

CHAPTER 7. STATUS AND TRENDS MONITORING

Purpose and Value of Monitoring and Evaluation

Monitoring and evaluation are tools that provide measures of change in species or habitat status, or the effects of activities, over time and allow for the interpretation of those measured changes. These tools allow an agency or organization to assess:

- Species population trends, estimates of population size, relative abundance, shifts in distribution, habitat use, response to management
- Habitat availability and condition over time
- Effects of management prescriptions
- Progress in implementation activities
- Progress towards intended goals, objective, and outcomes
- Adaptive management responses

Assessing changes in populations and habitats over time, especially in response to applied conservation actions, requires monitoring at multiple levels (e.g., species, guilds, natural communities, implementation activities) and across multiple scales (e.g., local, statewide, regional). Monitoring is therefore a critical component of any conservation program, necessarily linked to management objectives.

Species-specific monitoring is critical to assessing population status and trends over time. Monitoring of individual species, when coordinated at the appropriate level, contributes to the conservation of species at scales far beyond individual state boundaries. Monitoring actions at the species guild level (e.g., ephemeral pond amphibians) are essential to tracking and assessing habitat-level impacts over time. Monitoring at this level allows us to measure the effectiveness of habitat-based management activities. Habitat and natural community monitoring is necessary to track landscape-level trends and to anticipate future needs as threats change. Monitoring of the implementation of conservation activities is needed to measure success and advancement towards goals, and to adapt conservation actions to respond appropriately to new information or changing conditions (see *Chapter 8 for a discussion of implementation and effectiveness monitoring*).

Monitoring of North Carolina's Wildlife and Habitats

Extensive species and habitat monitoring already take place in North Carolina (Table 7.1). Much of this monitoring, especially at the species and guild level, is accomplished through cooperative partnerships among agencies. The Commission coordinates a great deal of species status and population monitoring, ranging from requirements of species recovery plans, to species trend assessment following baseline survey work. Monitoring is also a standard component of many other agency planning efforts (e.g., US Forest Service Land and Resource Management Plans, Department of Defense Integrated Natural Resource Management Plans). It is key that future monitoring efforts build on and utilize these existing systems.

Table 7.1. Existing species monitoring efforts underway in North Carolina.

Lead Agency/ Organization ¹	Monitoring Efforts Underway ²	Cooperators ³	Time Frame (annual unless otherwise noted)
STATE AGENCIES			
NC Wildlife Resources Commission	Anuran monitoring (to begin in 2005)	NC Herpetological Society, NCMNS, NCPARC, universities, USGS, volunteers	
	Breeding Bird Survey	USGS, volunteers	
	Monitoring Avian Productivity and Survivorship	Institute of Bird Population Studies, volunteers	
	Bird migration monitoring	Partners in Flight, volunteers	Spring/fall
	Breeding and winter songbirds on Commission Game Lands and CURE areas		
	Colonial waterbird inventory (estuarine surveys)	NC Audubon Society, NCDPR, NPS, USACE, USFWS	Every 2-3 years
	Breeding shorebirds (Piping plover)	NC Audubon Society, NCDPR, NPS, USFWS	
	Breeding shorebirds (American oystercatcher and Wilson's plover)	NC Audubon Society, NCDPR, NPS, USFWS	Every 2-3 years
	Nonbreeding shorebirds	NPS, USFWS	
	Bald eagle	NCDPR, NCNHP, USACE, USFWS, USMC, timber companies	
	Red-cockaded woodpecker	DoD, NCDPR, NCDPR, private consultants, Sandhills Ecological Institute, TNC, USFS, USFWS	
	Peregrine falcon	NCDPR, USFS, volunteers	
	Sea Turtle Nesting Beach Monitoring Program	BHIC, DoD, NC Audubon Society, NCDPR, NPS, USACE, volunteers	
	Sea Turtle Stranding And Salvage Network	BHIC, DoD, Duke University, NC Aquariums, NC Audubon Society, NCDMF, NCDPR, NCSU Vet School, NERR, NOAA Fisheries, NPS, USACE, volunteers	
	Bog turtle	NPS, Project Bog Turtle, TNC, USFS, USFWS, volunteers	Periodic (moving towards triennial)
	Green salamander	USFS, USFWS, universities, volunteers	Periodic
	State-listed salamanders (western region)	Land trusts, NCMNS, NPS, USFS, universities	Periodic
	Western region bats	Flittermouse Grotto of the National Speleological Society, USFS, USFWS, volunteers	Periodic (some species biennial)
	Northern flying squirrel	NPS, USFS, universities	
	State- listed small mammals (western region)	Land trusts, NCMNS, universities, USFS, USNPS, volunteers	Periodic
Black bear populations	DoD, private timber companies USFS, USFWS		
White-tailed deer (check stations, harvest data, DMAP)	DoD		
Raccoon field trial survey - population trend	Participating raccoon hunting clubs		

¹In some cases, there may be multiple lead agencies involved in a given monitoring effort depending on location (e.g., red-cockaded woodpecker), but for simplicity, the monitoring effort has been listed just once in the table above.

²NC Partners in Flight maintains a detailed listing of ongoing bird research and monitoring efforts in North Carolina, many of which are so specific/selective they have not been listed in the table above. See Johns 2004 for the complete list.

³See the Key to Abbreviations and Acronyms for a complete listing of all abbreviations and acronyms used herein.

Lead Agency/ Organization ¹	Monitoring Efforts Underway ²	Cooperators ³	Time Frame (annual unless otherwise noted)
NC Wildlife Resources Commission, <i>continued</i>	All furbearers, nongame and foxes - trapper harvest/effort survey	Mail survey to all licensed trappers	Every 5 years
	All furbearers, nongame and foxes-Distribution survey	All Division of Wildlife Management field biologists	
	Total take by WDCA's and Gov. Animal Control-all species	WDCA's, all long-term depredation permittees	
	Nest box monitoring (waterfowl)	USFWS	
	Quail count and covey surveys on NCWRC Gamelands		
	Avid Quail Hunter Survey and Avid Grouse Hunter Survey	Volunteers	
	Dove, tundra swan counts		
	Wild Turkey Summer Brood Survey	NCDFR, private individuals, USFS, USFWS	
	Grouse and turkey drumming counts	USFS	
	Riverine Index of Biotic Integrity sampling		Variable (most rivers every 2-3 years)
	Anadromous fish (American shad, hickory shad, striped bass)	NCDMF	
	Game fish community and reservoir stock assessments [black basses, black and white crappie, striped bass and Bodie bass, walleye, muskellunge (river and reservoir environments)]	Duke Power, NCSU (Gaston Reservoir), Progress Energy, USFS	Variable (stock dependent)
	Brook, brown, and rainbow trout reproducing populations	NPS, USFS	
	Annual mussel and fish surveys		
	Mussel relocation project monitoring		Variable (project dependent)
	Cheoah River restoration project monitoring (fish, mussels, crayfish, salamanders)	APGI, NCDOT, USFS, USFWS	Annual, biennial, and 5-year intervals
	Pigeon River fish restoration project monitoring	BRPP, NCWDQ, TNDEC, TVA, UT-K, WCU	Annual
Western crayfish monitoring	NCDWQ, NCMNS, NPS	Periodic ⁴	
State and federally-listed species monitoring, including candidates and species of concern.	LTWA, NCDOT, NCDWQ, NCNHP, NCSU, TVA, USFWS, USFS	Variable (species, locality dependent)	
NC Division of Water Quality	Fish communities, fish kill investigations, benthic macro-invertebrate Index of Biotic Integrity monitoring	NCWRC	5-year cycle, per basin
NC Museum of Natural Science	Yellow-bellied sapsuckers (S. Appalachian breeding population)	Mars Hill College, NPS, NCWRC, USFS, USFWS, others in multi-state work group	
	Carolina Gopher Frog	NCDPR, NCNHP, TNC, SCDNR, SREL, USFWS	
	Southern Hognose Snake	NC Herpetological Society, NCNHP, NCWRC	
NC Division of Marine Fisheries	Extensive fisheries monitoring, including all Fisheries Management Plan species (too many to list)	NOAA-Fisheries, NCWRC	

⁴Development of a more regular monitoring schedule in progress (as of 2005).

Table 7.1 (continued). Existing species monitoring efforts underway in North Carolina.

Lead Agency/ Organization ¹	Monitoring Efforts Underway ²	Cooperators ³	Time Frame (annual unless otherwise noted)
NC Natural Heritage Program	Summer butterfly counts	Volunteers	
NC Division of Parks and Recreation	Nest box monitoring (multiple species), eagle counts, waterfowl counts	USACE, volunteers	
FEDERAL AGENCIES			
US Fish & Wildlife Service	International Shorebird Surveys	NPS, NCWRC	
	Wood ducks (banding program and nest box monitoring)	NCWRC	
	Mid-winter waterfowl surveys	NCWRC	
	Tundra swan productivity	NCWRC, other mid-Atlantic states	
	Mourning dove call count survey	NCWRC	
	Migratory game bird harvest estimates	NCWRC	
	Breeding bird counts, species specific surveys, waterfowl banding and surveys at multiple National Wildlife Refuges		
	Cerulean warbler monitoring (Roanoke River NWR)	Volunteers	
US Forest Service	Management Indicator Species		
	Songbirds on USFS land		
	Index of Biotic Integrity		
National Parks Service	Blue Ridge Parkway permanent plots	Mars Hill College	
	MAPS banding stations	Volunteers	
NOAA Fisheries	FMP species; federally listed and depleted marine species	NCDMF, NCWRC	
US Department of Defense	Various monitoring efforts outlined in base-specific INRMPs (e.g., listed species, other game and nongame species, natural communities)	Volunteers	
OTHER			
Mecklenburg County Parks and Recreation	Grassland songbirds, raptor nest boxes, Project Feederwatch, migration banding stations, MAPS, nest productivity, waterfowl counts	Volunteers, Cornell University	
North Carolina Audubon	Christmas Bird Count	Volunteers	
	Golden-winged warbler Atlas Project	Cornell University	
	Important Bird Area monitoring		
International Paper	G1 and G2 Natural Heritage Program ranked species occurrences on International Paper land		Variable (species dependent)

Lead Agency/ Organization ¹	Monitoring Efforts Underway ²	Cooperators ³	Time Frame (annual unless otherwise noted)
Weyerhaeuser Company	G1 and G2 Natural Heritage Program ranked species occurrences on Weyerhaeuser land	Coastal Land Trust, NCNHP, TNC	Variable (species dependent)
	Cool Springs Environmental Education Center: annual reptile and amphibian monitoring, stream water quality and aquatic invertebrate monitoring, migration monitoring for neotropical songbirds		
Tennessee Valley Authority	Fish and benthic macroinvertebrate Index of Biotic Integrity monitoring (In TN river tributary basins only; for watershed/HUC quality assessment)	NCWRC	Variable (5-year cycle for most HUCs, 2-year for Fixed Stations)
Progress Energy	Fish and benthic invertebrate sampling in rivers/ reservoirs with Progress Energy facilities	NCWRC	
Duke Power	Fish community sampling near all Duke Power facilities (trace element sampling near some)	NCWRC	
Robust Redhorse Conservation Committee	Robust redhorse monitoring (Georgia, South Carolina, North Carolina)	RRCC Signatory members	
Davidson College Herpetology Lab	Catawba River Corridor Coverboard Program	Annie Springs Close Greenway, CCARI, Catawba Lands Conservancy, Catawba Valley Land Trust, Duke Power, Iredell Co. Parks and Recreation, Mecklenburg Co. Parks and Recreation, NCWF, SCDNR, SCDPRT, SCWF, The Home Depot	
	Drift fence monitoring and snake population monitoring on the Davidson College Ecological Preserve		
	Semi-aquatic turtle monitoring		
	Box turtle population monitoring (Davidson, NC)		
	Urban amphibian population monitoring		
	Evaluation of detectability of anurans		
Howell Woods Environmental Learning Center	MAPS banding stations, migration banding stations, Project Feederwatch, point counts	Cornell University, volunteers	
Weymouth Woods State Nature Preserve	Migration banding stations	Volunteers	

However, Table 7.1 is only a basic framework from which to initiate a more formalized inventory of monitoring programs in North Carolina; this is a critical first step to strengthening monitoring efforts. Many other monitoring efforts are conducted in the state on smaller scales or for more species-specific needs, by universities, private organizations, and others (especially for birds). As stipulated in species-specific recovery plans, state and federally-listed species receive regular monitoring attention, as coordinated through efforts among the Commission, the US Fish & Wildlife Service, and NOAA Fisheries (see Appendix I for a list of species recovery plans).

In North Carolina, the majority of publicly owned lands are controlled by the following agencies, each of whom conducts monitoring of species and habitats on their properties statewide. The Commission should continue coordination with these groups to identify shared priorities and facilitate efficient monitoring and data synthesis:

- Department of Defense – Integrated Natural Resource Management Plans stipulate monitoring needs for each installation:
 - Camp Lejeune Marine Base
 - Cherry Point Marine Air Station
 - Fort Bragg Army Base
 - Seymour Johnson Air Force Base
 - Pope Air Force Base
- US Forest Service – Land and Resource Management Plans identify monitoring needs related to each forest's Management Indicator Species and communities:
 - Croatan National Forest
 - Uwharrie National Forest
 - Nantahala and Pisgah National Forests
- US Fish & Wildlife Service – Comprehensive National Wildlife Refuge (NWR) Plans⁵:
 - Alligator River NWR
 - Pea Island NWR
 - Mackay Island NWR
 - Currituck NWR
 - Mattamuskeet NWR
 - Cedar Island NWR
 - Swanquarter NWR
 - Pee Dee NWR
 - Pocosin Lakes NWR
 - Roanoke River NWR

Importance of Collaborative Monitoring Efforts

The value of coordinated monitoring efforts within and among states cannot be overstated. In North Carolina, for example, coordinated efforts have helped to sustain and strengthen monitoring programs on sea turtles and colonial nesting waterbirds. Commission participation in local planning initiatives such as the Sandhills Partnership (see Chapter 4C case study), regional planning teams such as the South Atlantic Migratory Bird Initiative, and cooperative agreements such as the North Carolina Colonial Waterbird Cooperative Agreement (with 12 state and federal agency and non-profit signatories) give credence to the success and importance of such collaborations. At a regional and national level, coordinated efforts such as the Breeding Bird Survey have contributed greatly to assessing long-term population trends among birds nationwide.

In the face of limited resources and often wide-ranging species, there is increasing need to strengthen and expand collaborative monitoring efforts. With collaborative monitoring efforts come the need for strong data standards and a centralized system for housing and managing data and analyzing results. The needs addressed in this, and other state Strategies, may point to opportunities to improve regional monitoring standards. Agencies may face challenges in favoring protocols that are best for addressing local needs, but that are not compatible with data collected elsewhere, or conversely, in favoring protocols that are compatible with data elsewhere, but not applicable at the local level. Standardized techniques must, at least indirectly, work to provide local management relevance (Hunter 2000). It will be important to use/improve data collection techniques that are compatible with larger-scale or with counterpart monitoring efforts to ensure data can be integrated appropriately (Atkinson et al. 2004).

Regional and national coordination is needed to evaluate the capacity of existing state-programs to combine and monitor populations across their range. This may be a role that the Status and Trends Program of the US Geological Survey initiates post-Plan approval. Where necessary, existing programs should be strengthened and new, comprehensive monitoring programs developed. Specific to bird monitoring recommendations, the recently drafted Coordinated Bird Monitoring Workgroup

⁵As of early 2005, all are still in development – contact Bob Glennon at the US Fish & Wildlife Service (Bob_Glennon@fws.gov) for details.

of IAFWA report (2004) will facilitate discussions on coordinated bird monitoring among representatives of the US Fish & Wildlife Service, the US Geological Survey, and the North American Bird Conservation Initiative, which will facilitate trickle-down to state entities, etc. There is also a need to establish a 'protocols' library. Again, there is potential that this will be coordinated at a regional or national level through the Status and Trends Program of the US Geological Survey.

Bird Monitoring Efforts as a Model

The efforts of the various North American Bird Conservation Initiative (NABCI) programs form a base from which to expand and improve 'All-bird monitoring' and coordination efforts in the state and the southeast region as a whole, as well as a model on which to build coordinated monitoring efforts for other taxa. Through the monitoring infrastructures developed by the various NABCI programs, our state-specific monitoring efforts for birds contribute to regional, national, and even international bird conservation efforts. The monitoring recommendations put forth in the various NABCI program reports are echoed throughout our Plan. We will continue to integrate the recommendations of these reports, which address monitoring at different scales, during implementation:

- **National**
 - o Regional

North American Bird Conservation Initiative

- o South Atlantic Migratory Bird Initiative (SAMBI) Pelagic Bird Conservation Plan (SAMBI 2004, DRAFT)
- o SAMBI Implementation Plan (Watson and McWilliams 2004, DRAFT)
- US Shorebird Conservation Plan (Brown et al. 2001)
 - o Southeastern Coastal Plains-Caribbean Regional Shorebird Plan (Hunter et al. 2000)
- North American Waterbird Conservation Plan (Kushlan et al. 2002)
 - o Southeastern US Region Waterbird Conservation Plan (Hunter 2004, DRAFT)
- North American Waterfowl Management Plan (NAWMP Committee 2003)
 - o Atlantic Coastal Joint Venture Strategic Plan (ACJV 2004)
- PIF North American Landbird Conservation Plan (Rich et al. 2001)
 - o Southern Blue Ridge (Hunter et al. 1999)
 - o Piedmont (Cooper and Demarest 1999)
 - o South Atlantic Coastal Plain (Hunter et al. 2001)

Box 1: The National Biological Information Infrastructure (NBII)

The NBII is an electronic information network coordinated by the US Geological Survey that provides users access to biological data and information about plants, animals, and ecosystems across the United States. Data and information maintained by federal, state, and local government agencies, and private-sector organizations are linked through the NBII and made accessible to a variety of audiences. Implementation of the NBII is proceeding through a network of nodes that serve as interconnected entry points to the NBII and information maintained by partners (www.nbio.gov).

The following nodes are applicable to North Carolina and could be considered as a potential system to house or disseminate information collected during implementation of the Plan.

- Bird Conservation Node
- Fisheries and Aquatic Resource Node
- Southern Appalachian Information Node (SAIN). Current projects within this node include:
 - Oriental Bittersweet in North Carolina – occurrence and extent of the invasive plant
 - Appalachian Inventory and Monitoring Information Synthesis – SAIN's Appalachian Inventory & Monitoring Information Synthesis project will provide access, synthesize, and disseminate information from inventory and monitoring activities of various agencies and organizations throughout southern Appalachia.
 - Southern Appalachian Volunteer Environmental Monitoring – a Southern Appalachian Man and the Biosphere program that trains volunteers from around the southern Appalachian area to monitor ecological health in their community (e.g., invasive exotic plant surveys, water quality monitoring). Resulting data can be used to determine the best approaches for effective management, as well as improve public awareness of the threats. Ongoing projects include: Upper Little Tennessee River project; Brook trout population status; All Taxa Biodiversity Inventory of the Great Smoky Mountain National Park.

Habitat/Natural Community Monitoring

Ongoing habitat monitoring conducted by the Commission is largely associated with habitat restoration activities in order to gauge success in pre- vs. post- restoration treatments, though other efforts coincide with regular species monitoring (e.g., habitat monitoring is a component of biennial colonial waterbird monitoring). Common performance indicators include acres managed (e.g., burned, planted, clearcut, thinned), linear feet managed (e.g., planted, stabilized), and usable habitat indices (e.g., vegetation diversity, structure). Habitat monitoring is a critical component of projects such as:

- CURE Program areas (areas that are being restored to quality early successional habitat)
- Game Lands management activities
- Watershed Enhancement Program activities
- Waterfowl Management Areas/impoundments
- Hydropower remediation/Federal Energy Regulatory Commission relicensing efforts

As related to larger-scale habitat monitoring efforts, the number of agencies and organizations tracking trends associated with particular habitat types or regions of the state makes coordination and statewide assessments difficult. There is variability in terms of what is actually monitored, the indicators and criteria that are measured, and ways of measuring those indicators. A key improvement might be the establishment of a statewide clearinghouse of information for assessing habitat status and environmental trends information across North Carolina. Still, this would require substantial document of 'who-is-measuring-what-and-how' so that imprecise or incorrect correlations or data comparisons aren't made.

In addition, the vast majority of land in North Carolina is in private ownership, emphasizing the importance of refining and strengthening remote sensing techniques when direct access to lands may not be feasible.

Given the varied habitat monitoring efforts going on across North Carolina, it is impossible to use a single trend to make a gross assessment of changes in habitat quality and quantity. A variety of indicators used in combination, however, could provide an indication of habitat and ecosystem conditions (i.e., "canaries in the coal mine"), such as forest conversion rates, land development rates, wetland losses, percent impervious surface changes by watershed or river basin, and/or Impaired Waters listings.

Habitat Monitoring Efforts Underway

- Coastal wetlands inventories and functional assessments as well as beach erosion rates are conducted by the NC Division of Coastal Management. Annual wetland and stream buffer losses and gains are tracked by the Wetland/401 Unit of the NC Division of Water Quality. Wetlands mitigation site monitoring is conducted by the Wetlands Restoration Program, now housed within the Ecosystem Enhancement Program (a joint effort between the NC Department of Transportation, the Army Corps of Engineers, and the NC Department of Environment and Natural Resources).
- The US Forest Service, Forest Inventory and Analysis (FIA) Work Unit conducts periodic forest surveys of North Carolina (and nationwide) to provide statistics for measuring changes and trends in the extent and condition of forest land, associated timber volumes, and rates of timber growth, mortality, and removals. North Carolina contains four forest survey regions, the Mountains, Piedmont, Northern Coastal Plain, and Southern Coastal Plain. The most recent survey, which compares 2002 data to 1990 data, highlights trend changes across the following topics: forest land area, ownership, forest type, stand size, stand treatment, softwood volume, hardwood volume, growth, mortality, and removals. Although the previous and current inventories are similar in scope, they differ in sampling design and intensity, standards and definitions, and in methods used to determine key attributes such as stocking, forest type, and stand-size class. Recent changes in methods, plot design, and sampling intensity were necessary to increase national

consistency between FIA Research Work Units. These changes complicate the comparison of data between surveys and make detection of genuine resource trends difficult, but will improve consistency in future analyses.

- The Natural Resource Conservation Service's National Resources Inventory (NRI) program collects and disseminates information on a state, regional and national level about the status, condition, and trends of soil, water, and related resources in the United States, including land use, erosion, nonfederal and federal lands inventory, cropland use, prime farmland, and wetlands and deepwater habitats. From 1977–1997, the NRI was conducted every 5 years, but since 1997 it has been conducted annually.
- The NC Division of Water Quality conducts extensive Index of Biotic Integrity monitoring for their basin-wide planning efforts, including lake assessments, phytoplankton monitoring, physical and chemical water quality monitoring, and aquatic toxicity monitoring (as well as fish and benthic macroinvertebrate monitoring mentioned about in Table 7.1). The Division also designates and maintains a list of impaired waters [305(b) and 303(d) Reports] and tracks percent impervious surfaces by basin.
- NOAA Fisheries (formerly known as the National Marine Fisheries Service) conducts submerged aquatic vegetation (SAV) mapping and monitoring in coordination with the Environmental Protection Agency and the NC Division of Water Quality. According to the Coastal Habitat Protection Plan, however, no quantified trends analysis is available for the state as currently there is only one complete SAV mapping dataset (1983–1991) (Street et al. 2004).
- The NC Natural Heritage Program tracks Significant Natural Heritage Areas using a 'scorecard' analysis to monitoring, as well as compare, the relative quality of these high quality habitats/natural communities through time.
- Gap Analysis Project (GAP) land cover data provides a potential source with which to assess land cover trends over time. However, due to differences in methodologies between the 1992 North Carolina land cover and the 2001 North Carolina land cover, it is inaccurate to do a direct comparison between the two data sets. The National GAP office has developed a change detection methodology to handle these differences and to prevent misuse of GAP land cover data. However, there are no plans at the state level to employ this methodology on the 1992 and 2001 data, due to lack of funding. Regional GAP efforts across the southeast (www.segap.org) do present potential opportunities for land cover change detection analyses in the future. (For more about the North Carolina and regional GAP efforts, see Appendix K).

Box 2: Habitat monitoring guidelines

In 2005 Defenders of Wildlife commissioned a habitat monitoring guidelines project conducted by Illahee (a consulting firm in Portland, Oregon). Habitat monitoring: an approach for reporting status and trends for state Comprehensive Wildlife Conservation Strategies (Schoonmaker and Luscombe 2005) is a tool to guide future habitat monitoring advances in states across the nation. The 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 authors offer 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. They identify the following six basic elements of a successful habitat monitoring program:

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 Plan, existing conservation projects.
3. Determine what elements of the Plan 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 communication system for reporting and disseminating information to decision-makers and other stakeholders, including the public.

The recommendations and guidance set forth in Schoonmaker and Luscombe (2005) should be considered in future advances made to habitat and conservation action monitoring in North Carolina.

Monitoring Needs Synopsis

Broad monitoring needs, as mentioned above, include:

- **Formal inventory of existing monitoring efforts (following a standardized set of criteria to facilitate coordination among agencies and states)** – “What are we monitoring now?” This will facilitate answering the questions “where are there opportunities to better coordinate on this monitoring?” and “where are there monitoring gaps?” USGS Status and Trends Program may assist.
- **A monitoring protocols library/clearinghouse** – The US Geological Survey has committed to developing such a library for their own protocol development; opportunities are present to expand this site to include submissions by other agencies, organizations, with proper vetting.
- **Better intra-state coordination on monitoring efforts** – Potential partners include the Commission, US Fish & Wildlife Service, US Geological Survey, US Forest Service, NOAA-Fisheries, Department of Defense, and NC Division of Water Quality.
- **Strengthening of regional and national approaches to species and habitat status monitoring** – The best opportunities to facilitate these approaches are through coordination by representative groups (e.g., Partners in Amphibian and Reptile Conservation, US Geological Survey, NABCI efforts).

In North Carolina, birds and sea turtles are the only vertebrate groups that receive established and standardized long-term monitoring efforts. This fact emphasizes the importance of continuing these monitoring efforts to further strengthen trend and population estimates, and the importance of establishing monitoring efforts across all other taxa groups, as baseline inventory and survey data allow.

Monitoring needs of particular species, guilds, and habitats were detailed throughout individual sections of Chapter 5. The text below summarizes those needs. Individual species may not be named in all cases, but specific information can be found in the appropriate preceding habitat/basin sections.

General (Aquatic)

- Many aquatic species in North Carolina (especially crayfish and snail species) are still in dire need of distribution, survey, and inventory attention, in order to establish baseline data on which to build. For these groups, established monitoring priorities are not yet attainable.
- For those taxa and species with adequate baseline data, there is strong need to improve long-term monitoring across species groups, habitats, and management actions. Important partners (statewide) to engage in aquatic species and habitat monitoring include the NC Division of Water Quality, the NC Museum of Natural Sciences and the US Fish & Wildlife Service (basin-specific partners are identified within each basin section). Three fundamental monitoring needs include:
 - Long-term monitoring to identify population trends of priority species.
 - o Work with partners to establish appropriate protocol, schedule, and sites for long-term population monitoring.
 - o Currently, the western region basins may provide the most opportunity to initiate monitoring for selected fish and mussel species.
 - Special purpose monitoring to assess performance of specific conservation actions, including stream restoration projects, hydropower remediation, and species restoration projects.
 - Non-native species impacts: monitor populations of potentially injurious non-native species and impacts on priority species; specific non-native species are identified within the appropriate basins.

General (Terrestrial)

- As bird monitoring efforts are by far the most advanced and established of any species group, the establishment of protocol for other species groups (e.g., small mammals, amphibians, reptiles) should be developed with strong consideration of the lessons learned through the various monitoring efforts of NABCI.
- Expand monitoring efforts on public lands and initiate monitoring protocols on key private lands (especially industrial forest land).
 - Expand and refine standard bird monitoring protocols.
 - Develop appropriate protocol for amphibians, reptiles, and mammals (especially bats and small mammals).
 - Key partners include the US Forest Service, Department of Defense, US Fish & Wildlife Service, and private timber companies.

Birds

- Continue ongoing monitoring coordination and adhere to recommendations put forth in reports of the national and region entities of NABCI (e.g., Partners in Flight regional and state plans, Southeastern Migratory Bird Conservation Initiative, North American Waterbird Conservation Plan) and the Continental Bird Monitoring Workgroup of IAFWA to strengthen coordinating bird monitoring efforts. (See *'Bird monitoring efforts as a model'* above for more information on protocol and programs adhered to in North Carolina).
- Continue to participate in ongoing monitoring research that NC State University (Dr. Ted Simons) and the US Geological Survey Patuxent Wildlife Research Center are conducting to evaluate monitoring protocols for standard point counts and Breeding Bird Survey (estimation of detectability).
- Expand current bird monitoring across the state, especially Monitoring Avian Productivity and Survivorship and migration banding stations, as training opportunities and technical assistance allow, to improve population status information for birds not adequately sampled under existing protocol (e.g., Breeding Bird Survey).
 - Consider establishing 'surrogate' species where possible- species who may be representative of the habitat needs of a particular guild of species and are widespread enough to allow for population-level monitoring.
 - Key species (or species groups) include: Swainson's warbler, cerulean warbler, Henslow's sparrow, Bachman's sparrow, other grassland specialists, Wayne's black-throated green warbler, painted bunting, hawks, ground-nesters, cavity-nesters, owls.
 - Key habitats include longleaf pine, floodplain forest, early successional habitats, high elevation forest, pocosin, nonalluvial wetlands, and maritime forest. Ideally, monitoring should continue to be expanded across all habitats in order to strengthen trend data for all species.
- Continue established shorebird and waterbird monitoring efforts along all coastal and estuarine habitats; expand monitoring of secretive marshbirds along estuarine, lake, and tidal swamp habitats using established protocol (Conway 2004).
- Continue monitoring for recovering species such as bald eagles and peregrine falcons in their key habitats.

Mammals

- Develop and initiate standardized monitoring protocol for small mammals and bats. Key habitats to focus monitoring efforts in include: (for small mammals) floodplain forest, early successional habitats, mesic and oak forest, dry coniferous woodlands; (for bats) caves, floodplain forest, mesic forest dry coniferous woodlands.
 - Consider North American Bat Conservation Partnership (NABCP) monitoring recommendations (see <http://www.batcon.org/nabcp/newsite/index.html>, NABCP Strategic Plan):
 - o Initiate long-term status trend monitoring at key bat roosting locations (e.g., caves, mines, bridges).
 - o Use reliable and reproducible techniques, evaluating new population-monitoring techniques as needed.
 - o Define population units relevant for conservation planning and research.
 - Consider coordination of bat monitoring efforts in North Carolina (and throughout the southeast) through a unifying body (e.g., Southeastern Bat Diversity Network or US Geological Survey).

Amphibians and Reptiles

- Continue coordinated nesting and stranding monitoring of sea turtles with partners (NOAA-Fisheries, US Fish & Wildlife Service).
- Develop and initiate monitoring protocol for amphibians (especially wetland breeding anurans and salamanders) and reptiles (especially secretive snakes, priority turtle and terrapins). The following habitats are especially key in which to initiate amphibian and reptile monitoring efforts: longleaf pine, pocosin, wet pine savanna, floodplain forest, early successional habitats, dry coniferous woodlands, wetlands (including isolated wetlands, riparian corridors and bogs), maritime forest, estuarine habitat, rock outcrops.
 - Use North Carolina Partners in Amphibian and Reptile Conservation (NC PARC) as the umbrella program in North Carolina to foster establishment of protocol. NC PARC is initiating annual anuran surveys among partnering organizations beginning in 2005.
 - Work with the Southeastern PARC (SE PARC) organization to facilitate regional standards and data compatibility. SE PARC is currently (as of 2005) drafting 'Regional inventory and monitoring guidelines for reptiles and amphibians of the Southeast'.
 - Consider the work in process to develop reptile monitoring guidelines akin to existing amphibian guidelines developed by Heyer et al. (1994) (project coordination by US Forest Service and PARC).

Estuarine/Marine Habitats

The recently completed Coastal Habitat Protection Plan (CHPP; Street et al. 2004) includes a broad recommendation to coordinate and enhance water quality, physical habitat, and fisheries resource monitoring from headwaters to the nearshore ocean (key partners include the NC Department of Environment and Natural Resources, NC Division of Marine Fisheries, NC Division of Water Quality, NC Division of Coastal Management, and the NC Wildlife Resources Commission). The CHPP also identifies a number of key monitoring needs across specific coastal fisheries habitats:

Water Column

- Additional monitoring, paid for by the party responsible for the ditching, is needed to better assess impacts where extensive areas of wetlands were drained.
- Coastal research and monitoring needs to continue to improve our understanding of the processes of hypoxia and anoxia and the effect on fish populations.
- More detailed monitoring is needed to assess the extent oceanfront septic systems are causing degradation to nearshore coastal waters.

- Basic water quality parameters (flow, temperature, pH, and DO) should be identified for wastewater permit applicants to monitor. If the data indicate the presence of pollutants in the discharge water, toxic chemical monitoring and toxicity testing should be required. Nutrients and ammonia should be monitored if a mass balance approach indicates excess nutrients. Biological monitoring of the macrobenthic community should be required on facilities discharging more than 0.5 million gallons per day.
- Until treatment of ballast water is required and implemented, monitoring of port waters for algal blooms is recommended to minimize risks of introduction elsewhere.

Submerged Aquatic Vegetation (SAV)

- Since some SAV is present in the shallow portions of the Neuse and portions of the White Oak river basins, and water quality data indicate some level of eutrophication exists, nutrient levels may be limiting survival or expansion of SAV in these areas. These areas should be a high priority for monitoring of SAV and water clarity.
- Submerged grasses need to be monitored on a regular basis to assess the status of wasting disease and its association with human-induced stresses.

Wetlands

- Additional monitoring is needed to better assess impacts where extensive areas of wetlands were drained.

Soft Bottom

- Adequate monitoring of the effects of beach nourishment on the soft bottom community and associated surf fish populations is increasingly important as the number of beach nourishment projects increase and should be required for all large-scale or long-term nourishment projects.
- To adequately and correctly assess the direct and cumulative impacts of beach nourishment activities on fish, their habitat, and biological recovery rates, thorough monitoring must be conducted.
- Long-term monitoring is required, in combination with management actions that reduce discharge concentrations, to determine effectiveness and future management needs.

Hard Bottom

- Monitoring of hard bottom is needed to assess the level of impact from hook and line fishing.
- Monitoring of hard bottom should be initiated and coordinated with UNC-Wilmington or other ocean water quality monitoring programs to determine the effects of estuarine water quality, particularly nutrient and sediment loading, on hard bottom.
- Some habitats are ephemeral in nature (e.g., early successional habitats) thereby making it more difficult to track the extent of those types.

Box 3: Monitoring Protocol Resources

This listing represents some of the standard monitoring programs and protocols applicable to North Carolina. However, it is not a comprehensive synthesis of all protocols. A key need is to expand this basic list into a more comprehensive library of available protocols to facilitate standards among states and agencies.

Birds

Conway, Courtney J. 2004. Standardized North American marsh bird monitoring protocols. U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit.

DeSante, D. F., and K. M. Burton. MAPS Manual: Instructions for the establishment and operation of stations as part of the Monitoring Avian Productivity and Survivorship program. The Institute for Bird Populations. Point Reyes Station, CA.

Howe, Marshall, Jon Bart, Stephen Brown, Chris Elphick, Robert Gill, Brian Harrington, Catherine Hickey, Guy Morrison, Susan Skagen, and Nils Warnock, eds. 2000. A comprehensive monitoring program for North American shorebirds. Manomet Center for Conservation Sciences. <http://www.Manomet.org/USSCP/files.htm>

Hunter, W.C. 2000. Bird population survey, inventory, and monitoring standards for National Wildlife Refuges and partners in the Southeastern U.S. US Fish & Wildlife Service, Atlanta, GA.

Steincamp, M., B. Peterjohn, V. Byrd, H. Carter, and R. Lowe. 2003 (DRAFT). Breeding season survey techniques for seabirds and colonial waterbirds throughout North America. Waterbird Monitoring Partnership of the Waterbird for the Americas Initiative, U.S. Geological Survey, Patuxent Wildlife Research Center.

(continued on next page)

Ongoing Monitoring Efforts

Currently, at the state, region, and national levels, there are numerous projects underway involving research or guideline development to improve monitoring efforts and facilitate better standards. Recommendations or analyses eventually produced through these efforts should be considered in future monitoring program improvements.

State

- NC State University research (Dr. Ted Simons) with US Geological Survey Patuxent Wildlife Research Center evaluating monitoring protocols for standard point counts and Breeding Bird Survey protocols related to estimation of detectability in birds.

Box 3: Monitoring Protocol Resources (*continued*)

Amphibians and Reptiles

Amphibian and Reptile Monitoring Initiative (ARMI). USGS Patuxent Wildlife Research Center. <http://armi.usgs.gov/index.asp>

Dodd, C. Kenneth. 2003. Monitoring amphibians in Great Smoky Mountains National Park. 2003. U.S. Geological Survey Circular 1258.

Handbook for sea turtle volunteers in North Carolina. N.C. Wildlife Resources Commission. Raleigh, NC.

Heyer, W. R., M. A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster (eds.). 1994. Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.

North American Amphibian Monitoring Program (NAAMP). USGS Patuxent Wildlife Research Center. <http://www.pwrc.usgs.gov/NAAMP/protocol/>

Southeast Amphibian and Reptile Monitoring Initiative (SE ARMI). Florida Integrated Science Center. Gainesville, FL. <http://cars.er.usgs.gov/armi/>

Mammals

Measuring and monitoring biological diversity: standard methods for mammals. 1996. Editors: D.E. Wilson, F.R. Cole, J.D. Nichols, R. Rudran, M.S. Foster. Smithsonian Institution Press, Washington, DC.

Aquatics

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. *Fisheries* 6:21-27.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biotic integrity in running waters: a method and its rationale. Illinois Natural History Survey, Champaign, IL.

Strayer, D.L., and D.R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society, Monograph 8, Bethesda, MD.

Multiple Species

Manley, P. N., B. V. Horn, and C. Hargis. 2004 (DRAFT). Multiple species inventory and monitoring technical guidance. FSM Technical Guide. USDA Forest Service.

Regional

- Regional inventory and monitoring guidelines for reptiles and amphibians of the Southeast in development by SE PARC.
- Southern Appalachian Man and the Biosphere (part of NBII SAIN) - the Citizen Environmental Monitoring in Appalachia conference (Nov. 2004) focused on citizen environmental monitoring of water, invasive and exotic species, and forest health and sustainability.
- Southeast Gap Analysis Project - this regional initiative may provide an opportunity to assess habitat changes over time across the southeast region (<http://www.basic.ncsu.edu/segap/>).

National

- US Forest Service Multiple Species Inventory and Monitoring program (http://www.fs.fed.us/research/monitoring_vertebrate.html) — objectives of the program are to: 1) develop and evaluate sampling designs, detection protocols, and analysis procedures for multiple species of vertebrates and their habitats at ecoregional scales, and 2) develop national guidance in the form of a National Forest System technical guide that outlines how to monitor populations and habitats of multiple species in one integrated design.
- US Geological Survey Technical Report: Designing monitoring programs in an adaptive management context for regional multiple species conservation plans (Atkinson et al. 2004) — stepwise procedures for developing effective regional monitoring programs in an adaptive management context.
- Defenders of Wildlife/Illahee project (Schoonmaker and Luscombe 2005 DRAFT) – ongoing work among many western states to develop a potential habitat monitoring framework for use in all state Strategies to track habitat changes over time.

- US Geological Survey Status and Trends Program - coordination of state Plan monitoring needs/standardized protocol development; the focus of the program is to develop mechanisms to monitor status and trends of biological resources.
- Coordinated Bird Monitoring Group of IAFWA (2004) - this report is intended to be a spring-board for comprehensive discussions among NABCI partners on coordinating bird monitoring.

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