and thus enable you to generate sound reports from your habitat monitoring data and ensure the efficient and proper use of the data by future monitoring teams.
