



Chapter 10

Plan Review and Revision





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Introduction

Under U.S. Fish and Wildlife Service (USFWS) guidance, State Wildlife Action Plans (SWAPs) undergo a maximum ten-year revision cycle. Most SWAPs across the country were first published in 2005, were revised in 2015, and will be updated again in or before 2025. This cycle of revision allows the Maryland SWAP to be a living document that, through continuous information updates and periodic revisions, will guide Maryland's conservation planning for years to come.

As scientific knowledge and understanding of Maryland's species and their habitats continues to grow, information gathered during the implementation of the SWAP provides important updates to the body of scientific information maintained by Maryland Department of Natural Resources (MD DNR). In particular, the studies funded by State Wildlife Grants (described later in this chapter), other grants to MD DNR, and the activities of partners, including universities, form the basis of new scientific information to be incorporated into future revisions of the SWAP. MD DNR understands that conserving and protecting the state's wildlife requires a long-term commitment. During the plan's implementation, MD DNR will review, evaluate, and update progress on conservation actions, research, inventories, surveys, and monitoring on a periodic basis. As data gaps are filled, it is likely that new ones will be identified. In order to facilitate tracking of existing projects, identify data gaps, and coordinate with regional conservation efforts, a standardized database developed for the Northeast states will be populated with information from the SWAP.

The Wildlife and Heritage Service (WHS), specifically WHS's Natural Heritage Program (NHP), is the entity responsible for coordinating Maryland's SWAP (Plan) review and revision processes. This program is responsible for the conservation of nongame and endangered species, as well as significant natural communities, and it maintains a statewide database for rare species and natural communities. NHP will work to update the Plan as needed, especially in response to information that could affect management decisions. New information may be appended to the SWAP during the implementation phase in cases of major changes in the status or condition of SGCN or key wildlife habitats, or for new and rapidly emerging threats. For example, a new invasive species may become established in Maryland and the list of threats, actions, and SGCN may need to be revised to deal effectively with the new problem. However, most new information will be included during the next major SWAP revision in 2025.

In addition to the ongoing input into state and regional databases, geographic information system (GIS) datasets, and the evaluative reviews described above for adaptive assessment of conservation progress, MD DNR will work with its partners, including members of the scientific and conservation communities, and the Maryland Wildlife Diversity Advisory Committee, which supports and guides NHP, to continually assess the state of Maryland's Species of Greatest Conservation Need (SGCN) and their habitats. This assessment will include factors such as changes in threats and landscape-scale or significant local issues that need to be addressed. MD DNR may also recommend modifications to the overarching conservation actions or any specific actions provided in Chapter 7 based on any of these new and emerging significant threats. As part of this general review process and at other times when revision of Maryland SWAP may be necessary, MD DNR will seek broader input and comment from other agencies, organizations, experts, and the public.



As a statewide guidance document, SWAP offers an important opportunity to engage with MD DNR's partners in conservation. An important outcome of this plan will be the integration of SGCN, key wildlife habitats, and priority conservation strategies into MD DNR's plans and those of its many partners' plans and programs as they are being created or revised. This integration effort alone produces a ripple effect for conservation efforts across the state, providing a consistent and unified approach for conservation of Maryland's wildlife and habitats. Incorporation of SGCN and key wildlife habitats across many MD DNR programs and plans provides a focus for conservation targets for land acquisition and other conservation efforts. Integration of these SGCN and key wildlife habitats into the plans and programs of local, state, and federal partner agencies facilitates implementation of these actions by both private and public partners. In accordance with the importance of these partnerships, SWAP revisions will include updates on conservation partners' published wildlife conservation actions and plans, ultimately providing a broad examination of statewide efforts involving Maryland's SGCN and key wildlife habitats.

Maryland SWAP Review Schedule

Maryland DNR will coordinate and complete a comprehensive revision of this SWAP by October 2025 (Element 6). To adequately prepare for this ten-year revision, periodic scientific reviews involving partners will be performed to allow for re-evaluation of the status of SGCN, their habitats, and threats, as well as the effectiveness of the actions to date. The results of these scientific updates will be incorporated into future reviews and revisions of the SWAP. Committing to such significant coordination efforts indicates that Maryland DNR will continue to involve its many conservation partners and interested stakeholders in the SWAP process. The results of performance measures and monitoring described in Chapter 8 will also contribute to Plan revision. These processes will maintain the SWAP's status as a living, dynamic document and ensure that each revision includes the most current scientific and administrative information.

Between revisions, MD DNR and USFWS frameworks will guide the implementation process, maximizing opportunities for both internal and external implementation. For example, the existing USFWS process requires annual reporting and review with five-year Application for Federal Assistance work plans and evaluations for some funding streams. The WHS and most other MD DNR agency programs have annual reporting requirements from their federal grants or other funding sources. Annual or project-end results that indicate any changes or new information, including information from periodic review by technical experts, will be assessed for use in an adaptive management process and eventual plan revision.

In summary, the Maryland SWAP evaluation, review, and revision schedule will include the following benchmarks:

- Annual reporting for State Wildlife Grant (SWG) funding and other Federal Aid grant requirements
- Regular analysis and incorporation of tabular and spatial data into appropriate MD DNR and partner databases and GIS systems
- Regular incorporation and updates of priority Maryland SWAP Conservation Actions into MD DNR and partner plans
- Regular review of results of monitoring and performance measures



- Regular / ongoing status review of SGCN
- Every 10 years: complete revision, incorporating all interim updates and reviews.

Maryland SWAP and the State Wildlife Grant Program

With the completion of annual progress reports to the U.S. Fish and Wildlife Service (USFWS) Federal Aid Office, an iterative, adaptive process will include the incorporation of the results of research, monitoring, and survey efforts that provide for refinement of the priorities and actions of this plan. The revision of Maryland’s State Wildlife Action Plan (SWAP) is a condition for the continuation of USFWS State Wildlife Grant (SWG) funding. State Wildlife Grants were first appropriated in 2002 in the Department of the Interior’s appropriations budget. Until SWG funding was implemented, Maryland Department of Natural Resources (MD DNR) had lacked the means to plan and prioritize comprehensively for all wildlife, due to limited funding and inadequate programming. SWG funding and programming allows for the continuation and improvement of the protection and management of Species of Greatest Conservation Need (SGCN) and their habitats. The results of SWG-funded projects over the past 10 years largely provided the basis for revisions to the 2005 SWAP.

State Wildlife Grant Projects

The remainder of this chapter consists of an overview of Maryland’s SWG projects that were carried out in the period 2005-2015; that is, the period between the first SWAP publication and the first SWAP revision. Each project reviewed below includes a brief description and dates of project implementation and completion (unless still ongoing). This overview provides a glimpse of Maryland’s wildlife diversity and the effort and funding that are required to perform research, inventory, and monitoring activities, as well as planning for conservation, to restore these wildlife species and their habitats.

The MD DNR SWG projects are first listed in Table 10.1 and then summarized in more detail for the remainder of the Chapter. The projects are organized into five action type categories: 1) conservation planning, 2) technical assistance, 3) inventory, monitoring, and research, 4) database development and maintenance, and 5) restoration and protection. Certain SWG projects may apply to multiple categories; WHS staff chose the category they saw most appropriate to the specific project. For example, the SWG project, ‘Bog turtle assistance and monitoring’, is placed under the Technical Assistance category, but it could also be considered under the Inventory, Monitoring, and Research category due to the project’s dual purpose. Scientific names for SGCN in Table 10.1 and project descriptions are included in Appendices 1a and 1b. Scientific names for other species are included in the text of the chapter.



Table 10.1 SWG projects carried out during the 2005-2015 SWAP implementation period.

<u>Conservation Planning</u>
<ul style="list-style-type: none"> ▪ Develop a performance measures framework for conservation activities ▪ Identify Maryland’s “Biodiversity Conservation Network” (BioNet) ▪ Important Bird Areas Project ▪ Develop statewide management plan for the endangered eastern tiger salamander ▪ Develop statewide conservation strategies for priority reptile and amphibian (herpetofauna) conservation issues ▪ Assess rare freshwater fish conservation needs ▪ Management and conservation of the blackbanded sunfish on the Delmarva Peninsula ▪ Develop recovery strategies for state endangered species ▪ Develop conservation strategies for BioNet Tier 1 and 2 sites ▪ Vulnerability assessment of Maryland rare, Threatened, Endangered, and Greatest Conservation Need species and habitats to climate change
<u>Technical Assistance</u>
<ul style="list-style-type: none"> ▪ Bog turtle technical assistance and monitoring ▪ Environmental review ▪ Develop best management practices for rare species and habitats ▪ Appalachian region bird conservation cooperative ▪ Develop State Natural Areas Program ▪ Provide technical assistance for land use planning and management ▪ Natural Areas Inventory
<u>Inventory, Monitoring, and Research</u>
<u>Mammals</u>
<ul style="list-style-type: none"> ▪ Comprehensive rare bat surveys in western Maryland ▪ Status assessment of Maryland's boreal small mammals ▪ Identify Indiana bat maternity colonies
<u>Birds</u>
<ul style="list-style-type: none"> ▪ Statewide breeding distribution of rails and other marshbirds ▪ Breeding status of black rail ▪ Statewide breeding bird status assessment ▪ Avian salt marsh habitat study ▪ Co-coordinate the second Breeding Bird Atlas project ▪ Identify critical stopover habitat for songbirds ▪ Evaluate use of CREP buffers by birds
<u>Reptiles & Amphibians</u>
<ul style="list-style-type: none"> ▪ Investigate experimental reintroduction of northern pinesnake on the Eastern Shore ▪ Genetic variation and road mortality of central Maryland box turtles ▪ Assess population structure and condition of wood turtles ▪ Inventory of rare reptiles and amphibians ▪ Distribution, abundance, and habitat associations of eastern narrow-mouthed toad ▪ Factors affecting anuran community structure within Delmarva Bays ▪ Common map turtle distribution and habitat use in the lower Susquehanna River ▪ Diamond-backed terrapin population assessment and monitoring ▪ Update the status of the green salamander ▪ Coordinate the Maryland Amphibian and Reptile Atlas (MARA) project ▪ Evaluation of diamond-backed terrapin head-starting at Poplar Island ▪ Assess hellbender population status



<u>Invertebrates</u>
<ul style="list-style-type: none"> ▪ Statewide status assessment of Maryland's dragonflies and damselflies ▪ Survey of groundwater invertebrates ▪ Status and distribution of Maryland's moth fauna ▪ Status review of Maryland's rare, Threatened and Endangered butterflies ▪ Patterns of invertebrate species richness on inland sand dunes on the Delmarva ▪ Scientific descriptions of new species of globally rare subterranean invertebrates
<u>Multiple Taxa Groups</u>
<ul style="list-style-type: none"> ▪ Morbidity/mortality investigations for wildlife species of special concern ▪ Bird and bat migration over Appalachian ridges in the Mid-Atlantic Region ▪ Biodiversity assessment on Public Lands ▪ Biodiversity conservation assessment for SGCN ▪ Monitor SGCN and key wildlife habitats in central Maryland ▪ Review and update of the state's Rare, Threatened and Endangered Animal Species List ▪ Develop monitoring plans for the conservation of rare species and communities
<u>Aquatic species</u>
<ul style="list-style-type: none"> ▪ Survey of priority aquatic SGCN by Maryland Biological Stream Survey ▪ Species-level inventory of Maryland's freshwater benthic macroinvertebrates ▪ Collect crayfish and mussel data as part of the statewide Maryland Biological Stream Survey ▪ Population status of freshwater mussels ▪ Sentinel site sampling by the Maryland Biological Stream Survey ▪ Unionid mussel propagation and reintroduction ▪ Protection guidelines and baseline monitoring for the state's highest priority watersheds ▪ Estimating space requirements and extinction risk for Maryland brook trout ▪ Re-inventory of targeted brook trout populations in western Maryland ▪ Development of a captive broodstock program for Atlantic sturgeon restoration
<u>Key Wildlife Habitats</u>
<ul style="list-style-type: none"> ▪ Natural community classification ▪ Assess wildlife value of old growth forest ▪ Monitor rare plant communities and associated key wildlife habitats in Southern Maryland ▪ Community-level inventory of Upper Coastal Plain seepage and headwater wetlands ▪ Classification and assessment of bog and fen wetland complexes
<u>Database Development and Maintenance</u>
<ul style="list-style-type: none"> ▪ Natural Heritage Program database management ▪ Develop new GIS data products and update GIS applications
<u>Restoration and Protection</u>
<ul style="list-style-type: none"> ▪ Repair and maintain bat gates ▪ Restore habitat for amphibians in Carolina Bays ▪ Hellbender habitat, monitoring, and propagation ▪ Eastern tiger salamander habitat management on the Eastern Shore ▪ Restore endangered beetle habitat at Sharptown Dunes ▪ Restore and manage habitat for the globally critically imperiled Eastern sedge barrens leafhopper ▪ Shale barrens habitat restoration ▪ Restoration of BioNet Tier 1 Sites



Conservation Planning

Develop a performance measures framework for conservation activities (2010-2011)

Upon approval of the 2005 SWAP, Maryland DNR's Wildlife and Heritage Service (WHS) worked to develop a system to track progress of implementation of SWAP actions. NHP planned to use the information gleaned from the resultant framework for prioritizing NHP and other MD DNR activities, focusing conservation actions, and recruiting partners for SWAP implementation. However, this project was superseded by efforts to develop a region-wide system.

Identify Maryland's "Biodiversity Conservation Network" (BioNet) (2007-2012)

Through this project, WHS developed a Geographic Information System (GIS) data system that identifies and prioritizes the lands and waters necessary to conserve the full complement of Maryland's native terrestrial and freshwater plants and animals. More information about the development and conclusions of this project can be found in Chapter 7.

Important Bird Areas Project (2005-2010)

The Important Bird Areas (IBA) network in Maryland includes 43 sites that are monitored and targeted for conservation on the basis that they provide habitat for at-risk nesting, migrating, and over-wintering birds, for bird assemblages, and for birds that utilize concentration areas. This program began in Maryland in 2005 with a SWG grant that brought together MD DNR and the Maryland/Washington, DC office of the National Audubon Society (Audubon MD-DC). The grant funded identification of IBA sites, development of conservation information for each site, and outreach to area organizations. Since 2006, Audubon has led annual citizen science "bird blitz" surveys to provide information for the identification of IBAs in the state of Maryland. Audubon MD-DC also assisted counties on the Eastern Shore to incorporate IBAs into county planning processes, especially for those portions detailing sensitive areas in the counties.

Develop statewide management plan for the endangered eastern tiger salamander (2008-2012)

The eastern tiger salamander, once present across both Coastal Plain Provinces in Maryland, is state-listed as Endangered, and breeding populations are found only in Caroline and Kent counties on the Eastern Shore. Through this SWG project, WHS developed a statewide management plan for the eastern tiger salamander, a large salamander that spends much of its life underground and requires vernal pools to breed. Priorities for eastern tiger salamander conservation include habitat protection and restoration, a better assessment of the geographical distribution of the population, and a better understanding of population trends and demographics. From 2008 to 2012, MD DNR and partners, including Towson University, University of Delaware, and Delaware Nature Society, performed multiple surveys to determine salamander range, population dynamics, and breeding based on egg mass, larval, adult surveys in historical eastern tiger salamander habitats. NHP completed an adaptive management plan in 2010 with the assistance



Eastern tiger salamander
(Jim White, MD DNR)



of University of Maryland College Park graduate students (Rasolofoson et al. 2010) and, in 2011, the working group completed a GIS metapopulation mapping project.

Develop statewide conservation strategies for priority reptile and amphibian (herpetofauna) conservation issues (2008-2013)

This project addressed main concerns and actions brought up during a 2008 Maryland Herpetofauna Stakeholders Meeting. Working groups formed to focus on these various priorities. The Herpetofauna Atlas Working Group began a pilot atlas program that was eventually completed as a different SWG (“Coordinate the Maryland Amphibian and Reptile Atlas (MARA) project”; see page 15). The Habitat Preservation Working Group assessed greatest risks to herpetofaunal habitat and compiled a list of “Important Herpetofauna Areas” across the state. The Herpetofauna Education Working Group focused on raising public awareness of reptile and amphibian conservation issues by assessing current public exposure and creating products such as a brochure about turtle excluder devices that are legally required in Maryland on all recreational crab pots. The longest active working group, the Diamond-backed Terrapin Working Group, formed to educate WHS, which assumed management responsibility for terrapins from MD DNR Fisheries in 2007, regarding conservation issues and recent research findings for terrapins in Maryland. This SWG project, which culminated in 2013, was important as MD DNR continued to be an active participant in local and regional herpetofaunal partnerships, creating a knowledgeable base to address emerging concerns such as the *Ranavirus* threat. Activities for reptile and amphibian conservation, including the Terrapin Working Group, continue under other SWG projects. Partners from federal, state, and local governments; non-profit organizations; universities; and interested citizens assisted with these projects.

Assess rare freshwater fish conservation needs (2006)

Using existing data from the Maryland Biological Stream Survey (MBSS), this 2006 study looked into the conservation status and management needs of rare freshwater fish in Maryland’s streams. Of 84 watersheds surveyed, 25 watersheds were determined to be strongholds for at least one state-listed fish species, providing a crucial habitat to a rare species. Additionally, every watershed contained at least one aquatic species designated as an SGCN. MBSS ranked threats to freshwater biodiversity by watershed, and linked conservation actions to those threats to ultimately provide managers with possible conservation actions.

Management and conservation of the blackbanded sunfish on the Delmarva Peninsula (2008-current)

Beginning in 2008, MD DNR’s Resource Assessment Service sampled historical and potential locations of blackbanded sunfish in Maryland and Delaware and are now implementing an interstate conservation strategy through this ongoing SWG project. This conservation strategy was developed by a workgroup comprised of biologists from MD DNR’s Resource Assessment Service, MD DNR Fisheries Service, MD DNR Forest Service staff, Delaware Department of Natural Resources and Environmental Control, and Frostburg State University. Implementation of many of the actions recommended by this plan are already well under way or completed, with detailed surveys of blackbanded sunfish populations being completed in both historical locations and potential habitats across the Delmarva Peninsula. Beginning in 2015, MD DNR biologists captured individual sunfish to use as brood stock for a pilot captive propagation project.



Develop recovery strategies for species state-listed as Endangered (2011-2012)

In 2011, WHS staff began the lengthy process of developing recovery strategies for species listed as Endangered in the state. The project team worked to compile information on threats, recommended actions, and inventory, monitoring, and research needs for the target species. WHS staff reviewed information from the recently completed BioNet project to determine which species are found in tier 1 and tier 2 priority sites. Initial species targeted for recovery strategy development included Endangered mussels, amphibians, some invertebrates, and three bird species present at the BioNet Tier 1 and 2 sites.

Develop conservation strategies for BioNet Tier 1 and 2 sites (2011-2012)

One of the key actions in the SWAP is the identification of the most important sites throughout Maryland for wildlife diversity conservation. In 2010, MD DNR released the first version of the Biodiversity Conservation Network (BioNet) map and data (see Chapter 7 for more information about the development of BioNet). Using these data, WHS staff started developing conservation strategies for the highest priority areas. This project helped to ensure WHS staff focused attention consistently throughout all regions of the state, and provided conservation partners with additional information to aid in the conservation of important wildlife habitats. Some strategies that arose from this project were carried out under later SWG projects.

Vulnerability assessment of Maryland rare, Threatened, Endangered, and Greatest Conservation Need species and habitats to climate change (2009-2012)

One of the most difficult issues in writing the 2015 SWAP was working with the expansive amount of research presented in the last decade about the causes and effects of climate change. This SWG project supported regional networking opportunities for states and organizations to share information about climate change in the region and how individual states were integrating climate change topics into their own SWAPs. Using NatureServe’s Climate Change Vulnerability Index tool, WHS staff completed vulnerability assessments for 476 SGCN. In addition, the vulnerability to climate change of 47 non-coastal habitats (ecological community groups) was assessed using a habitat vulnerability model available from Manomet.



Delmarva fox squirrel, a species of concern in Maryland (J.H. Soares)

Technical Assistance

Bog turtle technical assistance and monitoring (2007-current)

Since 2007, MD DNR has collaborated with USFWS and Environmental Defense to protect and restore bog turtle habitat in Maryland. The bog turtle is federally and state-listed in Maryland as Threatened and the turtle’s recent struggles are generally attributed to changing agricultural practices that have decreased grazing and harmed wetland areas. MD DNR and partners (USFWS, Natural Resources Conservation Service, and State Highway Administration) have conducted vegetation management projects at over 30 sites since 1997, and the NHP has played an important role in providing technical assistance to these and other partners on issues associated with bog turtle conservation. This SWG project has been used for research and



monitoring projects at various sites, as well as funding technical assistance to public and private landowners for conservation of bog turtle habitat (Byer et al., in review).

Environmental review (2004-current)

Through this SWG project, Wildlife and Heritage Service (WHS) handles the important task of performing environmental reviews for all projects authorized, funded, or carried out by other Maryland state agencies so that they do not jeopardize the health and habitats of species listed as Endangered, Threatened, or In Need of Conservation in Maryland. Other organizations such as county planning agencies and private consulting firms also make use of this free-of-charge environmental review system to check for potential impacts to rare, Threatened, and Endangered species. WHS reviews thousands of projects each year to identify potential impacts to known locations of listed species and their habitats, and, upon finding threats to specific animals and plants, works with the agency to avoid or minimize disturbance. Important habitats often reviewed by this service include colonial waterbird nesting sites, Forest Interior Dwelling Species, and unique and sensitive natural communities harboring SGCN such as bogs, shale barrens, and vernal pools.

Develop best management practices for rare species and habitats (2008-2012)

WHS recognized a need for a publically available resource detailing best management practices (BMPs) for rare habitats, which harbor SGCN. During this project, WHS worked in collaboration with regional efforts to produce specific BMPs for three habitats and species groups for use by Maryland landowners, developers, industries, county environmental planners, conservation groups, and other stakeholders. These products will help address the overarching statewide conservation action included in the 2015 SWAP to “work with private landowners and public land managers to assist with appropriate management for key wildlife habitats and SGCN.” WHS compiled BMPs for forest nesting birds in forest key wildlife habitats and also for cave, mine, and spring, and cliff and rock outcrop key wildlife habitats.

Appalachian region bird conservation cooperative (2005-2007)

The mission of the Appalachian Bird Conservation Initiative is to conserve strong, healthy habitat in the Appalachian Mountains to maintain and improve Appalachian bird populations. This group cooperative is a partnership of private, state, federal, tribal, and non-government land owners and managers. Support for this project was no longer needed when the effort was funded by USFWS as the Appalachian Mountains Joint Venture.

Develop State Natural Areas Program (2008-2011)

Maryland’s landscape encompasses a diverse range of geographic features, including, but certainly not limited to, mountains, cliffs, wetlands, and rare serpentine barrens. In 2008, MD DNR used a SWG grant to explore a new idea with significance for wildlife conservation – the creation of a guide to highlight the “best of the best” of Maryland’s natural places and habitats, with a focus on Maryland’s diverse plant and animal species. The Natural Areas Guide process began with the steering committee carefully defining a “natural area” as well as a series of criteria used to decide which sites would be included in the guide. The steering committee, including members from MD DNR Forest Service, Park Service, Resource Assessment Service, WHS, and Maryland Geological Survey, identified Natural Areas in all parts of the state and laid out a process to assess future nominations for Natural Areas.



Provide technical assistance for land use planning and management (2006-current)

Towards the overall objective of ensuring that Maryland's SGCN and their associated key wildlife habitats receive appropriate levels of protection and management consideration, WHS staff provide technical guidance to local and state government agencies. Technical assistance provided to planning authorities includes biological information pertaining to the conservation of Maryland's SGCN, GIS data layers, and the geographic depiction of all known Ecologically Significant Areas.

Natural Areas Inventory (2013-current)

NHP is currently compiling resources to create a published inventory of a subset of Maryland's Natural Areas, which will eventually be made available to county governments, MD DNR's partners in conservation, and the general public. Using information collected through previous SWG-funded projects and accessible through the BioNet GIS project, MD DNR is assembling narrative descriptions of the most highly ranked natural areas, the threats to these areas, and management and conservation needs that must be addressed to conserve wildlife and their habitats in natural areas. The Natural Areas Inventory will be an important tool representing an extension of conservation science and planning. Based in data collected by MD DNR and its partners, the Inventory will be an accessible source of information for citizen conservationists in Maryland.

Inventory, Monitoring, and Research

Mammals

Comprehensive rare bat surveys in western Maryland (2006)

Bat surveys in western Maryland assessed rare bat populations in natural areas such as wetlands, bodies of water, to supplement caves and human-made bat roosting areas like mines and tunnels. During the summer of 2006, traps were set to determine the locations of potential summer roosts and maternity colony sites and to document species' presence (Haskew & Gates 2008). The results of the survey are an important gauge on where bats roost and gather in maternity colonies, and where rare bats are most likely to occur, especially in relation to human-made infrastructure. This work was carried out through a contract with University of Maryland Center for Environmental Science Appalachian Lab.

Status assessment of Maryland's boreal small mammals (2006)

With the publication of the 2005 SWAP came a renewed effort to determine the status, distribution, and abundance of SGCN in Maryland. A study conducted in 2005-2006 surveyed potential habitats of boreal small mammals in Garrett and Allegany counties, focusing on the rock vole and water shrew, which are Endangered species in Maryland. The survey found the southern water shrew in four locations, allowing MD DNR to focus conservation efforts around management zone and site interconnectivity strategies. The absence of the rock vole in this study highlights the need for conservation in the vole's known habitat areas.



Identify Indiana myotis maternity colonies (2007)

Maryland DNR partnered with the University of Maryland Center for Environmental Science Appalachian Lab to conduct important research related to the Indiana myotis, an SGCN that is listed as Endangered at both state and federal levels. These efforts identified Indiana myotis maternity roosts and foraging areas and worked to develop a color banding protocol for identification of the species from a distance across the northeastern region (Johnson & Gates 2007). Researchers collaborated with other range-wide projects involving DNA population analyses that collected additional information on roost and landscape characteristics of Indiana bat summer habitat.

Birds

Statewide breeding distribution of rails and other marshbirds (2005-2006)

MD DNR and conservation partners conduct regular surveys to determine the statewide distribution of breeding marshbirds, a group that includes rails, the pied-billed grebe, the American bittern, and the least bittern. Through this SWG project, WHS collected data and submitted information to the second Breeding Bird Atlas database to supplement observations for this group of species. Researchers were interested to find a significant change in black rail populations – the last survey from 1990-1992 found black rails to be one of the most common marshbird species, but the new survey did not observe any black rails. This finding led to a follow-up SWG-funded project.

Breeding status of black rail (2007)

This intensive black rail survey carried out in 2007 focused on the lower Eastern Shore, including areas that are considered regional and global population strongholds. WHS researchers detected black rails at only 16.5% of the locations where this SGCN was found in a previous (1990-1992) study.

Statewide breeding bird status assessment (2007-2008)

Following the completion of the second Maryland/Washington, DC Breeding Bird Atlas (BBA) in 2008, MD DNR partnered with the USGS Patuxent Wildlife Research Center to review the conservation statuses of Maryland’s breeding bird species. Based on records from the coordination of the BBA and other data sources such as the Biotics database, USGS’s Breeding Bird Survey, and published literature, this assessment identified 53 of the state’s 215 breeding bird species for potential conservation status rank changes. After an initial review by WHS staff, a committee of NGO, academic, and state and federal agency bird experts reviewed and finalized these changes, which were incorporated into a revision of the state’s Rare, Threatened, and Endangered Animal Species List.

Avian salt marsh habitat study (2011-2012)

A recent Comprehensive SWG allowed WHS to collect data for a multistate study of tidal marsh birds along the non-barrier-island Atlantic States through collaboration with Audubon MD-DC. Surveys were performed in 2011 and 2012 that identified SGCN including the American black duck, common gallinule, king rail, least bittern, marsh wren, swamp sparrow, and willet. These data were added to information collected in other states to identify regions and species in the



tidal marsh area that are most sensitive to land and seascape change in order to provide recommendations to inform tidal marsh bird conservation in the region.

Co-coordinate the second Breeding Bird Atlas project (2005-2006)

Through this project, WHS helped to coordinate the efforts of birdwatchers across the state with the goal of producing a second Maryland/Washington, DC Breeding Bird Atlas, an important resource that entails the collection of data for breeding bird species in more than a thousand site “segments.” MD DNR partnered with the Maryland Ornithological Society to recruit volunteers to perform surveys from 2002-2006. Over a hundred species accounts are included in the final product, which was published in 2010 by Johns Hopkins University Press (Ellison 2010). The database set up for this project continues to be important in conservation research and action.

Identify critical stopover habitat for songbirds (2005-2006)

Many regions of Maryland feature stopover locations or habitats where birds take rests from long migration flights. With development and habitat loss threatening these important habitats, this study sought to identify sites that support high concentrations of migratory songbirds. Researchers also assessed how landscape features, such as habitat size, distance to similar stopover locations, and habitat fragmentation affects the volume of migrants visiting the stopover areas. Through a partnership with the New Jersey Audubon Society, the study identified areas that harbored the highest concentrations of migrating songbirds. The Allegheny Plateau and Delmarva Peninsula regions were particularly important stopover sites, while major river systems hosted the greatest concentrations of migrants in Maryland (Mizrahi et al. 2006).

Evaluate use of CREP buffers by birds (2006)

An important focus of Maryland’s Conservation Reserve Enhancement Program (CREP) is the conversion of highly erodible land, such as cropland, to conservation buffers such as grass cover strips and riparian forest buffers. In addition to reducing run-off in these areas, buffers provide habitat for SGCN birds such as northern bobwhite, vesper sparrow, and savannah sparrow. WHS conducted this SWG-funded project under contract with the University of Maryland, College Park. Researchers measured bird species and species abundance in grass and forest buffers with the aim of determining the importance of such buffers for grassland-dependent birds. The study found evidence of nesting in conservation buffers for 13 species, and total bird density and species richness in buffers varied seasonally due to field use, seasonal mowing, and width of buffer strips (Blank & Gill 2006; Blank et al. 2011; Blank 2013). These findings suggest that CREP projects should consider the design and management of conservation buffers in light of their demonstrated importance to grassland-dependent species in Maryland.



Northern bobwhite (George Jett)



Reptiles and Amphibians

Investigate experimental reintroduction of northern pinesnake on the Eastern Shore (2005-2006)

MD DNR partnered with Delaware’s Natural Heritage Program to investigate the state of the northern pinesnake on the Delmarva peninsula. Multiple studies from both programs concluded that the pinesnake was not present in this area. Researchers determined that past threats to the snake’s habitat were likely clear-cutting of forests for agricultural purposes, habitat fragmentation, and persecution by humans. MD DNR determined that while Idylwild Wildlife Management Area and Pocomoke State Forest have habitat that could support introduced pinesnakes from New Jersey, records of pinesnake in Maryland could not be verified and reintroduction was not supported.

Genetic variation and road mortality of central Maryland box turtles (2005-2006)

MD DNR partnered with the University of Maryland, College Park to determine whether genetic differences are evident in different populations of eastern box turtles separated by roads. Researchers used road surveys to estimate the percentage of turtles lost to road mortality in the segregated populations. These data contributed to a thesis project entitled “Genetic Differentiation of Selected Eastern Box Turtle Populations in Fragmented Habitats, and a Comparison of Road-based Mortality Rates to Population Size” (Hagood 2009).

Assess population structure and condition of wood turtles (2005-2006)

This study surveyed the wood turtle population in Maryland’s Ridge and Valley physiographic province. The more remote study sites supported stronger isolated wood turtle populations, with some of the habitats supporting quite healthy populations. Much of the habitat studied was on State Forest land, so the information gathered is important to management of wood turtle populations that occur on these lands.

Inventory of rare reptiles and amphibians (2005-2006)

In assessing the population status of rare reptile and amphibian species, WHS addressed conservation planning needs for reptiles and amphibians through this project. WHS collected site specific data for regionally and globally rare SGCN. The results helped to direct conservation planning and actions, including watershed restoration, land planning, environmental review, state listing decisions, and MD DNR land management.



MD DNR biologist holding wood turtle (Scott Smith, MD DNR)



Distribution, abundance and habitat associations of eastern narrow-mouthed toad (2006-2007)

In an effort to determine the population distribution of the rare eastern narrow-mouthed toad, an SGCN and species listed as Endangered in the state, this study surveyed a total of 109 wetland habitats in Calvert and St. Mary’s counties in southern Maryland. Researchers located very few eastern narrow-mouthed toads, but the wetlands surveys found other SGCN, such as the six-lined race-runner and eastern box turtle. These monitoring efforts are necessary to track remaining populations of rare species and to best preserve the habitats in which they live.

Factors affecting anuran community structure within Delmarva Bays (2008-2009)

In this SWG project, WHS worked with Towson University to focus on anurans, the amphibian group that includes frogs and toads, in Delmarva Bay key wildlife habitats. The study analyzed 55 ponds in three counties using call surveys, dip net surveys, and multiple visualization methods to estimate forest cover around ponds. Anuran communities were characterized by collecting data on pond pH, temperature, and aquatic variation, as well as species identifications (Simpson 2009).

Common map turtle distribution and habitat use in the lower Susquehanna River (2008-2011)

The focus of this study was to measure map turtle distribution in the tributaries of the lower Susquehanna River for eventual use in developing a monitoring protocol. Surveys began in 2008 and were conducted under contract by Towson University. Researchers tracked movement of females as they left the immediate river area to nest, looked for nesting sites, performed diet analyses, and analyzed effects of the Conowingo Dam on map turtle populations. Data suggested that the dam hinders basking activity and movements of turtles due to changing water levels and periodically high flow rates (Richards-Dimitrie 2011; Richards-Dimitrie et al. 2013; Anderson 2014; Anderson et al. 2015).



Biologist using radio tracking transmitter to follow turtle movement (Scott Smith, MD DNR)

Diamond-backed terrapin population assessment and monitoring (2009-2010)

Although a commercial fishing ban was placed on the diamond-backed terrapin in 2007 to prevent overharvest, diamond-backed terrapin mortality as a result of bycatch in crab traps remains a major threat to the species. WHS aimed to get a better understanding of population dynamics of a terrapin population in Somerset County through this SWG-funded project. Although the project did not become a long-term monitoring project as originally hoped, the data obtained by this project were important in understanding terrapin biology and reducing terrapin mortality by suffocation in crab traps.



Update the status of the green salamander (2009-2010)

Up-to-date population status and distribution information is crucial to conservation and management decisions such as the legal listing or delisting of a species. WHS surveyed known green salamander habitats to determine the current status of the green salamander in Maryland and to document changes that occurred to their habitats, many of which are on state-protected land. Based on the data obtained from these surveys, the green salamander remains on Maryland’s Rare, Threatened, and Endangered Animal Species List.



MD DNR biologist with green salamander (Scott Smith, MD DNR)

Coordinate the Maryland Amphibian and Reptile Atlas (MARA) project (2009-current)

Recognizing a need for a comprehensive survey of Maryland’s herpetofauna similar to the Breeding Bird Atlas, MD DNR partnered with the Natural History Society of Maryland to organize volunteers to map the current distribution of all 90 species of amphibians and reptiles within the state (Cunningham et al. 2012). This SWG-funded baseline inventory of herpetofauna in the state, known as the Maryland Amphibian and Reptile Atlas (MARA), has distribution maps online currently, and a book with results and species accounts will be published in 2017. Read more about MARA in Chapter 3.

Evaluation of diamond-backed terrapin head-starting at Poplar Island (2009-current)

Head-starting is used as a conservation tool by a number of groups in Maryland to augment terrapin populations suffering from high rates of nest predation. Head-starting involves collecting eggs from the wild, incubating and hatching them in captivity, and rearing young until their size allows for greater juvenile survival when released back into the wild. WHS is conducting this project to determine whether head-started individuals actually survive to adulthood more frequently than wild individuals, whether head-starting causes any changes to terrapin life history, and, finally, whether the head-start program is a viable conservation strategy. This research is being carried out through a contract with Ohio University to conduct mark-recapture surveys at the Poplar Island archipelago area in the Chesapeake Bay. Researchers mark both wild and head-started diamond-backed terrapins at a young age and released the terrapins. In



Biologists checking crab pot for bycatch reduction devices (BRDs) (left); demonstrating BRD function (right) (Scott Smith, MD DNR)



subsequent years, researchers track these turtle cohorts through recapturing. As the project begins showing definite results, MD DNR will reassess its head-starting program for optimal conservation benefit.

Assess hellbender population status (2005-2006)

Through this project, WHS surveyed known habitat of the eastern hellbender, a large riverine salamander that is known to inhabit stretches of the Youghiogheny and Casselman rivers in western Maryland. While eight hellbenders were found during the study, findings indicate that the hellbender's range has contracted in both rivers since the species was last surveyed. The study also found that hellbender reproduction has ceased in these rivers. Future surveys will further assess the status of the hellbender in Maryland, including the possibility of a reintroduction program.

Invertebrates

Statewide status assessment of Maryland's dragonflies and damselflies (2005-2012)

Surveys from 2005 to 2012 assessed the status, distribution, abundance and natural community associations of Maryland's dragonflies and damselflies, a group collectively known as odonates. These surveys were a joint effort of WHS and Richard Orr, a regional dragonfly and damselfly expert, with additional records added from other contributors around the state. In addition to mapping the distribution of species, this project included work in ranking abundances of odonates, compiling new reports from other naturalists, and collecting rare dragonfly and damselfly specimens. The researchers also completed a comprehensive status review of all Maryland odonates, modifying conservation ranks and state legal statuses for use in the SWAP.



Spangled skimmer (Richard Orr)

Survey of groundwater invertebrates (2007)

An important outcome of the SWAP revision process is gaining an understanding of which areas of Maryland's wildlife need further research in order to implement best conservation practices. Knowledge of the invertebrates of Maryland is a major area lacking in detail. WHS used this SWG project to survey the distribution, abundance, and habitat associations of subterranean macroinvertebrates in groundwater habitats in upper Piedmont and Coastal Plain physiographic provinces. In the course of the study, WHS sampled 71 seeps and springs in nine Maryland counties and documented subterranean macroinvertebrates at 13 new localities. This research continued as the collected invertebrates were identified by species experts, with some found to be new species to science!

Status and distribution of Maryland's moth fauna (2008-2010)

While butterflies are one of the most well-known invertebrate groups in Maryland, moths, which make up 90% of the taxonomic group *Lepidoptera* (the butterflies and moths), have been largely overlooked despite their importance as pollinators and indicators of ecosystem health. This project aimed to gather existing information for contribution to a statewide moth database maintained by WHS. Sources of information included the Smithsonian Museum of Natural



History and the unpublished “Moths of Maryland” report. Following database population, WHS reviewed the statuses of moths included on the MD DNR Rare, Threatened, and Endangered Animal Species List based on newly gathered information. With the database presently containing over 20,000 records, gaps in moth knowledge can be identified and will be addressed with survey projects in the future. The compilation of such information is important for conservation of areas utilized or pollinated by moth species.

Status review of MD's rare, Threatened and Endangered butterflies (2009-2011)

WHS reviewed the status, key information gaps, and priority conservation needs for butterfly species that are listed, or have been considered for listing, on Maryland's Rare, Threatened, and Endangered Animal Species List with the assistance of taxonomic experts. SWG funding for this project allowed researchers to conduct range and population surveys for butterfly species such as the West Virginia white, Baltimore checkerspot, cobweb skipper, Olympia marble, and frosted elfin. In some cases, these surveys led to further research into causes of decline for these species, such as deer herbivory of food sources and impact of invasive plants. Information gained from this research is important in prioritizing species management and establishing conservation measures in protected areas. Published literature resulting from this project includes Frye (2012), Frye and Tangren (2013), and Frye and Robbins (2015).

Patterns of invertebrate species richness on inland sand dunes on the Delmarva (2007-2013)

Human disturbance and development pose tremendous threats to rare habitats whose plant and animal communities have not been well researched. One such rare community is the inland sand dune community that is a component of dry-oak pine forest key wildlife habitats. This SWG-funded project examined species richness and distribution from a community standpoint of select invertebrate groups and plants. Field work, including area surveys, pitfall traps, and litter sampling, yielded data contributing to better understanding of plant and invertebrate distribution in inland sand dune communities and their conservation needs. Target invertebrate groups were bees and ants, and other invertebrates were collected for separate entomology projects. Much of the data has recently been published by Frye and Frye (2012) and Frye et al. (2014).

Scientific descriptions of new species of globally rare subterranean invertebrates (2008-2013)

The 2005 SWAP demonstrated a deficiency in knowledge of rare subterranean invertebrates. Amphipods, isopods, and flatworms living in groundwater emergences and caves are often good indicators of habitat quality, especially in areas particularly vulnerable to habitat disturbance such as mines and Marcellus Shale deposits. This research supplemented information about known species, and new species were collected for identification by contracted taxonomic experts. Several new species of amphipods were described (Holsinger et al. 2011; Holsinger & Ansell 2014). The culmination of this research and previous studies funded by the USFWS has been compiled into a publication (Culver et al. 2012) describing the subterranean animals living in seeps and springs in the Coastal Plain and Piedmont of the Mid-Atlantic states as a monograph in *Northeastern Naturalist*. This region-wide analysis of biogeography and ecology will contribute to future management efforts for all groundwater ecosystems.



Multiple Animal Taxa

Morbidity/mortality investigations for wildlife species of special concern (2005-2006)

Assessing the health status of a wild animal when it dies is important for many reasons. The use of health assessment criteria using a suite of indicators can provide insight into the causes of population decline and impacts of environmental effects, providing valuable information for the evaluation of the status of wild populations. Such an assessment also provides an important baseline in the case of a natural disaster or disease outbreak, and is more accurate than similar assessments on captive animals. WHS worked with Maryland's State Veterinarian and staff from the Oxford Cooperative Lab on this SWG-funded project to address the need for a more consistent reporting system for wildlife mortality incidents, leading to the development of the MD DNR Wildlife Response Flow Chart, Protocol, and Wildlife Investigation form that are now used routinely by wildlife biologists in the state.

Bird and bat migration over Appalachian ridges in the Mid-Atlantic Region (2006-2008)

MD DNR contributed to a multiyear regional project in cooperation with New Jersey Audubon, USFWS, and USGS through this SWG project, as the Appalachian Mountain region studied nocturnal bird and bat migration patterns in order to assess the potential impacts of wind energy developments in the region. The migration routes were analyzed for SGCN forest-interior breeding birds and bats in need of conservation using marine radar and acoustic recording equipment, and MD DNR used this information to advise the wind power industry to site and operate developments so that impacts to SGCN were minimized to the extent possible. Important data collected from this study (Mizrahi et al. 2008) and from a companion study funded by MD DNR Power Plant Research Program (Gates 2006) included effects of weather, site, and landscape characteristics on migration pattern, migrant density, and optimal locations where migrants follow or cross Appalachian ridgelines.

Biodiversity assessment on s (2008-2012)

WHS oversees the management of 61 Wildlife Management Areas (WMAs) comprising 104,000 acres. MD DNR also owns and manages over 135,000 acres of State Forest lands. Together, these tracts represent some of the most intact landscapes, watersheds, and ecosystems remaining in the state and contain a critically important part of a core network of protected wildlife diversity conservation lands. MD DNR must periodically review biodiversity present in WMAs and State Forests in order to update information on species' population status and extent, threats, management and restoration needs for select SGCN, natural communities, and key wildlife habitats. These lands encompass important forest and wetland natural areas and support many SGCN. These inventory, monitoring, and research activities reported new data on SGCN in Maryland's public lands, including important updated information on rare invertebrate species.

Biodiversity conservation assessment for SGCN (2012-current)

This grant followed the "Biodiversity assessment on Public Lands" SWG project, covering a diverse array of conservation assessments. SGCN that have been monitored through this grant include the Baltimore checkerspot butterfly, the frosted elfin butterfly, the northern barrens and eastern pine barrens tiger beetles, the green salamander, the timber rattlesnake, and the wood turtle. Data were provided to land managers and incorporated into management plans for SGCN and key wildlife habitat conservation.



Monitor SGCN and key wildlife habitats in central Maryland (2012-2013)

Central Maryland, which includes Baltimore, Cecil, and Harford counties, contains an eclectic mix of habitats, including several rare key wildlife habitats. MD DNR contracted experts to perform a review of the rarest key wildlife habitats in the summer and fall of 2012 and spring of 2013. Surveyed key wildlife habitats included Floodplain Forest, Tidal and Non-tidal Shrub Wetland, Tidal Marshes, Dry Oak-Pine Forest and Beach-Dune-Mud habitats. WHS added results of the surveys to the Biotics database of the Natural Heritage Program; this information will be useful in conservation planning and monitoring activities.

Review and update of the state's Rare, Threatened and Endangered (RTE) Animal Species List (2007-current)

Through this ongoing project, WHS is extensively reviewing Maryland's RTE animal species list for information gaps, priority conservation needs, and potential changes to legal status or conservation ranks for each species. All animal taxa are being addressed by this review process, and species experts from MD DNR and partner organizations are working to determine the appropriate statuses for Maryland's RTE species. These status changes may be in response to new threats to taxa, such as spread of disease or increased development in important natural areas, or new inventory and monitoring data from WHS, conservation organizations, and academic partners.

Develop monitoring plans for the conservation of rare species and communities (2008-2009)

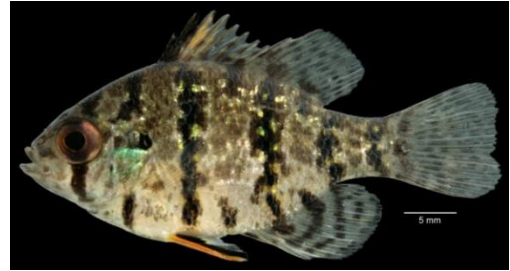
In order to be most efficient and effective in implementing Maryland's SWAP, MD DNR developed a strategy to target inventory, monitoring, and research (IMR) needs to meet SWAP objectives. The IMR strategy identifies a need for the development of monitoring plans for the rarest species, natural communities, and sites of high biodiversity to ensure the maintenance of these resources, identify the factors that affect them, and identify needed conservation actions. This project built on the results of a previous SWG project that considered how to target inventory, monitoring, and research. Through this SWG-funded project, WHS identified 27 species listed as Endangered in Maryland, 20 vegetation community associations, and six priority state rare ecological communities as priority targets for the development of monitoring plans using the best available information and statistical techniques. WHS coordinated efforts with regional work on bird conservation plans and needs for state lands where management activities might impact priority species and habitats. In order to prepare for the implementation of monitoring plans, this project also included developing a strategy, identifying potential partners, coordinating with regional monitoring efforts, and establishing a mechanism for consistent communication of activities/outcomes of monitoring to land managers and other partners.



Aquatic

Survey of priority aquatic SGCN by MD DNR's Resource Assessment Service (2006)

The goal of this survey was to determine the status, abundance, and habitat of three SGCN: the bridled shiner, blackbanded sunfish, and the mud salamander. MD DNR biologists conducted surveys for these species at historical collection localities and in areas with suitable habitat. Blackbanded sunfish and mud salamanders were collected from a limited number of sites (Chalmers 2007). However, no bridled shiners were found during these surveys despite considerable sampling efforts within areas of historical occurrence (Kilian et al. 2011). As a result of this survey effort, the state-listing statuses of bridled shiner and blackbanded sunfish were revised. Physical, chemical, and landscape data were recorded at sites where SGCN were found in order to improve knowledge for conservation. Kilian et al. (2009) provides a description of the physical, chemical, and biological characteristics of sites where blackbanded sunfish were found during this survey. Twenty-two additional fish and herpetofauna SGCN were found during this survey, adding to the knowledge of these species as well (Kilian et al. 2011).



Blackbanded sunfish (MD DNR)

Species-level inventory of Maryland's freshwater benthic macroinvertebrates (2005-2006)

From 2006 to 2007, MBSS compiled species-level benthic macroinvertebrate data collected from external sources to supplement MD DNR's data, which were generated mainly by MBSS and MD Stream Waders. This master macroinvertebrate list was geographically sorted so researchers know where species identifications are lacking in Maryland (Laycock et al. 2007). MBSS staff also worked to compile a species-level benthic macroinvertebrate voucher collection.

Collect crayfish and mussel data as part of the statewide Maryland Biological Stream Survey (2005-2012)

In 2006, MBSS expanded its stream survey protocol to investigate freshwater mussel and crayfish species and populations across Maryland, expanding knowledge of native and non-native distributions of these invertebrates. Physical and chemical data collected with crayfish and mussel counts add to knowledge of species' distribution. Crayfish data collected as part of these SWG-funded surveys contributed to the first status and distribution assessment of this fauna in fifty years (Kilian et al. 2010). MBSS also partnered with personnel from the MD DNR Fisheries Service and faculty from Hood College and Mount St. Mary's University to monitor the invasion of the rusty crayfish *Oronectes rusticus* in the Monocacy River watershed to track the spread and impacts of this invasive crayfish. Beginning in 2010, MBSS staff also coordinated the Chesapeake Bay Freshwater Mussel workgroup. SWG-funded mussel and crayfish surveys and invasive species monitoring efforts were submitted to peer-reviewed journals or technical bulletins (Ashton 2008; Ashton 2009a,b; Kilian et al. 2009; Kilian et al. 2010; Ashton 2011a,b; Kilian & Ciccotto 2011; Ashton 2012a,b,c; Kilian et al. 2012a,b).



Freshwater mussels with identification tags (Matt Ashton, MD DNR)

Population status of freshwater mussels (2007)

After an Endangered dwarf wedgemussel was discovered in a tributary of the Corsica River on Maryland's Eastern Shore in 2005, WHS worked with MBSS on this SWG project to determine the status of freshwater mussels, especially the dwarf wedgemussel, in the Corsica River watershed. Mussels were present at over 70% of surveyed sites and the dwarf wedgemussel was found at multiple sites. This SWG project also funded research into the status of two other rare mussel species, the brook floater and the green floater, at 56 freshwater sites in Maryland. The presence of these rare mussels is an important indicator of water quality and biodiversity in Maryland's waters.

Sentinel site sampling by the Maryland Biological Stream Survey (2007-current)

Since 2007, MD DNR's MBSS has monitored the water quality and biological diversity of streams throughout Maryland. A yearly SWG makes it possible for MBSS to annually survey high quality Sentinel Sites, tracking natural variability in physical, chemical, hydrologic, and biological conditions at these minimally impaired sites (Becker et al. 2010; Saville et al. 2014). This time series of data will be instrumental in documenting the potential influence of global climate change on Maryland's streams. Data from these Sentinel Sites are made available for such uses as the U.S. Environmental Protection Agency's Regional Monitoring Network, which is currently monitoring stream flow data in several Maryland streams using MD DNR-installed flow gages.

Unionid mussel propagation and reintroduction (2015-current)

Freshwater unionid mollusks are the most imperiled wildlife group in the United States. Maryland streams and rivers support fourteen SGCN of bivalve mollusks, including one species that is federally listed as Endangered and three that are state-listed as Endangered. In order to supplement decreasing mussel populations, WHS is partnering with MD DNR Fisheries Service to start a captive mussel breeding program in Maryland through this SWG project. A non-SGCN mussel species will be used to set up the hatchery. Following successful set-up, the hatchery will introduce SGCN mussels for propagation and evaluate how best to move forward with reintroduction.

Protection guidelines and baseline monitoring for the state's highest priority watersheds (2007-2013)

In 2005, the MD DNR Resource Assessment Service ranked 84 watersheds in Maryland based on their importance to aquatic biodiversity conservation and identified ten top priority Stronghold Watersheds in the state. To address the need for protection guidelines to guide conservation of SGCN within these watersheds, MD DNR Resource Assessment Service biologists conducted surveys within each priority watershed to 1) determine in greater detail the distribution of SGCN, and 2) acquire data on the physical habitat, chemical, and landscape characteristics that define the ecological requirements of these species. These surveys documented new records for important species and provided a baseline of distribution and abundance from which to track the future population status of SGCN as land use alterations and other changes occur in each watershed. Physical, chemical, and landscape data collected during these surveys also contributed towards a better understanding of the ecological requirements of the SGCN found in these areas. Data collected during these efforts were summarized into reports (Ciccotto & Stranko 2008; Ciccotto 2009; Graves et al. 2010; Graves 2011; Graves 2012)



to guide environmental review of projects and conservation actions within these important watersheds.

Estimating space requirements and extinction risk for Maryland brook trout (2007-2009)

Maryland's brook trout are struggling to survive in waters threatened by sedimentation, increasing acidity, and rising water temperatures. Through sampling procedures performed mostly in western Maryland, MD DNR Fisheries Service and University of Maryland Center for Environmental Science, Appalachian Lab aimed to estimate brook trout population sizes for over 50 Maryland streams, and, by using genetic information known about the brook trout, researchers estimated the ratio of breeding brook trout within these populations. Based on these estimates, the study found that many brook trout streams are at low risk of losing genetic diversity due to connectivity with other streams and other brook trout populations. In order to maintain this positive status and work towards restoring brook trout to their former range, management activities should focus on ensuring connectivity in Maryland's streams.

Re-inventory of targeted brook trout populations in western Maryland (2007-2008)

To assess brook trout population trends, MD DNR Fisheries Service and University of Maryland Center for Environmental Science, Appalachian Lab re-sampled 16 brook trout populations that were sampled in a 1988-1989 survey. All sites which exhibited high abundances of adult brook trout from 1988-1989 declined in the fifteen year period up to 2007. While this overall trend shows decreasing brook trout populations over time, several low abundance populations from 1988-1989 were able to persist at low abundance and, in some cases, increase in abundance by 2007. However, given that many traditionally strong populations saw brook trout loss in the re-survey, this information necessitated increased monitoring of brook trout stronghold watersheds.

Development of a captive brood stock program for Atlantic sturgeon in Maryland (2004-2006)

Atlantic sturgeon, an anadromous species that spends most of its life in the ocean but returns to freshwater rivers and streams to spawn, was historically an important species in Maryland. Due to overexploitation, declining water quality, and increasing numbers of stream blockages, the Atlantic sturgeon suffered a great decline in Maryland waters. At the initiation of MD DNR's captive breeding project in 1992, the Atlantic sturgeon was considered extirpated in Maryland waters. This SWG funding provided infrastructure to MD DNR Fisheries Service in partnership with the University of Maryland Center for Environmental Science Aquaculture and Restoration Ecology Laboratory, USFWS-Northeast Fishery Center, and University of Maryland Crane Aquaculture Facility, with in-kind match from Mirant Mid-Atlantic through their Aquaculture Center. Grant funds furthered the development of the captive breeding program, including a recirculating aquaculture system to accommodate year-long culture, addition of captured migrant sturgeon to the program to introduce new genetic material, research on transitioning larval sturgeon to commercial diet, and genetic sample processing.

Key Wildlife Habitats

Natural community classification (2005-current)

WHS is investigating the most important and unknown sites in the state for analysis of rare and unique communities, recognizing their value as coarse filters for numerous rare invertebrates that



have not yet been studied. The communities identified by this project form the basis of the key wildlife habitats for SGCN in the SWAP. By identifying the best habitats for invertebrate biodiversity, this project benefits invertebrate wildlife through the development of an ecosystem-based management strategy. Products of this research include multiple iterations of “The Natural Communities of Maryland: Classification of Ecological Community Groups” (J.W. Harrison, MD DNR, unpublished data), a widely used Natural Community Observation data form, the published paper “Ecology and Flora of Native-American Shell-middens of the Delmarva Peninsula” (McAvoy & Harrison 2012), and thousands of entries to the Biotics database and the Vegetation Plot Database. In addition, these surveys have initiated a number of other SWG projects.

Assess wildlife value of old growth forest (2005-2010)

This five-year survey identified over 40 old growth forests on state lands (Kahler & Brewer 2007). The wildlife value of old growth forests was analyzed by quantifying forest characteristics that support rare species and documenting the presence of rare animals in old growth forests. The survey yielded a great amount of information about bird and insect distribution in these forests, and researchers documented new records for several invertebrates in Western Maryland. WHS used the results of the survey to update relational biodiversity and state natural community databases, to identify key areas for conservation on state lands, and to set aside old growth management areas and inform their conservation on State Forest lands.

Monitor rare plant communities and associated key wildlife habitats in southern Maryland (2008, 2010-2011)

Through this project, WHS aimed to update the program’s database of rare plant communities and key wildlife habitats in Maryland’s five southern counties, an important step for the state’s biodiversity conservation network. Fieldwork took place from 2008-2011, and biologists developed a new rapid assessment form to best document the makeup of natural communities in southern Maryland. This information is of use to county planners, and part of this project involved MD DNR staff presenting information on natural areas and rare communities to county planning staff.

Community-level inventory of Upper Coastal Plain seepage and headwater wetlands (2007-2010)

Wetlands are some of the most important, and most threatened, areas for wildlife biodiversity in Maryland. This SWG project allowed MD DNR to significantly contribute to the body of information available for Upper Coastal Plain seepage and headwater wetland ecosystems through targeted surveys of water and soil quality, plant life, and invertebrate and herpetofauna communities in southern Maryland wetlands. The results of these surveys were used to refine classifications and rankings of some wetland communities and to better understand the requirements of SGCN utilizing these habitats. This research is also important for the development of best management practices for these areas (Harrison & Knapp 2010).

Classification and assessment of bog and fen wetland complexes (2008-2012)

Bog and fen wetland complexes support over 150 SGCN, as well as many rare plants. This assessment was a necessary step towards establishing and maintaining networks of bog and fen sites. A better understanding of the biological resources found in Appalachian Plateau bogs and



fens will contribute directly to conservation planning, resource identification and protection, and the state environmental review process. In the field, teams collected vegetation and ecological data like woody stem diameters, soil profile, water temperature, pH, conductivity, landscape information, geology and soil types, and GPS coordinates. Teams also collected and processed soil samples, entering information into a database and using ArcGIS to map the plant communities they identified. Other WHS staff members carried out research regarding the status and distribution of animals associated with bogs and fens of the Appalachian Plateau. The final analysis classified 26 different vegetation community types.

Database Development and Maintenance

Natural Heritage Program (NHP) database management (2005-current)

In 2004, NHP upgraded its central database to an integrated geographic information system (GIS) called Biotics. NHP uses this software to track the locations and population data for Maryland's declining wildlife and natural areas and to exchange data with the Natural Heritage Network's central database, managed by NatureServe. After retooling data management processes in place since the 1980s and training in Biotics, data entry and management quickly increased, with hundreds of new records being added every year. Recent advances in technology allow for more streamlined data entry in to the system, including use of Global Positioning System (GPS) field data recorders and iPads for field mapping and a cloud-based platform for easier NHP access. To facilitate the revision of the 2005 SWAP (Maryland Wildlife Diversity Conservation Plan), NHP used Biotics to generate a master database created to house information about SGCN.

Develop new GIS data products and update GIS applications (2009-current)

WHS and partners use a variety of GIS data products and information services to collect, manage, and share information. This project is designed as an ongoing review of these existing products and services to identify needs for updated or new systems. As a result, WHS staff have updated GIS data for such layers as Ecologically Significant Areas, Ecological Community Groups, Managed Areas, Delmarva fox squirrel habitat, the new Potential Forest Interior Dwelling Species Habitat layer, and key wildlife habitat layers. Additionally, WHS's Conservation Information System and the Parcel Scoring program are being updated from old ArcView technology. The Conservation Information System has been updated to a new ArcMap 10 platform, allowing multiple users to use the most up-to-date layers available.

Restoration and Protection

Repair and maintain bat gates (2006)

In order to protect hibernating and roosting bat populations, including SGCN bats, WHS initiated the installation of cave gates at the entrances to several caves and mines in Maryland. In 2006, WHS assessed the cave gates and all cave and mine gates of medium or high conservation value or of human safety concern



Cave gate (Dan Feller, MD DNR)



were repaired. Further assessment found that populations of bats have increased at every gated cave and mine since the gates were erected, and human-caused cave destruction has been greatly reduced due to controlled cave access.

Restore habitat for amphibians in Carolina Bays (2006)

Carolina Bays, which are referred to as Delmarva Bays in the 2015 SWAP revision, are rare and important natural communities in Maryland. These aquatic habitats support many SGCN, including historically rare amphibian species, but are threatened by invasive plants that can take over and disrupt these sensitive ecosystems. WHS selected 19 state-owned Delmarva Bays and associated flatwoods, designated as Non-tidal Wetlands of Special State Concern, for woody invasive plant removal. Among the species removed from these habitats were red maple, sweetgum, persimmon, and loblolly pine.

Hellbender habitat, monitoring, and propagation (2015-current)

The eastern hellbender, a salamander listed as Endangered in Maryland, is declining globally and in Maryland as a result of habitat loss, decreasing water quality, and pathogens such as chytrid fungus (*Batrachochytrium dendrobatidis*). An overabundance of crayfish, which consume hellbender larvae, also threaten the Endangered salamander. Through this project, WHS is expanding upon previous monitoring and inventory efforts by enhancing habitat to provide shelter and brood habitat and investigating the implementation of a head-starting system with MD DNR Fisheries Service.

Eastern tiger salamander habitat management on the Eastern Shore (2007-2009)

This project, undertaken from 2007-2009, revitalized the eastern tiger salamander populations at multiple wetland habitats. After eradicating thick growths of invasive plants at the sites, salamander egg mass numbers increased tenfold. WHS assessed the Massey Pond site in Kent County for construction of a water control structure to manage fish entry into the pond, but, after completion of invasive plant removal, WHS found that such a structure was not necessary. Invasive plant monitoring continues at these wetland sites.



MD DNR biologists looking for eastern tiger salamander egg masses (Scott Smith, MD DNR)

Restore endangered beetle habitat at Sharptown Dunes (2007-2015)

In an effort to restore the oak-lichen dune community for two rare tenebrionid beetles, *Schoenicus puberulus* and *Helops cisteloides*, WHS staff surveyed two dune complexes at Sharptown Dunes with assistance of a collaborator from the Smithsonian Institution. Although *S. puberulus* was determined to be extirpated due to severe habitat loss, *H. cisteloides* was detected in recoverable numbers. Restoration projects included pine clearing and prescribed burning to allow the recovery of the oak-lichen community and thus allow *H. cisteloides* to re-expand its population. Once the community has fully recovered, reintroduction of *S. puberulus* is planned.



Restore and manage habitat for the globally critically imperiled eastern sedge barrens leafhopper (2008-2011)



Soldiers Delight (Richard Orr)

The eastern sedge barrens leafhopper, state listed as Endangered, lives in a very specific habitat on one plant species in open, upland areas. The serpentine barrens found at Soldiers Delight provided this ideal habitat until the area became overrun with Virginia pine (*Pinus virginiana*) and invasive plants like mile-a-minute vine (*Persicaria perfoliata*),

tree-of-heaven (*Ailanthus altissima*), and Japanese barberry (*Berberis thunbergii*). After surveying the leafhopper populations at Soldiers Delight in 2008, MD DNR doubled the leafhoppers’ habitat by removing Virginia pine and invasive plants on 15 acres of overgrown leafhopper habitat. WHS staff completed a study of population and microhabitat characteristics in 2009 (Frye & Tyndall 2010).

Shale barrens restoration (2010-2013)

Turkey Camp Shale Barren and Hanging Prairie Shale Barren, (Allegany County) were ranked as the third and fourth highest statewide-priority biodiversity restoration sites by WHS, as both barrens were being overtaken by pignut hickory expansion due to fire exclusion and suppression. In 2009, WHS began restoration efforts at both barrens by treating hickories with a no impact drill-and-syringe technique, followed by prescribed burning at Hanging Prairie in 2010. In addition, tree-of-heaven was discovered on both barrens during the project and eliminated with the same technique. Intensive monitoring at Hanging Prairie documented rapid and significant increases in species diversity, richness, and biomass (Tyndall 2015). WHS continued work on these rare key wildlife habitats under the SWG project “Restoration of BioNet Tier 1 sites.”

Restoration of BioNet Tier 1 sites (2012-current)

After establishing conservation strategies for BioNet Tier 1 sites (see page 8, “Develop conservation strategies for BioNet Tier I Sites”), NHP treated select Tier 1 Delmarva Bay, inland sand dune, and Shale Barrens complexes for invasive species and detrimental woody plants. Long-term habitat monitoring is ongoing, utilizing permanent point photography and standard survey techniques. Several Tier 1 sites are shale barrens in Green Ridge State Forest, where prescribed burning is being used to reinstate a fire regimen and control invading pignut hickory trees (*Carya glabra*).



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