

CHAPTER SIX

Monitoring, Performance Evaluation, and Adaptive Management

OVERVIEW

Element 5 of the NAAT Guidelines requires that the WAP propose plans for a) monitoring species of greatest conservation need and their habitats, b) monitoring the effectiveness of the conservation actions proposed, and c) adapting conservation actions to respond appropriately to new information or changing conditions. Chapter 6 describes New Hampshire's plan for addressing this required element.

Conservation Strategy 900, presented on page 6-6, is the full-length version of New Hampshire's monitoring strategy and also serves as an example of one of the complete strategy templates that are being used internally by NHFG. Table 6-1 (page 6-13) shows some of the criteria for selecting efficient indicators and cross-references technical monitoring objectives with species, habitats, and risk factors.

Many objectives in chapter 5 are directly related to monitoring, performance evaluation, and adaptive management. Species and habitat profiles (Appendix A and B) also contain strategic information about monitoring and detailed information about potential monitoring protocols, performance evaluation, and adaptive management.

MONITORING

The full version of Conservation Strategy 900 (Monitoring, page 6-6) outlines seven categories of monitoring that apply to New Hampshire's wildlife:

- Conduct surveys to describe distribution (Objective 901)

- Detect changes in the condition of wildlife and habitats (Objective 902)
- Monitor population trends for threatened and endangered species (Objective 903)
- Measure direct effects of management (Objective 904)
- Monitor ecological responses to management (Objective 905)
- Select an efficient set of indicators by habitat (Objective 906)
- Report the condition of wildlife health by habitat (Objective 907)

Other strategies in chapter 5 that pertain to monitoring include:

- Provide technical guidance on monitoring protocols so the success of restoration and mitigation can be clearly demonstrated (408)
- Gather information about the locations of New Hampshire's wildlife and habitats and maintain a database to map populations and habitats (201, 202)
- Gather information about the condition of New Hampshire's landscape and maintain a database to assess the status of populations and habitats to help direct management actions (204, 205)

Within species and habitat profiles, monitoring needs were identified in several locations: distribution research (element 1.9), condition assessment research (element 2.9), threat assessment research (element 3.4), and conservation action research (element 4.2), conservation action performance monitoring (ele-

ment 4.1.X-D), and response monitoring (element 4.1.X-F).

Several important issues to consider when designing monitoring efforts include: existing monitoring programs and the scale and frequency of monitoring necessary to achieve objectives.

OVERVIEW OF EXISTING MONITORING PROGRAMS

National and State Monitoring Programs

An early step to developing new monitoring protocols is to identify what currently exists. In some cases, existing monitoring may be sufficient for particular species, habitats, risk assessment, or management response. Some monitoring programs could be easily adapted or expanded to focus on priorities. For example, the North American Amphibian Monitoring Program (NAAMP) actively monitors amphibian populations at select sites ('routes') in New Hampshire annually. These routes do not adequately sample for several amphibians of conservation concern (e.g., leopard frog, mink frog, Fowler's toad) but this program could be expanded to include several priority species or habitats. In other cases, an entirely new monitoring scheme may be necessary.

The following list of monitoring efforts should provide readers with a sampling of ongoing monitoring and the relative level and scale of existing programs among taxonomic groups. It should be obvious that some taxonomic groups and species have been monitored far more intensely than others have.

Plant & Natural Communities

NHNHB conducts ongoing inventories for natural communities and plants.

Invertebrates

The Marine Division of NHFG conducts ongoing monitoring programs for lobsters and breeding horseshoe crab around Great Bay and coastal New Hampshire. The NHFG Nongame & Endangered Species Program, NHNHB, TNC, USFWS, and UNH have conducted occurrence surveys for several threatened or endangered invertebrates including but not limited to dwarf wedgemussels, brook floaters, ringed boghaunter, cobblestone tiger beetle, and pine barrens Lepidoptera. Intense population and habitat management monitoring occurs for Karner blue

butterfly at the one extant population. Long-term population monitoring has been initiated for dwarf wedgemussels in the Ashuelot River.

Birds

Birds have traditionally been the most intensely monitored group of wildlife (other than perhaps game mammals). Major monitoring efforts have been initiated in New Hampshire by NHFG, USFWS, NHA, UNH, Dartmouth College, Vermont Institute of Natural Science, Biodiversity Research Institute, the Loon Preservation Committee, and others. New Hampshire participates in both nationally (Breeding Bird Surveys and Christmas Bird Counts) and state coordinated programs, as well as intense local surveys. NHBR is a state-reporting program for trained bird observations and is primarily used to collect distribution information. Long-term intense monitoring of occupied locations and population conditions has been conducted for several threatened and endangered species including common loon, piping plovers, bald eagle, osprey, and peregrine falcon. Habitat-based bird surveys have been conducted to varying extent for grassland, salt marsh, freshwater wetland, high elevation spruce fir, and floodplain forest habitats. Several game birds of conservation concern have been monitored annually as well (e.g., American black duck, ruffed grouse, American woodcock).

Fish

Anadromous fish species are monitored annually by NHFG and USFWS biologists at fishways during spring spawning runs. Atlantic Salmon populations are also monitored in cooperation with the USFWS and the USFS at designated salmon index sites. The Marine Division of NHFG has a number of ongoing monitoring programs as part of the multi-state management of marine fisheries administered by the Atlantic States Marine Fisheries Commission. Programs include a juvenile American eel survey and a juvenile finfish seine survey. The Marine Division also cooperates with the Maine Department of Marine Resources in the Inshore Trawl Survey, which has been monitoring marine fish populations in the Gulf of Maine since 2000. Surveys are conducted semi-annually by the NHFG Division of Inland Fisheries to monitor the populations of recreationally fished species such as brook trout. NHFG's Inland Fisheries also conducts surveys under the Fish Habitat Program to

assess the condition of fish habitats throughout the state. The Fish Habitat Program has recently initiated surveys to investigate the status of certain fish species of concern, including the bridle shiner, banded sunfish, redbfin pickerel, swamp darter, and the American brook lamprey.

Reptiles and Amphibians

New Hampshire participates in the nationally coordinated NAAMP, designed to examine long-term trends of breeding frog populations. The Amphibian Research and Monitoring Initiative (ARMI) has conducted some inventory work in New Hampshire including the Lake Umbagog National Wildlife Refuge. The Reptile and Amphibian Reporting Program (RAARP) and the Vernal Pool Identification and Documentation program are coordinated by NHFG and are designed to gather statewide distribution information based on volunteer observations. Surveys of malformed frogs have been conducted by the NHDES and UNH. Local occurrence and condition surveys have been conducted for some rare, threatened, and endangered species, but have been limited.

Mammals

NHFG intensely monitors population trends of big game (e.g., white-tailed deer, black bear, Moose, turkey) and furbearer populations. Traditionally, small mammals (e.g., bog lemmings, shrews) have had minimal monitoring; the USFS has conducted some small mammal inventories on the WMNF. Known bat hibernacula are inventoried periodically to get a general species and numbers count. Recently, an intense inventory was conducted for American marten by the NHFG, in cooperation with the University of Massachusetts-Amherst.

Scale

Monitoring can occur at several scales. Three of these efforts reflect a hierarchical set of spatial scales (National/Regional, State, Local). The fourth is a one-time survey for inventory purposes that may not necessarily occur with any regularity, and which can occur at any of the three spatial scales (Surveys). The appropriate scale will differ depending on the objective.

The first step for monitoring is to determine regional/national and statewide distributions for species and habitats of conservation concern. Once

statewide distributions are known, monitoring will be adapted to the condition of targeted local populations or habitat polygons. For habitats, we have assessed the statewide distribution by mapping predicted habitats. Following validation of habitat maps, target polygons will be identified to monitor habitat condition. Similarly, the distribution for many priority species is known, and monitoring will focus on identifying the condition of local target populations either directly or through indicators. As a population recovers, sampling intensity can decrease. Similarly, many monitoring efforts targeting challenging issues (e.g., climate change) may start at the regional level but intensify at the state or local level as specific issues are identified.

Some existing monitoring programs designed to detect long-term trends in species populations are coordinated nationally (e.g., NAAMP, BBS). However, many existing monitoring programs are specific to states (e.g., NHBR, RAARP), and wildlife obviously does not recognize these jurisdictional restrictions. Therefore, communication among states within a region will be critical for species and habitat conservation, and monitoring protocols should be designed or adapted to integrate with others. Monitoring of many priority species, especially those that are rare or locally distributed, often occurs at the local scale. Species that are difficult to detect will also require targeted local surveys.

Local

- Monitoring of single populations (terns, Karner blue butterfly)
- Monitoring of specific sites (IBAs, WMAs)
- Response to management (pine barrens, grasslands)

State

- Statewide sampling of priority species
- Indicators of biodiversity
- Changes in habitat availability or distribution (land use change)
- Status of statewide threats (mercury)

Regional/National

- Large-scale population trends (BBS, NAAMP)
- Monitoring of cross-border threats (acid deposition, mercury)

Surveys (small to large scale applications)

- Assessment of conditions before and after a perturbation (mortality at towers)
- Site inventories (IBAs)
- Validation of habitat models
- Snapshots of species' distributions (RAARP, Atlases)

Frequency

Frequent monitoring may be needed, especially when species are at immediate risk of extirpation from New Hampshire (e.g., Karner blue butterfly, timber rattlesnake). However, intense monitoring often is costly and may not be needed to ascertain a particular ecological response. Therefore, frequency of monitoring must be critically evaluated for any monitoring program initiated. Some programs will require consistent long-term annual monitoring to compare datasets and trends (e.g., BBS, NAAMP). However, as species begin to recover, monitoring often can be adapted to less intense methodologies or frequency. To initiate a discussion regarding the frequency of monitoring indicators, we identified three levels of monitoring frequency: annual, 2-5 years, and >5 year intervals (Table 6-1). Selection and monitoring of indicators will be reviewed before implementation.

Monitoring by Citizens

In some cases, monitoring by highly qualified scientists may not be necessary. Trained citizens can provide important information on the distribution of species and assist with monitoring of the condition of habitats. In addition to the cost-effective means of collecting valuable data, citizen science is a valuable tool in educating the public. Several groups have been actively studying the feasibility of using citizens to assist with scientific studies or monitoring (e.g., Ashuelot Valley Environmental Observatory, UNH). Trained citizens are already used heavily to collect distribution information for some groups of species (e.g., RAARP, NHBR).

Indicator Monitoring

It is not possible to intensely monitor every species and habitat listed in the WAP as well as those not listed. Therefore, in some cases effective monitoring requires an efficient set of indicators that are surrogates for species or habitat condition. The monitoring strategy prescribes a starting point for identifying an

efficient set of indicators for each habitat. Our approach is to seek efficient variables. By "efficient", we mean variables that fit into more than one of the categories described above and represent many wildlife. Efficient also means that we can measure a variable and detect changes with minimal effort. When a variable meets these criteria, we consider it a useful indicator because it indicates changes that are happening for many variables. Our goal is to select efficient indicators for habitats and species listed in the WAP and to monitor them rigorously.

Indicators to monitor habitat

To identify species to serve as appropriate indicators of habitat conditions and risks factors, we created Table 6-1 with several monitoring metrics (scale and frequency of monitoring needed). This table will help facilitate discussions of appropriate and efficient indicators. During the first steps of implementation (chapter 7), a working group will be convened to refine species-specific monitoring needs based on details provided in species and habitat profiles (Appendix A and B). This information will be used to select a set of habitat indicators.

PERFORMANCE EVALUATION

Performance evaluation was built into the WAP planning process at several stages including statewide strategies (Chapter 5) and species and habitat profiles (Appendix A and B).

Statewide Strategies

Performance evaluation is built into each strategy's objective (chapter 5) by explicitly identifying affected threats, expected benefits, and critical inputs. Two monitoring objectives were developed to measure the first two aspects of performance: the direct effects of management (affected threats, objective 904) and ecological response (expected benefits, objective 905). Periodic summary reports will include baseline information, measured indicators, trends in threatened and endangered populations, changes in the level of managed threats, and a summary of inputs. This information will be used to adapt management to current conditions. The following are strategies that pertain to performance evaluation:

- Track and evaluate performance to determine

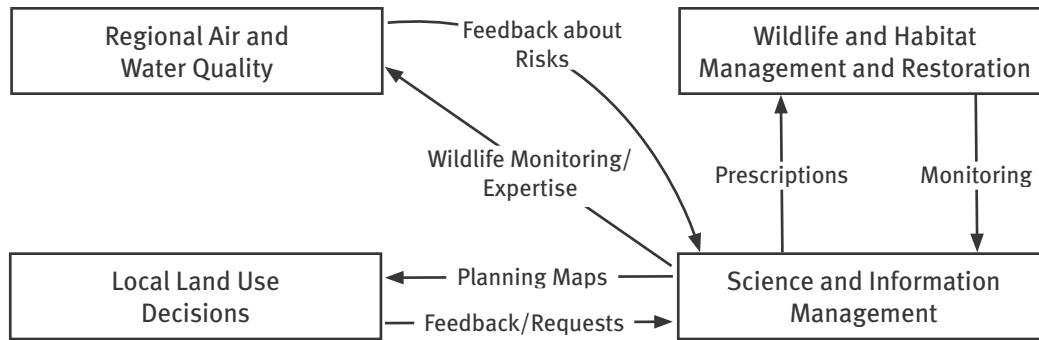


FIGURE 6-1 Adaptive management flow chart

the success of management actions. This entails measuring changes in the level of a risk factor, demonstrating a beneficial ecological response, and establishing a correlation between management and changes in threat levels (207, 904, 905)

- Monitor ecological health of under-surveyed taxa, indicators of condition, threatened and endangered species, effects of management, and ecological responses to management. Produce succinct, standardized periodic reports on wildlife health by habitat (901, 902, 903, 904, 905, 906, 907)

Conservation Actions for Species and Habitats

For each species and habitat, a profile template was completed to the extent that information was available (Appendix L). In element 4 of these profiles, priority Conservation Actions were identified. For each conservation action, we completed the conservation performance objective, performance monitoring, ecological response objective, and response monitoring. These objectives and monitoring will allow biologists to ascertain whether management is effective.

ADAPTIVE MANAGEMENT

Adaptive management incorporates conservation planning, implementation, monitoring, performance evaluation, and most importantly the ability to learn and adapt between each phase. Formalizing adaptive management will help ensure that strategies and actions are ecologically effective, efficient, and cost-effective. We built adaptive management into the planning process and it will be an integral part of implementation (chapter 7). The adaptive management flow chart (Figure 6-1) shows the framework we developed to guide our decision-

making. Identifying performance objectives for each strategy and action will be critical for evaluating performance and adapting when objectives do not meet expectations. Strategies listed in chapter 5 that pertain to adaptive management include:

- Research and comparatively analyze threats to the condition of wildlife populations and habitats (203, 204, 1001)
- Prioritize all proposed conservation actions before implementation to ensure that resources are targeted effectively (207, 1201, 1202)
- Refine and adapt all management activities to reflect new science (207, 904, 905, 1002)
- Manage information and develop media to disseminate to all levels in conservation (201, 202, 206, 401)

MONITORING STRATEGY (900)

900 DESCRIPTION

Monitoring entails the measurement of changes in ecological, spatial, or social variables over time. Traditionally, monitoring has included direct enumeration of species' populations, but also can include species' distributions, population productivity, genetic integrity, community analysis, habitat variables, and risks to wildlife health. Monitoring provides essential input and feedback for all kinds of wildlife conservation efforts, and is almost unilaterally prescribed when concern arises over a particular species or habitat.

It is not feasible to intensively monitor all species and habitats of concern. Certain species and other biological components that reflect pertinent ecological changes may serve as broad indicators of the health of natural systems. By tracking a subset of species or conditions, monitoring can elucidate the nature of threats and the effectiveness of restoration and management efforts prescribed to address those threats.

Monitoring programs must carefully evaluate statistical considerations to ensure that monitoring efforts provide useful information. The objectives presented in this monitoring strategy represent different levels of statistical rigor and monitoring intensity. Although there is some overlap between objectives, it is important to evaluate each to ensure that a monitoring program is comprehensive and adequately reflects the condition of species or habitats. Specific details about monitoring needs can be found in species and habitat profiles (Appendix A and B). Table 6-1 summarizes much of the information gathered during the planning process for priority species and habitats and indicates which monitoring objectives (901-905) are most appropriate for each species, habitat, and threat addressed in the WAP. Table 6-1 is an important first step in identifying an efficient suite of indicators (906).

900 GOAL

The goal of monitoring is to provide wildlife managers with meaningful data on the status of wildlife populations and habitats. Monitoring will provide data and feedback for performance evaluation and adaptive management. In some cases, broad early-de-

tection monitoring programs are necessary to inform managers about changes that may require more active management in the future. In other cases, it is necessary to monitor less tangible variables such as public attitudes, efficacy of regulatory enforcement, and economic values of natural resources.

901 OBJECTIVE: CONDUCT SURVEYS TO DESCRIBE DISTRIBUTION

Assess the distribution of wildlife species and habitats by conducting presence/absence surveys that range from targeted confirmation of historic wildlife records to participation in coordinated statewide and regional surveys. Generally, distribution surveys occur at relatively coarse spatial and temporal scales, and have little or no statistical power to detect trends in abundance.

901(A) Expected Benefits

Determination of presence/absence is the simplest form of monitoring. For some rare or poorly known species, surveys provide the only data available to guide conservation efforts. Distribution information is critical for implementing a management strategy. Periodic assessment of distribution is also valuable for more common or widespread species, potentially showing range expansions and contractions that reflect the nature or distribution of broad scale threats. Poorly surveyed taxa (i.e., amphibians, fish, and invertebrates), and rare wildlife benefit most from distribution surveys.

901(B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although distribution surveys form the baseline for all conservation efforts.

901(C) Existing Resources

Resources available for distribution surveys depend on taxa and scale, and are generally inadequate to obtain complete information about distribution. Models for distribution surveys exist in other states and in regionally coordinated efforts. Currently, the only distribution information that is consistently collected in New Hampshire is from volunteers par-

ticipating in the Reptile and Amphibian Reporting Program (RAARP) or New Hampshire Bird Records (NHBR), and via the Wildlife Sightings website. The information provided by these programs is not conducted in any standardized manner and thus only provide rough approximations of distributions in New Hampshire. NHNH conducts relatively comprehensive localized surveys of natural communities and plants and maintains records of exemplary natural communities, rare plants, and animals. All wildlife records are tracked via the Wildlife Sightings website, and records for tracked species of conservation concern are maintained by NHB. Taxonomic expertise is a limiting factor for many taxa, especially invertebrates.

901(D) Critical Inputs

- Develop contracts to utilize existing taxonomic expertise to identify existing unidentified collections
- The Wildlife Sightings and NHB databases require enhancement and maintenance
- Evaluate the feasibility of statewide atlas efforts for broad groups of under-surveyed taxa (e.g. reptiles, amphibians, fish, and invertebrates); models exist for Lepidoptera and Odonata atlases in other states. Integrate inter-agency survey results
- Repeat Breeding Bird Atlas at regular intervals
- Evaluate the need and feasibility of a mammal atlas
- Identify rare species requiring targeted searches.

901(E) Organization

NHFG needs to coordinate with independent consultants, university researchers, and other qualified individuals to ensure all wildlife sightings obtained during independent surveys are incorporated into the Wildlife Sightings database. All survey results conducted under this strategy also need to be incorporated into the database. NHFG can coordinate with RAARP volunteers and ASNH can coordinate with NHBR contributors to prioritize surveys. ASNH should repeat the Breeding Bird Atlas, which is now greater than 10 years old. Other distribution research should be assessed via discussions among interested partners including ASNH, TNC, universities, and others. Assessing compatibility of monitoring objectives within habitat types is described under 906, and reporting requirements are described under 907.

901(F) Feasibility: 2.19

901 (G) Initiation: 1 year

901 (H) Duration: <10 years

902 OBJECTIVE: DETECT CHANGES IN THE CONDITION OF WILDLIFE AND WILDLIFE HABITATS

Conduct monitoring to detect changes in the condition of wildlife populations and habitats. The purpose of this objective is to detect emerging risk factors (threats) and population declines before they become critical ecological problems. Variables that may be monitored include indicators of the extent or composition of habitats and natural communities, indicators of long-term trends in populations, and levels of risk factors that pose a potential threat to wildlife. Generally, indicators of condition will be monitored regularly across a network of fixed locations, with minimal statistical power to detect short-term local trends, and increasing power at broader spatial and temporal scales.

902 (A) Expected Benefits

Information on the current condition of indicator species or habitats can reflect broad patterns of distribution and abundance for all species and habitats. At a broad scale, monitoring programs such as the BBS generate trend information for many common species, and thus serve as an early warning system. Early detection of broad changes in condition will allow management to adapt incrementally, before species decline to threatened or endangered status, and before habitats are seriously degraded by emergent threats. Ultimately, this will preempt drastic and costly interventions.

902 (B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although monitoring broad changes in condition will indirectly allow managers to address any potential threat that arises.

902 (C) Existing Resources

Several existing programs assess broad patterns of species and habitat condition. Many broad-based threats (atmospheric pollution, water quality, population growth, etc.) are extensively monitored. SPNHF regularly reports on the status of landscape-level threats that are relevant wildlife habitat condition.

Additionally, existing remotely sensed data can provide an efficient means of evaluating habitat health at broad scales (e.g., looking at trends in habitat abundance and distribution over time) using GIS. Even with these resources to evaluate habitat health, many programs are inadequate (e.g., we currently cannot accurately assess the abundance or distribution of shrubland habitats using existing remotely sensed data) and assessments of habitat health are often not tied to wildlife population health.

NHDES monitors stream macroinvertebrates to detect changes in stream quality. Several regional monitoring initiatives exist for birds, including the North American Bird Conservation Initiative (NABCI). Similarly, the BBS, and to a lesser extent the North American Amphibian Monitoring Program (NAAMP) is an important monitoring program in New Hampshire. *Keeping Track* is an international organization based in Vermont that teaches mammal tracking and survey skills to individuals so the information can be applied to local and regional conservation planning. Such information can also provide an indicator of ecological health at the landscape level. For other taxa, however, there is rarely the funding, organizational structure, or expertise to conduct regional monitoring.

902 (D) Critical Inputs

- Identify appropriate indicators of habitat and wildlife health (Objective 906)
- Integrate existing air and water quality and other landscape level assessments of broad threats into assessments of wildlife and habitat health
- Coordinate with and participate in regional monitoring efforts, including BBS, NAAMP, and *Keeping Track*

902 (E) Organization

Species monitored under existing programs (e.g. Partners in Flight, NABCI, RAARP, Christmas Bird Count, BBS, stream surveys, etc.) need to be catalogued to determine how they interact with identified monitoring needs. Assessing compatibility of monitoring objectives is described under 906, and reporting requirements are described under 907.

902 (F) Feasibility: 1.88

902 (G) Initiation: 1 year

902 (H) Duration: Indefinite

903 OBJECTIVE: MONITOR POPULATION TRENDS FOR THREATENED AND ENDANGERED SPECIES

Monitor indicators of trends in population health for threatened and endangered species. Indicators of trends may include abundance, productivity, genetic diversity, or demographic structure. Trends will be used to assess the effectiveness of recovery efforts.

Generally, monitoring for population health should be able to detect local and relatively short-term trends with relatively high statistical power. For many species, it is feasible to achieve statistical power >0.8 with intensively surveyed fixed sampling units, but often, it is not feasible to achieve power >0.5. Decreasing intensity of monitoring (and power) is acceptable with increasingly stable populations.

903 (A) Expected Benefits

Intensive monitoring for threatened and endangered species helps ensure that inputs invested in recovery are effective, and definitive confirmation of recovery can lead to changes in listing status and potentially free resources for other threatened or endangered species. The species most likely to benefit may include timber rattlesnake, piping plover, roseate terns, cobblestone tiger beetle, Karner blue butterfly, Blanding's turtle, spotted turtle, lynx, American marten, White mountain arctic, White mountain fritillary, spruce grouse, New England cottontail, brook floater, dwarf wedgemussel, eastern pondmussel.

903 (B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although the breakdown of population processes in small populations is, in itself a threat (see Scarcity). Accurate measurement of population parameters, as means of directing intervention, may help determine recovery.

903 (C) Existing Resources

Resources vary extensively depending on the species being monitored. Many species listed at the federal level (e.g., Karner blue butterfly, roseate tern, bald eagle, and peregrine falcon) receive regular funding and are the subject of extensive work throughout their ranges. Other federally listed species and the majority of state-listed ones are not adequately monitored, generally because of limited expertise and funding. Expertise frequently exists within the academic sci-

entific community, and there is high potential for collaboration among academic researchers, regional, and state recovery efforts. Resources and technical expertise exist within USFWS and USGS to evaluate monitoring protocols.

903 (D) Critical Inputs

- Develop monitoring protocols for listed species
- Collaborate with other states, federal agencies, and IAFWA to evaluate existing protocols to determine effectiveness
- Implement revised and existing protocols
- Evaluate opportunities for collaboration

903 (E) Organization

Threatened and endangered species monitoring is currently conducted via partnerships and contracts involving NHFG, NHA, USFWS, academic researchers, and private consultants. Existing contracts may be amended to implement new protocols. Contracts for rare amphibians, invertebrates, and fish need to be developed, most likely with academic researchers or consultants. Existing regional programs should be taken into consideration. Monitoring and reporting requirements need to be integrated with all recovery plans and incorporated into the scope of service for new contracts. Assessing compatibility of monitoring objectives within habitat types is described under 906, and reporting requirements are described under 907.

903 (F) Feasibility: 1.56

903 (G) Initiation: 1 year

903 (H) Duration: >10 years

904 OBJECTIVE: MEASURE DIRECT EFFECTS OF MANAGEMENT

Measure the magnitude of changes in threats as a direct result of management. Indicators that may be measured to quantify the direct effects of management are highly variable. Some examples include the level of duff or canopy reduction by fire or forestry, rate of survival of propagated plants, rate of recreational visits by a group targeted for education, or changes in the distribution of lead sinkers after restrictions are implemented. Generally, measuring the direct effects of management entails detecting local and

relatively short-term changes with moderate power (0.5-0.8). Typically, change need only be measured over several intervals (i.e., before and after implementation), depending on the duration and frequency of management and the degree to which effects attenuate over time. Sample sizes and units will vary widely, and often statistical or quantitative methods are not applicable. For example, some types of management may be recorded photographically.

904 (A) Expected Benefits

Measuring whether management inputs have their intended direct effect is a critical component of performance evaluation and adaptive management. Together, information on the direct effect and the ecological response (see 905) allow managers to evaluate linkages between problems and solutions. Species and habitats under restoration or management will benefit most.

904 (B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although measuring direct effects of management help determine whether management affects threats.

904 (C) Existing Resources

Resources available for threat monitoring vary in conjunction with the nature of a given threat. Many broad-based threats (atmospheric pollution, population growth, etc.) are already extensively monitored, while local threats (effects of a particular dam on stream conditions, human use of beaches, etc.) are poorly monitored or not monitored at all. Effects of department-level habitat management are monitored by NHFG, but need integration across programs. Habitat management projects completed under existing cost-share programs (e.g., WHIP, FLEP – see strategy 800) and other projects on private lands are rarely monitored.

904 (D) Critical Inputs

- Funding to adequately monitor effects on public and private lands is needed
- Existing cost-share programs should set aside a segment of funding to support monitoring of habitat management effects
- Appropriate indicators need to be identified by a group of stakeholders to make monitoring effective

and cost efficient (objective 906)

- Trained staff or contractors are needed to apply monitoring protocols, analyze data, and make habitat management recommendations based on principles of adaptive management

904 (E) Organization

Monitoring and reporting requirements need to be integrated with all NHFG management plans and incorporated into the scope of service for new contracts. NHFG and UNH Cooperative Extension should work with other conservation partners and land managers in monitoring the effects of their work. Regional coordination is needed to ensure appropriate levels of funding are provided for monitoring of existing cost-share programs that are funded by the federal government (e.g., WHIP, FLEP). Assessing compatibility of monitoring objectives within habitat types is described under 906, and reporting requirements are described under 907.

904 (F) Feasibility: 1.56

904 (G) Initiation: <1 year

904 (H) Duration: >10 years

905 OBJECTIVE: MONITOR ECOLOGICAL RESPONSES TO MANAGEMENT

Conduct monitoring to determine whether the changes caused by management are having the desired beneficial effect on wildlife. Indicators that may be measured to quantify ecological responses to management are highly variable. For example, if captive breeding is proposed as a management tool, it is necessary to measure whether captive-reared individuals are successfully surviving and reproducing in the wild. See 904 for typical monitoring requirements.

905 (A) Expected Benefits

Follow-up monitoring of ecological responses to management is a critical component of performance evaluation and adaptive management, allowing managers to test the underlying assumption that management benefits targeted species or habitats. Together, information on direct effects (see 904) and ecological responses allow managers to evaluate linkages between problems and solutions (i.e., whether management is actually improving the health of wildlife and habitats,

and whether the problem being managed is actually the cause of diminished wildlife health).

905 (B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although monitoring ecological responses may allow for better understanding of how threats affect species and habitats or the extent to which management reduces any given threat.

905 (C) Existing Resources

Resources needed and available for monitoring under adaptive management vary extensively depending on the species or habitat being managed and the scale at which management is occurring. Ideally, indicators measured under 902, 903, and 904 will adequately reflect ecological responses (905) to evaluate management.

905 (D) Critical Inputs

See objectives 902, 903, 904, 906, 907 for additional inputs. Develop or evaluate protocols prior to implementation of management.

905 (E) Organization

See objective 904. Assessing compatibility of monitoring objectives within habitat types is described under 906, and reporting requirements are described under 907.

905 (F) Feasibility: 1.56

905 (G) Initiation: 1 year

905 (H) Duration: >10 years

906 OBJECTIVE: SELECT AN EFFICIENT SET OF INDICATORS BY HABITAT

Select an efficient set of indicators of wildlife health and management performance by habitat type. It is not feasible to monitor all species, risk factors, and management within a given habitat. Key components for monitoring within each habitat type includes under-surveyed taxa, indicators of condition, threatened and endangered species, effects of management, and ecological responses to management. Objectives 901, 902, 903, 904, 905 represent criteria for determining the collective adequacy of monitoring to provide

essential information on wildlife health and management performance. Existing monitoring programs, known threats, and proposed management will be systematically evaluated by habitat to identify compatible objectives and a set of efficient indicators.

906 (A) Expected Benefits

Choosing an appropriate set of indicators streamlines monitoring by reducing the number of species that need to be surveyed on a regular basis, allowing a finely-tuned system of detecting responses to changes in threats or management activity. For example, if available evidence indicates that a rare mussel is most sensitive to the availability of a fish host species, it may actually be more effective to monitor populations of the fish than the mussel. This would be even more appropriate if the fish was known to be a good indicator of several other environmental variables, such as stream temperature, sedimentation, or hydrologic alteration. Choosing indicators should not replace direct monitoring for the most threatened taxa, nor should it be assumed that threatened and endangered species are the best indicators.

906 (B) Affected Threats

Threats are not directly affected by the implementation of any monitoring strategy, although monitoring may allow for better understanding of how threats impact populations or the extent to which a given threat has been reduced through management.

906 (C) Existing Resources

Information on monitoring needs was gathered in species and habitat profiles completed for the WAP. Needs were tabulated and refined to reflect known threats and strategies (see Chapter 5). Within habitat types, the feasibility and efficacy of proposed indicators need to be evaluated. Criteria for assessing indicators are developed under the previous objectives, and during the *Assessing Biodiversity Indicators Workshop* (TNC 2005).

906 (D) Critical Inputs

NHFG should conduct a workshop or series of workshops to assess all indicators proposed in the WAP and identify other appropriate indicators by habitat. This will allow the termination of redundant monitoring for species and habitats, and reduce the intensity for over-surveyed or over-monitored taxa.

906 (E) Organization

NHFG will host a workshop or series of workshops to assess ongoing monitoring and indicators proposed in the WAP. TNC may serve as a partner in workshop organization.

906 (F) Feasibility: 3.28

906 (G) Initiation: 1 year

906 (H) Duration: 1 year

907 OBJECTIVE: REPORT THE CONDITION OF WILDLIFE HEALTH BY HABITAT

Produce succinct, standardized annual reports on the condition of wildlife health by habitat.

907 (A) Expected Benefits

Standardized reporting on a set of indicators selected by an informed process will provide critical information to summarize the status of ongoing monitoring and management, and serve as input to adapt management to current conditions. Funding invested in ineffective management may become available for more effective approaches. Reports may lead to changes in listing status and potentially free resources for other threatened or endangered species.

907 (B) Affected Threats

See above

907 (C) Existing Resources

Biometric expertise and data management resources to analyze and summarize monitoring data for most rare and declining wildlife are limiting. For instance, NHFG currently only has one biologist who works part time analyzing wildlife data for the entire department. Even when NHFG staff or partners collect rigorous data, data are often not summarized annually or for multiple years. Data collected on similar projects in different states are typically not integrated across state and regional programs to inform planning and management.

907 (D) Critical Inputs

Additional biometricians are needed for data analysis, interpretation, and reporting. Standardized reporting protocols are needed to guide NHFG staff and contractors. Technical assistance is needed for contractors

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to collect and report data according to the developed standards.

907 (E) Organization

USFWS should coordinate sharing of data among states in the region for all threatened and endangered species. NHFG should coordinate data analysis and reporting of wildlife health within the state.

907 (F) Feasibility: 2.06

907 (G) Initiation: 1 year.

907 (H) Duration: >10 years

TABLE 6.1 Preliminary Criteria for Selecting Indicators. (in 9 sections, beginning on page 6-14).

For each species and habitat, potential monitoring needs were categorized according to the technical objectives (901-905) described in the Monitoring Strategy and species/habitat profiles. In the first column, each species and risk factor represents a factor or variable that needs to be monitored. Under objectives 901-905, letters signify the type of change that may need to be measured for each factor. The type of change measured varies among objectives, with intensity generally increasing from left to right. Often, objectives overlap. For a given species, all five objectives may be met with a single rigorous protocol. Many wildlife species, risk factors, and/or overall habitat condition may be highly correlated with a single species. Such species are considered ‘efficient’ indicators for a given habitat type. The next step in developing a WAP monitoring program is to evaluate potential indicators based on how well they represent all of the X’s, whether programs exist already, and whether the necessary frequency and scale are cost effective. The goal is to identify one or a few indicators for each habitat that will reflect all of the X’s in the table.

Footnotes Used in the Table:

- 1 Many species are associated with more than one habitat. For a complete list of species associated with each habitat, see Appendix D [species and habitat cross-walk].
- 2 Many possible indicators exist for the listed risk factors. Ideally, species with X’s under one of the objective columns will serve to detect changes in the levels of risk factors.
- 3 Not all associated species are listed under each habitat. For a complete list of species associated with each habitat, see Appendix D [species and habitat cross-walk].
- 4 Objective 901 includes targeted and broad distribution surveys. Targeted surveys are likely to be prescribed for poorly studied rare species, and broad distribution surveys will be accomplished via atlas development or existing programs.
- 5 Objective 902 is intended for early detection of broad changes in the condition of habitats or the levels of risk factors.
- 6 Objective 903 is intended to address rigorous detection of population trends for the most imperiled species.
- 7 Objective 904 was developed to measure the direct effects of management in order to evaluate the performance of specific projects.
- 8 Objective 905 is intended to measure the ecological responses of wildlife to management activities. Ideally, objective 904 and 905 will serve to establish a correlation between management and response.
- 9 Existing programs will augment or serve instead of new monitoring programs.
- 10 1= annual, 2=2-5 years, 3=>5 years. Indicators that require frequent monitoring are undesirable.
- 11 A = Local, B = State, C = Regional/National, D = Surveys.

TABLE 6.1

Species ¹ and Risk ² Factors by Habitat ³	Distribution (901) ⁴	Detect Change (902) ⁵	Population Trend (903) ⁶	Management Effect (904) ⁷	Ecological Response (905) ⁸	Existing Programs ⁹	Frequency ¹⁰	Scale ¹¹
ALPINE								
American Pipit	X	X					2, 3	A, B, D
White Mountain Frillary	X		X			WMNF	3	A, D
White Mountain Arctic	X		X			WMNF	2	A
Acid Deposition		X					2	A
Climate Change		X						
Scarcity		X	X					
GRASSLAND								
Upland Sandpiper	X	X	X	X	X		2, 3	B
Northern Harrier	X	X	X	X	X	T&E, BBS	2	A, C
Grasshopper Sparrow	X	X	X	X	X	NHBR, BBS, T&E	2	A, B, C, D
Purple Martin	X	X	X	X	X	T&E, BBS	2	A, B, C, D
Eastern Meadowlark	X	X		X	X	T&E, BBS	2	A, B, D
Vesper Sparrow	X	X				BBS	1	B, C, D
Horned Lark	X					NHBR, BBS	2	B, C, D
Northern Leopard Frog	X	X				NHBR, BBS	2	B, C, D
Black Racer	X					RAARP	2	B, D
Smooth Green Snake	X					RAARP	3	B, D
Agriculture				X	X	RAARP	2	B, D
Transportation Infrastructure		X		X	X			
Predation and Herbivory				X	X			
SHRUBLAND								
Ruffed Grouse	X	X		X	X		2, 3	B
Golden-winged Warbler	X	X		X	X	NHFG, BBS	1	B, C
New England Cottontail	X		X	X	X	NHBR, BBS	1	A, B, C, D
	X			X	X	UNH	2	A, B, C, D

TABLE 6.1

Species ¹ and Risk ² Factors by Habitat ³	Distribution (901) ⁴	Detect Change (902) ⁵	Population Trend (903) ⁶	Management Effect (904) ⁷	Ecological Response (905) ⁸	Existing Programs ⁹	Frequency ¹⁰	Scale ¹¹
American Woodcock	X	X		X	X	NHFG	1	B, C
Natural Succession				X	X			
Development		X						
Predation and Herbivory				X	X			
APPALACHIAN OAK PINE FOREST								
Timber Rattlesnake	X		X		X		1, 2	A
Development		X						
Transportation Infrastructure		X		X	X			
Scarcity		X	X					
Altered Natural Disturbance				X	X			
AQUATIC (7 watershed groups)								
Common Loon	X	X	X	X	X	LPC	1	A, B, C
Bald Eagle	X	X	X	X	X	T&E	1	A, B, C
Osprey	X	X				T&E, BBS	2	B
Brook Trout	X						2?	B, D
Burbot	X						3?	?
Lake Trout							?	?
Lake Whitefish	X	X					?	A, D
Round Whitefish	X	X					2, 3	A, D
Slimy Sculpin	X	X					2	A, D
Sunapee Trout	X							C
Atlantic Sturgeon	X						3	A
Swamp Darter	X						3	A, D
Banded Sunfish	X						3	A, D
Bridled Shiner	X						3	A, D

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American Brook Lamprey	X						3	A, D
Finescale Dace	X						3	A, D
Northern Redbelly Dace	X						3	A, D
Redfin Pickerel	X						3	A, D
Tessellated Darter	X						3	A, D
Shortnose Sturgeon	X						3	A
Rainbow Smelt	X	X					2, 3?	A, B?
Atlantic Salmon			X	X	X			
Alewife	X	X					2?	B?
Blueback Herring	X	X					2?	B?
American Eel	X	X					2?	B?
Sea Lamprey	X						2?	B?
American Shad	X	X					2?	B?
Dwarf Wedgemussel	X	X	X				2	A, B
Brook Floater	X	X	X				2	A, B
Eastern Pond Mussel	X						2	
Recreation		X		X	X			
Introduced Species		X		X	X			
Development		X						
Non-point Source Pollution		X		X	X			
Altered Hydrology				X	X			
Mercury	X	X						
Agriculture		X		X	X			
CAVES and MINES		X		X	X		1, 2	A, B
Eastern Pipitrelle	X						2	A, B, D

TABLE 6.1

Species ¹ and Risk ² Factors by Habitat ³	Distribution (901) ⁴	Detect Change (902) ⁵	Population Trend (903) ⁶	Management Effect (904) ⁷	Ecological Response (905) ⁸	Existing Programs ⁹	Frequency ¹⁰	Scale ¹¹
Eastern Small-footed Bat	X						2	A, B, D
Indiana Bat	X						2	D
Northern Myotis	X						2	A, B, D
Recreation				X	X			
CLIFFS								
Peregrine Falcon	X	X		X	X		2, 3	A, B
Golden Eagle	X	X	X	X	X	T&E	2	A, C
Recreation				X	X	NHBR	3	C, D
Mercury		X						
COASTAL ISLANDS								
Common Tern	X	X	X	X	X	T&E	1	A, B, C
Roseate Tern	X	X	X	X	X	T&E	1	A, B, C
Arctic Tern	X		X			T&E	1	A, B, C
Black Guillemot	X					CBC	2	A, C
Purple Sandpiper	X	X				NHBR, CBC, PRISM	2	C
Scarcity		X	X					
Development		X						
Predation and Herbivory				X	X			
Oil Spills		X		X	X			
Introduced Species		X		X	X			
Unsustainable Harvest		X		X	X			
DUNES		X		X	X			
Piping Plover	X		X	X	X	T&E	1	A, B
Least Tern	X					NHBR, T&E	2	A, B, C
Semipalmated Sandpiper	X	X				NHBR, PRISM	1	A, C

TABLE 6.1

Species ¹ and Risk ² Factors by Habitat ³	Distribution (901) ⁴	Detect Change (902) ⁵	Population Trend (903) ⁶	Management Effect (904) ⁷	Ecological Response (905) ⁸	Existing Programs ⁹	Frequency ¹⁰	Scale ¹¹
Recreation				X	X			
Predation and Herbivory				X	X			
Development		X						
Scarcity		X	X					
Oil Spills		X		X	X			
FLOODPLAIN FOREST		X		X	X			
Red-shouldered Hawk	X	X				NHBR, BBS	2	C, D
Cerulean Warbler	X					NHBR, BBS	2	A, D
Wood Turtle	X	X				RAARP	2	B, D
Development		X						
Transportation Infrastructure		X		X	X			
HEMLOCK-HARDWOOD-PINE FOREST		X		X	X			
Development		X						
Introduced Species		X		X	X			
Altered Natural Disturbance		X		X	X			
HIGH ELEVATION SPRUCE-FIR FOREST		X		X	X		2, 3	B, C
Bicknell's Thrush	X	X				Mt. Birdwatch	1	B, C, D
Spruce Grouse	X	X				NHBR	2	B, C, D
American Marten	X		X			NHFG	2	B, C, D
Unsustainable Harvest		X		X	X			
Development		X						
Scarcity		X						
Acid Deposition		X						
LOWLAND SPRUCE-FIR FOREST		X		X	X			
Rusty Blackbird	X	X				NHBR, BBS	1	B, C, D

TABLE 6.1

Species ¹ and Risk ² Factors by Habitat ³	Distribution (901) ⁴	Detect Change (902) ⁵	Population Trend (903) ⁶	Management Effect (904) ⁷	Ecological Response (905) ⁸	Existing Programs ⁹	Frequency ¹⁰	Scale ¹¹
Threatened Woodpecker	X					NHBR, BBS	2	B, C, D
Purple Finch	X	X				NHBR, BBS	1	B, C, D
Bay-breasted Warbler	X	X				NHBR, BBS	1	B, C, D
Spruce Grouse	X	X				NHBR, NHFG	2	B, C, D
Hoary Bat	X						2	B, C
Unsustainable Harvest				X	X			
Development		X						
Scarcity		X	X					
Non-point Source Pollution				X	X			
Altered Natural Disturbance				X	X			
MARSH AND SHRUB WETLANDS								
Pied-billed Grebe	X	X	X	X	X	NHBR	2	B
American Bittern	X	X				NHBR, BBS	2	B, C, D
Sedge Wren	X	X				NHBR	2	C
Least Bittern	X	X				NHBR	2	C
Common Moorhen	X	X				NHBR	2	C
Great Blue Heron	X	X				NHFG, BBS	2	A, B
American Black Duck	X	X				NHFG, MWWWS	1	B, C
Ribbon Snake	X					RAARP	3	D
Blanding's Turtle	X	X	X			RAARP	2	A, B, C, D
Spotted Turtle	X	X				RAARP	2, 3	B, D
Development		X						
Transportation Infrastructure		X		X	X			
Mercury	X	X		X	X			
Scarcity		X	X					

TABLE 6.1

Species ¹ and Risk ² Factors by Habitat ³	Distribution (901) ⁴	Detect Change (902) ⁵	Population Trend (903) ⁶	Management Effect (904) ⁷	Ecological Response (905) ⁸	Existing Programs ⁹	Frequency ¹⁰	Scale ¹¹
NORTHERN HARDWOOD-CONIFER FOREST								
Development		X						
Acid Deposition		X						
PEATLANDS								
Palm Warbler	X	X				NHB	2, 3	B
Ringed Boghaunter	X	X				NHBR, NWR, BBS	2	C, D
Northern Bog Lemming	X					T&E	2	A, D
Mink Frog	X	X				RAARP, NAAAMP	3	D
Development		X					3	B, D
PINE BARRENS								
Whippoorwill	X	X		X	X	NHB, TNC, NHFG		
Common Nighthawk	X	X		X	X	NHBR, PIF, ASNH	1	B, C, D
Eastern Towhee	X	X				NHBR	2	A, B, C, D
Eastern Hognose Snake	X	X				BBS	1	B, C, D
Fowler's Toad	X	X				RAARP	2	A, D
Box Turtle	X					RAARP, NAAAMP	2	A, D
Pine Barrens Zanclognatha	X	X				RAARP	3	A, D
Karner Blue Butterfly	X		X	X	X	NHFG, NHARNG, TNC	1	A, D
Frosted Elfin	X	X				NHFG, NHARNG, TNC	1	A, D
Sleepy Duskywing	X					NHFG, NHARNG, TNC	1	A, D
Wild Indigo Duskywing	X					NHFG, NHARNG, TNC	1	A, D
Barrens Itame	X	X				NHFG, NHARNG, TNC	1	A, D
Barrens Xylotype	X	X				NHFG, NHARNG, TNC	1	A, D
Persius Duskywing	X	X				NHFG, NHARNG, TNC	1	A, D
Pine Pinion Moth	X	X				NHFG, NHARNG, TNC	1	A, D

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Species ¹ and Risk ² Factors by Habitat ³	Distribution (901) ⁴	Detect Change (902) ⁵	Population Trend (903) ⁶	Management Effect (904) ⁷	Ecological Response (905) ⁸	Existing Programs ⁹	Frequency ¹⁰	Scale ¹¹
Broad-lined Catopryrha	X	X				NHFG, NHARNG, TNC	1	A, D
Phyllira Tiger Moth	X	X				NHFG, NHARNG, TNC	1	A, D
The Cora Moth	X	X				NHFG, NHARNG, TNC	1	A, D
Development		X						
Altered Natural Disturbance		X		X	X			
Scarcity		X	X					
Transportation Infrastructure		X		X	X			
Predation and Herbivory		X		X	X			
Introduced Species		X		X	X			
SALT MARSH		X		X	X			
Neison's Sharp-tailed Sparrow	X	X				NHCP, DU	1	A, B
Saltmarsh sharp-tailed Sparrow	X	X				UNH	2	A, C
Seaside Sparrow	X	X				UNH	1	A, B, C
Willet	X	X				UNH	2	C
Development		X				UNH, NHBR, PRISM	2	C
Altered Hydrology		X		X	X			
SAND/COBBLE SHORES/BANKS								
Cobblestone Tiger Beetle	X		X				2	A, D
Puritan Tiger Beetle	X		X				3	A, D
Scarcity		X						
Altered Hydrology		X		X	X			
TALUS SLOPES AND ROCKY RIDGES		X		X	X			
Recreation				X	X			
UPLAND FORESTS		X						
Lynx	X					NHFG	3	C

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Bobcat	X					NHFG	2	B
Eastern Red Bat	X						2	B, C
Silver-haired Bat	X						2	B, C
Cooper's Hawk	X	X				NHBR, BBS, CBC	1	B, C, D
Northern Goshawk	X	X				USFS, BBS	1	B, C, D
Development		X						
Scarcity		X	X					
VERNAL POOLS	X	X		X	X			
Marbled Salamander	X					RAARP	3	D
Jefferson Salamander	X	X				RAARP	2	B, D
Blue-spotted Salamander	X	X				RAARP	2	B, D
Development		X						
Transportation Infrastructure		X		X	X			
Acid Deposition		X		X	X			
NON-BREEDING BIRDS		X		X	X		1, 2, 3	A, B, C, D
Development		X						