Habitat Monitoring:

An Approach for Reporting Status and Trends For State Comprehensive Wildlife Conservation Strategies

F I N A L

prepared by

Illahee

Portland, Oregon

Peter Schoonmaker, Ph.D.
Wayne Luscombe, Ph.D.

22 March, 2005

Comments on this paper are welcome. Please submit them to:

Sara Vickerman and Bobby Cochran
svickerman@defenders.org bcochran@defenders.org
(503) 697-3222
1880 Willamette Falls Dr.
West Linn, Oregon 97068

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In order to ensure that states are making strategic investment decisions and working effectively to prevent additional species from becoming endangered, Congress has mandated that each state prepare a Comprehensive Wildlife Conservation Strategy by October, 2005. The strategies have eight elements which the U.S. Fish and Wildlife Service will use to determine if a state's plan satisfies the legal requirements. One of the elements is a monitoring plan that will assess the success of the conservation actions.

This paper provides a framework for a habitat-based monitoring program for assessing overall impacts of state-based conservation efforts, as well as background and guidance for data collection and analysis. Although it does not directly address species monitoring in detail, the authors assume that states will integrate the species monitoring that is proposed or already underway with habitat monitoring, and that it will be as strategic as possible. The paper stresses the importance of building a constituency of involved stakeholders and ensuring that the development of a fish and wildlife conservation strategy and monitoring program is a goal-driven process.

In order to develop and implement a monitoring program, each state may consider establishing a fish and wildlife habitat monitoring group, to facilitate cooperative monitoring, assessment, and reporting activities. The monitoring group could be a collaborative partnership among federal, state, and local agencies, as well as landowners, conservation organizations and other interest groups.

Creating and implementing a monitoring strategy is an exercise in adaptive management, and that the monitoring program is itself a step in the larger adaptive process of managing natural resources.

The components of a statewide monitoring program, focused on habitat, would ideally be able to answer the following questions in a spatially explicit (map-based) context:

In the short term, were planned conservation actions carried out?

In the medium term, did conservation actions have the hypothesized effects? Did they have the desired effects on habitats and species?

In the long term, how much of each habitat of interest was there historically and is there currently? Where is that habitat? What is its ecological condition? What is the conservation status? What is the desired amount, location and condition?

States may want to map existing conservation areas or current conservation networks to serve as a starting point for setting priorities.

A key recommendation in this paper is for state agencies and partners to create a map-based state-level registry of conservation actions (such as easements, tax incentives, voluntary acquisition, cost shares, stewardship agreements, and certified agriculture and forestry operations) undertaken by all parties to document progress toward meeting Comprehensive Wildlife Conservation Strategy goals.

It is important for fish and wildlife habitat monitoring groups to assess and report their progress in a timely and easily accessible manner, using interactive, user-friendly web sites that provide several levels of information useful to partners, decision makers, and the general public.

Assuming Comprehensive Wildlife Conservation Strategy goals are in place, the basic elements of a monitoring program include:

1. Identify the decision-makers, partners, and resources needed for a fish and wildlife habitat monitoring group to track conservation actions, adaptive management hypotheses, and longer term changes in habitat distribution, condition, and conservation status.

2. Work with partners to identify available information sources, determine whether existing data are adequate to establish a meaningful baseline, and secure and/or enhance GIS data layers. Data can include for example: statewide registry of conservation actions, present land use / land cover map, aquatic resources map, historic vegetation map, existing conservation network areas, priority habitats identified in the strategy, existing conservation projects.

3. Determine what elements of the strategy are suitable for monitoring by agencies, organizations and citizens. Set up systems to train field naturalists and citizen volunteers to collect data, using consistent protocol.

4. Evaluate the impact of conservation actions periodically and make adjustments as necessary within an adaptive management framework.

5. Update the land use, land cover data every five to ten years to track changes, both positive and negative, affecting habitat.

6. Develop an efficient and effective communiction system for reporting and disseminating information to decision-makers and other stakeholders, including the public.

BACKGROUND AND PURPOSE

The conservation of fish, wildlife and associated habitat is increasingly recognized as an important factor in sustaining regional, national, and global environmental, economic, and social systems. In the United States most responsibilities for managing fish and wildlife resources fall to the individual states, which in the past have taken very different approaches to fish and wildlife management. In order to ensure that states are making strategic investment decisions, Congress has mandated that each state prepare a Comprehensive Wildlife Conservation Strategy (wildlife strategy) by October, 2005 in order to continue receiving funding from the State Wildlife Grants Program. Congress specified 8 required elements, which the U.S. Fish and Wildlife Service will use to determine if a state's plan satisfies the legal requirements. One of the elements is a monitoring plan that will assess the success of the conservation actions.

A number of states have sought assistance in the development of an effective monitoring capability. To provide some assistance, this report focuses on monitoring habitat and conservation actions, rather than species or threats, although these may be strategically monitored as part of an overall effort.

Natural resource professionals at local, state and national levels all have a responsibility to employ society's limited resources as efficiently as possible to ensure that natural resource goals and objectives are met. As policies are translated into goals, objectives, and on-the-ground actions, agencies need a system for measuring progress, preferably a system that provides historical context, both in terms of agency objectives (i.e., track changes in objectives) and habitat abundance, condition and distribution.

Monitoring programs should address the needs of policy makers, decision-makers within agencies, and engaged constituents within conservation and land-user groups. These are the stakeholders who influence program adoption, funding and implementation.

This paper provides some background information on coarse to medium scale habitat monitoring techniques and proposes a framework for a statewide system. It is designed for state fish and wildlife agencies and their partners to help them meet the monitoring requirement in the development of wildlife strategies.

> ***BOX 1:*** Monitoring is important, it is difficult, and it is often avoided or overlooked. But future colleagues in fish and wildlife conservation will value this effort immensely.

Specifically, this paper provides guidance for monitoring wildlife habitats and conservation programs to ultimately determine the collective

effectiveness of conservation actions, and to adapt proposed conservation actions as needed in response to new information and changing conditions. The paper offers suggestions for developing conservation goals, building baseline data on the distribution and status of habitats across large landscapes, and detecting changes over time to measure outcomes, thereby providing a mechanism for implementing adaptive management strategies. Monitoring programs should be useful at state and national scales, while providing context for local and regional conservation efforts.

This paper is the result of a study commissioned by Defenders of Wildlife, in October, 2004, to prepare a framework that may be used to assist states in the development of a monitoring program for the federally mandated Comprehensive Wildlife Conservation Strategies. The study, assisted by a grant from the Doris Duke Foundation, was conducted by Illahee, a 501 c 3 nonprofit organization that promotes science-based, policy-relevant environmental inquiry, based in Portland, Oregon.

WHY MONITOR?

GOALS

Just as man-made infrastructure can be thought of as capital that provides production services to society, functioning habitat can be thought of as natural capital that provides ecosystems services-clean water, air purification, flood control, fiber, food, wildlife, recreation, and aesthetic values-to society. In both cases, state and federal agencies have been assigned the tasks of encouraging appropriate "stocks" of economic and natural capital such that our economy and environment can live off the production, or "interest", from that capital.

One of the primary goals of the State Wildlife Grants Program is to keep vulnerable species off the endangered species list by addressing those species' needs. The loss, conversion, and degradation of habitats are arguably the most acute threats to fish and wildlife. Therefore most conservation actions will likely focus on the conservation, restoration, and improved management of land and water to better meet the needs of fish and wildlife.

Resource agencies monitor individual species, sites, programs, and habitats, but a more comprehensive system is needed to determine whether the collective efforts of these agencies and their conservation partners are accomplishing statewide conservation goals (Whitman and Hagen 2004). Fish and wildlife agencies and their partners often have extensive, but disparate, databases on various species, many of which are mandated to be monitored. Species are important to monitor, as species abundance and distribution have been prime drivers for state fish and wildlife agencies. To the extent species are monitored in the context of habitat, it is more efficient to select a few easily sampled indicator species that are strongly associated with priority habitats, and that act as "umbrella species" for other taxa of interest. The relationship between indicator and umbrella species can be somewhat murky. Both owe their origin to Paine's (1966) "keystone species." Indicator species are functionally linked to other species and habitats (but aren't necessarily keystone species), whereas umbrella species may or may not be functionally linked, but rather are used as conservation tools owing to their widespread distribution compared to the species and habitats they are used to protect. The interaction between indicator species and their habitats can be quantified (albeit

BOX 2: In thinking about monitoring programs, resource managers might ask themselves, "What key things do I wish my predecessors had begun monitoring 50 years ago? What will my colleagues 10, 20 even 50 years down the road wish I had kept track of?"

imperfectly) using wildlife habitat relationships or key ecological functions (Marcot and Vander Heyden 2001). In any case, it is not possible nor especially informative to attempt to monitor all species, or even all species of greatest conservation need, so the list of species to be monitored is more likely to be useful if it is short and strategically developed.

A monitoring program begins with clearly defined goals that are linked directly to the state wildlife strategies. Goals should generate action, performance indicators and targets, which can then be used to assess if goals were met and whether they need to be adapted to changing conditions (Teaming With Wildlife Committee State Wildlife Grants Work Group, Brain Stenquist, Chair, 2004).

INDICATORS

Any monitoring program will be faced with the challenge of selecting a discrete set of indicators, which relate directly to goals and objectives, and are linked to targets (essentially an indicator's desired numerical value with a deadline). Choosing indicators is difficult. Whitman and Hagen (2003) present a useful framework for selecting indicators (www.manometmaine.org) that includes five broad categories for indicator evaluation:

1. Relevance — the degree to which the indicator measures the issue of concern
2. Practicality — the feasibility (cost, time, skill) of measuring the indicator
3. Scientific merit — the extent to which the indicator is supported by science
4. Ecological breadth — the number of ecological components the indicator includes
5. Usability — the ability of decision makers make decisions using the indicator

Furthermore, Whitman and Hagen summarize important qualities that indicators should have:

1. Intended use is clear
2. Simplify status of a complex systems
3. Sensitive to known stressors
4. Able to distinguish between anthropogenic stressors and natural variation
5. Provide early warning of change
6. Not greatly sensitive to sample size
7. Low variability in response
8. Easy and inexpensive to measure
9. Easy to understand and translate into decision making
10. Represent cause and effect relationships

Whitman and Hagen also discuss the pressure-state-impact-response indicator framework developed by Friend and Rapport (1979) and discussed in the context of the evolution of environmental indicators by Hammond et al. (1995) where:

- **Pressure indicators** represent the level of a pressure or stressor that affect a natural resource.

- **State** (or condition) **indicators** describe the current state or condition of a natural resource.

- **Impact indicators** indicate the change in a natural resource as a result of a pressure.

- **Response indicators** indicate the level of human action taken to reduce the pressure on a value of interest.

In the context of fish and wildlife habitat monitoring, condition indicators track habitat condition, impact indictors track change over time, and response indicators track conservation actions. Fish and wildlife organizations will likely use pressure indicators (sometimes referred to as "threats") to prioritize conservation actions. Most scientists use state (i.e., condition) indicators, where as policy makers use response indicators. Natural resource managers charged with implementing policy using best available science

find themselves at the interface of policy and science, and may face the most acute challenges in integrating the various indicator types into a usable framework.

Monitoring habitats across ownership and jurisdictional boundaries

Ownership and jurisdictional boundaries add at least four more challenges to the already complex question of how to monitor habitats. First, ownership and jurisdictional boundaries sometimes coincide with habitat boundaries, but often they do not. Second, not only are the goals of federal, state, local and private land owners different, but conservation goals within each of these categories can vary widely. Third, ownerships change over time, with these changes being moderately linked to (either caused by or causing) changes in habitat condition. And finally, the motivations for habitat monitoring and the resulting habitat monitoring programs (if any) vary widely in terms of approach, proprietary versus public information, and data compatibility.

Given these challenges, adjacent land owners within states and ecoregions need to be familiar with one another and build trust through periodic interaction. Collaborative initiatives, such as completing Comprehensive Wildlife Conservation Strategies and establishing multi-stakeholder monitoring groups are fundamental to developing a fish and wildlife monitoring program that has credibility within and beyond the stakeholder group (McKinney et al., 2004).

Monitoring programs should be useful at the national level

Individual states have different habitats, species, land use regulations, development priorities, economic pressures, political pressures, and conservation opportunities. Yet there is value to national level decision-makers, agencies, private investors and the general public in being able to see a coherent national habitat picture. Rapidly improving technology and the need to be efficient and accountable suggest that there is value in striving for some consistency in monitoring the overall distribution and condition of habitat across state boundaries. In addition to coordinating with federal information managers in agencies such as U.S. Geological Survey and the Federal Geographic Data Committee, monitoring groups will achieve more national consistency by engaging state-level federal stakeholders.

ORGANIZING AN EFFECTIVE STATEWIDE HABITAT MONITORING PROGRAM

PARTNERSHIPS AND COOPERATION

The creation of an effective state-wide habitat monitoring program requires participation by a variety of public and private partners. By working together and pooling resources, it should be possible to make more effective use of increasingly limited funding. State fish and wildlife agencies may choose to lead this effort or identify another entity to take on the responsibility of designing and implementing the program. Monitoring programs that feed information back to practitioners will help ensure that lessons learned can be incorporated into future project design through adaptive management.

To meet the requirements of Comprehensive Wildlife Conservation Strategies by October 1, 2005, state fish and wildlife agencies and their partners need to submit plans for developing a monitoring program. In order to develop and implement a monitoring program, each state may consider establishing a fish and wildlife habitat monitoring group (monitoring group), which would facilitate cooperative monitoring, assessment, and reporting activities. The monitoring group would be a collaborative partnership including federal, state, and local agencies, as well as conservation organizations, landowners, and other interest groups. Members could also be drawn from various geographic regions within the state to ensure broad biological and policy knowledge within the group. The challenge will be for the group to be diverse, yet small enough to work efficiently.

The agencies and organizations in the monitoring group will likely have expertise in resource management, ecological science, habitat monitoring, data management, and public involvement. Many of these partners will be able to contribute information on habitat status, location and condition, as well as conservation actions. The monitoring group can provide a periodic comprehensive summary of the status and trends in habitat, and facilitate an assessment of the effectiveness of various programs within the state.

This monitoring framework assumes that the state has already formed partnerships to develop its wildlife strategy, embarked on a statewide habitat assessment, developed statewide conservation goals, and compiled basic spatially explicit data layers. However, it is understood that states are starting from different points in terms of availability of data, defining conservation goals, and overcoming the unique challenges presented in developing state wildlife strategies. While recognizing that these disparities exist among states, the monitoring framework proposed here assumes that the states are working as best they can to coordinate stakeholders, define conservation goals, and identify, compile, and create data.

A number of different groups have vested interests in fish and wildlife conservation and habitat monitoring. These groups include state and federal agencies responsible for fish and wildlife, forests, agriculture, land use, industry, and transportation.

In addition, local municipal agencies, non-governmental organizations, and private sector entities also have an interest in habitat conservation issues and strategies.

Monitoring partners can be involved in the design of the monitoring program, particularly with the development of the objectives and selection of indicators. A state-level monitoring program will require accessing information held by different agencies and organizations. A registry of conservation actions can be a helpful first step in organizing and sharing information. Involvement of partners will also help ensure cooperation with data collection, information sharing, and program implementation.

State agencies and their partners can avail themselves of several opportunities for coordinating their habitat monitoring efforts. At the national level, numerous federal and private organizations provide coordination, common data formats, and nationally consistent habitat GIS data coverages (e.g. Federal Geographic Data Committee, land use/land cover data). At the regional level, coordinating habitat monitoring across state lines is beneficial because states may wish to share strategies and information, and ensure that their "polygons match up" (i.e. that they are using consistent approaches and terminology to map ecological areas). By working together state-to-state, sharing approaches and pulling together partners from public and private sectors, states may be able to develop monitoring strategies that complement one another and can be aggregated upward to the national level.

A system for sharing information, (including reports, data and programmatic objectives) can be developed so that the stakeholders can track overall progress on an agreed set of conservation objectives, and coordinate decision-making, monitoring goals, and adaptive management of the program.

Citizen science

The role of citizen science in habitat monitoring is evolving. Properly trained citizens not only reduce the cost of data collection and ground-truthing, they can also become engaged supporters of fish and wildlife conservation. As the eminent ecologist Gordon Orians has observed, many citizen scientists may have more detailed and intimate knowledge of a particular landscape than professional biologists who may not spend as much time in the field. On the other hand, citizen scientists can present a challenging variable for the resource manager because they fall outside of the usual within-organization structure, may not be familiar with organizational norms, and must be trained and potentially tested to ensure that they provide reliable information (birds.cornell.edu/LabPrograms/CitSci/). That said, some of the most successful monitoring programs are carried out by citizen scientists, such as the Christmas Bird Count. Washington and several other states have NatureMapping programs (see box 3, next page) and other states are considering the possibility. (www.fish.washington.edu/naturemapping). Missouri has "stream teams," (www.mostreamteam.org) and Oregon has an extensive, though variable, watershed council system that utilizes citizens for baseline data collection, (oregon.gov/OWEB/WSHEDS/wsheds_councils_main.shtml).

BOX 3: **Nature Mapping is a program that began in Washington State**
It aims to create a national network to facilitate the exchange of information between natural resource agencies, academia, land use planners, local communities, and schools through public education and participation in data acquisition. The goal is to promote fish and wildlife conservation. The approach is to train individuals to become aware of natural resources and to provide the tools to inventory and monitor these resources.

According to John Pierce, ecologist with the Washington Department of Fish and Wildlife, "Citizen Science is not just a nice idea that should be considered whenever possible. The design, development and integration of an organized Citizen Science Network into the monitoring strategy of all Comprehensive Wildlife Conservation Strategies is the only way we are going to achieve the long-term goals for conservation and biodiversity."

Why Citizen Science? Washington has found that:
- With proper design, training, purpose and commitment, data collected by citizens is comparable in quality to data collected by professionals;
- Citizens experience incredible rewards by participating in field studies, provided that they receive positive feedback and the purpose is clear;
- Citizen science programs can train the next generation of conservationists;
- Citizens can be better informed to participate in policy discussions and;
- Agencies don't have the resources to do it alone!

Communicating progress: a transparent, real-time approach

The fish and wildlife habitat monitoring group can develop various strategies for reporting findings to stakeholders. A possible approach for reporting and disseminating monitoring results might include:

1. Creating an interactive, user-friendly web site that provides several levels of information from big-picture summary, to medium scale thematic reports, to fine scale monitoring information such that it is useful to partners, decision makers, and the general public.
2. Producing a periodic technical report for monitoring group members and national policy makers (such as the State Wildlife Grant Program) with executive recommendations for agency leaders and policy makers.
3. Producing a periodic "glossy summary" for the general public in order to enhance public understanding of fish and wildlife habitat status, trends and monitoring, and to increase public support for this activity.

A FRAMEWORK FOR MONITORING HABITAT STATEWIDE

ADAPTIVE MANAGEMENT

The monitoring framework presented here is part of an adaptive management approach. Adaptive management has been defined in various ways and used to varying degrees of success since its development in the early 1970s (Johnson 1999, Stankey et al. 2003). Perhaps the most direct shorthand for explaining adaptive management is that managers treat actions like experiments. There are also more elaborate definitions, such as this from the British Columbia Forest Service:

Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form-"active" adaptive management-employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed.

Creating and implementing a monitoring strategy is an exercise in adaptive management, and the monitoring program is itself a step in the larger adaptive process of managing natural resources to meet statewide conservation goals. As part of this adaptive management cycle, the monitoring group would be partly responsible for ensuring that the "act" step is linked to a hypothesis in the "plan" step in such a way that it can be monitored and handed on to the "evaluate" step in the cycle.

The components of a statewide monitoring program, focused on habitat, should be able to answer the following questions in a spatially explicit (map-based) context, from an adaptive management approach. These questions are likely to be repeated in different, but overlapping temporal cycles, from short to medium to long term. The key is closing the loop when these questions are answered (or hypotheses are tested) and

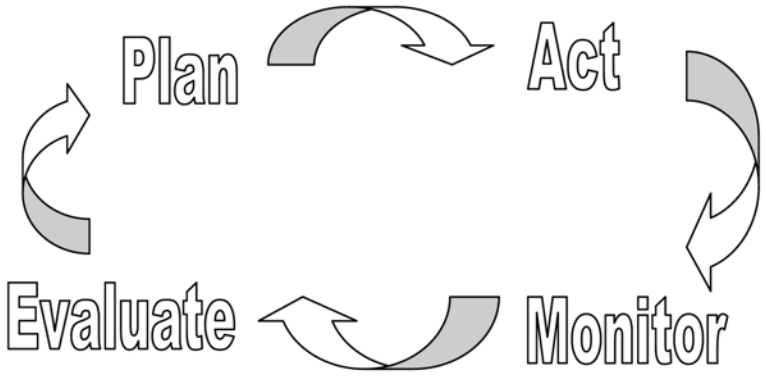


FIGURE 1: **Adaptive management cycle.** The adaptive management cycles can be expanded to several more steps, such as 1. Assess problem. 2. Plan, 3. Act, 4. Monitor, 5. Evaluate, 6. Adjust. (Repeat).

moving forward with fresh plans and actions, which are then tested - or monitored - yet again, and so on.

In the short term, were planned conservation actions carried out?

In the medium term, did conservation actions have the hypothesized effects? Did they have the desired effects on habitats and species?

In the long term, how much of each habitat of interest was there historically and is there currently? Where is that habitat? What is its ecological condition? What is the conservation status? What is the desired amount, location and condition? In relation to habitat management,

Monitoring conservation actions

Since significant changes in the overall distribution, condition, and status of fish and wildlife habitat will take a long time to detect, an interim step could be tracking the implementation of conservation actions on an annual or biennial basis. Ideally, conservation actions will be monitored to demonstrate progress toward strategy goals, and some conclusions can be drawn regarding the effects or outcomes at the site level and more broadly across the landscape. Future research on cause and effect will enhance knowledge about which conservation actions produce the best results at the lowest cost.

The fish and wildlife habitat monitoring group can compile a spatially explicit database of conservation actions currently being undertaken in the state (Table 1). The database would include information about conservation actions taken by each member of the monitoring group including agencies, organizations and other program providers. The information collected would include conservation goals, location, habitat type(s), kinds(s) of conservation action(s), number of acres or stream miles, cost of project, funding source(s), etc. (see Tables 2 and 3).

In the short term, the first question asks whether state agencies and their partners have made strategic investments in the region's natural capital at the habitat level. In the medium term, did the conservation actions themselves work, with explicit reference to hypotheses formed in the planning stage of the adaptive management cycle? Finally, over the long term, the last questions correspond to the time frame of ecological effects monitoring. Have desired species or habitats increased, declined or remained stable? Can this result be linked to actions undertaken by the agency and

Table 1: Conservation action questions, examples, type and time frame

Action Question/Hypothesis	Example	Monitoring Type	Time Frame
1. Was the conservation action implemented?	Were the trees planted?	Compliance monitoring	Short term (~1 year)
2. Did it work as hypothesized?	Did the trees survive and grow?	Effectiveness monitoring	Medium term (~2 to 5 years)
3. Did it have the desired effect on species and habitats?	Do the trees provide better habitat?	Validation monitoring	Long term (~10 to 50 years)
4. Was it the action that caused the effect?	Did planting the trees provide better habitat or did climate change?	Causality	Long term (~10 to 50 years)

partners to implement the wildlife strategy? These latter questions can also be posed in the form of hypotheses to be tested.

The use and effectiveness of tools such as voluntary acquisition, easements, incentives, and certification can be monitored and analyzed not only in terms of accomplishments but also cost effectiveness. For example, do forests certified as sustainably managed by either the Sustainable Forestry Initiative or the Forest Stewardship Council result in greater fish and wildlife abundance and diversity? Are easements and incentives as effective as acquisition and under what conditions? Answering these questions through a monitoring strategy can help states be more strategic in prioritizing fish and wildlife management tools.

States can create a state-level registry of conservation actions undertaken by all parties. Different types of conservation tools, such as easements, tax incentive programs, voluntary acquisition, cost share programs, stewardship agreements, and certified agriculture and forestry operations, could be depicted with different color dots (or symbols or polygons) on maps that also show statewide conservation priority areas. This would allow state agencies and their partners to display the relationship between investments and conservation priorities to identify geographic or habitat gaps in implementation of the wildlife strategy.

Table 2: Example conservation action monitoring measures

Goals	Actions	Targets	Mappable Indicators
Protect, restore, enhance habitat through…	Tax incentives Restoration projects Easements Acquisitions Habitat improvement Certification Stewardship agreements Tracking threats	Acres, Transactions Site-based actions in a. priority habitat b. other habitat	Acres, Transactions Site-based action by Date
Example…. Protect, restore, enhance 17,000 acres of oak woodlands through…	Tax incentives Restoration projects Easements Tracking threats	5000 ac. deferred tax status 5000 acres light burn/yr 7000 ac. in cons easements zero sudden oak death	3500 ac. to date 2700 ac in 200x 2500 ac to date 2 cases, contained

Table 3: Example voluntary registry of typical conservation actions

Agency	Action	Habitat Type	Location	Funding	Reference
• Federal • State • Non profit • Private	• Cooperative • Restoration • Incentives • Acquisition • Easements • Certification	• Priority • Other	Coordinates , polygons	• Source • Amount • Type	Web, paper, contact

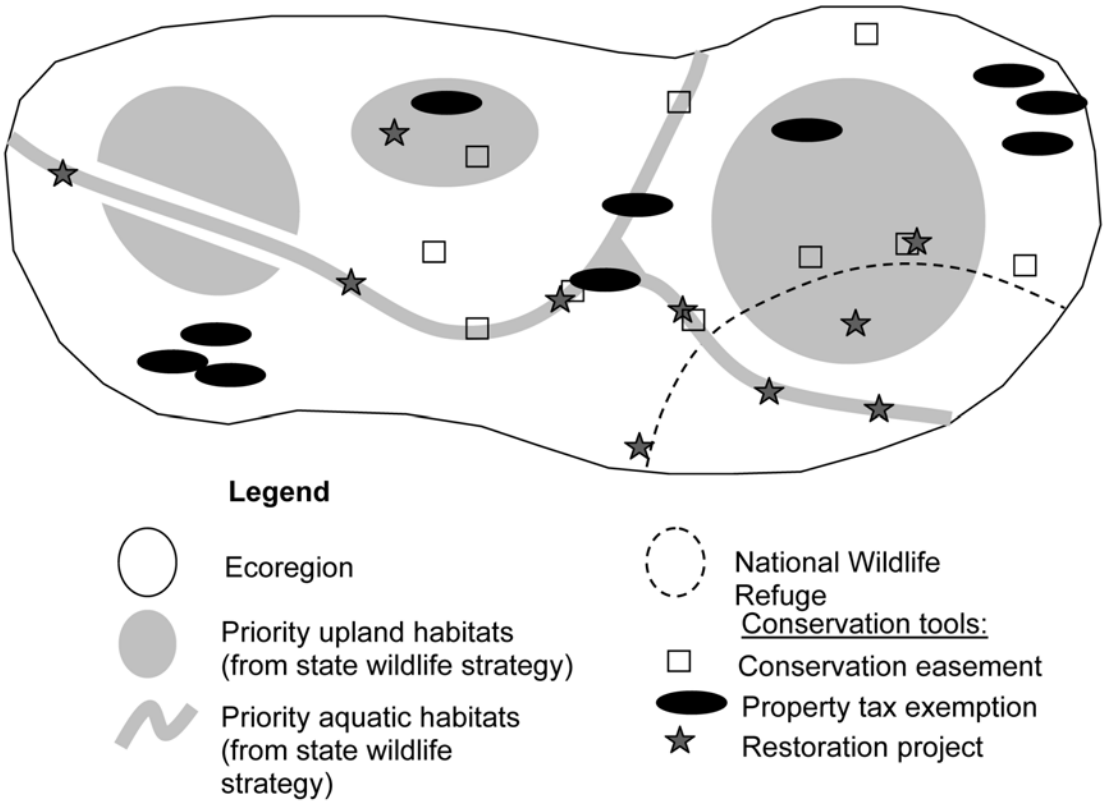


FIGURE 2: **Schematic map of conservation actions.** Mapping conservation actions allows state agencies and conservation partners to evaluate whether their conservation actions are occurring in priority habitats. Some projects include more than one action on the same property (overlapping symbols). Conservation easements (squares) tend to occur on priority habitats, but the western area has none. Property tax exemption participants (circles) occur across the landscape. Restoration projects (stars) are focused near and in the wildlife refuge and in the aquatic habitats. The distribution of conservation actions suggests that future actions need to focus on priority upland habitats (particularly the western upland habitat) and that the property tax program needs to be delivered more strategically.

MONITORING HABITATS

Beyond documenting status and trends in habitat abundance, condition and distribution, states can map existing conservation areas or current conservation networks, and compare these to past conditions and future desired conditions. States can also map priority habitats, and assess the use and effectiveness of tools such as voluntary acquisition, easements, incentives, mitigation, and certification.

A key issue is the definition of "habitat." For the purposes of this paper, habitat is defined as a recurring biological community that is found in similar physical environments and is influenced

by similar dynamic ecological processes, such as fire or flooding. This is similar to NatureServe's ecological systems. This is not a wildlife-centric definition (food, shelter, safety) but one that allows mapping surrogates (e.g., vegetation) for wildlife habitat. The meaning and measurement of habitat will continue to be debated, as it has for over a century; the important thing is to chose a reasonable definition, move on and adjust as necessary.

HISTORIC VEGETATION

Where possible, the monitoring group may want to compile or acquire historical (including pre-European) habitat information. In most cases estimates of pre-European conditions are useful mainly for comparison purposes and do not imply restoration goals, as it would be neither possible nor desirable in most places to return to these conditions. Only a few states, including Oregon, Massachusetts, Minnesota and Michigan, have adequate maps of historical vegetation patterns. States that do not have such datasets or maps available from early surveys might consider developing them in order to better understand how wildlife habitat has changed over time and to identify important agents of change.

Current land use / land cover

National Land Cover Data consists of 21 fairly coarse categories interpreted from Landsat Thematic Mapper images, are available to states from the U.S. Geological Survey at approximately 10-year intervals. Images of any particular location in the United States are actually taken every 16 days, but interpreting these images is costly. Furthermore satellite images are best compared every five to ten years, as this interval is needed to detect significant changes on most landscapes. Where change is rapid and/or extensive, more frequent imagery may be needed, but this will impose an added cost on states and their partners, especially if they want to use a higher resolution habitat classification system than the National Land Cover Data System.

AQUATIC RESOURCES

Aquatic habitat can be expressed in area for some wetland habitats, and in stream reach or stream miles for others. Aquatic habitats can be especially challenging to monitor, as they are often linear in nature and difficult to sample. Linear features are especially difficult to sample using remote imagery, and for this reason, streams and rivers are most effectively sampled using field-based techniques. Most comprehensive habitat classification systems delineate aquatic habitat according

BOX 4: **Minnesota's Mysterious Marschner Map***

In the late 1920's, using over 200 volumes of Minnesota's Public Land Survey notes made between 1847-1907, Francis Joseph Marschner, a researcher for the USDA Bureau of Agricultural Economics, painstakingly created a map of the pre-European settlement vegetation of Minnesota. No one really knows how he used these notes to construct the map, and it is very possible this man never set foot into the state of Minnesota. That said, all who rely on it for their work are unwavering in their praise of the map and its value to the study of Minnesota's vegetation.

The Minnesota strategy is using the Marschner map to better understand what major landscape changes occurred over the past 100 years. Comparing Marschner's map to the 1990's Minnesota GAP land cover map, staff has identified the broad habitat types that have decreased by more than 50%. They believe this information, used in conjunction with species-habitat models and some of the original bearing tree land survey information, will be critical to better managing Minnesota's species in greatest conservation need.

*Information on Marschner from an article by Tim Brady, "The Mystery of a Map and a Man", Minnesota Conservation Volunteer, Jan-Feb, 2003.

BOX 5: **Example habitat monitoring approaches - Missouri**

The strength of Missouri's wildlife diversity program is inventory and survey, although the agency also monitors extensively. Strategy products include ecological assessments of terrestrial systems, aquatic systems, and assessments by partners, which represent their specific conservation initiatives. With participation from conservation partners Missouri selected 31 conservation opportunity areas that will integrated into conservation landscapes in the strategy. Stakeholder teams will develop strategic plans for each conservation landscape, addressed in the eight required elements of the Comprehensive Wildlife Strategy.

The profiles of each conservation landscape will include what monitoring is presently being done in the landscapes, what is important to monitor relative to the conservation actions that have been identified, and how monitoring will be accomplished in the near future. The state's strategy will propose focusing monitoring within the conservation landscapes (priority habitats), and may suggest that some current monitoring efforts be abandoned. Several examples of excellent, scientifically valid monitoring programs have been undertaken by the Missouri Department of Conservation, then later abandoned because they are complicated and expensive. Monitoring will focus primarily on habitats, using land cover data on a regional basis, and use groups of representative species to evaluate ecosystem functioning and restoration efforts. Monitoring target species on a periodic basis is considered a way to verify or "test" habitat based monitoring. Monitoring declining species is seen as a losing strategy, and often not a good test of success.

to the Cowardin (1979) system. In addition to a few selected hydrological, physical, and water quality measures, indices of biotic integrity hold promise as indicators of healthy aquatic habitats. A strength of such indices is that they are unitless and allow for comparison between regions. This can also be a weakness, in that managers unfamiliar with aquatic systems can end up managing by index rather than by biology. Indices of biotic integrity combine information from structural, compositional, and functional parameters and facilitate quantitative comparison of different settings in terms of a single metric. The best-known bioassessment index for aquatic communities is Karr's index of biotic integrity, which has been developed for fish and macroinvertebrates. This index combines species richness and composition, trophic composition, and organismal abundance and condition (Karr and Chu 1999). The Ohio EPA (1987) and Plafkin et al. (1989) developed indices of biotic integrity based on benthic invertebrate communities.

CURRENT CONSERVATION STATUS

The monitoring group may also consider compiling a spatially explicit database of the existing conservation network, derived from national, state and local protected areas, habitat enhancement, restoration and mitigation projects, as well as other initiatives that enhance wildlife habitat and ecosystem integrity. (Figure 2) (e.g. www.biodiversitypartners.org/habconser/cnd/vision.shtml)

PRIORITY HABITATS

Priority habitats to be conserved and monitored can be identified based on the maximum value provided for the greatest number of species of concern, or based on their importance for individual species of special concern, or based on habitat rarity or decline from historical conditions. Priority habitats that are particularly important for fish and wildlife conservation, that are especially rare, or that have been identified as declining or of special concern should be identified and tracked. These may already be identified by the state and

partners as part of the strategy, or may be part of a subsequent effort.

ECOLOGICAL STATUS OF HABITAT

Habitat status and trends, by their nature, may change slowly through time especially over large landscapes. Therefore monitoring and assessment of changes in habitat status will likely require longer term protocols than conservation action or adaptive management hypothesis monitoring. The habitat monitoring group can collaboratively develop baseline information on amount, location, condition and status of key habitat types, beginning with a coarse ecoregion approach (Bailey 1995), refining that baseline to a finer ecological system or habitat approach (e.g., NatureServe 2002, Gap Analysis 2003).

Describing habitat condition is particularly challenging. Condition might be quantified by percentage of some structure, vegetation type, indicator species, or ecological process compared to either historical or future desired condition. This numerical comparison can be translated to a more intuitive description such as "good, fair, and poor" much the way biologists classify species populations as endangered, threatened, of concern, and healthy." The monitoring group can start to track habitat with four questions outlined in Table 4 on the next page (page 18):

BOX 6: Approaches to Habitat Assessment and Monitoring in Georgia

As part of the strategic conservation planning process, , the Georgia Department of Natural Resources contracted with the Natural Resource Spatial Analysis Laboratory at the University of Georgia to develop statistics on land use/ land cover change from 1974 to 1998 for each of five Georgia ecoregions. The lab had previously done this analysis statewide during the Georgia Land Use Trends study. Analysts simply calculated land use/land cover change for each ecoregion by percent and area and develop maps showing the spatial patterns of change. This information will be used to provide a broad-scale picture of problems or threats facing wildlife species. In addition, the wildlife agency will work with the lab to develop coverage of subsequent dates (possibly at five-year intervals) as part of the long-term habitat monitoring effort.

The department also contracted with the Natural Resource Spatial Analysis Lab, Information Technology Outreach Services at the University of Georgia, and the State Archives Office to scan and digitize land lot surveys from the 1800s and develop the basic modeling tools for producing historic vegetation maps. This pilot project will produce historic vegetation maps for three state-owned wildlife management areas - one in the Blue Ridge, one in the Piedmont, and one in the Coastal Plain. The department will use these maps to help determine management priorities for these areas.

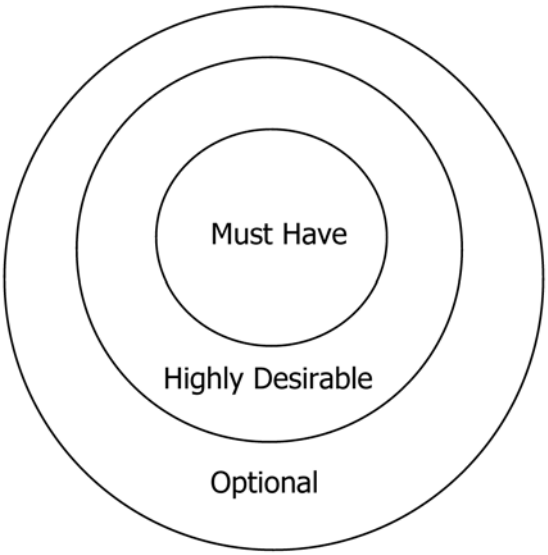
The Southeastern Regional Gap Analysis effort will provide more consistency in mapping land cover across the region, and the NatureServe ecological systems will be used to the extent possible. However, there are several ecological systems that can't be adequately differentiated or mapped using Landsat TM imagery. It might be possible to address some of these with the use of aerial photography, digital elevation models, or other ancillary data, but it is likely that ecological systems will remain a classification system best applied using a combination of aerial photography, topography, soils, and field-based vegetation mapping. The wildlife department hopes to use ecological systems as the standard for habitat mapping on public lands.

Table 4: Habitat condition relative to desired condition

Habitat Question	Question Type (mapped)	Time Frame	Example of Indicators
1. How much of each habitat of interest is there? a. in the past? b. currently? c. do we want there to be?	Quantitative	Longest term, monitored at 5-10 year intervals.	How many acres of oak woodlands are there?
2. Where is the habitat? a. in the past? b. currently? c. where we want it to be?	Geographic	Longest term, monitored at 5-10 year intervals.	Where are patches of oak woodland >10 acres
3. What is its ecological condition? a. in the past? b. currently? c. do we want it to be?	Ranking	Longest term, monitored at 5-10 year intervals.	Is it in excellent, good, fair or poor condition?
4. What is its conservation status? a. in the past? b. currently? c. do we want it to be?	Ranking	Longest term, monitored at 5-10 year intervals.	Does current management enhance or sustain condition?

SCALE AND SCOPE ISSUES

Because of limitations on human, financial and information resources, comprehensiveness and intensiveness are inversely related. Monitoring program can be "broad" or "deep," but it is difficult to do both simultaneously and effectively. An intermediate number of conservation indicators and habitat categories, with a few of these being intensive or "deep," are probably best for the purposes of statewide monitoring. Upon initiation monitoring programs will not be perfect; the important thing is to identify a core set of "must have" measures at the outset, and plan for building onto that program over time as resources permit and circumstances change.



GEOGRAPHIC SCALE

A key challenge is to find ways of relating the indicators across geographic, temporal, and administrative scales. The monitoring group can determine areas to be monitored and specify the level of detail. Ideally, habitat will be monitored at the statewide level, including distribution of conservation actions and habitats, against an ecoregional background. Ecoregions, used by groups like the Nature Conservancy, provide an ecologically-based scale for monitoring conservation as opposed to the state, or other jurisdictional scale. For some conservation actions and for rare or rapidly changing habitats of concern, measurements may be made and tracked at finer scales.

Developing a conservation monitoring program based on assessments of changes to habitat and land use can provide a relatively simple but effective way of gauging the impacts of the wildlife strategies. Most changes to land use patterns occur rather gradually except in local areas of concentrated and intensive conversion. On a large geographic scale covering an entire state, for example, a one percent annual change of land use from one category to another would be difficult to measure statistically, but a change of that

FIGURE 3: Indicator priority can be depicted as a bulls-eye with must-have data at the center, and lower priority data toward the outer rings.

magnitude would be extreme if it were sustained over several years and measured over a longer time frame.

Monitoring groups will appreciate that geographic and temporal scales are interdependent. For example, it is not possible to identify or measure the impacts of climatic change from one year to the next; such impacts require longer timeframes in the realm of decades, centuries, or even millennia and occur over larger geographic scales, such as statewide, multi-state regions, and planet-wide.

TEMPORAL SCALE

The monitoring group will want to review progress toward monitoring program objectives either annually or biannually to determine if conservation actions have been effective in accomplishing statewide conservation goals, given ecological and policy circumstances, should be refined. The monitoring group may also consider whether the sum of the conservation actions collectively contribute to overall statewide conservation goals, and recommend to managers programmatic course corrections that move the state toward overall objectives.

National Land Cover Data can be updated at least every five to ten years, using Landsat Thematic Mapper imagery, depending on data availability and budget constraints. Habitats of special concern due to rarity, wildlife value, or likelihood of rapid change can be monitored more closely or frequently using one or more of the following methods: aerial photography, real property transaction records, key species records, plot-based or line-transect monitoring.

DEPTH AND AFFORDABILITY OF THE MONITORING PROGRAM

Monitoring strategies must be affordable and relevant or they will be abandoned. The temptation to create monitoring strategies that collect information on "everything but the kitchen sink" is strong; but programs that increase efficiency and effectiveness by developing highly targeted monitoring strategies, exploring resource sharing with other agencies, and, where appropriate, engaging citizen volunteers will be more successful.

Many levels of government appear to be entering a period of reduced or flat revenue, so any system that is adopted must strive for efficiency and accountability. Some of the recommendations above - considering a bulls-eye strategy for must-have measurements, coordination and sharing of expertise between states, and using "free" data where possible - can all lower the costs of monitoring strategies.

The temptation is to measure everything. This can lead to spiraling costs and an unsustainable monitoring program. Most decision makers do not have the time to "drill down" through extensive monitoring protocols. Although there may be interesting issues that can be explored through detailed analysis, these issues are unlikely to be relevant to policy makers and agency managers, and are unlikely to be supportable in the long term.

BOX 7: A monitoring strategy must be affordable and produce useful information, or it will be abandoned.

CONSISTENCY AND FLEXIBILITY

Monitoring fosters flexibility and adaptation as long as trends are fed back into the decision-making loop, but the monitoring program itself must find a balance between flexibility and consistency. Monitoring programs that change too easily fail to provide comparable data over time, while systems that are too rigid result in the collection of information that is less relevant over time as conditions change.

ADAPTING TO AN UNCERTAIN FUTURE

The conservation landscape will look different two, five, ten, or fifty years from now, just as natural resources and conservation priorities have

changed dramatically in the past 50 years. Wildlife agencies and monitoring programs have no special access to crystal balls, but certain changes are likely: climate is constantly changing, affecting species differentially; human population and associated pressures and impacts will grow; budgets are unlikely to increase as a percentage of state or federal income; current remote sensing, database, and analysis systems are likely to increase orders of magnitude in power; agency responsibilities, cooperative agreements and even identities will evolve at varying rates.

BOX 8: **Data Consistency**

Changing monitoring protocols not only produces inconsistent data, it can produce misleading data. One example from the Willamette River in Oregon, where certain pollutants were added to a monitoring list, led to the false conclusion that pollution in the river had doubled in three years. Document data collection standards carefully and explicitly.

DATA SOURCES AND MANAGEMENT

Satellite imagery is useful for showing coarse-scale changes in vegetation, patterns of development, and major disturbances. However, there is no national data set that is adequate to show changes in habitats at fine spatial (less than 30 meters) and fine temporal (annual) scales. One option would be for the states and partners to work with the U.S. Geological Survey to enhance the National Land Cover data set to include additional categories for natural landscapes. Another option is to work with the Gap Analysis Program staff to develop a more consistent product that can be used to detect changes. NatureServe has an ecological classification system, but it is not uniformly available as spatial data.

BOX 9: **Emerging Technology and the Future**

Remote sensing systems and data handling technologies are improving constantly. The 30-meter resolution satellite data available to agencies now will likely be replaced by higher resolution data in the near future.

Both Gap Analysis and NatureServe's Ecological Systems approaches identify useful habitat units at a scale intermediate between coarser Ecoregions (Bailey 1995, 1998) which are useful as an organizing framework for states and the very fine scale of the National Vegetation Classifications System (Comer, et al., 2003) which may be too fine-grained to be cost effective for most states to use statewide for habitat status and trend determination. Both Gap Analysis and Ecological Systems have been used effectively by states for assessing wildlife habitat status, and Gap Analysis will be migrating to NatureServe's Ecologic Systems over the next few years.

One caveat, no matter what system is used, is that an intermediate number of habitat or land use categories are probably best for the purposes of statewide monitoring. Some states with diverse ecological landscapes may have over 50 habitat types, while other states with more uniform ecological landscapes, such as those in parts of the Midwest, may not have much more than a dozen. If the number of habitat / land use types reaches into the triple digits, it may be necessary to expand the monitoring and data analysis budget, which may pose a challenge.

Identifying trends in habitat status will require repeated observations. Using Landsat Thematic Mapper imagery is the most cost effective way for states to track medium scale habitat change. Thematic Mapper's 30-meter resolution and 10-year interval may be too coarse for some trend detection, especially for linear features such as streams and wetlands, and for urban / suburban / exurban boundaries. States can purchase additional Landsat imagery or use aerial photography for

these situations, but must bear significant additional costs. Landsat imagery can also be augmented by LIDAR (Light Detection And Ranging). LIDAR uses the same principle as RADAR, by transmitting light out to a target and analyzing light reflected back. LIDAR better resolves structural habitat characteristics important to wildlife, but it is far more expensive than Landsat Thematic Mapper imagery, and is best used for selected complex habitats where detecting structural characteristics is paramount (www.lidar.com).

Fish and wildlife habitat monitoring groups will recognize that information is the foundation of a monitoring and assessment program, but can pose the most significant challenges to creating an effective wildlife strategy. The collection of appropriate information can be costly, time-consuming, and technically difficult; therefore, decisions about what to collect and how to collect it need to be made carefully with due consideration given to what is feasible, practical, and effective, and appropriate for the scale of analysis. The newest and most expensive high-tech equipment may not produce the most useful information.

Monitoring groups can develop their own data management system, but can save time and money by following common data standards, and adopting a common glossary of terms and measures. Monitoring groups can establish a data management committee composed of data managers from partner organizations, to adopt common data standards and a glossary. Because virtually all fish and wildlife habitat monitoring information has a spatial component, a good place to start is to ensure that the monitoring group ollows the Federal Geographic Data Committee's framework for geospatial information (www.fgdc.gov /index.html). The objectives of the standard are to provide a common set of terminology and definitions for the documentation of digital spatial data.

Technicians have numerous options for turning imagery and ground-based data into maps useful for tracking conservation action or habitat status and trends. Various vegetation and habitat classification systems have been proposed over the years, based mainly on vegetation structure and taxonomy, but also soils, landforms and other phenomena. Some states will already have well-developed habitat and conservation maps for a monitoring group to use. Others may need to develop these resources.

Thematic Mapper Data: This program takes 30-meter-resolution 185 x 185 km images of the earth's surface, returning to each location every 16 days. The U.S. Geological Survey has developed a coarse 21-category National Land Cover Data system, and organizations can use this as a starting point to further refine Landsat images to their own classification systems, or start from square one with the raw images. Obviously the more land cover or vegetation classes one desires to distinguish, the more time and money is needed. Landsat imagery is commonly ground-truthed with plot data, which has been made much easier with the advent of inexpensive, portable Global

BOX 10: **Mapping Habitats and Conservation Actions**

Because habitats occur on landscapes they can be mapped. In addition, most conservation actions have a spatial component, and can be mapped as well. Mapping conservation actions and habitats begins with U.S. Geological Survey base maps. Most agencies then acquire some kind of imagery (either photographic or satellite-based) and interpret these images into land use / land cover categories. For most organizations the most cost effective approach is to use NASA's Landsat Thematic Mapper data (geo.arc.nasa.gov/sge/landsat/landsat.html)

Positioning Systems. Landsat and other imagery are limited not only in their spatial resolution, but in their ability to detect structural and taxonomic change. For phenomena requiring higher resolution, aerial photography may be necessary, and for even higher resolution, the most expensive alternative is needed: point, plot or transect-based sampling.

BOX 11: **Two Caveats Regarding Satellite Imagery**
First, satellite images don't pick up fine scale habitat features like snags, caves and stream features. Second, satellites eventually fail. Thematic Mapper satellites have failed in the past, and they will fail in the future. The issue is, will they be replaced?

NatureServe: NatureServe's Ecological Systems of the United States (Comer et al. 2003, (www.natureserve.org) defines 599 terrestrial and aquatic ecological systems across the United States. These systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. They are intended to provide a classification unit that is readily mappable, often from remote imagery, and readily identifiable by conservation and resource managers in the field. Most states have 10 to 30 of these ecological systems. A few have around 100, which may be the upper limit for practical monitoring.

Gap Analysis Program: This U.S. Geological Survey program (www.gap.uidaho.edu/default.htm) provides state, regional, and national assessments of the conservation status of native vertebrate species and natural land cover types of the United States, and facilitates the application of this information to land management activities. The Gap Analysis Program has worked with most states to provide landcover maps. These maps, derived from Landsat Thematic Mapper data delineate a similar number of habitats as the NatureServe system, and the two systems are merging toward NatureServe's Ecological Systems protocol. Gap Analysis Projects take about four years to complete for a particular state.

CONCLUSION

Monitoring conservation actions and habitat trends is a crucial step in fish and wildlife conservation. Without this "testing" step, the entire adaptive management process breaks down. And when this process breaks down, wildlife policy and management wanders.

Habitat monitoring is difficult on several counts. Managers may not be sure what to measure. Routine measurements are less exciting than bold new initiatives. Funding often flows to new "innovative" projects. This isn't to say monitoring can't be seen as innovative, and indeed the adaptive management cycle is one of constant change and renewal. Perhaps most challenging for many organizations is that monitoring may generate answers that are not immediately welcome. Change is difficult, and managing adaptively all but guarantees change. Added to all this is the fact that the technical aspects of habitat monitoring are challenging: sample design, choosing remote or ground-based data collection, data analysis, and reporting.

Perhaps most challenging are the conceptual and organizational aspects of habitat monitoring. This report provides some concepts and a framework that states and their partners may find useful as they look to track conservation actions of numerous collaborators, test wildlife management hypotheses, and monitoring trends in habitat status and condition. The goal should be to determine if the sum of all these conservation parts is leading in a desired direction. The answer will almost certainly be complex, in time and space. In the face of this complexity and uncertainty, fish and wildlife habitat monitoring groups must stay the course; prospective monitoring partners are engaging in work that is bigger than any one organization, but is fundamental to the success of all.

APPENDICES: DATA SOURCE TABLE

Table 5: Useful information sources for fish & wildlife habitat monitoring groups.

Data Source	Utility	URL
NATIONAL LEVEL		
EPA Environmental Monitoring and Assessment Program	status and trends of national ecological resources	http://www.epa.gov/emap/
EPA Multi-Resolution Land Characteristics Consortium	partnership, excellent data	http://www.epa.gov/mrlc/
EPA North American Landscape Characterization	change detection using MSS data	http://www.epa.gov/nerlesd1/land-sci/north-am.htm
EPA Regional Vulnerability Analysis	regional scale, priority-setting assessment	http://www.epa.gov/reva/
Federal Geographic Data Committee	data standards	http://www.fgdc.gov/
Nature\Serve Ecological Systems	similar to habitats, 599 categories	http://www.natureserve.org/prodServices/ecomapping.jsp
NOAA Coastal Change Analysis Program	land cover & change analysis, 30 m resolution	http://www.csc.noaa.gov/crs/lca/ccap.html
USDA Aerial Photography Field Office	aerial photography, 3- and 10-meter resolution	http://www.apfo.usda.gov/

Data Source Table, *continued*

Data Source	Utility	URL
USDA Forest Inventory and Analysis	remote imagery & permanent plots	http://fia.fs.fed.us/
USDA Landscape Analysis and Assessment	regional and national landscape change analysis	http://www.srs.fs.usda.gov/4803/landscapes/
USDA National Resource Inventory	soil & water	http://www.nrcs.usda.gov/technical/NRI/
USGS EROS Data Center	one-stop shopping for remote imagery	http://edc.usgs.gov/
USGS Gap Analysis Project	multiple coverages	http://www.gap.uidaho.edu/
USGS Global Land Cover Characterization	1 km resolution	http://edcdaac.usgs.gov:80/glcc/glcc.asp
USGS National Land Cover Data	21-class land cover classification	http://landcover.usgs.gov/natllandcover.asp
USGS National Vegetation Classification System	multi-agency vegetation system	http://biology.usgs.gov/npsveg/nvcs.html
USGS National Water-Quality Assessment	data on 50 major river basins	http://water.usgs.gov/nawqa/
REGIONAL LEVEL (Interstate project initiatives)		
Federal (e.g., Northwest Forest Plan)	regional resource and economic planning	http://www.reo.gov/
State (e.g., Northwest Power Conservation Council)	regional resource and economic planning	http://www.nwcouncil.org/
Multi-stakeholder (e.g., Northern Forest Lands Council)	regional resource and economic planning	http://www.northernforestlands.org
STATE LEVEL		
Fish and Wildlife Departments	varies by state	http://www.iafwa.org/members/state_agency_websites.htm
Forestry Departments	varies by state	http://www.nearctica.com/organize/govern/sforest.htm

Data Source Table, *continued*

Data Source	Utility	URL
Other Natural Resource or Environmental Agencies	varies by state	http://offices.fws.gov/statelinks.html
Biodiversity Partnerships	varies by state	http://www.biodiversitypartners.org/
State Natural Heritage Programs	varies by state	http://www.natureserve.org/visitLocal/
Non – profit Organizations	varies by state and region	http://www.nbii.gov/about/partner/ngo.html
State Universities	various projects and coverages	http://www.csrees.usda.gov/qlinks/partners/state_partners.html
COUNTY / LOCAL LEVEL		
County Agencies	ownership records	http://www.statelocalgov.net/
Regional governments	varies by region	http://www.narc.org/
City Parks, Water and Environmental Agencies	varies by city and agency	no central web site
Local aerial photography	high-resolution aerial photography	no central web site

GLOSSARY

Adaptive management - a cyclical process (plan, act, monitor, assess, repeat) in which managers treat actions as experiments, from which they improve management actions.

Conservation action - a specific conservation tool (e.g., habitat improvement, mitigation, acquisition or restoration) employed in a specific location.

Conservation network - a system of land and water that is managed for the primary purpose of conserving the representative ecological attributes of a region. A conservation network may include lands that are used for other purposes, like recreation, agriculture, or forestry, as long as the ecological values are given special consideration, and the overall configuration of the network accommodates the needs of native species and habitats.

Citizen science - a collaboration between managers and scientists on the one hand, and citizens on the other, in which trained and qualified citizens participate in the scientific process, especially the collection of data.

Ecological System - a recurring biological community that is found in similar physical environments and is influenced by similar dynamic ecological processes, such as fire or flooding.

Goal - an overarching statement of desired condition at some time in the future.

Habitat - for the purposes of this paper, similar to an ecological system: a recurring biological community that is found in similar physical environments and is influenced by similar dynamic ecological processes, such as fire or flooding.

Habitat status - the geographical extent, ecological condition and management paradigm of a particular habitat.

Habitat trend - change in habitat status over time, measured by monitoring that habitat in a consistent and comparable manner.

Habitat monitoring group - a cooperative partnership between federal, state, and local agencies, conservation organizations, and wildlife interest groups formed to facilitate monitoring, assessment, and reporting activities.

Impact indicator - indicate the change in a natural resource as a result of a pressure.

Indicator - a measure that tracks goals, objectives, actions, and targets (or inputs, outputs, and outcomes) by stating them in specific and observable terms.

Landsat - satellite-based imaging system that provides an array of remote images of various resolutions and spectral types, for example Thematic Mapper data.

Land Use Land Cover - a coarse 21-category system for interpreting Thematic Mapper images, developed by U.S. Geological Survey.

LIDAR - Light Detection And Ranging. LIDAR resolves structural habitat characteristics better than Thematic Mapper images but is far more expensive.

Monitoring - repeated measurement carried out in a consistent manner so that observations are comparable over time.

Monitoring, compliance - asks the question "did the organization do what it said it would?"

Monitoring, effectiveness - asks the question "did the organization's action accomplish the stated proximate goal (the objective) to be accomplished by the action?"

Monitoring, validation - asks the question "did the organization's action accomplish the stated goal (usually broader than an objective) to be accomplished by the action. Did it result in a positive outcome for the habitat or species?"

Objective - the proximate and measurable manifestation of a goal.

Pressure indicator - represents the level of a pressure or stressor that affect a natural resource.

Response indicator - indicates the level of human action taken to reduce the pressure on a value of interest.

State (or condition) indicator - describes the current state or condition of a natural resource.

Target - goal or objective with a deadline (i.e. how much by when). Targets specify expected results for a given period of time and provide measurable milestones that help gauge progress toward an objective (e.g., restore 1000 acres of oak woodland by 2040). Targets can be a discrete number or a range between two numbers.

Thematic Mapper - Landsat remote imaging system that takes 30-meter-resolution 185 x 185 km images of the earth's surface, returning to each location every 16 days.

ABOUT ILLAHEE

Illahee is a 501 c 3 nonprofit organization with a mission to promote science-based, policy-relevant environmental inquiry. Illahee's three core programs are the Illahee Institute, the Illahee Lectures and the Illahee Report. (www.illahee.org)

PROJECT PERSONNEL

Peter Schoonmaker is founding Board President of Illahee, a non-profit organization that promotes science-based, policy-relevant environmental inquiry. He has worked with numerous conservation organizations, community groups, government agencies, and natural resource businesses to craft mutually beneficial forest, fisheries and watershed partnerships in the Pacific Northwest. He holds a Ph.D. in biology from Harvard University.

Wayne Luscombe is an independent consultant, providing services in areas related to project and program monitoring and evaluation, decision support systems, spatial information technologies, and international development. He has worked with environmental units of the World Bank for nearly twenty years and has worked on development projects in more than a dozen countries. He holds undergraduate degrees in mathematics and geography and a Ph.D. in geographic information systems from Simon Fraser University.

ABOUT DEFENDERS OF WILDLIFE

Defenders of Wildlife is a national non-profit organization headquartered in Washington D.C. Its mission is to protect and restore native wild animals and plants in their natural communities. The Northwest Office, whose staff manages this project, emphasizes alternative approaches to environmental decision-making by facilitating partnerships among divergent interests seeking constructive solutions to environmental problems. Defenders invites you to visit a special site designed to support collaborative conservation approaches, www.biodiversitypartners.org.

ACKNOWLEDGEMENTS

This project was made possible through a generous grant from the **Doris Duke Charitable Foundation**.

The authors thank the following people who assisted in the development of this paper: Gail McEwen, Holly Michael, Audrey Hatch, Peg Boulay (Oregon Department of Fish and Wildlife); Joe LaTourrette, Chris Sato, John Pierce, Tim Quinn, Rocky Beach, Jeff Koenings (Washington Department of Fish and Wildlife); Rita Dixon (Idaho Department of Fish and Game) Dennis Figg (Missouri Department of Conservation); Ken Bierly (Oregon Watershed Enhancement Board); Mike Carrier (Oregon Governor Kulongoski's office); Norm Johnson, Jimmy Kagan, Susan Morre, Hal Salwasser, Gail Achterman (Oregon State University); Bruce Marcot, Tom Spies (U.S. Forest Service, PNW Research Station); Jeff Tryens (Oregon Progress Board); David Hulse (University of Oregon); Chris Robbins, Dan Salzer (Oregon Nature Conservancy); Andrew Yost, Jennifer Weikel (Oregon Department of Forestry); Brian Stenquist, Emmett Mullin, Daren Carlsen (Minnesota Department of Natural Resources); Steve Bender (Texas Parks and Wildlife); Tom Kohlsaat (South Carolina Dept. of Natural Resources); Salinda Daley (North Carolina Wildlife Resources Commission); Bill Graves (New Mexico Department of Game and Fish); Rick Schneider (Nebraska Natural Heritage Program); Jon Ambrose (Georgia Department of Natural Resources); Christen Mitchell (Hawaii Division of Forestry and Wildlife); Dave Case, Phil Seng (D.J. Case and Associates); Karen Terwillinger (Terwilliger Consulting); Mike Fraidenberg (Dynamic Solutions); Jon Haufler (Ecosystem Management Research Institute); Verlyn Ebert (U.S. Fish and Wildlife Service); Dan James, John Mosesso, Susan Haseltine, Paul Dresler (U.S. Geological Survey); Dwight Fielder, Mark Hilliard (U.S. Bureau of Land Management); Robin O'Malley (Heinz Center); Mary Klein (NatureServe); Steve Zack (Wildlife Conservation Society); Susan Kidd (Georgia Conservancy); Terry Riley (Teddy Roosevelt Conservation Partnership); Sara Vickerman, Rick Brown, Katie Frerker, Bobby Cochran, Cheryl Hummon, Kassandra Kelly, Jeff Lerner, Frank Casey (Defenders of Wildlife). Any errors remain the responsibility of the authors.

REFERENCES

Bailey, R.G. 1995. Description of the Ecoregions of the United States, 2d ed., USDA-Forest Service Miscellaneous Publication 1391, Washington, D.C., 108 pp.

Bailey, R.G. 1998. Ecoregions: The Ecosystem Geography of the Oceans and Continents, Springer-Verlag, Inc., New York, 176 pp.

Defenders of Wildlife 2003. The Biodiversity Partnership www.biodiversitypartners.org

Britan, G. M., 1991. Measuring Program Performance for Federal Agencies: Issues and Options for Performance Indicators. US General Accounting Office. Washington, D.C

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia. www.natureserve.org/publications/usEcologicalsystems.jsp

Cornell Lab of Ornithology 2005. Citizen Science. www.birds.cornell.edu/LabPrograms/CitSci/

Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online. www.npwrc.usgs.gov/resource/1998/classwet/classwet.htm (Version 04DEC98).

Dvornich, K. 2005. The Nature Mapping Program in Washington. www.fish.washington.edu/naturemapping.

Federal Geographic Data Committee. www.fgdc.gov /index.html

Friend, A., and D. Rapport. 1979. Towards a comprehensive framework for environmental statistics: a Stress-Response approach. Statistics Canada, Ottawa.

Gap Analysis Program. www.gap.uidaho.edu.

Hammond, A., A. Adriannse, E. Rodenburg, D. Bryant, and R. Woodward. 1995. Environmental Indicators: A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development. World Resources Institute, Washington, D.C.

Hubbard, L., D. James, and J. Smart, 2001. A Guide to the State Project. New South Wales National Parks and Wildlife Service-Conservation Assessment and Priorities Unit. www.nationalparks.nsw.gov.au/npws.nsf/Content/Monitoring+conservation+across+NSW

Johnson, B. L. 1999. The role of adaptive management as an operational approach for resource management agencies. Conservation Ecology 3(2): 8. www.consecol.org/vol3/iss2/art8/

Karr, J. and E. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press. Washington DC.

Marcot, B. G., and M. Vander Heyden. 2001. Key ecological functions of wildlife species. Pp. 168-186 in: D. H. Johnson and T. A. O'Neil, Technical Coordinators. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis OR.

McKinney, M., J. Parr and E. Seltzer. 2004. Working Across Boundaries: A Framework for Regional Collaboration. Land Lines: vol 16, Number 3. www.lincolninst.edu/pubs/pub-detail.asp?id=912

Mosse, R., and L. E. Sontheimer, 1996. Performance Monitoring Indicators Handbook. World Bank Technical Paper No. 334. The World Bank. Washington, D.C.

National Parks and Wildlife Service, 2002. NSW Biodiversity Strategy-How to carry out a bioregional assessment. www.nationalparks.nsw.gov.au/npws.nsf/content/How+to+carry+out+an+assessment

Ohio Environmental Protection Agency (Ohio EPA). 1987. Biological criteria for the protection of aquatic life: volumes I-III. Ohio Environmental Protection Agency, Columbus, Ohio.

Oregon Watershed Enhancement Board Web Site. 2005 (accessed). www.oregon.gov/OWEB/WSHEDS/wsheds_councils_main.shtml

Paine, R. T. 1966. Food web complexity and species diversity. American Naturalist 100: 65-75

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Sigwerth, C. 2005 (accessed). Missouri Stream Team. www.mostreamteam.org

Stankey, G.H., B.T. Bormann, C. Ryan, B. Shindler, V. Sturtevant, R.N. Clark and C. Philpot. 2003. Adaptive management and the Northwest Forest Plan. J. For. 101(1): 40-46. Teaming With Wildlife Committee State Wildlife Grants Work Group (Brain Stenquist, Chair). 2004. Thoughts on monitoring success of comprehensive wildlife conservation strategies (plans). Memo to State Directors. www.teaming.com/pdf/6%20Monitoring%20Success.pdf

Whitman A. A. and J. M. Hagan. 2003. Biodiversity indicators for sustainable forestry. Report to the National Commission on Science for Sustainable Forestry. www.manometmaine.org

Wildlife Conservation Society, June 2002. Monitoring Conservation Project Effectiveness. Living Landscapes Bulletin 6. www.conserveonline.org/2002/07/s/LLP-Bulletin6-English;internal&action=buildframes.action