

CHAPTER 6: SOUTH CAROLINA'S COMPREHENSIVE MONITORING PROGRAM

Purpose and Justification for Monitoring

Throughout most of the history of natural resource conservation, single species management has been the focus. Threatened and endangered species, especially, have been the subject of intensive management. However, the literature provides testament to the effects of missed indices and unanticipated events on successful conservation. Although sometimes individual species need targeted management approaches, the majority of species would benefit from a broader strategy aimed at their shared ecosystems. The animals included on South Carolina's Priority Species List each have individual ecological roles connected in myriad ways to others. From this perspective, multi-species and systems approaches to conservation become the clearer path to accomplishing the many goals and strategies that the SCDNR has identified in the SWAP.

It seems apparent that this view of management will require constant and consistent adaptation to change. Single alterations in community function—such as the loss of a keystone species—can produce ripple effects that confound the most complete systems model. Despite imperfect knowledge, however, management must still move forward if conservation is to succeed. Likewise, as the system evolves, so does the method of management. Adaptive management cannot proceed without vigilant attention to these changes. Monitoring and evaluation then become the essential tools for detecting, measuring, and interpreting these changes over time.

Assessing changes in populations and habitats over time, especially in response to applied conservation actions, requires monitoring at multiple levels (species, guilds, natural communities, and implementation activities) and across multiple scales (local, statewide, regional, and national). Through varying styles of monitoring, SCDNR can detect species-specific trends from estimates of population size, relative abundance, or distributional shifts. Similarly, by measuring species associations such as longleaf pine-associated reptiles, we can assess habitat-level responses. Monitoring of habitats leads to identification of challenges or impacts of management activities or landscape alterations. Finally, monitoring simply helps us understand the effects, intended or otherwise, of any management approach.

During the initial planning stages before 2005, SWAP project leaders received guidance from partners—including USFWS, USGS, NPS and USFS—aimed at identifying essential elements in the design of effective monitoring programs to support the SWAP and its subsequent implementation. South Carolina's team attended meetings to discuss collaborative efforts and structural design of SWAP monitoring programs. Paul Dressler from the USGS presented a list of the basic elements of a monitoring program. Representatives of USFS and NPS provided descriptions of current monitoring programs instituted at varied scales by their agencies. This information has proved invaluable in considering the framework and strategies the SCDNR will employ through implementation of the SWAP to create a more effective and efficient statewide monitoring program.

Cooperative efforts remain essential to accomplishing the goals of these programs. SCDNR works first to ensure that existing programs remain effective where they meet the needs of conservation strategies within the SWAP. Monitoring continues to be a necessary component of most SCDNR efforts outside of the SWAP as well. The structure of the South Carolina Monitoring Program builds on existing SCDNR monitoring efforts and, where appropriate, partners' monitoring programs. Additional partnerships and support will continue to be researched during the development of the monitoring program.

Current Monitoring Programs in South Carolina

Monitoring programs are not a novel approach in successful conservation. International and domestic efforts to monitor migratory bird species provide excellent resources for developing species-level monitoring programs. The North American Breeding Bird Survey (BBS) is a well-known, long-term, continental sentinel monitoring program. The Christmas Bird Count similarly provides documentation of winter distribution and abundance for bird species. Such efforts set precedents in data collection and distribution which other taxa monitoring programs might find beneficial to emulate. Other bird surveys established in South Carolina include the International Migratory Bird Day and Backyard Feeder Watch. Of important note is the consistent, effective use of volunteers, or "citizen scientists," to conduct these assessments.

In South Carolina, current monitoring projects for both SWAP priority species and others include the following:

- The US Army Corps of Engineers and South Carolina Ocean and Coastal Resource Management (OCRM) provide essential monitoring efforts for marine invertebrates.
- SCDHEC monitors water quality while surveying for some freshwater invertebrate species.
- SCDNR assesses commercial fishery stocks and State Shellfish Grounds on an annual basis to evaluate shellfish population status.
- SCDNR estuarine trammel net sampling efforts have sampled SC estuaries since 1990, with over 20,000 net sets that intercept 151 species of fish.
- SCDNR's electrofish sampling program evaluates species abundance in the critical oligohaline stretches of SC rivers.
- SCDNR longline surveys monitor inshore waters for a number of species of concern, especially sharks.
- SCDNR monitors juvenile American Shad abundance and timing of outmigration in the Pee Dee, Edisto, and Savannah Rivers, as well as the Santee Cooper Lakes and tributaries.
- SCDNR monitors the movements and critical habitat use of adult Shortnose and Atlantic Sturgeon along the East Coast as part of a multi-state collaboration between SC, GA, and NC.
- SCDNR monitors Shortnose Sturgeon habitat use in the Santee Cooper Basin as part of the Santee Accord.
- SCDNR monitors young-of-the-year American Eel in the Rediversion Canal and Goose Creek Reservoir.

- SCDNR monitors the adult American Shad and Blueback Herring spawning migration in coastal rivers. Additionally, the SCDNR monitors fish passage of American Shad and Blueback Herring at the St. Stephen Fish Lift.
- The South Carolina Estuarine and Coastal Assessment Program (SCECAP) monitors habitat quality of estuarine waters statewide and identifies specific sites with degraded water or sediment quality.
- The SCDNR-SEAMAP program currently monitors the abundance of fish and decapod crustaceans using a trawl survey of coastal waters (4 to 10 m; 13 to 33 ft.) from North Carolina to Florida.
- South Carolina participates in the Harvest Information Program (HIP) that has been fully implemented nationwide, allowing for comparisons of migratory game bird numbers and harvest levels in South Carolina.
- Comprehensive hunter harvest surveys have been conducted for all species in South Carolina periodically since 1963. Fifteen surveys have been completed spanning 44 years. (1963–64; 1966–67; 1975–76; 1978–79; 1981–82; 1984–85; 1991–92; 1993–94; 1999–2000; 2002–03; 2004–05; 2006-07; 2008-09; 2010-11; 2012-13).
- The South Atlantic Fishery Management Council (SAFMC) assesses stock status of many species.
- Reproductive effort and fledging success of South Carolina nesting Bald Eagles has been documented (mid-winter surveys) on an annual basis since 1986.
- SCDNR monitors the reproductive effort and success of Wood Storks nesting in South Carolina.
- A spring Whistling Call Count Survey for Northern Bobwhite has been conducted annually since 1979.
- South Carolina has participated in Mourning Dove Call Count Surveys since 1966. Annual banding also occurs across the State.
- Annual summer Wild Turkey Brood Surveys have been conducted since 1982 to monitor reproductive success.
- Over 1,250 Furbearer Scent (Tracking) Station Survey routes have been run annually since 1984, while Black Bear Bait Stations have been monitored every other year since 1993 for the mountain population.
- Fox Squirrel Sighting Surveys were initiated in 1989 and began being conducted on even number years starting in 1994.

This list only briefly describes some of the monitoring efforts SCDNR undertakes in current management programs. An extensive list of monitoring efforts currently employed across the State and region is included in Appendix 7.

Additionally, the Freshwater Fisheries section of the Wildlife and Freshwater Fisheries Division of the SCDNR has run continued surveys of user preferences and user impact on the fisheries of the State. The following are those programs completed within the last 25 years.

- 1990 - Freshwater fishing study
- 1998 - South Carolina fishing license holders opinions and attitudes toward fisheries management and the South Carolina Department of Natural Resources, results of Largemouth Bass and Smallmouth Bass anglers

- 1998 - South Carolina fishing license holders opinions and attitudes toward fisheries management and the South Carolina Department of Natural Resources
- 1999 - Youth and fishing in South Carolina
- 1991, 1996 and 2001 - The 2001 Economic Benefits of Freshwater Fishing in SC
- 2000 - Striped Bass anglers' attitudes toward fisheries management on Lake Murray
- 2000 to present - Annual Cooper River Tailrace Canal American Shad Fishermen Survey
- 2001 - South Carolina youth aquatic survey
- 2003 - South Carolina residents' attitudes and behaviors toward aquatic resources
- 2003 - South Carolina and Georgia anglers' attitudes on fishing regulations on Lake Russell
- 2004 - South Carolina fishing license holders opinions and attitudes toward fisheries management and the South Carolina Department of Natural Resources

Authors of the SWAP species accounts identified monitoring, survey, and research needs for priority species. Recommendations for individual species can be located in the separate volume, Supplemental Volume: Priority Species Accounts. Several needs are currently being addressed to varying degrees while others still need to be done. Some of the general needs for monitoring efforts are described here.

Many freshwater species—especially invertebrates such as crayfish, snails, and mussels—lack distribution and survey information for baseline data upon which a monitoring program could be built. Similarly, many of the marine fish and marine invertebrates on South Carolina's Priority Species List have only recently received initial survey attention and will require further study to create effective tracking programs. Where baseline data is available for freshwater aquatic species, there is a strong need to improve long-term monitoring across species groups. SCDNR fisheries biologists have recently developed a system for stream habitat monitoring and assessment (Decision Support Tools for Stream Conservation), made possible through State Wildlife Grants. Otherwise, monitoring is needed to assess specific management actions such as buffer establishment and species restoration projects. Impacts of introduced or exotic species on priority species remain a concern for many freshwater systems.

A pressing issue for monitoring terrestrial species is the establishment of taxa-relevant monitoring protocols such as those already established for birds. Efforts to expand monitoring on public lands and initiate monitoring on key private lands, where possible, should be addressed. A monitoring protocol for small mammals and bats should be developed. Survey and data needs are most pressing for all species of bats on South Carolina's Priority Species List. Therefore, it may be most important to survey and institute long-term monitoring programs at roosting locations. A pilot project on conducting bat acoustic surveys statewide is currently being developed.

Ongoing monitoring coordination and support of recommendations of national and regional planning bodies (such as PIF, SAMBI, NABCI, NAWMP and others) should be continued. Primary landbird species identified for specific monitoring programs include Swainson's Warbler, Henslow's Sparrow, Bachman's Sparrow, Wayne's Black-throated Green Warbler, Loggerhead Shrikes and Painted Buntings. Baseline studies are currently being conducted on Black Rail and MacGillivray's Seaside Sparrow which will help with their future monitoring. Key habitats of concern include pine savannah and pine woodland, early-successional types,

grasslands, and forested wetlands. Efforts to continue the monitoring of migratory and resident waterbirds and waterfowl are also recommended.

Development of monitoring protocols for amphibians and reptiles is of primary importance. SE PARC has published an Inventory and Monitoring Guide for the US and has developed protocols for some species. SCDNR's continued involvement in this process is important for both the continued development and refinement of reptile and amphibian monitoring guidelines.

Strategies for South Carolina's Comprehensive Monitoring Program

The following are specific strategies outlined for the advancement of South Carolina's Comprehensive Natural Resources Monitoring Program (South Carolina Monitoring Program). These strategies were developed during the initial iteration of the SWAP in 2005. Continuing to address these strategies should be considered a priority for future implementation goals. Where progress has been made, successes are discussed in italics under each strategy.

Strategy 1: Initiate a comprehensive monitoring program to coordinate monitoring efforts, including establishment of a collaborative working group staffed with agents both from the SCDNR and partner agencies. Data sharing in regards to common monitoring efforts should be a priority.

- Coordinate monitoring efforts across scales and jurisdictions through partnerships, defining scope as a function of the monitoring subject.
- Provide a means to share information, provide advice, and coordinate state monitoring efforts to be nationally and internationally compatible.
- Develop an ecologically-based framework considering the incorporation of an ecosystem-based approach to allow for regional compatibility.
- Use monitoring results to prepare future iterations of the SWAP.
- Build on existing state monitoring systems; utilize existing protocols where applicable.
- Support local planning initiatives, regional planning teams, and existing cooperative agreements where appropriate (See Appendix 3 for a list of existing partnerships).
- Develop a monitoring process that is easily understood, sustainable, cost-effective and relevant to all parties involved, and paced appropriately.
- Include assessments of cumulative impacts and, where possible, an interdisciplinary approach (geologic, genetic, ecologic, climatic).
- Maintain participation in monitoring networks as established between states during the national SWAP planning efforts.

Strategy 2: Create a South Carolina Comprehensive Natural Resources Data Initiative. Currently, there are various means of storing data in use by the agency. Unfortunately, many of these data layers are housed within separate divisions and are not compatible across operating systems at this time. A goal would be to standardize data gathering and prepare a repository for housing it. This data could then be retrieved in-house or shared, as appropriate, with partners or the public. Specifics of this initiative may include the following:

- Develop a standard system to facilitate species, habitat, and monitoring data collection for storage and dissemination across the agency and partnerships.
- Create a SWAP project monitoring system to link tracking of conservation actions with recommendations and appropriate species of concern.
- Establish standard operating procedures for project reporting and provide access to templates for web-based data input that will support research and monitoring efforts.
- Provide public and partner access to information collected and maintained to increase ownership and collaborative efforts. This collaborative data interface should allow for input directly from the field.
- Examine the ability to link previous databases with new information through consistent species and habitat codes.
- Collaborate with neighboring and regional states to create standardized platforms, enabling information exchange at broader scales.
- Spatially relate all database information, where appropriate, to provide summarizations through geographic information systems (GIS) software capabilities.
- Regularly update the conservation status (S-ranks; state listings) of species in South Carolina.
- Track distribution and status of all priority species with the intent to expand the database for tracking non-priority species as well.
- Use element of occurrence points to create more accurate range maps for species.
- Design the database with the intent to facilitate future reporting and revisions of the SWAP.

Strategy 3: Translate species-level goals and objectives to habitat and landscape scales for implementation and monitoring.

The Freshwater Fisheries division has created a Decision Support Tools application for online modeling of watershed impacts relative to deforestation, urbanization, road building, and other disturbance scenarios. Element of Occurrence Records (EORs) for freshwater fish species are overlaid to represent species that may be affected by habitat alterations. These new EORs were made possible by the Stream Assessment Survey (2006-2011) funded by State Wildlife Grants. Further needs include:

- Accomplish long-term objectives of monitoring key habitats using existing and new GIS programs.
- Continue to update and analyze the existing GAP databases and crosswalk this information with a statewide habitat characterization as provided in the SWAP.
- Design and implement an aquatic GAP initiative to support aquatic monitoring.
- Complete periodic updates of land use and land cover in the State to help translate threats from species to a habitat scale.
- Elevation models of the State, especially the coastal counties, should be updated and at a finer scale so that potential sea level rise due to climate change can be more accurately predicted and charted over time.
- Evaluate the existing SWAP species' goals for feasibility and applicability at broadening scales.

- Utilize landscape-level remote sensing and other mapping techniques, which are of particular value given the proportion of key habitats and priority species that are located on private lands.
- Monitor partnerships and public involvement such as conservation easements, stewardship agreements, and volunteer efforts at the habitat scale.

Strategy 4: Augment monitoring group efforts by developing or expanding citizen science partnerships, where appropriate. The SCDNR already relies on volunteers and citizen scientists to assist with surveys and DNA collection for research, especially in freshwater and marine fisheries. A page has recently been created on SCDNR's website dedicated to citizen science links. Further suggestions include:

- Consider the efficacy of developing and training citizen science groups to expand data gathering capability across the State.
- Build public understanding of ecological issues and meet the varied educational and public outreach recommendations for priority species by involving increasing numbers of citizens and institutions in basic status and trends monitoring efforts.
- Encourage partnerships with secondary and higher education institutions to provide students with opportunities to integrate classroom learning with practical experiences.
- Increase the use of graduate training programs in creating and implementing response monitoring, an excellent opportunity for standard graduate level research.

While presented last, it is important to consider the potential benefits of citizen-based programs (AFWA 2012). The Breeding Bird Survey and Christmas Bird Counts are citizen initiatives. These programs provide some of the most complete data on bird distributions. Already, South Carolina citizens utilize online reporting systems for monarch butterfly counts, green darner migration counts, firefly sightings, Purple Martin scout sightings, and Swallow-tailed Kite sighting reports. Support for continued conservation efforts can only benefit from a sense of ownership and collaboration among partners and the public. For more information regarding public input and partnership development, see Chapter 7.

Monitoring Program Defined

As the SCDNR proceeds with the refinement of the South Carolina Monitoring Program in support of the SWAP, several elements of design must be considered; these are outlined in Box 6-1 and are adapted from guidance provided to the States by federal partners.

BOX 6-1: BASIC ELEMENTS OF A MONITORING PROJECT AND PROGRAM

- Identification of monitoring goals and objectives
 - What is the question and why; identify existing information; conceptual model
- Identification of targets to monitor
 - Selection based on above results and availability of resources (fiscal/human)
- Establishing monitoring protocol (peer reviewed)
 - All elements documented (question; sampling design; methodology; anticipated analysis/analytic tools; data management and reporting strategy; schedule)
- Quality assurance and quality control
 - Assuring and controlling quality; training and potential certification of users
- Data management and archiving
 - Scheme to ensure data are documented, maintained, archived, and accessible
- Data analysis and assessment
 - Anticipated analysis including estimates of confidence
- Reporting
 - Reporting formats and schedule (useable, understandable, responsive) to user
- Periodic review and evaluation
 - Ensure project is responsive to the need and reflects the best available science

Monitoring targets will be dictated during the program implementation and adaptive management process; this process is more thoroughly described in Chapter 8: Implementation and Adaptive Management. In most cases, one or more of the following types of programs will be developed:

- 1) **Targeted species or habitat status and trends.** This type of monitoring tracks the status and trends of selected species, habitats, and communities and how they respond to management.
- 2) **Multi-species context or habitat condition.** Context or condition monitoring for either species or habitats allows us to track change at the ecosystem level to understand patterns of change.
- 3) **Cause and effect or response.** Cause and effect or response monitoring, in reality, mimics traditional research on the underlying explanation of observed events.
- 4) **Management action effectiveness.** Effectiveness monitoring relates directly to adaptive management as it assesses how well management actions undertaken achieve desired results.

Effective monitoring must integrate trend data with cause and effects for successful adaptive measures to be taken. Likewise, it must integrate habitat description with species measures. Viewing either as a surrogate for the other is inappropriate. Habitat-species relationships are not

always well understood; often, quality habitat will lack presence of expected species. Species trends, conversely, cannot provide direct insight into changes in habitat composition.

Targeted Monitoring

Targeted species status and trends monitoring might assess species presence/absence, population density, productivity (number of offspring), breeding success, offspring and adult survival, and/or the use of treated areas. In general, this form of monitoring is very similar to existing efforts to monitor harvested species. Targeted monitoring focuses on species or primary habitats selected due to risk, concern, or interest. Strengths of this facet of monitoring are first, the ability to narrow perspective to those elements likely to change, and second, to tie monitoring efforts to management actions. However, a drawback of such a focused effort is the very assumption that a relationship truly exists between the target and the attributed management action or threat. It is necessary, then, to conduct targeted monitoring within a contextual frame produced in the second division of monitoring efforts: condition and context monitoring.

For comparatively well-studied species, targeted monitoring protocols have been described—often in great detail—in recovery plans, conservation plans, published literature, and gray literature; SCDNR will use these if available. If no established protocol exists, SCDNR will adapt protocols from similar species or develop its own protocols based on what is known about the species. In developing protocols, we will follow Oakley et al. (2003). For species deemed important to target but with disparate information, inventories must first be conducted. When presence data are assembled, distributions of the species, along with population conditions can be mapped and used to direct future efforts.

Context and Condition Monitoring

Context monitoring is not restricted to particular species or system elements. Rather it provides status and trend information on a wide range of related facets of an ecosystem. With context monitoring, managers may detect unanticipated effects on a system that would have been lost in a targeted approach. It is a necessary link between targeted and response monitoring. In contextual monitoring, data may be collected for species not identified in specific targeted studies as described above. Additionally, monitoring of communities can provide context documentation against which targeted trends can be evaluated. Context-based monitoring extends to the habitat or landscape level when possible to further explain trend relationships between populations and habitats. When appropriate, context and condition monitoring will rely heavily on the identification of indicators. For example, with their large home range, Swallow-tailed Kites can serve as umbrella species for other area-sensitive wetland wildlife including Neotropical migrants, Barred Owls, Red-shouldered Hawks, Pileated Woodpeckers, river otters and black bears. The selection of appropriate indicators is challenging. The SCDNR will rely on the guidance provided by Schoonmaker and Luscombe (2005) (see Box 6-2 for additional definitions and discussions of indicators). It is important to stress that context and condition monitoring is not intended to follow every component of a system but rather provide a picture of the system from a broader perspective.

BOX 6-2: DEFINITION AND SELECTION OF INDICATORS**Categories for Indicator Evaluation:**

- Relevance – the degree to which the indicator measures the issue of concern
- Practicality – the feasibility of measuring the indicator
- Scientific merit – the extent to which the indicator is supported by science
- Ecological breadth – the number of ecological components the indicator includes
- Usability – the ability of decision makers to make decisions using the indicator

Qualities of Valid Indicators

- Intended use is clear
- Simplifies status of a complex system
- Sensitive to known stressors
- Able to distinguish between anthropogenic stressors and natural variation
- Provide early warning of change
- Not greatly sensitive to sample size
- Low variability in response
- Easy and inexpensive to measure
- Easy to understand and translate into decision making
- Represents cause and effect relationships

Pressure-State-Impact-Response Indicator Framework

- **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

Response Monitoring

Response monitoring or cause and effect monitoring (Holthausen et al. 2005) dovetails tightly with the objectives of targeted and condition/context monitoring and is the monitoring of species responses to management changes at the project (or several projects) level. It can be further described as the collection and assessment of observations to evaluate changes in condition in relationship to actions (Elzinga et al. 2001). Response monitoring of relationships between targets and conditions integrates monitoring with research. For this reason, efficiency may be increased where researchers and managers work closely to identify objectives for management. With proper choice of management goals and well-identified expectations that are defensibly quantifiable, response monitoring lends itself easily to the collaborative development of research efforts.

Effectiveness Monitoring

A final necessary division of monitoring includes efforts to quantify the effects of management actions in relation to management goals, rather than the effectiveness of an action taken. Effectiveness monitoring will be essential to adaptive management and future revisions of the SWAP. It involves not only looking at outcomes but at processes. This type of monitoring can determine whether the treatments were applied as they were conceptualized and prescribed. In order to adapt management efforts effectively, managers must be able to evaluate why an action is successful or unsuccessful and be able to gain a clear understanding of actions implemented so that future assessments are based on actual occurrences.

Proposed quantifiable criteria of management actions include net increases in partner and public involvements, removal of threats to priority species, or successful completion of conservation actions. Additional qualitative measures will be important as well (see Chapter 8: Implementation and Adaptive Management, for further descriptions of implementation and review). Of course, the long-term measure of effectiveness would be a reduction in the number of species of conservation need.

The balance between these four forms of monitoring is an important consideration in the design of conservation actions and projects at all scales. Additional attention will be given to the appropriate use of each facet of monitoring to most effectively meet the goals of the SWAP.

Experimental Design for Monitoring Programs

As successful research is typically built on detailed experimental design, so shall design efforts benefit the SWAP monitoring process. Attention to statistical design will improve the applicability of most monitoring outputs. While not all facets of the program need to be rigorously treated, an understanding of traditional scientific reasoning may increase the effectiveness of the program as a whole. Additionally, response monitoring endeavors would likely rely on sound analytical design due to their relationship to research.

Analyzing monitoring data most effectively will require the use of several techniques including traditional hypothesis testing, as well as less traditional techniques such as information theoretic methods (Burnham and Anderson 2001) and meta-analysis (Franklin and Shenk 1995). The object will be to determine whether actions do or do not produce their intended effect. Model comparisons and comparisons of treatments across differing areas and scales may require extended analysis of non-traditional statistical testing and inference.

Setting Monitoring Objectives

The proposed South Carolina Monitoring Program working group will establish measurable monitoring objectives through the planning of the monitoring program and selection of individual projects. These objectives will be closely tied to priorities for conservation actions as provided in Chapter 5: Statewide Conservation Strategies. Statistically defensible design will be employed, if applicable, to the measurements made. Attention in these decisions should also be given to the provision of opportunities for local and community involvement as well as cooperation among agencies and stakeholders. Similarly, a primary directive for selection of

objectives within the outlined framework should be the ability to acquire and use information for adaptive management.