Chapter 1. Overview

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1.1 Objective

Information about status and trend of wildlife **habitat**[1] is important for the U.S. Department of Agriculture, Forest Service to accomplish its mission and meet its legal requirements. As the steward of 193 million acres (ac) of Federal land, the Forest Service needs to evaluate the status of wildlife habitat and how it compares with desired conditions. Habitat monitoring programs provide information to meet the needs of the agency while fostering use of standardized, integrated approaches to produce robust knowledge. This technical guide provides current, scientifically credible, and practical protocols for the inventory and monitoring of terrestrial wildlife habitat. Protocols include data standards, data-collection methods, and methods for detecting and monitoring changes over time (Powell 2000).

To our knowledge, this document is the first comprehensive guide to monitoring wildlife habitats. It serves a unique role by providing protocols specifically tailored to habitat monitoring, which is especially pertinent for the Forest Service, given its role in managing landscapes that support a wide diversity of taxa across the major biomes of North America.

Protocols described in this guide address habitat monitoring for terrestrial wildlife. In the past, the term *wildlife* was used to denote all terrestrial vertebrates, especially game birds and mammals, but later was expanded to include species of conservation concern. In more recent years, the term has broadened to encompass the full array of all biota in an ecosystem (Morrison et al. 2006). In this technical guide, the term terrestrial wildlife includes terrestrial vertebrates and invertebrates, but managers may also find the protocols applicable for monitoring rare plants.

Although population monitoring is a necessary and critical complement to habitat monitoring (chapter 2, section 2.2.2), this guide does not address population monitoring per se because several excellent published resources exist on this topic. Two Forest Service technical guides describe population monitoring: (1) Manley et al. (2006) provide protocols for inventory and monitoring of populations of groups of wildlife species, using standardized Forest Service plot data to assess habitat conditions at plot sites; and

[1] Terms indicated in bold typeface are defined in the glossary in appendix B.

(2) Vesely et al. (2006) describe protocol development for monitoring populations of wildlife, fish, and rare plants. Thompson et al. (1998) and McComb et al. (2010) are also good references for monitoring wildlife populations.

The target audience for this guide is professionals (e.g., ecologists, biologists, silviculturists, and planners) charged with forest planning, project impacts analysis, and habitat monitoring at ranger district, national forest or grassland, and regional levels. This guide may also benefit other agencies and organizations that want to standardize their approaches to wildlife habitat monitoring. Protocols and process steps in this technical guide are recommendations, not agency requirements or policy. This guide follows national direction for inventory, monitoring, and assessment as described in Forest Service Manual (FSM) 1940 (USDA Forest Service 2009).

This first chapter describes the origins of the technical guide, business requirements for wildlife habitat information, key concepts of habitat monitoring, recommended roles and responsibilities of Forest Service personnel for completing and applying the protocols, the relation of habitat monitoring to other Federal inventory and monitoring programs, and information about data storage and reporting related to habitat monitoring. Chapter 2 describes selection of habitat attributes for monitoring, and chapter 3 addresses planning and design of habitat monitoring programs.

Chapters 4 through 7 provide specific guidance for monitoring selected habitat attributes (e.g., vegetation structure and composition), monitoring habitat within a landscape context, and monitoring human disturbance agents. Chapter 8 offers recommendations for data analysis, whereas chapter 9 addresses data storage and reporting. Chapter 10 provides detailed examples of habitat monitoring for two individual species and a monitoring plan for a species group.

1.2 Background and Business Requirements

1.2.1 Background

A wildlife protocol development team was established in 2001, under the auspices of the Ecosystem Management Coordination Staff in the Washington Office of the Forest Service, to identify and prioritize species or groups of species that would benefit from standardized inventory or monitoring protocols throughout the Forest Service. This team initially identified the need for population monitoring protocols, which resulted in three products: (1) a protocol for monitoring multiple species (Manley et al. 2006), (2) a set of protocols for monitoring the northern goshawk (*Accipiter gentilis*) (Woodbridge and Hargis 2006), and (3) a general guide for developing other population monitoring protocols (Vesely et al. 2006).

The Washington Office later identified the need for national protocols to address habitat monitoring in support of land management planning. When wildlife habitat is

included in a land management plan's objectives and desired conditions, habitat monitoring is a necessary component of the plan's monitoring program. Most national forests and grasslands undertake habitat monitoring and would benefit from guidance on selecting key habitat attributes for wildlife as well as standard protocols for inventory and monitoring habitat attributes at a variety of spatial scales. This technical guide provides such guidance. It represents the best available science from a broad base of published literature and from expertise of research scientists, ecologists, and statisticians who co-authored individual chapters.

1.2.2 Business Requirements

Specific business requirements of the Forest Service for standardized habitat monitoring arise from the need for information in (1) land management planning, for which structured monitoring can facilitate plan revisions or amendments; (2) recovery of threatened and endangered (T&E) species and sensitive species; and (3) environmental analyses for projects as prescribed in various laws, regulations, and policies (table 1.1). Information needs range from status and trends of ecological diversity to population trends in relation to habitat change for individual species or species groups. Integration of habitat monitoring with monitoring of other resources is critical for meeting agency information needs while ensuring efficient use of funds and staffing.

The habitat monitoring protocols described in this guide address additional business requirements of the Forest Service beyond those listed in table 1.1 and include—

- Improving consistency in monitoring species and species groups, as identified in the National Inventory and Monitoring Action Plan of 2000, across all administrative units of the Forest Service.
- Integrating habitat monitoring with other ongoing data-collection activities (e.g., Forest Inventory and Analysis [FIA] Program, intensified grid inventories, and **Common Stand Exams**) for greater efficiency.
- Ensuring that the best available science is considered in habitat monitoring through documentation of the monitoring process and consistent application and appropriate interpretation of science.
- Ensuring that effects of climate change on habitat are incorporated in monitoring programs, as appropriate, using guidance such as the Forest Service "National Roadmap for Responding to Climate Change" and climate performance scorecard (USDA Forest Service 2010a).
- Providing standardized habitat information for broad-scale assessments.
- Understanding effects of management actions on habitat, such as activities related to the Healthy Forests Initiative and the Healthy Forests Restoration Act.
- Providing standardized habitat information for other existing or emerging national and regional business requirements, such as program and budget planning and execution.

Table 1.1.—*Forest Service business requirements for habitat monitoring in relation to existing laws, rules, and policies.*

No.	Business requirement	Target group	Type of information needed	Analysis scale[a]	Type of report
1	To provide information on habitats needed to maintain viable populations of existing native and desired nonnative vertebrate and invertebrate species (NFMA 1982 reg. at 36 CFR 219.19)	Vertebrates, invertebrates, and plants whose populations are at risk	Habitat abundance, distribution, condition, and trend	Mid and broad scale: the planning area, usually a local management unit (e.g., national forest, grassland) or multiple administrative units	LRMP, AMS, annual monitoring and evaluation reports, supporting regional assessments
2	To provide information on MIS for planning and monitoring under the 1982 rule for the NFMA[b]	MIS	Habitat condition and trend as related to population change, or habitat only (depends on specific language in the LRMP)	Mid and broad scale: the planning area, usually a local management unit (e.g., national forest, grassland) or multiple administrative units	LRMP or AMS, annual monitoring and evaluation reports, supporting regional assessments
3	To aid in the recovery of species listed under the ESA (FSM 2670) (USDA Forest Service 2005a)	Federal threatened or endangered species	As indicated in recovery plans; typically habitat trends and trends in stressors	Mid, broad, and sometimes national scale: geographic range, significant portion of range, or ESU of the listed species	Annual reports of recovery plans and habitat conservation strategies; BA, BO
4	To avoid Federal listing of plant and animal species (FSM 2670, USDA DR 9500-004) (USDA Forest Service 2005a)	Plant or animal species designated "sensitive" by the Forest Service	Distribution, status, and trend of habitats	Mid, broad, and sometimes national scale	Habitat conservation strategies and agreements; progress reports; annual monitoring and evaluation reports; BA, BE, project records
5	To provide information for environmental analysis of proposed projects (NEPA)	TES, MIS, sensitive, socioeconomic species, and migratory birds	Availability of suitable habitat in the project area and larger landscape context	Base (local), mid, and broad scale: usually the project area and larger landscape context; dependent on project scope, species affected, etc.	Landscape or watershed assessment; road analysis; project EIS, EA, or CE; BE, BA, BO; post-activity monitoring reports
6	To work cooperatively with States in the conservation of selected species (as described in the Sikes Act)	Species identified for conservation through an MOU between a State and the Forest Service, including species identified in State comprehensive wildlife conservation strategies	Information as specified in the MOU or strategy	A State or the range of a species within a State	Progress reports as specified by the MOU
7	Account for the effects of global climate change on forest and rangeland conditions (Forest and Rangeland Renewable Resources Planning Act of 1974)	Vertebrates, invertebrates, and plants whose habitats may be at risk from climate change	Habitat abundance, distribution, condition, and trend	Mid and broad scale: the planning area, usually a local management unit (e.g., national forest, grassland) or multiple administrative units	LRMP, annual monitoring and evaluation reports, supporting regional assessments

AMS = analysis of the management situation. BA = biological assessment. BE = biological evaluation. BO = biological opinion. CE = categorical exclusion. CFR = Code of Federal Regulations. EA = environmental assessment. EIS = environmental impact statement. ESA = Endangered Species Act. ESU = ecologically significant unit. FSM = Forest Service Manual. LRMP = Land and Resource Management Plan. MIS = ***management indicator species****. MOU = Memorandum of Understanding. NEPA = National Environmental Policy Act. NFMA = National Forest Management Act. TES = threatened, endangered, and sensitive species.*

[a] *See chapter 4, section 4.2.4, for definition of scale as used in this guide.*

[b] *MIS, a concept developed in the 1982 planning rule to implement the NFMA (USDA Forest Service 1991). The use of MIS is in effect for all planning units until their plans are revised under a new planning rule.*

Source: Adapted from Vesely et al. (2006): table 1.1.

1.3 Key Concepts

1.3.1 Habitat

Clements and Shelford (1939) originally defined *habitat* as the physical conditions surrounding a species, a population, an assemblage of species, or a community. Hall et al. (1997: 175) further defined habitat as—

> ...the resources and conditions present in an area that produce occupancy—including survival and reproduction—by a given organism. Habitat is organism-specific; it relates the presence of a species, population, or individual (animal or plant) to an area's physical and biological characteristics. Habitat implies more than vegetation or vegetation structure; it is the sum of the specific resources that are needed by organisms. Wherever an organism is provided with resources that allow it to survive, that is habitat.

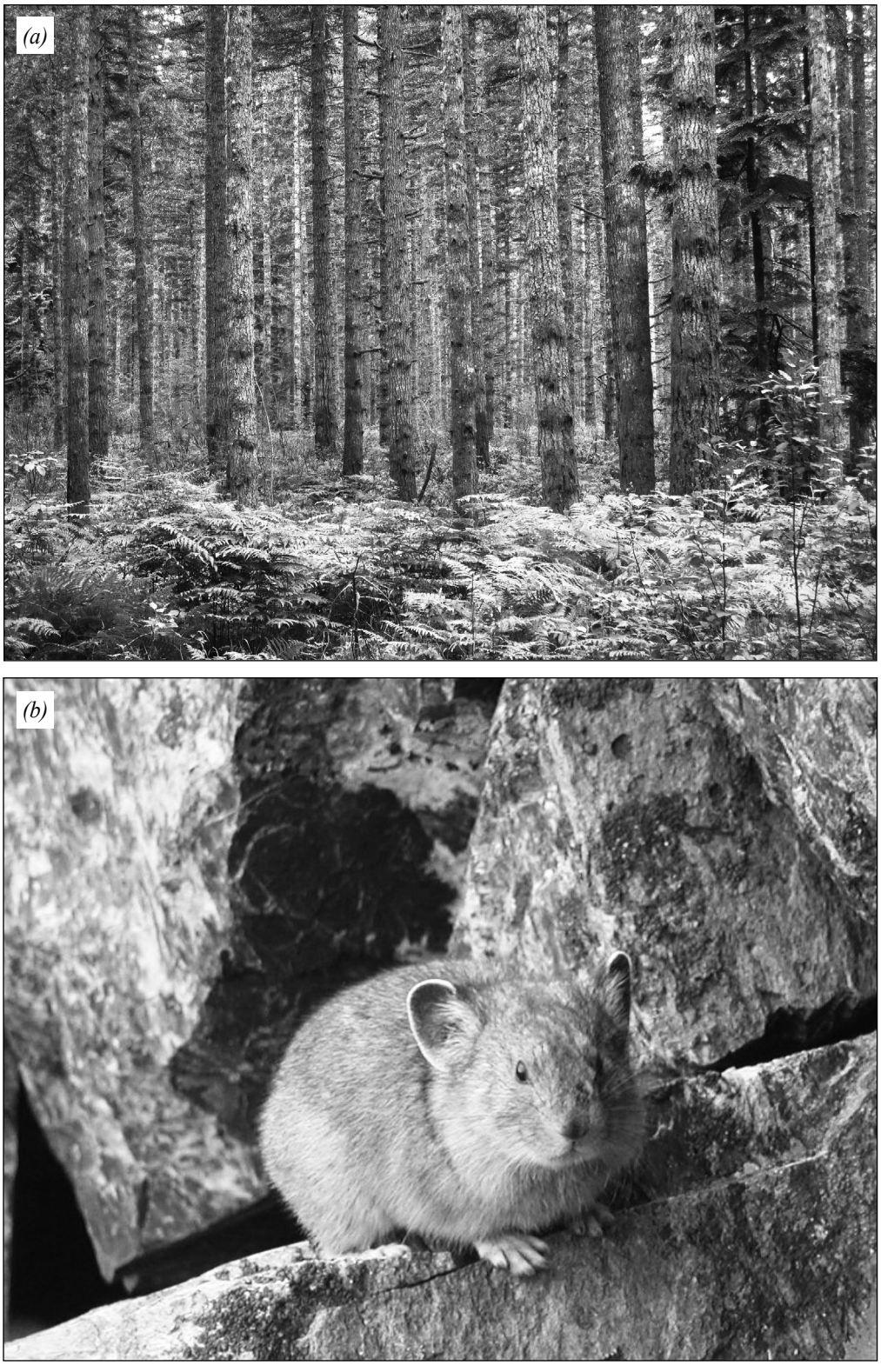
Two key concepts are embedded in this latter definition. First, the organism defines its habitat through its selection of resources to meet its unique needs (Morrison et al. 2006). Corollary to this concept is the notion that no single system of habitat classification can describe habitat for all species.[2] Daubenmire (1952, 1984) conceived the term ***habitat type*** to refer to the vegetation association in an area or to the potential of vegetation to reach a specific climax stage. We (the authors of this technical guide) concur with Hall et al. (1997) in discouraging use of the term "habitat type" when referring to wildlife-habitat relationships because of its original usage in referring to vegetation but not wildlife.

Second, habitat is not equivalent to vegetation or vegetation structure. Although vegetation is the foundation for wildlife habitat, habitat may also be composed of natural physical features (e.g., water bodies, caves, or crevices), anthropogenic structures (e.g., bridges and mines), other nonvegetative factors (Morrison et al. 2006), or other organisms, such as prey species (figure 1.1). The definition by Hall et al. (1997) presumes that if the required resources are present (i.e., habitat), then the organism will occur there. In some instances, however, the suite of requisite habitat components may be present, but other circumstances, such as competitive exclusion of northern spotted owls (*Strix occidentalis caurina*) by barred owls (*Strix varia*), may prevent occupancy.

The importance of specific attributes may vary with a species' life stage, season of use, or order of habitat selection (chapter 2, section 2.3.2). For example, large trees and closed canopies are important attributes of northern goshawk habitat for nesting, but they are not essential at other times of the year (Squires and Reynolds 1997). Similarly, marbled salamanders (*Ambystoma opacum)* require ponds for depositing eggs (Petranka 1990), but adults migrate to a variety of wooded upland habitats in the nonbreeding season.

[2] Systems of habitat classification are commonly used in wildlife management and conservation planning (e.g., Northwest Habitat Institute 2006); these systems are best described as classifications of terrestrial communities or ecosystems. We avoid the term *habitat classification* in this guide because its use implies that habitat may be defined without reference to the species.

Figure 1.1.—*Although vegetation structure provides key habitat attributes for many wildlife species (a), it is not equivalent to habitat. Habitat is species specific and may include manmade or physical features such as talus slopes occupied by American pika (Ochotona princeps) (b). Photo credit: Mark Penninger (pika).*



Although habitat can be defined conceptually, the process of monitoring habitat requires that habitat be defined in quantifiable, reportable terms (chapter 2, section 2.3.2; chapter 3). Further, habitat can be monitored by selecting individual habitat attributes (e.g., snag density) or by combining attributes in an integrated measure to describe habitat through use of a habitat model (chapter 5).

1.3.2 Definition and Types of Monitoring

This technical guide emphasizes monitoring, rather than inventory, following the definition from FSM (1940: 19)—"The collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a resource or management objective. A monitoring activity may include an information needs assessment; planning and scheduling; data collection, classification, mapping, data entry, storage, and maintenance; product development; evaluation; and reporting phases." The repetition of measurement is a fundamental concept of a monitoring program (chapter 3). The detection of change over time may alert managers to positive or deleterious effects of an activity. Conversely, the detection of no change may demonstrate a lack of effect or the need to continue monitoring for a longer time period.

In contrast to monitoring, inventory is the survey of "an area or entity for determination of such data as contents, condition, or value, for specific purposes such as planning, evaluation, or management" (USDA Forest Service 2009: 19). Although measurements or evaluation conducted for inventory may underpin a future monitoring program, and often precede monitoring, the data are not always useful for monitoring (Elzinga et al. 1998) (chapter 3, section 3.2.3).

Holthausen et al. (2005) defined three types of monitoring for terrestrial animals and their habitats.

1. **Targeted monitoring** keeps track of the condition and response to management of species and habitats that are identified as being of concern or interest.
2. **Cause-and-effect monitoring** investigates the mechanisms that underlie habitat and species response to management and other forms of disturbance. This type of monitoring is conducted using a rigorous statistical sampling framework, testing a priori hypotheses.
3. **Context monitoring**, which is broader in scope, addresses a wide array of ecosystem components at multiple scales without specific reference to influences of ongoing management.

The focus of habitat monitoring described in this guide is targeted monitoring of specific management activities on habitat. Monitoring of selected habitat attributes for species or species groups at the initiation and completion of a planning period permits evaluation of whether desired conditions or management objectives were met and whether species exhibited associated responses. Context monitoring may be useful when it evaluates a broad suite of habitat attributes at multiple scales and across multiple management

units, such as national forests or grasslands. Cause-and-effect monitoring is generally outside the scope of this guide because it requires a fully developed research program (Elzinga et al. 1998, Holthausen et al. 2005).

Habitat Versus Population Monitoring

A clear distinction between habitat and population monitoring is necessary for developing a successful wildlife habitat monitoring program—habitat monitoring should not be confused with population monitoring. In habitat monitoring, key attributes of habitat, such as canopy cover of key tree species or the number of vernal pools, are monitored over time, whereas in population monitoring, the organisms themselves are monitored through appropriate protocols, such as point-counts or line transect surveys. Although habitat is essential for population persistence, the maintenance or restoration of habitat does not guarantee population persistence or recovery (Mulder et al. 1999), or even presence. Information about species' habitats is used to ensure that essential habitat attributes are maintained or restored to meet desired conditions. This information is especially important for the Forest Service because of its land management stewardship responsibilities. The Forest Service must not only identify the habitat needs of species of concern, but it must also evaluate the condition of wildlife habitat and compare it with desired conditions as part of the planning process described in planning documents.

The emphasis on habitat monitoring in this guide does not replace the need to assess population status and trend (chapter 2, section 2.2.2). Monitoring to detect changes in population status under different management scenarios provides valuable information about a species' response to management activities. Population monitoring is often recommended in recovery plans for T&E species. Also, situations in which habitat does not strongly influence population dynamics require population monitoring to adequately address species' responses to other forms of environmental change (O'Neil and Carey 1986). For example, many populations of *Sceloporus* lizards are believed to be declining because of effects of temperature warming during the breeding season (Sinervo et al. 2010).

Concurrently collecting habitat and population data strengthens wildlife-habitat-relationships models and provides more valid interpretation of observed changes in both populations and habitats (Cushman et al. 2008b, Manley et al. 2006, McComb et al. 2010, Mulder et al. 1999). The Multiple Species Inventory and Monitoring (MSIM) protocols provide explicit guidelines for this dual-purpose monitoring (Manley et al. 2006). Habitat monitoring may sometimes be more logistically feasible than population monitoring. For example, rare species (e.g., Allen's hummingbird [*Selasphorus sasin*]), or those with low detectability (e.g., wolverine [*Gulo gulo*], northern pygmy-owl [*Glaucidium gnoma*]), that are not at risk are often better candidates for habitat monitoring than population monitoring, owing to the extensive effort required in sampling their populations compared with sampling habitats (chapter 2, section 2.3.1). Even in these situations, habitat monitoring results need to be compared periodically with population data to verify the assumed relationship between habitat and populations.

Habitat monitoring may be critical when the ecological trajectory of habitat is unclear—for instance, if the outcome of management is uncertain or the ecological response of habitat to disturbance is not clearly understood. In addition, habitat monitoring could be a useful way to evaluate the effects of climate change on species or species groups (chapter 2, section 2.2.7).

1.3.3 Sources of Uncertainty in Habitat Monitoring

Several sources of uncertainty challenge the development of habitat monitoring protocols and their subsequent application (chapter 3). These challenges include the following—

- Determining all relevant attributes that define habitat for a given species.
- Using the correct spatial and temporal scales to monitor habitat for a given species.
- Accurately measuring selected habitat attributes.
- Identifying errors associated with modeling and mapping wildlife habitat.
- Understanding how management actions affect habitat and how species respond to habitat change.
- Evaluating the relative role of habitat versus other factors (e.g., plasticity of behavioral responses, competition, or life history traits) that also influence population response to environmental change.

By definition, habitat is multiscalar and multidimensional, encompassing a suite of attributes associated with a particular species (1.3.1; chapter 2, section 2.2.6). Moreover, our knowledge of precisely what environmental attributes constitute habitat for a species is scant for all but the most well-studied organisms. Because of this inherent complexity, monitoring habitat presents unique challenges that are not found with other forms of monitoring, including population and vegetation monitoring. Monitoring efforts may not correctly identify the key habitat attributes for common species, or even reveal them for rare species.

1.3.4 The Habitat Monitoring Team

The habitat monitoring team is the group of people assembled for developing a habitat inventory or monitoring program at a local planning unit (e.g., forest or grassland level or regional level). The members of the team should collectively have the following skills:

- Sufficient understanding of the monitoring objectives.
- Knowledge about the **habitat requirements** of the species selected for monitoring.
- Understanding and experience with statistical sampling issues.
- Knowledge of management plans or activities that might affect **habitat quality** or quantity.
- Knowledge of the potential response of selected species to changes in habitat quality or quantity resulting from management actions.

Recommended members of a team are one or more wildlife biologists or ecologists, a planning specialist, and a statistician. The team may also include expertise drawn from forest, range, grassland, and fire ecology disciplines. The team should use expertise from Research and Development (R&D), including members of the FIA program, and expertise within the National Forest System (NFS). Forest Service cooperators should also be encouraged to participate in habitat monitoring teams.

1.3.5 Partnerships

Effective habitat monitoring requires collaboration with multiple entities, because habitats for most species or species groups are not confined to lands managed by the Forest Service, and a variety of rules and regulations (e.g., Migratory Bird Treaty Act, Endangered Species Act), many of which are administered by other agencies, govern activities that affect wildlife habitats and populations. Habitat monitoring programs can be expensive and time consuming, owing to development, implementation costs, and application of results (chapter 3). Because of these constraints, the implementation of a monitoring project often lies beyond the means of a single organization. Thus, the Forest Service may benefit from sharing monitoring responsibilities and costs when appropriate (Holthausen et al. 2005, Schoonmaker and Luscombe 2005). Monitoring projects that successfully share information among multiple practitioners ensure that future monitoring incorporates previous lessons learned (Schoonmaker and Luscombe 2005). Using stringent data-quality standards also enhances sharing of monitoring data among multiple partners (chapter 9).

1.3.6 Role of Monitoring in Adaptive Management

Adaptive management is a systematic approach for improving environmental management and building knowledge by learning from management outcomes. It entails explicit hypothesis testing, monitoring, and evaluation in a process that accelerates learning based on results of policy implementation (Holthausen et al. 2005, Stankey et al. 2005, Walters and Holling 1990). Monitoring is thus a key component of adaptive management—only through monitoring can the results of management and the potential need for change in management be determined (Elzinga et al. 1998, Murray and Marmorek 2003). For monitoring to inform adaptive management, it must readily distinguish between effects of local management activities and effects of more broad-scale processes or activities, such as wildfires and climate change (Holthausen et al. 2005).

Any of four actions may be appropriate in an adaptive management context after comparing monitoring results with management direction and the original monitoring program objectives: (1) modify the monitoring approach to improve its ability to estimate changes or trends in habitat and to evaluate effects of management direction, (2) modify management direction in response to noncompliance or undesired effects, (3) modify both

monitoring and management direction, and (4) document that none of the previous actions are necessary because the monitoring process worked effectively to meet monitoring program objectives.

Changes in habitat monitoring protocols as a result of adaptive management practices must not be so frequent or drastic that consistency in data collection and analysis is lost (Schoonmaker and Luscombe 2005). Habitat monitoring programs must find a balance between consistency and flexibility; monitoring should provide comparable data over time, but it should provide flexibility so the data collected remain relevant over time as conditions change.

1.4 Recommended Roles and Responsibilities

1.4.1 National Responsibilities

- Develop the habitat monitoring technical guide using expertise from ecologists within the NFS and R&D (including FIA) and from external organizations.
- Ensure that habitat monitoring protocols developed for the technical guide comply with standards previously adopted by the Forest Service, such as those for classifying and mapping existing vegetation (Warbington 2011).
- Encourage the use of existing Forest Service data sources such as FIA, Common Stand Exam data, national geographic information system layers, and regional vegetation inventories for monitoring wildlife habitat (Powell 2000); other data relevant to habitat monitoring, such as species distributions and habitat databases, are available from nongovernmental organizations such as The Nature Conservancy and NatureServe.
- Periodically review the habitat monitoring technical guide for relevance to agency business requirements and update as needed (section 1.7).
- Work collaboratively with national applications, such as the Natural Resource Manager (NRM; http://fsweb.nris.fs.fed.us/), to integrate habitat monitoring information into existing applications (chapter 9). (This Web site and others beginning with "fsweb" are internal to the Forest Service and thus not available to outside users.)
- Provide training and technical expertise to regional and local management unit (e.g., forest, grassland, national recreation area, prairie) staff, as appropriate, for implementing habitat monitoring protocols.

1.4.2 Regional Responsibilities

- To ensure compatibility and scalable results, encourage habitat monitoring across multiple regions and local management units for species whose geographic ranges span more than one region or local management unit.
- Collaborate with other regions and the Washington Office to develop, coordinate, and conduct training in the use of existing data sources and the collection of field data.
- Coordinate with Federal, State, and local government agencies, tribes, scientists, partners, and members of the public to maximize collaboration in habitat data collection across administrative boundaries.
- Evaluate and apply habitat monitoring data, as needed, to inform broad-scale assessments.
- Collaborate with Forest Service R&D to develop additional habitat monitoring protocols, as needed.
- Synthesize and interpret local monitoring data for regional application.

1.4.3 National Forest Responsibilities

- Determine the need for monitoring specific habitats or habitat attributes used in evaluating progress toward achieving or maintaining land management plan objectives or desired conditions.
- Follow the protocols described in the habitat monitoring technical guide when monitoring habitats of specific species or species groups.
- Collaborate with adjacent private and State landowners in implementing habitat monitoring whenever feasible.
- Use data from existing and ongoing data-collection efforts to the extent possible.
- Seek opportunities to monitor habitats in collaboration with adjacent NFS lands and with other agencies, organizations, scientists, and members of the public.
- Ensure that local management units enter habitat monitoring data into the appropriate information system, such as NRM.
- Use the information obtained from habitat monitoring to inform local Forest Service management decisions.
- Alert region of unique, local habitat monitoring situations or a need for improved monitoring protocols.
- Integrate broad-scale habitat monitoring strategies beyond the boundaries of the local management unit, as appropriate.
- Synthesize and interpret local and regional monitoring data for national application.

1.5 Relationship to Other Federal Inventory and Monitoring Programs

The protocols developed and data collected under the auspices of habitat monitoring relate to several existing inventory and monitoring programs within the Forest Service, with other Federal agencies, and beyond. The programs to which the habitat monitoring protocols relate most directly are described in the following paragraphs.

- This technical guide for monitoring wildlife habitat builds on existing protocols contained in the Terrestrial Ecological Unit Inventory (TEUI) (Winthers et al. 2005) and Existing Vegetation Classification and Mapping (Warbington 2011) technical guides. Classification of vegetation is a key step in defining vegetation components of habitat for many species (Morrison et al. 2006; chapters 4, 5). The TEUI protocols include the classification and mapping of ecosystems, which also may be used in defining habitat for species or species groups. Moreover, the ecological units defined in the National Hierarchy Framework, such as the land type associations described in the TEUI technical guide, may form the geographic basis for mapping, ranking, and sampling habitat at appropriate scales (Cleland et al. 1997, DeMeo 2002, MacFaden and Capen 2002, Winthers et al. 2005).
- Protocols developed by Manley et al. (2006) for habitat monitoring include field measurement of several environmental characteristics at MSIM sampling points, such as tree density by size class, canopy cover, and snag and log density (see Manley et al. 2006: table 11.1). At the MSIM monitoring points, FIA data (phase 2 [P2] and some phase 3 [P3]; chapter 4, table 4.3) function as the primary environmental measures. Environmental data collected at MSIM points within the sampling area for a specific habitat monitoring program can be examined to determine what, if any, additional habitat data need to be collected to meet habitat monitoring objectives. Data collected under the MSIM protocols can also be used in wildlife-habitat relationship modeling and thus can inform the selection of habitat attributes to monitor (chapter 2, section 2.3.4; chapter 5).
- This technical guide prescribes use of data from ongoing inventory and monitoring programs (e.g., FIA data, LANDFIRE products; see chapter 4, sections 4.4 and 4.5 for details about use of existing data and protocols) to the degree possible. Core variables collected by FIA (chapter 4, table 4.3) can provide baseline information about habitat attributes on forested lands, but they may not be measured frequently enough at an individual point to satisfy some habitat monitoring objectives (e.g., sampling at many western FIA grid points occurs at 10-year intervals). Data collection under the auspices of FIA on nonforested lands is increasing and will be useful in describing habitat attributes, such as shrub cover, on these lands.
- This technical guide will be entered into the Natural Resources Monitoring Partnership protocol library, an online database of protocols maintained by The Nature Conservancy

and accessible to every natural resource agency and organization in the United States and Canada (http://www.conservationgateway.org/ExternalLinks/Pages/natural-resources-monitor.aspx).

- Habitat monitoring protocols as described in this guide can assist in activities undertaken under the auspices of the Healthy Lands Initiative of the Bureau of Land Management, which emphasizes science-based monitoring and habitat conservation and enhancement.

The approaches to habitat monitoring described in this technical guide may be useful in collaborating with States as they implement State Comprehensive Wildlife Action Plans. Among the eight elements mandated by Congress for these strategies are a monitoring plan and descriptions of the abundance, locations, and conditions of key wildlife habitats (Schoonmaker and Luscombe 2005; http://teaming.com/state-wildlife-action-plans-swaps).

1.6 Quality Control and Assurance

Habitat monitoring protocols described in this technical guide have been designed to be scientifically defensible. Processes that ensure the protocols are sound and uniformly applied include (1) incorporation of existing, standardized data-collection methods (e.g., FIA) built on a science-based sampling methodology; (2) reliance on qualified personnel to craft the protocols; (3) rigorous peer review of the document; and (4) training to encourage consistent application of the protocols. Subsequent chapters describe quality-control measures related to specific aspects of habitat monitoring.

The authors of this technical guide represent a diverse cross-section of expertise from professional and scientific ranks, including national and regional wildlife and vegetation ecologists, research ecologists and wildlife biologists, statisticians, and planners. Qualified professionals, both within and outside the Forest Service, reviewed the technical guide (see acknowledgments). In addition, a statistical review of the entire technical guide ensured that it provides robust methods of data collection, sampling design, and statistical analysis, which, in turn, will generate reliable results when properly applied.

1.7 Change Management

Monitoring programs and protocols must be adaptable to reflect the refinement of existing monitoring techniques and the evolution of new techniques as well as (1) changing conditions on NFS lands (e.g., impacts on habitat of climate change or increasing human population density near NFS lands); (2) emerging issues facing land management (e.g., energy development); and (3) new agency direction resulting from laws, regulations, policies, or case law that affect monitoring. After 5 years, a review of the habitat monitoring technical guide will determine whether the protocols for monitoring habitat attributes and

effects of human disturbance agents on wildlife habitats remain credible and current, or if they need updating with better and more recently developed methodologies. Given the rapidly evolving development of some techniques, especially remote sensing applications, the authors anticipate changes in the technical guide will be warranted at the 5-year review checkpoint. The basic direction of the guide, however, in terms of selecting habitat attributes for monitoring, planning and designing a monitoring program, and establishing monitoring objectives will likely remain intact.

1.8 Conclusions

Habitat monitoring is a critical component of a comprehensive inventory and monitoring program for wildlife on lands managed by the Forest Service and other agencies and organizations. Although several existing excellent resources describe population monitoring protocols, this guide provides standardized protocols for monitoring wildlife habitat, which is of special concern to the Forest Service, given its role as steward of nearly 200 million ac of lands across the United States. Strategic monitoring of a carefully selected suite of habitat attributes, using standardized protocols and existing data where suitable, will yield key information to guide management to meet or maintain desired conditions. Applying the results of habitat monitoring within an adaptive management framework ensures that management and the monitoring protocols evolve as needed to address emerging issues and changes in habitat conditions.