Chapter 8

Monitoring and Effectiveness Measures

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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Introduction

This chapter provides an overview of approaches and strategies for monitoring Maryland's Species of Greatest Conservation Need (SGCN), their habitats, and the effectiveness of implemented conservation actions. These conservation actions are outlined in Chapter 7 and in Chapter 7 appendices. An inventory of existing monitoring programs for wildlife and habitats are included in this Chapter, as well as descriptions of some of the regional monitoring programs applied by Northeast states. This chapter describes the use of monitoring data in an adaptive management framework to assess and improve the effectiveness of conservation actions. At the end of the chapter, a proposed approach to Maryland's framework for monitoring and measuring effectiveness measures is described with an example, which will assist in the successful implementation of the State Wildlife Action Plan (SWAP).

Monitoring was recognized as one of the most crucial needs for biodiversity conservation in the 2005 Wildlife Diversity Conservation Plan, and it is still recognized as a priority need for the 2015 - 2025 revision. This is because monitoring is essential in all aspects of conservation, from tracking which species are present and where they are present (their distribution), to evaluating priorities for future land protection and restoration. The information provided through monitoring Maryland's SGCN, their habitats, and the effectiveness of conservation actions will allow the Maryland Department of Natural Resources (MD DNR) and partners to reduce threats facing the state's fish and wildlife resources. As new threats and unfavorable conditions, such as changes in land use and climate patterns intensify, new information and data are needed to understand how to manage natural resources appropriately and sustainably.

The long-term successful implementation of Maryland's SWAP (Plan) will, at a minimum, prevent more SGCN from becoming increasingly rare and endangered, prevent key wildlife habitats from being degraded and irreparably lost, and minimize or mitigate threats to both. A critical measure of success will also include the reversal of population trends, such that rare species will become more abundant and the restoration of degraded key wildlife habitats within a natural landscape will increase. These are long-term outcomes of the success of this SWAP, recognizing the many external factors that might limit implementation. Another important measure of the effectiveness and adaptability of this SWAP is the frequency and degree of integration of SWAP targets into the operations of MD DNR's many programs, as well as those of its partners and stakeholders. Maryland's monitoring framework and adaptive management strategy will focus on evaluating the long-term progress towards these broad objectives.

Inventory, Monitoring, and Research

The activity referred to in this chapter as "monitoring" can be defined as the collection of data over a period of time, usually at certain defined and repeated intervals. Inventory and research are other activities that are frequently related to monitoring. Inventory includes the collection of baseline data such as whether a particular species is present and where it can be found. Repeating an inventory survey, especially at regular intervals, is one type of monitoring. Scientific research can be defined as a systematic investigation used to solve a problem or answer a question. Using the scientific method, investigators move through a

cycle of observing, asking questions, formulating ideas to explain what they see (hypotheses), making predictions from the hypotheses, collecting data to test the predictions (which may involve an experiment), evaluating the results, and altering the hypotheses as needed. The cycle can then begin again as predictions from the revised hypotheses are tested. Monitoring can be thought of as part of the scientific research process when data needed to test predictions are collected over a period of time. In other words, the results of an experiment or management activity are "monitored" to see if they are consistent with the predictions.

Inventory, monitoring, and research activities as defined above are all important conservation actions for SGCN and their habitats. Inventory provides basic information on the location, number, and condition of species and habitats. Scientific research on species and habitats is critical to understand needs, interactions, and responses to threats so that land managers and others have the basic information needed to develop effective conservation strategies for individual species and habitats. Monitoring that is not connected to particular questions or hypotheses is often referred to as status assessment or surveillance monitoring (Nichols & Williams 2006; Lambert et al. 2009). Status assessment or surveillance monitoring can provide updated information such as the current population size, distribution, reproductive output, and threats for a particular species or habitat, and, if repeated through time, can demonstrate changes in these parameters (trend monitoring). Effects monitoring goes a step further, linking changes in populations or habitat condition to changes in the environment. Although status assessment or surveillance monitoring is needed to establish current conditions or to demonstrate trends, it may not provide enough information to meet conservation goals. For example, status monitoring alone does not address reversing the decline of a population or analyzing the impacts of threats in order to reduce them. Monitoring, whether to collect current inventory data or data to address predictions from a research hypothesis, should not be viewed as a stand-alone activity, but rather as a component of a larger process of conservation-oriented science or management (Nichols & Williams 2006). The collection of monitoring data should be targeted to answer specific, well-defined questions and the link between monitoring data and improved conservation outcomes should be determined in advance.

Monitoring and Adaptive Management

Monitoring is fundamental in the process of evaluating how conservation actions actually affect targeted species and habitats. By providing conservation planners the ability to adjust actions and better understand how ecological systems function, monitoring the outcomes of conservation and management activities fits under the bigger picture approach of adaptive management. Adaptive management is a sequential, iterative process that uses monitoring data to improve management actions (Figure 8.1). Franklin et al. (2007) explain, "adaptive management is an approach to natural resource policy that embodies a simple imperative: policies are experiments; learn from them." Adaptive management includes the process of hypothesizing how ecosystems work, analyzing results from monitoring, and comparing results with action expectations (Williams & Brown 2012). The conservation actions can then be modified to better manage decisions to achieve conservation objectives through the improved understanding of ecological processes (Lancia et al. 1996). This is particularly important for complex natural systems because responses to conservation actions can be

difficult to predict, especially when there is uncertainty about current conditions (e.g., unknown threats, unavailable or incomplete population data, and unknown species response to habitat alteration).

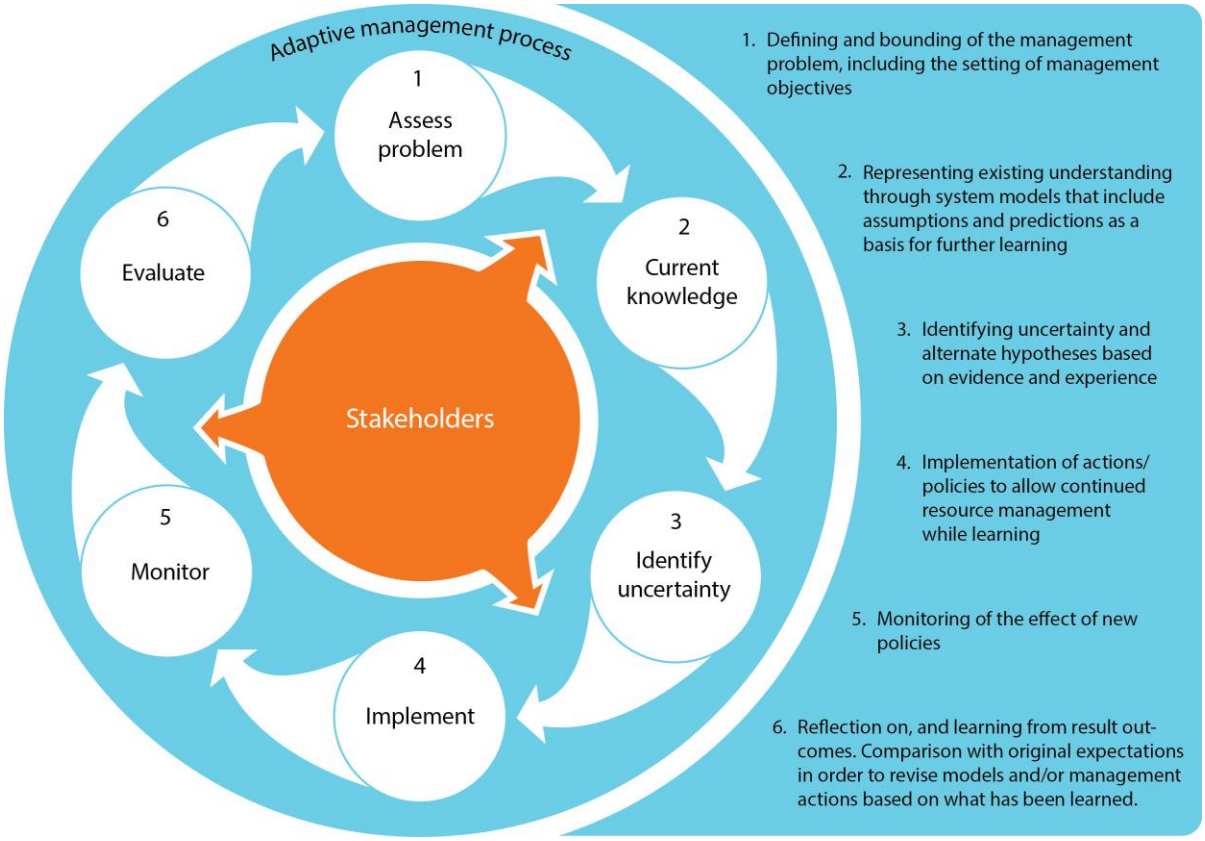

Figure 8.1 The adaptive management process, including the role of monitoring. Source: Rist et al. 2013.

Monitoring clearly plays a critical role in the process of tracking and improving wildlife conservation. An example of how to set up monitoring programs to meet the needs of adaptive management was developed by the Northeast Coordinated Bird Monitoring Partnership to improve conservation for birds (Lambert et al. 2009). These ten steps are suggested to optimize the value of monitoring and to carry out effective conservation:

1) Establish a clear purpose;
2) Determine whether an existing program or protocol meets your needs;
3) Assemble a team of collaborators with complementary interests and skills;
4) Summarize the relationship of target populations to other ecosystem elements, processes, and stressors;
5) Develop a statistically robust approach to sampling and data analysis;
6) Design and pilot standardized field protocols that minimize error and bias;

7) Identify or develop a data management system;
8) Implement the monitoring program;
9) Present results in a format that supports sound management and conservation decisions; and
10) Evaluate and adjust management and monitoring to make better conservation decisions.

Although this example was developed initially for monitoring birds, these 10 steps provide general guidance for the development of effective and efficient monitoring activities that can directly feed into the adaptive management process and are be most useful for the conservation of all SGCN, key wildlife habitats, and plant species of concern.

Monitoring Species of Greatest Conservation Need and Key Wildlife Habitats: Working with Partners to Implement Conservation Actions

Monitoring is identified as a priority need for a number of Species of Greatest Conservation Need (SGCN) and their key wildlife habitats in Chapters 3 and 7. Maryland is fortunate to have an extensive monitoring system (**Element 5**) already in place for many species, habitats, and environmental parameters, including hundreds of state, federal, local, and grassroots monitoring projects and programs. Tables 8.1 and 8.2 list many of the existing plans and programs that have been developed by local, state, regional, national, or international partners that include monitoring SGCN or their habitat components in Maryland. Many of the conservation actions identified in Chapter 7 related to monitoring were developed with these existing monitoring actions/plans in mind, as potentially providing the majority of the SWAP monitoring framework. Implementation of the SWAP will rely heavily on the existing monitoring projects and programs conducted by MD DNR's partners. Wherever possible, the SWAP recommends and supports the full implementation of partners' plans (e.g., U.S. Fish and Wildlife Service, Atlantic States Marine Fisheries Commission, Partners in Flight Bird Conservation Regions, The Nature Conservancy, and Bat Conservation International), especially those that have recommended or identified standardized monitoring actions and protocols for regional and/or national consistency. These existing monitoring efforts will be utilized as mechanisms to achieve SWAP conservation actions and implementation partnerships wherever applicable at the local, state, regional, and national levels.

Monitoring programs are scale-dependent. For example, within each key wildlife habitat, the most appropriate level of monitoring, whether it is at the species, species group, taxonomic group, habitat, or community level, will be identified to best monitor that biotic system at the relevant ecological scale. Implementation of this SWAP also involves monitoring at a variety of geographic scales, including local, state, regional, national, and international, according to the suitability and recommendation of relevant partners' plans and programs. Standardized monitoring protocols, such as those of the Breeding Bird Survey and the International Shorebird Survey, are utilized wherever appropriate so that Maryland's data will be compatible with regional and national conservation efforts.

Regional Monitoring Coordination

The Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) has obtained Regional Conservation Needs (RCN) Grants for several key regional monitoring projects for the Northeast region. These projects track status and trends of Regional Species of Greatest Conservation Need (RSGCN) and their habitats, and evaluate the effectiveness of conservation actions in the Northeast states. In 2006, the NEFWDTC identified the development of a regional monitoring and performance measurement project as a high priority. Although individual Northeast states had developed their own monitoring programs to track the status and condition of wildlife species and habitats, the Committee recognized the importance of coordinating monitoring and evaluation activities across the entire Northeast region. Several key factors cited by the Committee in supporting the development of regional monitoring activities include the large number of shared priority species and habitats, the relatively limited funding available in any one state for monitoring and evaluation activities, and the presence of many regional experts who have knowledge of particular taxa or ecosystems throughout the Northeast (Terwilliger Consulting, Inc. & NEFWDTC 2015).

Several examples show the breadth and diversity of regionally coordinated monitoring activities in the Northeast, especially those activities funded through the RCN Grant Program. A number of taxa-specific survey, inventory, and monitoring programs have been developed and implemented with the support of the Northeast Association of Fish and Wildlife Agencies (NEAFWA) and through other regional collaborations. With RCN funding, surveys and assessments have been conducted or are in the process of being conducted, and monitoring protocols have been developed for wood turtle, eastern black rail, shrubland birds (McDowell 2011), aquatic habitats (Gawler 2008), and frogs (assessment in progress, based on data collected during call surveys). Detailed avian indicators have also been developed for assessing the magnitude of threats and the effectiveness of conservation measures (Northeast Coordinated Bird Monitoring Partnership 2007). The consistent and widespread use of common monitoring methodologies and survey protocols will support regional assessments of the status and trends of SGCN and their habitats. Links to monitoring plans and tools developed through the RCN Grant Program are available on the RCN Final Products website (Terwilliger Consulting, Inc. & NEFWDTC 2015).

Coordinated Data Management

Maryland DNR and its partner organizations collect and compile a wide variety of biological data that, when integrated with similar data collected by other states, regions, or countries, can greatly enhance the ability to evaluate trends in species population sizes and distribution, habitat losses and gains, and other common parameters across broad geographic areas. Increasingly, partners are working to coordinate survey and monitoring efforts that follow standardized data collection methods and protocols. These data can be used most effectively if centralized databases are developed and maintained where data gathered by multiple agencies can be entered, stored, and accessed by contributing partners through a series of security levels established and controlled by the data owners. Biotics, an integrated, web-enabled platform for tabular and spatial data management, is the most extensive example of a centralized database related to SGCN and key wildlife habitats. Used and populated by members of the NatureServe network (especially state Natural Heritage Programs, often part

of a state government agency), the system provides built-in support for shared methodology and data standards with a focus on rare species, natural communities, and site conservation planning. Maryland contributes data tracking the status of over 1,100 rare native plants and animals to this database, which is updated daily with the results of inventory, monitoring, and research activities by MD DNR and its partners. This international compilation of over 30 years of monitoring data is publicly available through the NatureServe Explorer website.

To meet other needs, NEAFWA has funded the development of a database for regional invertebrate RSGCN, through a partnership with the Carnegie Museum of Natural History in Pittsburgh (Fetzner 2012). For bird monitoring data, the Avian Knowledge Network (AKN) offers state-of-the-art, web-based data management systems for bird monitoring data that are endorsed by the North American Bird Conservation Initiative (NABCI) and satisfy many of the best avian data management practices outlined in NABCI's *Data Management Best Practices and Standards for Biodiversity Data Applicable to Bird Monitoring Data* (Martin & Ballard 2010). The AKN is a partnership of people, institutions, and government agencies supporting the conservation of birds and their habitats based on data, the adaptive management paradigm, and the best available science. The AKN is currently developed, supported, and used by many federal, state, and non-profit organizations and has proven to be extremely effective in providing secure data storage capabilities and facilitating the application of monitoring standards to make datasets comparable across institutions and political boundaries. The AKN has also been used to manage data of other taxa (e.g., marine mammals) and could be formally extended for these purposes. To make better use of revised SWAPs, a comprehensive database is being developed that will include all species, habitats, actions, and threats from the individual Northeast State Wildlife Action Plans.

Climate Change: Monitoring a Major Regional Threat *(excerpted from Staudinger et al. 2015)*
Climate change will require novel management decisions with unknown outcomes; thus monitoring is essential to tracking successes and failures, helping refine future actions and approaches, and identifying effective adaptation strategies and management practices (West et al. 2009; Lawler et al. 2010). Monitoring also reduces uncertainty by providing current data as well as insight on how species and habitats are responding to climate change and other stressors. In many cases, monitoring programs were not designed with climate change impacts in mind and may need to be adjusted to accommodate new challenges and information needs (Heinz Center 2008). This includes identification of key indicators and metrics that track ecological responses, including certain demographic parameters and the seasonal timing of life history events (phenology) across components of biodiversity (species, ecosystems, and biomes). Monitoring can also provide advance warning of the direct and indirect impacts of climate change and other stressors (Heinz Center 2008; Staudinger et al. 2012). A recent report that served as input to the National Climate Assessment (Staudinger et al. 2012) made a series of recommendations on monitoring in the context of climate change, which are summarized here.

- Improved, better-integrated, and increasingly coordinated monitoring systems are needed to detect, track, and attribute species and habitat shifts to climate change over varying spatiotemporal scales.

- Existing long-term monitoring sites provide a historical context of the underlying trajectories of fish and wildlife populations and dependent habitats, and are useful in detecting drivers of change, the places where ecological systems are adapting (or not), as well as novel shifts in range, phenology and species interactions.
- Locally based observation networks can be "nested" within a larger-scale network to deliver information to a wider range of managers and policy makers in order to better detect changes due to climate and interactions with other anthropogenic stressors.
- Inserting monitoring protocols with consistent metrics into projects will be critical to make inferences across studies and document large scale trends in and wildlife species.
- Ecological monitoring of transition zones between ecosystems may provide early warning of potential biome shifts.
- Increased monitoring is needed to detect and subsequently eradicate invasive species before they become established in new locations or expand their range into new territories.

The following are examples of a regional project *(NorEaST)* and national program *(National Phenology Network)* that address these monitoring recommendations. In addition, Staudinger et al. (2015) identified various examples of how monitoring can address climate change, as well as other anthropogenic stressors, through specific adaptation strategies and actions.

NorEaST – A coordinated regional monitoring initiative for Northeast stream temperatures

One example of how individual disparate monitoring locations can be linked together to inform landscape and regional scale adaptation is showcased by the NorEaST project. Climate change is expected to alter stream temperature and flow regimes over the coming decades, and, in turn, influence distributions of aquatic species in those freshwater ecosystems. To better anticipate these changes, there has been a need to compile both short- and long-term stream temperature data for managers to gain an understanding of baseline conditions, historic trends, and future projections. Pooled data from many sources, even if temporally and spatially inconsistent, can have great value both in the realm of stream temperature and aquatic response. Unfortunately, many agencies lack sufficient resources to compile data, conduct data quality assurance and control, and make accessible stream temperature data collected through routine monitoring.

The NorEaST web portal was developed to serve as a coordinated multi-agency regional framework to map and store continuous stream temperature locations and data for New England, Mid-Atlantic, and Great Lakes states. Stream temperature monitoring locations and metadata contributed by 47 different organizations can be viewed for over 10,000 monitoring locations across 22 states. Stream temperature sites can be viewed on the *NorEaST* mapper. Ultimately the goal of this project and portal is to make these data available to managers and the public to aid in adaptation and management planning and in implementing conservation actions.

The NorEaST web portal was built to map stream temperature locations, store stream temperature data, and deliver stream temperature data through web services to stakeholders, including easy access through R software. Preliminary applications of this project have allowed evaluations of seasonal associations of fish species with stream thermal conditions (e.g., range of summer and fall temperatures), the identification of thermally sensitive fish species, and investigation into previously unknown potential differences of fish-temperature associations across regions. Updates on this project can be found on the Northeast Climate Science Center website.

National Phenology Network

The National Phenology Network (NPN) provides national standardized protocols for collecting phenology observations, advice, and education materials for the collection and organization of new phenology data, and supports the development of tools and approaches for natural resource decision-making. NPN developed *Nature's Notebook* as a citizen science tool to gather phenology observations on plants and animals nationally. Citizen science, a term broadly used to describe the collection of scientific data by the general public, is a growing way to monitor and track changes in species responses to climate change, and to supplement existing scientific monitoring networks (Newman et al. 2012). Public engagement through citizen science increases awareness of conservation and climate adaptation issues and can help extend limited resources for activities like monitoring. Numerous institutions across the Northeast and Midwest are using NPN's Nature's Notebook tool and contributing to a larger network of monitoring programs to inform an overall understanding of phenological responses to climate change.

Regional, State, and Local Monitoring Programs in Maryland

The Chesapeake Bay may be one of the most monitored ecosystems in the country, with a wide range of state, federal, local, regional, academic, and non-governmental organizations (NGOs) actively facilitating research and monitoring programs. Recent water quality and habitat quality monitoring data for Chesapeake Bay, the Coastal Bays, and estuarine tributaries (periodic and continuous data) are available online through the state's Eyes on the Bay Monitoring Program. The Chesapeake Bay Monitoring Program, which brings together Maryland, Pennsylvania, Virginia, the District of Columbia, multiple federal agencies, and over 30 scientists, tests for nineteen chemical, physical, and ecological components 20 times each year. The Chesapeake Bay Program maintains a clearinghouse of monitoring data on the Chesapeake Bay's physical, chemical, and living resources. The Alliance for the Chesapeake Bay's Citizen Water Quality Monitoring Program is a regional network of trained volunteers who track the condition of waters draining into Chesapeake Bay using weekly water quality tests throughout Maryland, Pennsylvania, and Virginia.

MD DNR monitors freshwater aquatic communities through the Maryland Biological Stream Survey (MBSS), which conducts comprehensive biological and chemical monitoring of freshwater streams and rivers throughout the state and publishes reports on their health, allowing MD DNR to monitor SGCN that live in those environments. In addition, dozens of groups of community volunteers participate in watershed-based water quality and stream monitoring activities, and the Maryland Water Monitoring Council serves as an umbrella organization for many of these groups. MD DNR's Resource Assessment Program created a

guidance manual to educate volunteer stream monitors (Stream Waders), creating a standardized system for data gathering (MD DNR 2008). NGOs such as the National Audubon Society, Trout Unlimited, and FrogWatch USA perform important monitoring projects for aquatic and other wildlife, many of which engage community volunteers.

The 2015 Comprehensive Conservation and Management Plan for Maryland's Coastal Bays (Maryland Coastal Bays Program 2015) formulated a detailed monitoring strategy for the Coastal Bays that builds on existing partnerships between the Maryland Coastal Bays Program (MCBP), MD DNR, and other state and national programs to present monitoring based conservation actions for the Coastal Bays. Monitoring plays an important role in many conservation plans, as detailed knowledge of ecological systems is necessary before conservation planners are able to address ecological issues with specific actions. In addition to stand-alone research projects that are part of the Coastal Bays Management Plan, monitoring actions drive other conservation actions within categories of education and outreach and policy issues. The existing monitoring programs for Maryland's coastal and aquatic resources are integral to the SWAP's monitoring framework for key aquatic and wetland habitats and SGCN.

While extensive monitoring programs for Maryland's aquatic and wetland habitats already exist, likely driven by the national importance of the Chesapeake Bay estuary and its tributaries, far fewer monitoring programs support Maryland's terrestrial habitats. MD DNR leads many of these programs, and is involved with most terrestrial monitoring programs in the state via the important geographic information system (GIS) tools in which MD DNR specializes. The MD DNR Natural Heritage Program (NHP) tracks hundreds of species and natural communities, maintaining a detailed database on their abundance and distribution. Monitoring programs for certain species and taxa groups, such as Puritan and northeastern beach tiger beetles, bog turtle, marshbirds, and colonial waterbirds, are ongoing, as are other monitoring programs within the MD Wildlife and Heritage Service (WHS), including mid-winter waterfowl surveys. Status and trend data for additional species can be tracked by adapting the existing NHP database or by developing additional data systems, as needed, to include data on the status of all SGCN species, research and survey results, and ongoing inventory and monitoring projects.

The U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), National Park Service (NPS), National Oceanic and Atmospheric Administration (NOAA) and Department of Defense branches (U.S. Army, U.S. Navy, US. Army Corps of Engineers) also monitors various fish and wildlife resources and their habitats in Maryland. The USFWS monitors migratory bird populations, federally listed species, non-native invasive species such as nutria, and other wildlife populations on National Wildlife Refuges in Maryland. The Chesapeake Bay Program (CBP), made possible by a partnership between USFWS, EPA, and other federal, state, and local entities, monitors the Chesapeake Bay ecosystem. The USGS Patuxent Wildlife Research Center carries out long-term monitoring programs for amphibians, birds, wildlife diseases, water quality, and sea-level rise in the Chesapeake Bay watershed region. NPS monitors the habitats and wildlife resources of Assateague Island National Seashore, Chesapeake & Ohio Canal National Historical Park, and other NPS properties in the state. NOAA assesses the status and

trends of many fisheries resources and the habitats at the Chesapeake Bay National Estuarine Research Reserve (CBNERR). The U.S. Army monitors fish, wildlife, and submerged aquatic vegetation (SAV) habitats at its Aberdeen Proving Ground. The U.S. Army Corps of Engineers has comprehensive ecological monitoring programs for its island restoration projects in the Chesapeake Bay. The U.S. Navy monitors birds at Patuxent Naval Air Station, Bloodsworth Island, Indian Head, and other naval properties. Several of these federal partners also work with MD DNR to protect and monitor the resources of the Chesapeake Bay. By coordinating with these federal partners and others, MD DNR can better implement the SWAP's monitoring framework.

Many of these programs engage the public in monitoring activities, benefiting both monitoring objectives and public knowledge of Maryland's wildlife. BioBlitzes are popular monitoring programs offered by many organizations in Maryland. These one-day programs engage participants in citizen science around the state, as participants canvas specified state parks, wildlife refuges, and other natural areas to identify wildlife. Many organizations host and/or lead BioBlitzes in Maryland, including the National Audubon Society, the Maryland Native Plant Society, USGS's Patuxent Wildlife Refuge, Maryland Biodiversity Project, the National Aquarium, and many watershed societies.

The following tables (8.1, 8.2) demonstrate the diversity of monitoring programs that exist in Maryland to track species, species groups (or guilds), natural communities, and habitats. This network of monitoring programs, which includes aquatic and terrestrial species and habitat monitoring initiatives, provides data for use in conservation planning; federal, state, and local government decision-making; and private citizens' projects. These tables list individual monitoring programs, associated organization(s), the target of the monitoring activities, and the monitoring level (individual species, groups of species, and/or habitat focused).

Species Monitoring Programs

Management of wildlife populations relies on the collection of data about particular species populations. Monitoring programs may focus on one species, such as the Delmarva fox squirrel, or on multiple species within a general species group, such as waterbirds or pollinators. Existing wildlife species monitoring programs are a major source of data needed to set priorities and formulate protection strategies for SGCN listed in Maryland's SWAP. Of the 125 species and species group monitoring programs documented below as being active in Maryland, 75 new programs were added for this SWAP revision.

Table 8.1 Species and species level monitoring programs in Maryland. List is presented in alphabetical order by Implementation Lead.

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
FrogWatch USA	Association of Zoos and Aquariums	Frogs, toads		X	
Bird Blitz Survey	Audubon Maryland-District of Columbia (Audubon MD-DC)	Priority birds		X	
Important Bird Area Stewards	Audubon MD-DC	Priority birds		X	X
Saltmarsh Habitat and Avian Research Program	Audubon MD-DC, MD DNR WHS	Tidal marshbirds		X	X
Lights Out Baltimore!	Baltimore Bird Club	Migrating birds, urban birds		X	
Secretive Marsh Bird Monitoring	CBNERR	Marshbirds		X	
Chesapeake Bay Monitoring Program	CBP	Water quality monitoring, fish, shellfish, blue crab, plankton, benthos		X	X
National Nightjar Survey	Center for Conservation Biology	Nightjars		X	
Project OspreyWatch	Center for Conservation Biology	Osprey	X		
Wood Duck and Bluebird monitoring	Chesapeake Bay Environmental Center	Wood duck, bluebird	X		
Bluebird Nest box monitoring	Chester River Field Research Station	Eastern bluebird	X		
Foreman's Branch Bird Observatory	Chester River Field Research Station	Birds		X	
Grassland Breeding Bird Ecology Study	Chester River Field Research Station	Grassland breeding birds		X	X
Northern Bobwhite Point Counts	Chester River Field Research Station	Northern bobwhite	X		
A Swift Night Out!	Chimney Swift Conservation Association	Chimney swift	X		
Golden-winged Warbler Surveys	Cornell Lab of Ornithology	Golden-winged warbler	X		
Project FeederWatch	Cornell Lab of Ornithology	Winter birds		X	
Project NestWatch	Cornell Lab of Ornithology	Birds		X	
Great Backyard Bird Count	Cornell Lab of Ornithology, National Audubon Society, and Bird Studies Canada	Birds		X	

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Regional Black Rail Survey	Eastern Black Rail Working Group	Black rail	X		
Appalachian Golden Eagle Winter Survey	Eastern Golden Eagle Working Group, MD DNR WHS	Golden eagle, other scavengers	X	X	
Hawk Counts	Hawk Migration Association of North America	Hawks		X	
Monitoring of Avian Productivity and Survival	Institute for Bird Populations	Songbirds		X	
Rusty Blackbird Spring Migration Blitz	International Rusty Blackbird Working Group	Rusty blackbird	X	X	
Winter Water Bird Survey	Jug Bay Wetlands Sanctuary	Waterbirds		X	
International Shorebird Survey/Program for Regional and International Shorebird Monitoring	Manomet	Shorebirds		X	
Bald Eagle Nest Monitoring Project	Maryland Bird Conservation Initiative	Bald eagle	X		
Forest Pest Management Program (Invasive and Non-Invasive)	Maryland Department of Agriculture (MDA), USDA	Insects (Asian longhorned beetle, gypsy moth, etc.)	X	X	X
Fish and Shellfish Contaminant Monitoring Program	Maryland Department of the Environment (MDE)	Fish, shellfish, crabs		X	
National Coastal Assessment	MD DNR Chesapeake and Coastal Service, U.S. EPA	Water quality and condition, contaminants, floral and faunal communities, habitat		X	X
Coastal Fisheries Program fish population monitoring in Coastal Bays and Atlantic Ocean	MD DNR Fisheries	Water quality, recreational and commercial fish		X	X
Commercial Fishery Harvest Monitoring	MD DNR Fisheries	Commercial finfish and shellfish species	X	X	X
Fall and Winter (Fish) Stock Assessment	MD DNR Fisheries	White perch, yellow perch, catfish, forage fish, invasive fish	X	X	
Fish Passage Monitoring	MD DNR Fisheries	Fishes		X	X
Marine Mammal and Sea Turtle Stranding Response Program	MD DNR Fisheries	Marine mammals, sea turtles		X	

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Fisheries Habitat and Ecosystem Program, Habitat Investigations	MD DNR Fisheries	Recreational fish species in tidal waters	X	X	X
Fish Health/Disease Program	MD DNR Fisheries	Striped bass	X		
Juvenile Index Survey	MD DNR Fisheries	Juvenile commercial and recreational species, key forage species	X	X	
Stock Assessment of Selected Adult Resident and Migratory Fish in Maryland's Chesapeake Bay	MD DNR Fisheries	Resident and migratory Chesapeake Bay fishes	X	X	
Survey, Inventory, and Management of Maryland's Coldwater Fishery Resources	MD DNR Fisheries	Brook trout, rainbow trout, brown trout, benthic macroinvertebrates	X	X	
Fish population surveys (Gunpowder, Potomac, and Patuxent River watersheds)	MD DNR Fisheries Service, Trout Unlimited	Trout (focus on brook trout)	X	X	X
American and Hickory Shad Restoration Surveys in Maryland Rivers	MD DNR Fisheries, Interstate Commission on the Potomac River Basin, USFWS, Washington, DC Fisheries	Shad	X		
Spawning Horseshoe Crab Voluntary Monitoring program	MD DNR Fisheries, MCBP	Horseshoe crab	X		
Aquatic invasive species monitoring	MD DNR Fisheries, RAS	Non-native crabs, nutria, other non-native species	X	X	X
Investigation of Anadromous Alosids in Chesapeake Bay	MD DNR Fisheries, RAS, USFWS	Alosine species	X	X	
Macroinvertebrate tailrace studies on the North Branch Potomac, Savage River, Gunpowder below Prettyboy, and Big Hunting Creek	MD DNR RAS	Macroinvertebrates		X	
Maryland Biological Stream Survey	MD DNR RAS	Stream fauna biodiversity	X	X	X

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Submerged Aquatic Vegetation (SAV) Population Monitoring	MD DNR Resource Assessment Service (RAS), CBNERR-Maryland, Virginia Institute of Marine Science	SAV habitat, water quality, water depth		X	X
Bat hibernacula surveys	MD DNR WHS	Hibernating bats		X	
Bog turtle monitoring	MD DNR WHS	Bog turtle	X		X
Brown Pelican Population Monitoring	MD DNR WHS	Brown pelican	X		
Colonial waterbird monitoring	MD DNR WHS	Colonial waterbirds		X	
Chronic Wasting Disease Monitoring	MD DNR WHS	White-tailed deer, sika deer	X		
Deer Management Program	MD DNR WHS	White-tailed deer, sika deer	X		
Distribution and Status of the Hellbender in Maryland	MD DNR WHS	Eastern hellbender	X		
Eastern Tiger Salamander Study (distribution, population status)	MD DNR WHS	Eastern tiger salamander	X		
Furbearer Management Program	MD DNR WHS	Furbearer species		X	
Game bird species surveys	MD DNR WHS	Northern bobwhite, American woodcock	X		
Terrestrial invasive species monitoring	MD DNR WHS	Non-native and invasive plants and animals	X	X	X
Maryland Survey of Bowhunters	MD DNR WHS	Deer, wild turkey, northern bobwhite, furbearer species	X	X	
Mute Swan Aerial Surveys (population status and trends)	MD DNR WHS	Mute swan	X		
Nongame/Guild monitoring	MD DNR WHS	Marshbirds, freshwater mussels, Forest interior birds		X	
Restoration site monitoring	MD DNR WHS	Restored natural communities	X	X	X
Wild Turkey Observation Survey	MD DNR WHS	Wild turkey	X		

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Rare species monitoring, including federally listed; rare natural communities	MD DNR WHS, RAS	Rare species and rare natural communities	X	X	X
Dredged Material Containment Facilities Survey	Maryland Environmental Service	Birds		X	
Hart-Miller Island Dredged Material Containment Facility Surveys	Maryland Environmental Service	Birds		X	
Bird Counts (Winter, Spring Migration, Breeding, Fall Migration)	Maryland Ornithological Society	Birds		X	
Dredged Material Containment Facilities Survey	Maryland Environmental Service	Birds		X	
Christmas Bird Count	National Audubon Society	Birds		X	
Bird Source (national monitoring program)	National Audubon Society, Cornell Lab of Ornithology	Birds		X	X
Fisheries Statistics & Economics program (stock assessments, landings)	NOAA-National Marine Fisheries Service	Fisheries species	X	X	
Bird Monitoring in National Parks	National Park Service	Birds		X	
Feral horse population monitoring, Assateague Island	National Park Service	Feral horses	X		
Piping Plover Breeding Biology, Foraging Ecology and Behavior on Assateague Island	National Park Service	Piping plover	X		X
Butterfly Counts	North American Butterfly Association	Butterflies		X	X
Otter Point Creek Monitoring Programs	Otter Point Creek – Anita C. Leight Estuary Center	Fishes, herpetofauna		X	X
Bluebird, Wood duck, and Winter Feeder Monitoring	Pickering Creek Audubon Center	Birds	X	X	
Project Owlnet	Project Owlnet (Dave Brinker, MD DNR)	Saw-whet owls, owls	X	X	
Project SNOWStorm	Project SNOWStorm (Dave Brinker, MD DNR)	Snowy owl	X		

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Raptor Nest Monitoring	Raptor Conservation Committee of Southern Maryland Audubon Society	Raptors (American kestrel, barn owls, osprey)	X		
Forest Bird Survey on Eastern Shore	Salisbury University Department of Biological Sciences	Forest birds		X	
Migratory connectivity Project	Smithsonian Migratory Bird Research Center, USGS	Migratory birds	X		
Pickering Creek Audubon Center eBird and Bluebird Monitoring Program	Talbot County Bird Club	Bluebirds, other species	X	X	
Mid-Atlantic Restocking Project at Chester River Field Research Station	Tall Timbers Research Station and Land Conservancy	Northern bobwhite	X		
Maryland State Summer Acoustic Bat Monitoring	University of Maryland Center for Environmental Science Appalachian Lab, MD DNR, University of Maryland College Park	Bats		X	
Status of the Bald Eagle in Maryland (mid-winter surveys, nesting productivity)	U.S. Army Aberdeen Proving Ground, USFWS	Bald eagle	X		
National Mid-winter Bald Eagle Survey	U.S. Army Corps of Engineers	Bald eagle	X		
Poplar Island Restoration project monitoring	U.S. Army Corps of Engineers, USFWS	SAV, fish, wildlife, habitats		X	X
Bald Eagle Population Monitoring Program	USFWS	Bald eagle	X		
Integrated Waterbird Management and Monitoring Survey	USFWS	Waterbirds		X	
American Black Duck Seasonal Survival	USFWS Blackwater National Wildlife Refuge (NWR)	American black duck	X		
Delmarva Peninsula Fox Squirrel Atlas Project	USFWS Blackwater NWR	Delmarva fox squirrel	X		
Delmarva Peninsula Fox Squirrel Occupancy Modeling	USFWS Blackwater NWR	Delmarva fox squirrel	X		
Maryland Amphibian and Reptile Atlas	USFWS Blackwater NWR	Herpetofauna		X	

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Waterfowl population monitoring	USFWS Blackwater NWR	Waterfowl		X	X
Marshbird monitoring	USFWS Blackwater NWR	Marshbirds		X	
Tundra Swan Monitoring Program Eastern Neck NWR	USFWS Eastern Neck NWR	Tundra swan	X		
Wildlife monitoring at Eastern Neck NWR	USFWS Eastern Neck NWR	Waterfowl, songbirds, white-tailed deer	X	X	X
Integrated Deer Population Monitoring	USFWS Patuxent Research Refuge	White-tailed deer	X		X
Northeast Passive Acoustic Bat Monitoring	USFWS Patuxent Research Refuge	Bats		X	
Shrubland Right of Way Breeding Bird Survey	USFWS Patuxent Research Refuge	Birds		X	X
Shrubland Right of Way Pollinator Survey	USFWS Patuxent Research Refuge	Pollinators		X	X
Songbird Nest Box Monitoring	USFWS Patuxent Research Refuge	Birds		X	
Whip-poor-will Survey	USFWS Patuxent Research Refuge	Whip-poor-will	X		
Wood Duck Nest Box Monitoring	USFWS Patuxent Research Refuge	Wood duck	X		
Anuran Call Survey	USFWS Patuxent Research Refuge	Anurans		X	
Wildlife monitoring at Patuxent Research Refuge	USFWS Patuxent Research Refuge	White-tailed deer, waterbirds, reptiles, amphibians, harvested species	X	X	X
Midwinter Waterfowl Survey	USFWS, MD DNR	Waterfowl (ducks, geese and swans)	X	X	
Midwinter Waterfowl Survey	USFWS, MD DNR	Waterfowl		X	
Chesapeake Bay Nutria Eradication Program	USFWS, MD DNR, USDA Animal and Plant Health Inspection Service	Nutria	X		X
Nocturnal Bird Migration Through the Central Appalachians	USGS	Nocturnally migrating birds in the Central Appalachians		X	

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Radar Analysis of Fall Migration Stopover Sites in the Northeastern U.S.	USGS	Migrating birds		X	
Migration Monitoring at Patuxent Wildlife Research Center	USGS Bird Banding Laboratory	Migrating birds		X	
Assessing The Relative Habitat Value Of Restored Versus Natural Coastal Marshes And Islands To Migratory Birds In Chesapeake Bay	USGS Patuxent Wildlife Research Center	Nesting waterbirds		X	X
Atlantic Seaduck Monitoring Program	USGS Patuxent Wildlife Research Center	Seaducks	X		
Atlantic Seaduck Study	USGS Patuxent Wildlife Research Center	Seaducks		X	X
Bird Banding Laboratory	USGS Patuxent Wildlife Research Center	Birds		X	
Breeding Bird Survey	USGS Patuxent Wildlife Research Center	Birds		X	
Diving Duck Distribution, Abundance, and Food Habits in Chesapeake Bay	USGS Patuxent Wildlife Research Center	Diving ducks		X	
North American Amphibian Monitoring Program	USGS Patuxent Wildlife Research Center	Amphibians		X	
Northeast Amphibian Research and Monitoring Initiative	USGS Patuxent Wildlife Research Center	Amphibians		X	X
Osprey Nesting Platform Monitoring	USGS Patuxent Wildlife Research Center	Osprey	X		
West Nile Virus Surveillance	USGS, MD Dept. of Health and Mental Hygiene	West Nile Virus	X		
Eastern Brook Trout Joint Venture	USGS, USFWS, U.S. Forest Service, MD DNR Fisheries Service	Water quality, brook trout populations	X		X
Oriole migration monitoring	University of Maryland, Baltimore County Department of Biological Sciences	Baltimore and orchard orioles	X		

*Acronyms are listed within text the first time they are mentioned in each Chapter; all acronyms used in Maryland's State Wildlife Action Plan are defined in the Supplemental Document, 'Acronyms'.

Habitat Monitoring Programs

Habitat monitoring programs in Maryland frequently focus on the state's greatest aquatic resource, the Chesapeake Bay. A variety of water quality monitoring programs exists to track nutrients, sediments, and pollutants affecting the Bay or flowing into the Bay from a number of tributaries. Other habitat monitoring programs include programs that focus on the habitats of specific SGCN, as well as programs that track habitat health at wildlife sanctuaries such as Chesapeake Marshlands National Wildlife Refuge, and programs that monitor variables like air quality and land use that affect habitats across Maryland. Data from these programs are collected, analyzed, and provided to conservation biologists and managers at the state and federal level in order to efficiently and effectively manage for these important wildlife habitats. Of the 99 habitat monitoring programs documented below as being active in Maryland, 23 programs were added for this SWAP revision.

Table 8.2 Habitat-level monitoring programs in Maryland. List is presented in alphabetical order by Implementation Lead.

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Alliance Citizen Monitoring Program	Alliance for the Chesapeake Bay	Water quality monitoring			X
American Chestnut Land Trust Water Quality Monitoring Program	American Chestnut Land Trust	Water quality monitoring			X
Conservation Easements	American Chestnut Land Trust, MD DNR Maryland Environmental Trust, local land conservancies and trusts	Easement condition			X
Water Quality Monitoring	Anacostia Watershed Society	Water quality monitoring			X
Assateague Coastkeeper	Assateague Coastal Trust	Water quality monitoring			X
Important Bird Area Stewards	Audubon MD-DC	Threats to habitats, priority birds		X	X
Audubon Naturalist Society Water Quality Monitoring Program	Audubon Naturalist Society	Water quality monitoring, benthic surveys			X
Baltimore County Stream Monitoring	Baltimore County Department of Environmental Protection and Sustainability	Water quality monitoring			X
Water quality Monitoring	Blue Water Baltimore	Water quality monitoring			X

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Baltimore Ecosystem Study – Long-term Ecological Research (LTER) project	Cary Institute of Ecosystem Studies	Ecological indicators (water quality, air quality, vegetation, etc.)		X	X
Chesapeake Bay Monitoring Program	Chesapeake Bay Program	Water quality monitoring including benthos, nutrients and sediments, freshwater inputs, chemical containments; SAV		X	X
Water quality Assessment of Chester River and Tributaries	Chester River Association	Water quality monitoring			X
Periodic Outfall Monitoring	Friends of Sligo Creek	Water quality monitoring			X
Water quality monitoring data management	Interstate Commission on the Potomac River Basin	Water quality monitoring			X
Stream monitoring	Izaak Walton League of Maryland	Aquatic insects, chemical contaminants, physical appearance		X	X
Magothy River Creek Watchers	Magothy River Association	Water quality monitoring			X
The Magothy River Index	Magothy River Association	Water quality monitoring, SAV		X	X
Beach Water Quality Sampling Program	Maryland Beaches Program	Beach habitat health			X
Maryland Coastal Bays Volunteer Water Quality Monitoring Program	Maryland Coastal Bays Program, MD DNR, NPS	Water quality, algal blooms		X	X
Shoreline Change and Rate Monitoring	Maryland Geological Survey	Shoreline change			X
Resource Assessment of Atlantic Coast Areas	Maryland Geological Survey	Mineral, water, land resources			X
Great Herring Bay Stream and Shore Survey	Maryland Save Our Streams	Water quality monitoring			X
Stream monitoring	Maryland Stream Waders	Water quality monitoring, stream life		X	X
Watershed Water Quality Monitoring	Maryland Water Monitoring Council	Water quality monitoring			X
Acid Mine Drainage Restoration monitoring	MDE	Water quality monitoring			X

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Forest Pest Management Program	Maryland Dept of Agriculture (MDA), USDA	Forest impacts from insect pests (Asian longhorned beetle, gypsy moth, etc.)	X	X	X
Coastal LIDAR (high resolution elevation data)	MD DNR Chesapeake and Coastal Service	Water quality monitoring			X
Coastal Fisheries Program fish population monitoring in Coastal Bays and Atlantic Ocean	MD DNR Fisheries	Water quality, tuna, billfish, other fish	X	X	X
Fisheries Habitat and Ecosystem Program, Habitat Investigations	MD DNR Fisheries	Recreational fish species in tidal waters	X	X	X
Spawning Horseshoe Crab Voluntary Monitoring program	MD DNR Fisheries, Maryland Coastal Bays Program	Horseshoe crab habitat	X		X
Invasive species monitoring	MD DNR Fisheries, RAS	SAV, non-native crabs, nutria, other non-native species	X	X	X
Special Rivers Project monitoring	MD DNR Forest Service	Water quality monitoring			X
Continuous Monitoring Program	MD DNR RAS	Water quality monitoring			X
Chesapeake Bay Monitoring Program, Ecosystem Processes Component	MD DNR RAS	Water quality monitoring			X
Chesapeake Bay Monitoring Program: Eyes on the Bay	MD DNR RAS	Water quality and habitat monitoring		X	X
Tidal Water and Habitat Quality Monitoring program	MD DNR RAS	Water quality monitoring			X
Coastal Bays Water Quality Monitoring Program	MD DNR RAS	Water quality monitoring, SAV		X	X
Marcellus Shale Stream Monitoring Coalition	MD DNR RAS	Water quality monitoring in possible hydraulic fracturing area			X
Maryland Biological Stream Survey	MD DNR RAS	Ecological resources and conditions of stream and river habitat	X	X	X

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Maryland River Input and Main bay Monitoring program	MD DNR RAS	Water quality monitoring, flow rate monitoring			X
Deer Management Program	MD DNR WHS	White-tailed deer; sika deer	X		X
Mast survey (food supply for forest-dwelling fauna)	MD DNR WHS	Forest-dwelling animals		X	X
Nongame/Guild monitoring	MD DNR WHS	Marshbirds, freshwater mussels		X	X
Rare species and natural community monitoring	MD DNR WHS	Rare species and natural communities	X	X	X
Restoration site monitoring	MD DNR WHS	Restored natural communities	X	X	X
Air Quality Monitoring	MDE	Air quality monitoring (ozone, pollutants)			X
Shellfish Harvest monitoring	MDE	Water quality monitoring, disease, contaminants		X	X
Wetland Mitigation Monitoring	MDE	Water quality monitoring, SAV, sea-level rise		X	X
Wetland status and trends	MDE	Water quality monitoring, SAV, sea-level rise		X	X
Water Quality Monitoring Program	MDE	Water quality monitoring			X
Water quality monitoring	Nanticoke Watershed Alliance, Nanticoke Creekwatchers	Water quality monitoring		X	X
LANDSAT Remote Sensing (land use/land cover)	National Aeronautics and Space Administration, USGS, MD Department of Planning	Land use			X
Chesapeake Bay Water Quality Monitoring	National Aquarium in Baltimore	Water quality monitoring			X
NOAA Restoration Center Programs	NOAA	Oil spill and contamination monitoring			X
Sea-level rise monitoring	NOAA – National Geodetic Survey	Sea-level monitoring			X

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
National Estuarine Research Reserve System-wide Monitoring Program	NOAA, CBNERR	Water quality monitoring, weather, land use			X
National Estuarine Research Reserve System Wide Monitoring Program	NOAA, CBNERR	SAV, water quality		X	X
Assateague Island geomorphology	NPS	Shoreline change			X
Estuarine tides and water levels, Assateague Island NS	NPS	Tidal changes			X
Vegetation change monitoring, North End of Assateague Island NS	NPS	Vegetation		X	X
Water Quality Monitoring (Potomac River)	Potomac Riverkeeper	Water quality monitoring			X
Operation Clearwater	Severn River Association	Water quality monitoring			X
Severn River Water Quality Monitoring	Severn Riverkeeper	Water quality monitoring			X
South River Operation Clearwater	South River Federation	Water quality monitoring			X
State of the Beach monitoring program	Surfrider Foundation	Water quality monitoring			X
Aberdeen Proving Ground Environmental Monitoring	U.S. Army Aberdeen Proving Ground	Groundwater contaminants, water quality monitoring			X
Disposal Area Monitoring System	U.S. Army Corps of Engineers	Water quality monitoring			X
Poplar Island Restoration project monitoring	U.S. Army Corps of Engineers	Water quality monitoring, fish, SAV, habitats		X	X
Fort Meade Environmental Monitoring	U.S. Army Environmental Center	Groundwater contaminants			X
Multi-Resolution Land Characteristics	U.S. EPA	Land cover			X
Chesapeake Bay Benthic Monitoring Program	U.S. EPA Chesapeake Bay Program, MD DNR, Versar, Inc.	Water quality monitoring, benthic invertebrates		X	X

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Forest Inventory Analysis	U.S. Forest Service	Forest distribution			X
Chesapeake Bay Monitoring	University of Maryland Center for Environmental Science Chesapeake Biological Laboratory	Water quality monitoring, phytoplankton, SAV		X	X
Chesapeake Bay Remote Sensing Program	University of Maryland Center for Environmental Science, Maryland Sea Grant	Water quality monitoring (chlorophyll)		X	X
National Resources Inventory	USDA Natural Resources Conservation Service	Land use, wetlands distribution			X
National Wetlands Inventory Program	USFWS	Wetland distribution			X
Chesapeake Bay Nutria Eradication Program	USFWS – Blackwater NWR, USDA Animal and Plant Health Inspection Service	Nutria habitat destruction	X		X
Establishment of Rhinoncomimus Weevils for Mile-a-minute Control	USFWS Eastern Neck NWR	Biological invasive plant control	X		X
Integrated Deer Population Monitoring	USFWS Patuxent Research Refuge	White-tailed deer habitat destruction	X		X
Invasive Plant Survey	USFWS Patuxent Research Refuge	Invasive plants		X	X
Shrubland Right of Way Breeding Bird Survey	USFWS Patuxent Research Refuge	Shrubland right-of-way		X	X
Shrubland Right of Way Pollinator Survey	USFWS Patuxent Research Refuge	Shrubland right-of-way		X	X
Shrubland Right of Way Vegetation Survey	USFWS Patuxent Research Refuge	Shrubland right-of-way		X	X
Effectiveness of Hydrological Restoration Efforts	USFWS Blackwater NWR	Hydrological changes in marsh			X
Marsh Surface Elevation Trajectory	USFWS Blackwater NWR	Marsh surface elevation			X
Monitoring Delmarva Fox Squirrel occupancy following forest management practices	USFWS Blackwater NWR	Forest habitats			X

Monitoring Program or Action	Implementation Lead	Target	Monitoring Level		
			Individual Species	Groups of Species	Habitat
Maryland Marsh Restoration Project	USFWS Blackwater NWR, Audubon MD-DC	Marsh habitats			X
Chesapeake Bay River Input Monitoring Program	USGS	Water quality monitoring			X
Ground-Water Level Monitoring	USGS	Water quality monitoring			X
National Water Quality Assessment Program	USGS	Water quality monitoring			X
WaterWatch, measuring streamflow conditions of Chesapeake Bay tributaries	USGS	Water quality monitoring			X
Assessing The Relative Habitat Value Of Restored Versus Natural Coastal Marshes And Islands To Migratory Birds In Chesapeake Bay	USGS Patuxent Wildlife Research Center	Water quality monitoring, wetlands health, bird habitat		X	X
NPS Vital Signs Monitoring Program	USGS Patuxent Wildlife Research Center	Water quality, SAV		X	X
Predicting the Persistence of Coastal Wetlands to Global Change Effects	USGS Patuxent Wildlife Research Center	Sea-level monitoring			X
LIDAR Topographic Surveys, Assateague Island	USGS, NPS	Topographic survey			X
Eastern Brook Trout Joint Venture	USGS, USFWS, U.S. Forest Service, MD DNR Fisheries Service	Water quality, brook trout populations	X		X
Submerged Aquatic Vegetation Surveys	Virginia Institute of Marine Sciences	SAV, water quality		X	X

*Acronyms are listed within text the first time they are mentioned in each Chapter; all acronyms used in Maryland's State Wildlife Action Plan are defined in the Supplemental Document, 'Acronyms'

Monitoring Gaps and Improving Monitoring for Conservation

It is impractical and inefficient to have individual and separate monitoring actions for each of the 610 Species of Greatest Conservation Need (SGCN) and 59 key wildlife habitats. It is more practical to develop an effective monitoring framework or strategy that monitors the status and condition of select species and habitats, conservation action effectiveness, and, finally, the incorporation of new information and adaptive responsiveness of this Plan. This is one of the overarching conservation strategies identified in Chapter 7: "Develop programs and strategies to monitor key wildlife habitats and the effectiveness of conservation actions." Within the next few years, monitoring needs related to priority conservation actions (Chapter 7 and Appendices) will be reviewed, and alternatives for implementing monitoring and conservation actions will be developed to benefit the overall key wildlife habitat, community, and/or assemblage, including many of the other SGCN, in order to maximize limited resources and maintain practicality and efficiency.

To begin the process of review, priority conservation actions for monitoring can be matched with existing monitoring programs in Tables 8.1 and 8.2 to see if these programs are already meeting needs or can be modified to better meet SWAP priorities. Despite the many local and regional monitoring programs in Maryland, monitoring data may still be lacking because 1) programs do not exist, or 2) monitoring programs exist, but they are not part of a defined adaptive monitoring framework that addresses particular conservation priorities. In cases where not enough information exists to monitor a SGCN or key wildlife habitat, or monitoring protocols have not yet been developed, this need has been documented and followed by a research action or other conservation action to address that information need (Chapter 7). This is true for some taxa groups, such as small mammals and especially invertebrate groups, for which standardized protocols need to be developed and for taxa where baseline data do not exist to form the basis of a monitoring protocol. In these cases, high priority taxa research or data needs/gaps have been identified by taxa experts, planners, and stakeholders in Chapters 3 and 7. If monitoring programs do not currently exist for a SGCN or taxa group, viable options may exist to monitor closely-related species occupying the same habitats; monitor appropriate indicator species or other ecological indicators (Dale & Beyeler 2001; Carignan & Villard 2002); monitor threat reduction (Salafsky & Margoluis 1999); or use a multiple species-natural community approach (Barrows et al. 2005).

Monitoring of SGCN and their habitats should be targeted to guide future conservation efforts and conducted in a way to make data relevant to scientists and useful to land managers in an adaptive management framework as discussed earlier in this chapter. Continued coordination with regional development of monitoring programs, protocols, and data management is also critical to maximize the effectiveness and efficiency of monitoring activities for conservation. The use of permanent, centralized regional and national databases for species that range across broad geographic areas, such as Biotics for rare species or the AKN database for birds, is particularly needed for the exchange and integration of relevant biological data. An evaluation of monitoring for the revised Plan can also benefit from assessing monitoring data management capacity and needs, identifying bottlenecks to integrating monitoring data at a larger scale, and evaluating how well Maryland is meeting best management practices and standards for data management as outlined by Martin and Ballard (2010).

Monitoring Outcomes: Effectiveness Measures

Measuring the success of the Maryland SWAP is a challenging endeavor that requires assessing the results of individual conservation actions, as well as the overall impact of implementing the Plan. Using an adaptive management approach can provide a measure of effectiveness for a focused conservation action by clearly defining the desired outcome and how that outcome is to be measured. For complex conservation challenges and in the face of incomplete knowledge, however, other systems have been developed to address the need to demonstrate measurable impacts that can be attributed to the actions that were carried out. For example, implementing adaptation actions for climate change impacts can benefit from structured decision making and scenario planning in addition to the adaptive management process (Staudinger et al. 2015).

Maryland's assessment strategy (**Element 5**) involves a long-term commitment to the success of the SWAP. Populations that have been declining for decades may take decades to reverse and, therefore, many decades pass may before the results of conservation actions can be fully realized. Thus, an effective assessment strategy incorporates the concept that many conservation actions involve different temporal scales; both short-term conservation actions as well as long-term strategies are necessary to bring about the conservation of SGCN and key wildlife habitats. Furthermore, differing geographic scales need to be taken into account. To provide measures of effectiveness at these different scales for use in adaptive management, the Association of Fish and Wildlife Agencies (2012) recommends developing a "theory of change" linking actions to their ultimate desired impacts. This can be achieved through a five-step process:

1) Define the conservation action;
2) Describe, via a results chain, the theory of change as to how the action will lead to desired impacts;
3) Identify a limited set of effectiveness measures to assess progress at key points throughout the life of the project;
4) Develop and test effectiveness measures to ensure they provide meaningful information within existing human, legal, and financial constraints, and
5) Collect, analyze, and share data about the effectiveness measures to show whether or not the conservation action achieved the desired impact, why it succeeded or failed, and how implementation of the action can be improved over time under different conditions.

Using this system, if the activity provides the expected results, effectiveness measures help to communicate the success so that others may follow suit. Besides having more effective and efficient conservation actions, tracking the success of actions helps to ensure the most efficient use of limited staffing and funds.

To measure large-scale results and overall effectiveness measures, metrics developed for the region, including the regional approaches outlined later, will be used. Some examples of measurable outcomes related to long-term goals are listed in Table 8.3 by conservation action category (see Chapter 7 for more information about conservation actions in SWAP). In a

broad sense, performance measures generally relate to success in conserving land, amassing scientific knowledge, funding conservation priority projects, increasing involvement of the public and partners, and reducing threats to SGCN and their habitats.

Table 8.3 Examples of performance measures developed to assess effectiveness of conservation activities. Performance measures are listed by major conservation action categories used in SWAP Chapter 7.

Conservation Action Category	Examples of Performance Measures
Land and Water Acquisition and Protection	• Percentage of protected lands where management plans are being implemented • Percentage of land acquisitions that minimize habitat fragmentation • Number of acres of prioritized land purchased, leased, or put into easement that are BioNet priority tiers • Number of acres protected that are SGCN habitat • Number of agreements with private landowners
Law and Policy	• Number of enforcement actions related to laws and regulations that reduce illegal harvest of SGCN or destruction of habitat • Number of laws and policies enacted to address threats identified in the Plan • Measures of positive responses of SGCN and key wildlife habitats to improved law and policy changes, including reduction of key threats and impacts
Direct Management of Natural Resources	• Number of acres or river miles restored/converted to target habitat • Number of dams removed • Acres or stream miles of invasive species removal • Number of active volunteers trained in invasive species survey and removal • Number of management actions implemented as planned • Indication that the direct management action is reducing key threats • Number of acres burned; indication that target species (post-burn) has benefitted from action • Species response (e.g., population size, nest success) of SGCN to direct management actions • Key habitat targets/processes (e.g., size, condition) response to direct management actions • Number of bat boxes built and installed; number of bats using structures
Planning and Administration	• Number of acres protected for SGCN conservation • Number of key wildlife habitat management plans developed/implemented • Number of SGCN conservation plans developed/implemented • Number of grants administered/completed • Number of conservation plans using/implementing BioNet • Number of local government and municipal plans incorporating SGCN and habitat conservation

Data Collection and Analysis – Inventory, Monitoring, and Research	• Number of surveys/inventories focused on SGCN • Number of surveys/inventories focused on key wildlife habitats • Number of research projects focused on SGCN • Number of research projects focused on key wildlife habitats • Indication that researcher provides clear answers to research questions • Confirmation that data are used to develop and inform conservation action recommendations
Education, Outreach, and Technical Assistance	• Number of education, outreach, and technical assistance actions implemented • Indication that education, outreach, and technical assistance changes are achieving increased awareness, behavior change, participation, and other anticipated outcomes • Number of landowners signing up, or continuing their training for landowner assistance programs • Number of acres managed for SGCN in Wildlife Management Areas • Number of Master Naturalist participants
Actions to Address Climate Change	• Incorporation of adaptation strategies into local government and state land management plans • Acres protected for marsh migration corridors • Acres of island created • Acres of marsh protected from sea level rise • Number of conservation plans including actions to address climate change • Number of species with highest vulnerability scores addressed by MD DNR or partner conservation plans

For conservation actions related to more specific conservation targets, such as priority conservation actions for groups of SGCN and key wildlife habitats (Chapter 7), the five-step process described above, including 'results chains,' provides the framework that MD DNR can use to develop performance measures. "Results chains" (Foundations of Success 2007; Margoluis et al. 2013) are graphical diagrams that link actions to the desired impacts through a series of short-, medium-, and long-term results in an "if-then" fashion (Figure 8.3 – 8.4). Building a results chain starts with a specific conservation action, then links are added to related threats, species, and habitats. Indicators and effectiveness measures are selected for key steps in the results chain, providing both intermediate, shorter-term and ultimately, longer-term measures of success. Examples of results chains and more information on this framework for measuring success for Maryland's SWAP priority conservation actions can be found later in this chapter.

Using Regional Approaches to Monitor Effectiveness in Maryland

The Monitoring and Performance Reporting Framework

The NEAFWA (Northeast Association of Fish and Wildlife Agencies) Monitoring and Performance Reporting Framework (NEAFWA 2008) is intended to help each Northeast state meet the expectations set by Congress and the USFWS for the Wildlife Action Plans and the State Wildlife Grants (SWG) programs. The goal of this framework is to assess the status and trends of SGCN and their habitats across the Northeast states, and to evaluate the effectiveness of activities intended to conserve species and habitats across the Northeast.

The monitoring framework identified eight conservation targets (defined as species, landscape features, or vegetation communities important to fish and wildlife): forests, freshwater streams and river systems, freshwater wetlands, highly migratory species, lakes and ponds, managed grasslands and shrub lands, regionally significant SGCN, and unique habitats in the Northeast. For each target, key threats were identified, along with conservation actions that could help alleviate or eliminate the effects of that particular stressor. Indicators were proposed for tracking status and trends of each of the targets, and data sources were identified for each of the indicators (NEAFWA 2008). Table 8.3 from NEAFWA (2008) lists the indicators, including stressors, which were selected by workshop participants for each of the eight conservation targets (Terwilliger Consulting, Inc. & NEFWDTC 2015). Data sources for indicators appropriate to Maryland that can be used to monitor effectiveness of the SWAP were identified as part of a SWG project. In Table 8.3, indicators with existing and relatively complete Maryland-specific data are indicated in bold text. These data are the result of monitoring programs listed in Tables 8.1 and 8.2 above. Marine and estuarine systems were not included in the NEAFWA (2008) analysis. For estuarine systems, existing monitoring programs that address selected species, such as diamond-backed terrapin and sea ducks, could provide useful indicators. For marine systems, monitoring programs that are being carried out currently and that are being developed related to offshore wind projects provide data that could be used to monitor the status of target habitats and species.

Table 8.4 Conservation targets and proposed indicators for the Northeast. Bold text indicates that relatively complete data specific to Maryland are available. Source: NEAFWA 2008.

Targets	Proposed Indicators
Forests	**1a. Forest area - by forest type** **1b. Forest area - by reserve status** 2. Forest composition and structure - by seral stage **3. Forest fragmentation index** **4. Forest bird population trends** 5. Acid deposition index
Freshwater streams and river systems	**1. % impervious surface** **2. Distribution and population status of native Eastern brook trout** **3. Stream connectivity (length of open river) and number of blockages** **4. Index of biotic integrity** 5. Distribution and population status of non-indigenous aquatic species

Freshwater wetlands	**1. Size/area of freshwater wetlands** **2. % impervious surface flow** 3. Buffer area and condition (buffer index) 4a. Hydrology - upstream surface water retention 4b. Hydrology - high and low stream 5. Wetland bird population trends 6. Road density
Highly migratory species	1. Migratory raptor population index 2. Shorebird abundance **3. Bat population trends** 4. Abundance of diadromous fish (indicator still under development) 5. Presence of monarch butterfly
Lakes and ponds	**1. % impervious surface/landscape integrity** 2. % shoreline developed (shoreline integrity)
Managed grasslands and shrub lands	To be developed
Regionally Significant Species of Greatest Conservation Need	1. Population trends and reproductive productivity of federally listed species **2. State-listing status and conservation status ranks of highly imperiled wildlife** 3. Population trends of endemic species
Unique habitats	1. Proximity to human activity/roads 2. Wildlife presence/absence 3. Wildlife population trends **4. Land use/land cover changes**

State Wildlife Grants Effectiveness Measures Project

Building on the success of the Northeastern Regional Monitoring and Performance Measures Framework (NEAFWA 2008), the Association of Fish and Wildlife Agencies (AFWA) led an effort to develop an approach for measuring the effectiveness of wildlife conservation activities funded under the USFWS's SWG program. In September 2009, AFWA's Teaming with Wildlife Committee formed the Effectiveness Measures Working Group. This working group included representatives from state fish and wildlife agencies as well as private, academic, and non-governmental conservation partners with expertise in wildlife conservation and performance management.

In April 2011, the working group released a final report that outlines a comprehensive approach to measure the effectiveness of the activities funded under the SWG program, which was outlined above as a proposed approach to monitor effectiveness of the Maryland SWAP at different scales. The report builds on the monitoring framework that was originally developed in the Northeast states and recommends a set of common indicators for measuring status, trends, and/or effectiveness of thirteen general types of conservation actions that are commonly supported by SWG. These actions include direct management of natural resources, species restoration, creation of new habitat, acquisition/easement/lease, conservation area designation, environmental review, management planning, land use planning, training and technical assistance, data collection and analysis, education,

conservation incentives, and stakeholder involvement. The report includes sample templates and forms that could be used for reporting the results of conservation activities funded through SWG, as well as a discussion of the specific methods by which these reporting methods could be incorporated into in the USFWS's grants management database (Terwilliger Consulting, Inc. & NEFWDTC 2015).

Wildlife TRACS

The State Wildlife Grants Effectiveness Measures Project has informed the development of Wildlife TRACS, a database designed by the USFWS to record information about conservation activities funded through the Wildlife and Sport Fish Restoration Program, including SWG. When fully functional, Wildlife TRACS is intended to track and report project outputs, effectiveness measures, and species and habitat outcomes. Wildlife TRACS has the potential to track long-term outcomes for species and habitats in Maryland, above and beyond the types of short-term output measures commonly tracked by funding agencies (e.g., number of publications, number of workshops, number of people contacted). Because it is being designed to be responsive to the needs of the state agencies receiving SWG funding, Wildlife TRACS includes its own customized classifications of conservation actions and threats. These classifications are based, at least in part, on the classifications developed jointly by the International Union for the Conservation of Nature (IUCN) and the Conservation Measures Partnership. In general, the IUCN classification of threats is more useful in describing RCN grant projects than the Wildlife TRACS classification of threats. In contrast, the Wildlife TRACS classification of actions is more useful in describing RCN grant projects than the IUCN classification of threats (Terwilliger Consulting, Inc. & NEFWDTC 2015).

Northeast Lexicon for Common Planning and State Wildlife Action Plan Database

Wildlife conservation planners in the Northeast states have long recognized a potential ambiguity in many of the terms that are used to describe fish and wildlife conservation activities. For example, a "target" may refer to a number, an area, a specific site, a species, a group or guild of species, a vegetation community, or an ecosystem type. There is an acute need to develop a standard lexicon that provides conservationists with a uniform terminology that accurately and adequately describes the work of state fish and wildlife agencies. Although lexicons have been developed by the IUCN and the CMP, they are designed primarily for international conservation and sustainable development projects, activities that differ in many important ways from fish and wildlife conservation activities in the Northeast states. Thus, the NEFWDTC has developed a regional conservation lexicon that can be used by state wildlife agencies and partners to describe their conservation projects (Crisfield & NEFWDTC 2013). The lexicon project will result in a set of common terms that can be used by state wildlife agencies and their partners to describe wildlife conservation activities in the Northeast (Terwilliger Consulting, Inc. & NEFWDTC 2015). The use of a standardized terminology in Maryland will make it possible to combine information across state lines to measure effectiveness of conservation actions that address wide-ranging species or large-scale threats.

Measuring Effectiveness by Linking Conservation Actions to Impacts

Although measuring the effectiveness of a conservation action requires more than counting short-term outputs, it is not possible to rely solely on measures of the ultimate impacts – the status of the species and habitats of interest—to measure effectiveness. This is because as confidence in the measures increases, the cost of measurement and the time required to detect change also increases (Figure 8.2). To solve this problem, the best effectiveness measures require defining a *theory of change* or *results chain* that links actions through outcomes to the ultimate impact. The basic components of a results chain are strategies connected to outcomes (objectives) connected to the goal or impact on the target (Conservation Measures Partnership 2013).

Data are collected at key steps to assess outcomes from intermediate actions and to determine if elements in the chain need to be revised. The use of results chains contributes to adaptive management and effective conservation by making assumptions explicit, facilitating the development of targeted monitoring plans, and developing action plans that efficiently address conservation priorities (Margoluis et al. 2013).

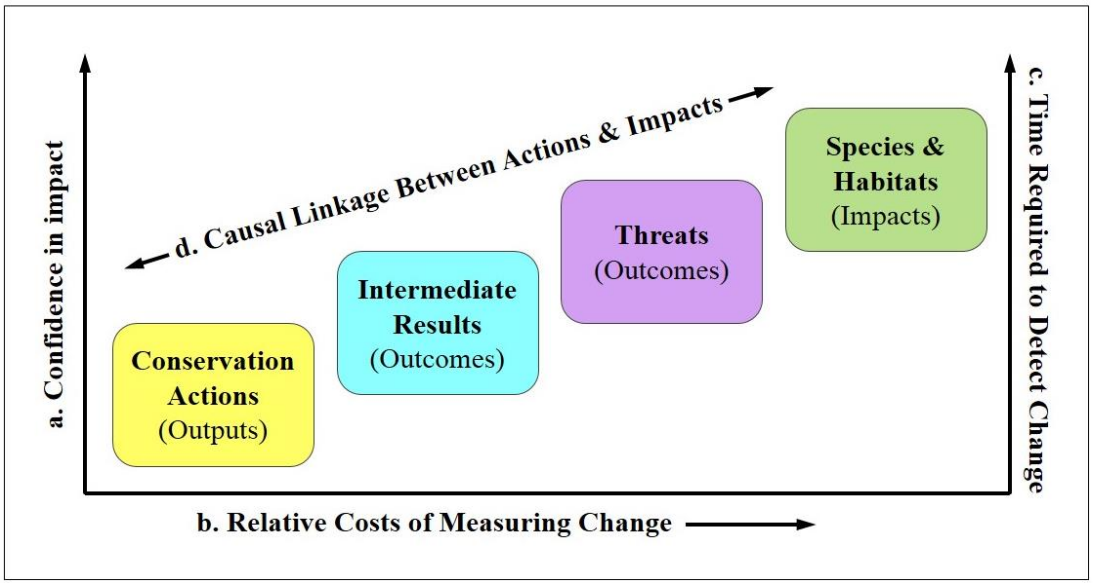

Figure 8.2 Constraints on measuring performance considering linkages between outputs, outcomes, and impacts. Source: Adapted from Association of Fish & Wildlife Agencies 2012.

Using this framework, effectiveness or performance measures can be identified for priority conservation actions identified in Chapter 7. Tools such as Miradi software and the Open Standards for the Practice of Conservation (Conservation Measures Partnership 2009, 2013) are available to assist with developing and using results chains. Following is an example of a result chain from a SWG-funded project to develop an adaptive management plan for the conservation of eastern tiger salamander, a SGCN that is listed as Endangered in Maryland. The goal of the strategy was to maintain both the rare Carolina (Delmarva) Bay wetland and seasonally flooded forest, and a viable eastern tiger salamander population. After selecting specific targets and assessing threats, MD DNR and partners developed a conceptual model, or overview of how the system and population works, including variables that describe the

system and the effects of threats or stressors on the system and population. This model identified strategies, contributing factors, and direct threats related to the population and habitat goals (Figure 8.3). The construction of the conceptual model is often the most difficult part of the exercise. This model is needed, however, to clearly demonstrate the assumptions about connections between conservation targets, threats, and conservation strategies. The process of constructing these models can also identify priority research needs.

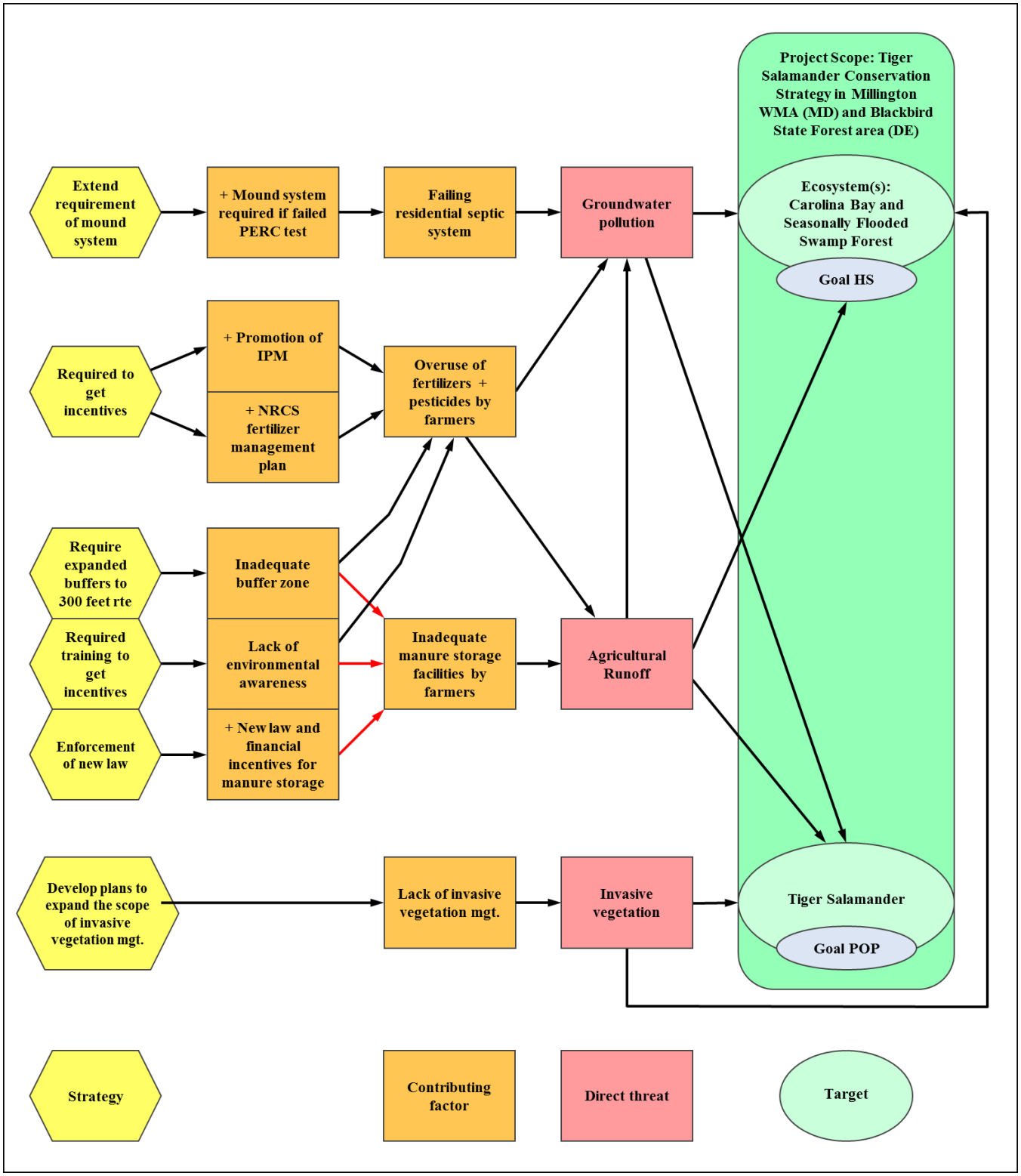

Figure 8.3 Simplified conceptual model showing the strategies developed for eastern tiger salamander.
Source: Adapted from Rasolofoson et al. 2010.

Specific goals were developed for the general targets that were impact-oriented, measurable, time-limited, and specific (Rasolofoson et al. 2010). For example, a 15-year goal for an increase in the number of tiger salamander egg masses and increase in the number of breeding ponds was set. Next, results chains were developed for two of the strategies that were most likely to be effective in addressing critical threats or restoring targets: "require expanded buffers to 300 feet" and "develop plans to expand the scope of invasive vegetation management" (Figures 8.4 and 8.5). Monitoring strategies were developed by answering "what, how, when, who, and where" questions related to the specific goals and activities in the results chains. For example, the number of tiger salamander egg masses would be counted on a biennial basis during the breeding season by MD DNR and partners at known, historical, and managed sites related to the tiger salamander population conservation target in Figure 8.4.

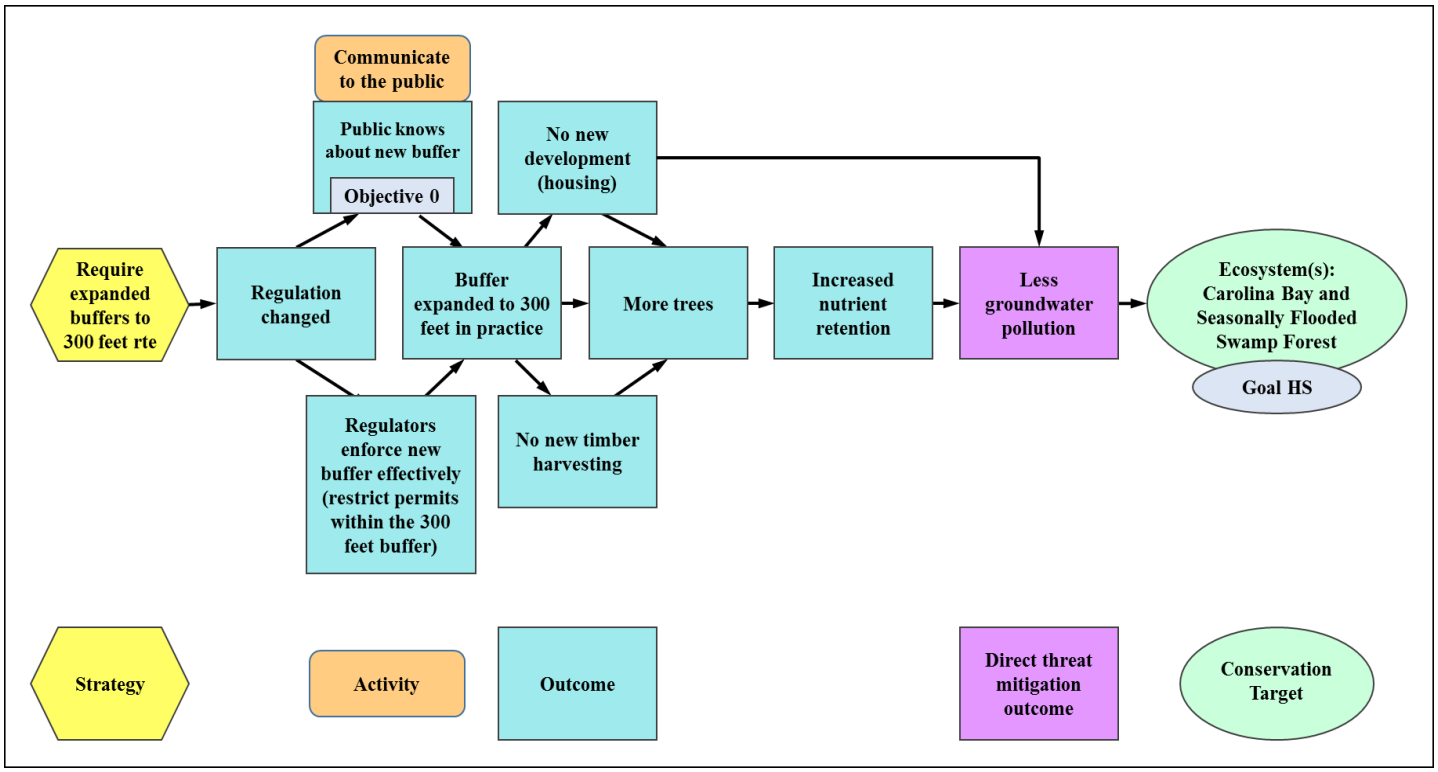

Figure 8.4 Results chain for the strategy "Require expanded buffers to 300 feet." Source: Adapted from Rasolofoson et al. 2010.

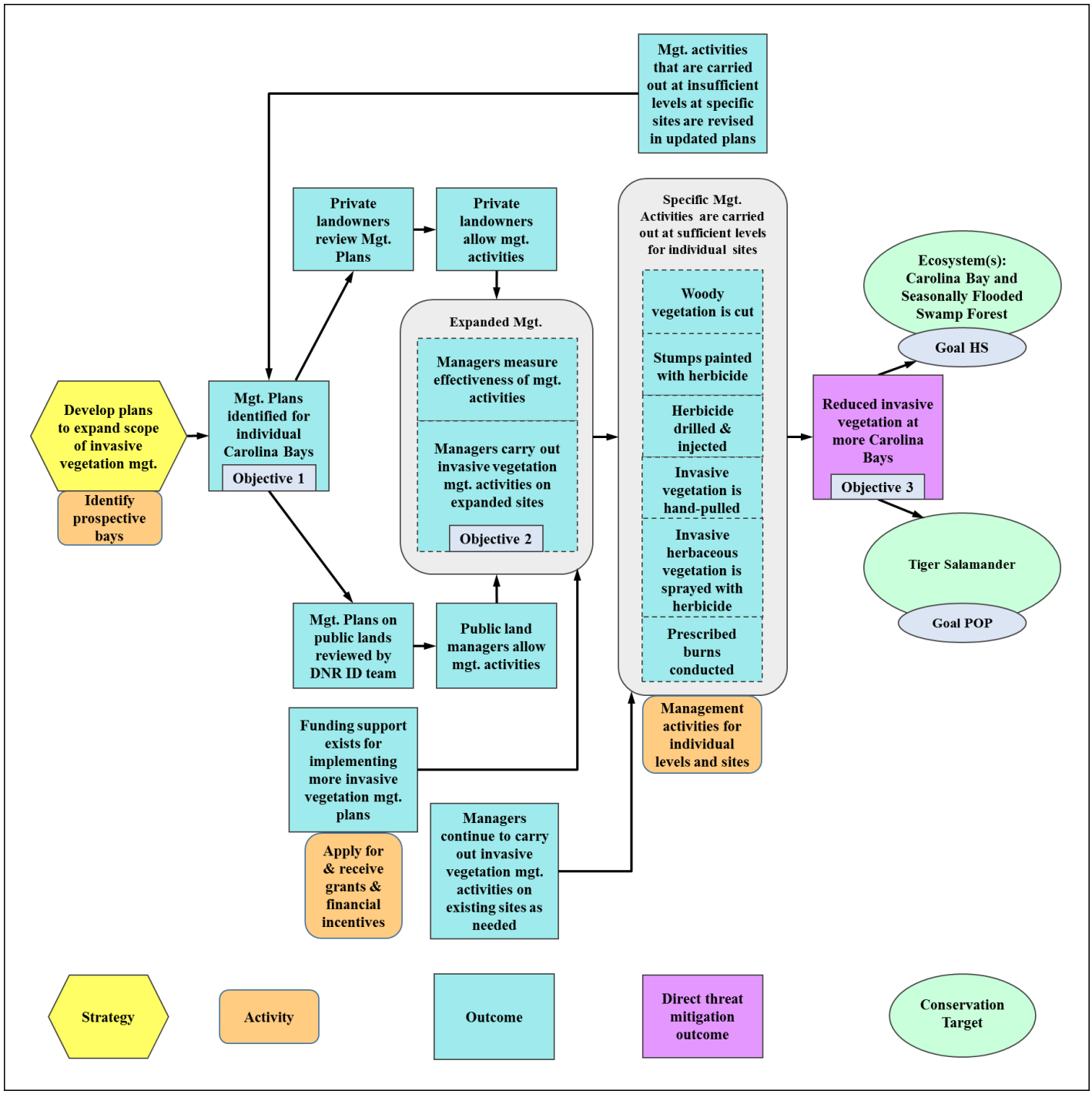

Figure 8.5 Results chain for the strategy "Develop plans to expand the scope of invasive vegetation management." Adapted from Rasolofoson et al. 2010.

Given the knowledge and effort needed to build conceptual models and results chains, it is most efficient to group priority conservation actions by the threats, species groups, or habitats that they have in common and to create results chains for broader conservation targets and threats. This makes it possible for priority actions identified in Chapter 7 to be

addressed in a way that provides maximum benefit to multiple species and habitats, and to develop strategies that address multiple threats.

This chapter provides information pertinent to **Element #5** regarding the establishment of a monitoring framework. An overview of some of the more extensive monitoring programs currently in place within Maryland is presented and specific objectives and timelines for expanding MD DNR's capacity to measure and track outcomes are listed. Chapter 9 will cover information relating to **Element #7:** describing outreach and coordination efforts with partners and the public in developing the Plan as a collaborative state-wide guidance document. Implementation strategies for Maryland's SWAP are also discussed in Chapter 9.

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