CHAPTER 4
Conservation Actions

Table of Contents

Take Action! Get Involved! 5

Introduction 9

Background and Rationale 9

Conservation Action Classification System 11

Conservation Action Description 12

Best Practices for Conservation Actions 15

International Conservation Actions 15

Overview 15

Regional Conservation Actions 19

Regional Conservation Needs Program 19

Regional Action 21

Pennsylvania Conservation Actions 22

1.0. Coordination and Administration 24

1.1. Coordination and administration 24

1.2. Incentives 25

2.0. Direct Management of Natural Resources 27

2.1. Create new habitat or natural processes 27

2.2. Dam and Barrier Removal 28

CASE STUDY: Dam Removal as a Habitat Restoration Tool 29

2.3. Fire Management 30

CASE STUDY: Habitat Restoration Using Prescribed Fire 31

2.4. Fish and Wildlife Habitat Structures 33

2.5. Grazing/farm management 35

2.6. Hazard or infrastructure removal 38

2.7. Instream modification 38

2.8. Invasive species control 39

2.9. Living shorelines 40

2.10. Planting/seeding 41

2.11. Vegetation management 41

2.12. Water management 42
2.13. Wildlife damage management 42
2.14. Wildlife disease management 43
3.0. Data Collection and Analysis 43
3.1. Database development and management 43
3.2. Research, survey or monitoring - fish and wildlife populations 44
3.3. Research, survey or monitoring - habitat 44
3.4. Research, survey or monitoring – utilization 44
4.0. Education 46
4.1. Educator/instructor training 46
5.0. Facilities and Areas 46
5.5. Cooperatively managed areas for hunting 46
5.6. Fish-Passage Facilities 47
5.7. Fish screening and related facilities 48
5.8. Hatcheries 48
5.15. Wildlife management areas 49
6.0. Land and Water Rights Acquisition and Protection 50
6.1. Land acquisition 50
6.2. Water rights acquisition 50
6.3. Conservation area designation 51
6.4. Private lands agreements 51
7.0. Law Enforcement 52
7.1. Law enforcement 52
8.0. Outreach 52
8.1. Partner and stakeholder engagement 52
9.0. Planning 53
9.1. Land use planning 53
9.3. Species and habitat management planning 54
9.4. State Wildlife Action Planning 54
10.0. Species Reintroduction and Stocking 55
10.1. Native species restoration 55
10.2. Production and stocking for recreational purposes 55
11.0. Technical Assistance 56
11.1. Environmental review 56

11.2. Technical assistance 57
100.0. Law and Policy 57
100.1. Legislation 57
100.3. State Regulations 58
101.0. Species Management 58
101.1. Species management 58
102.0. Partnerships 58
102.1. Non-governmental organizations (NGO) 58
Conservation Opportunity Areas (COA) 60
Introduction 60
Need 60
Decision Problem 60
Decision Analysis 61
Summary 62
COA Definitions and Considerations 62
Relevant Management or Implementation Plans 63
Introduction 63
Invasive Species 63
State Game Lands Management (PGC) 68
Pennsylvania Game Commission, State Game Lands (SGL) Comprehensive Plan Structure 68
SGL Plan Sections and Guidance Directly Relevant to the Wildlife Action Plan 69
State Forest Management (PADCNR) 73
Ecological Considerations 74
Water Resources 75
Faunal Resources 75
Eastern Hemlock Management Plan 79
Agricultural Land Management 80
Streams, Wetlands and Watersheds 81
Forests 83
Grasslands 84
Anadromous Fishes 84
Pollinator Conservation 85
Climate Change 85
Adapting to Climate Change: Getting Started 85

Adaptation Concepts 85
Principles of Adaptation 86
Developing Adaptation Strategies and Actions: Broad Goals to Specific Tactics 88
Processes for Adaptation Planning and Implementation 89
Regional Adaptation Strategies: Case Studies 89
National Adaptation Strategies 90
Goals, Strategies and Actions 96
Pennsylvania's Adaptation Strategy 98
Recommendations 98
Habitats 100
Forests 100
Aquatic resources 101
Appendix 4.1 102
Exhibit 1. International Bird Conservation 102
Appendix 4.2 112
Exhibit 1. Birds 112
Exhibit 2. Mammals 118
Exhibit 3. Amphibians 119
Exhibit 4. Reptiles 120
Exhibit 5. Fishes 121
Exhibit 6. Mussels 124
Exhibit 7. Invertebrates 125
Appendix 4.3 138
Exhibit 1 138

Take Action! Get Involved!

***There are many opportunities for citizens to help Pennsylvania's Species of Greatest Conservation Need and their habitats**. Only a willingness to become involved is needed!*

Habitat Enhancement

Maintaining and enhancing habitats will be important for Pennsylvania's Species of Greatest Conservation Need. From backyards to large tracts, there are many actions you can take. Here are few ideas:

- ✓ **Manage forests wisely to support Species of Greatest Conservation Need**
- ✓ **Plant trees to protect and restore stream banks**
- ✓ **Control invasive plant species along streams, in forests, and around wetlands**
- ✓ **Plant milkweed and other native wildflowers to help monarch butterflies, bees, and other pollinators**
- ✓ **Implement "Best Management Practices" for vernal (seasonal) pools**
- ✓ **Install a rain garden to protect and improve water quality by reducing urban run-off into waterways and wetlands**
- ✓ **Landscape with native plants to provide food and shelter for wildlife**

Resources

Here are a few resources to learn more about what you can do to support habitats for Species of Greatest Conservation Need:

- **Pennsylvania Game Commission**-Private Landowner Assistance Program
- **Pennsylvania Fish and Boat Commission**-Lake and stream habitat improvement
- **Pennsylvania Department of Conservation and Natural Resources**-*iConserve Pennsylvania*
- **Pennsylvania Association of Conservation Districts**-Resources
- **Pennsylvania Land Trust Association**-Members
- **Pennsylvania Woodland Owners Associations –** County contacts
- **Foundation for Pennsylvania Watersheds**-Conservation activities
- **Pennsylvania Organization for Watersheds and Rivers**-Watershed Directory
- **USDA Forest Service-Pollinators**-Things you can do for pollinators
- **USDA Natural Resource Conservation Service; Farm Service Agency**-Conservation programs
- **Pennsylvania Natural Heritage Program-** Vernal pool Landowner's Guide
- **Pennsylvania Natural Heritage Program-** Invasive Plant Management Decision Analysis Tool
- **Pennsylvania Native Plant Society –** Native plant information and suppliers

Species and Habitat Monitoring

Collecting long-term data (monitoring) is important to understand the status of species and their habitats. There are many opportunities for citizens to become involved. For example, monitoring assistance is needed for:

- ✓ **Monarch butterflies**
- ✓ **Birds**
- ✓ **Bats**
- ✓ **Amphibians and Reptiles**
- ✓ **Vernal (seasonal) pools**
- ✓ **Invasive species**
- ✓ **Wildflowers**
- ✓ **Water Quality**

Monitoring Support

Here are a few places to learn more about what you can do to support monitoring for Species of Greatest Conservation Need and their habitats:

- Monarch Watch and Pollinator Monitoring
- Bird monitoring (eBird)
- Audubon Christmas Bird Count
- Appalachian Bat Count
- Amphibian and Reptile Surveys (PARS)
- Pennsylvania Mammal Atlas
- Vernal Pools-Pennsylvania Natural Heritage Program
- Invasive Species
- Nature Abounds™ SENIOR Environment CORPS™
- iNaturalist
- Floral and faunal research in Pennsylvania State Parks
- Water Monitoring: Alliance for Aquatic Resource Monitoring (ALLARM)
- National Water Quality Monitoring Council
- Consortium for Scientific Assistance to Watersheds (C-SAW)
- Citizen Scientist Starter

Note: It is recommended to become involved with an established monitoring group. Permits and restrictions may apply!

Planning and Habitat Protection

- ✓ **Work with local Township Planning Boards and other authorities to conserve open space.**
- ✓ **Conservation easements to protect riparian buffers, wetlands, forests and other important habitats.**

Here are few places to learn more about what you can do to support planning and habitat protection for Species of Greatest Conservation Need:

- ❖ Pennsylvania Land Trust Association-Land Use Ordinances & Development Standards
- ❖ Pennsylvania Land Trust Association-Model Conservation Easement Documents
- ❖ Pennsylvania Land Trust Association-Model Organizational Policies
- ❖ USDA Natural Resources Conservation Service (Agricultural Conservation Easement Program)
- ❖ USDA Natural Resources Conservation Service (Healthy Forests Reserve Program)

Images Betsy Leppo, Mary Walsh, Tony Ross

Introduction

For decades, Pennsylvania's fish and wildlife have endured a broad range of serious threats, and consequently, the populations of many species have been greatly diminished or lost entirely from the Commonwealth. Today, species face imperilments (Chapter 3, Threats) that are no less challenging than those of the past; often with effects intensified by climate change. Yet, with well-planned and consistently implemented management actions, species can recover. Factors contributing to a species' decline may be the result of many interacting threats (e.g., invasive species and habitat fragmentation) and thus, recovery may be similarly complex, time-intensive and involve an enduring commitment. Concerted recovery efforts may span decades: the bald eagle (*Haliaeetus leucocephalus*) is an example of a successful recovery that required many years. Thus, securement of species identified in this Plan may be founded largely in the conservation actions we take today. Full recovery may be achieved only beyond the duration of this Plan, yet the trajectory for recovery of these species may be established through this Plan. Identifying and implementing effective conservation actions can be particularly challenging, especially in a dynamic environment, or when no tested conservation actions have been developed. We are, however, not without options for coping with imperilments and, as discussed in this chapter, there are many effective conservation actions that can be implemented today to establish the course for recovery of these species. Where options for recovery are few or untested, structured data collection and analysis can assist with identifying effective methods to support species and habitats.

Background and Rationale

Adapted from Crisfield (2013)

Conservation actions have been described as "interventions undertaken by project staff or partners designed to reach the project's objectives and ultimate conservation goals" and often considered synonymous with strategies, interventions, activities, responses, and monitoring (Salafsky et al. 2008).

With the federal reporting requirements for State & Tribal Wildlife Grant projects, and eventually other federally funded Wildlife and Sport Fish Restoration Projects (WSFR), many conservation actions in this Plan follow categories in Wildlife TRACS (Tracking and Reporting Actions for the Conservation of Species) (USFWS 2014; 2015). However, not all Wildlife TRACS categories fully encompass the scope of conservation actions required for this Plan, or at the regional scale. Therefore, we also have adopted conservation actions described by the International Union for Conservation of Nature (IUCN) Hierarchical Action Classification System (Salafsky et al. 2008). Both Wildlife TRACS and the IUCN classification systems are considered national "best practices" by the Association of Fish and Wildlife Agencies (AFWA 2012). For conservation actions to be effective, the National Best Practices Report (AFWA 2011b; AFWA 2012) identified "a need for more specificity with regard to on-the-ground actions." During development of the Northeast Lexicon (Crisfield 2013), *S.M.A.R.T* implementation goals (Doran 1981; Table 4.1) were recognized as an approach to clarify descriptions of conservation actions, bringing into consideration the recommendations of AFWA (2012).

Table 4.1. S.M.A.R.T. attributes for planning. (Adapted from Doran 1981).

Specific	Target a specific area for improvement
Measurable	Quantify or suggest an indicator of progress
Assignable	Specify who will do it
Realistic	Results can realistically be achieved, given available resources
Time-bound	Specify when results can be achieved.

Additionally, *Action Descriptors* based on *S.M.A.R.T.* planning are well-aligned with the conservation action development process outlined in the Conservation Measures Partnership's Open Standards for the Practice of Conservation (CMP 2013). Steps 1 and 2 are the basis for developing conservation actions (Fig. 4.1) with Steps 3, 4, and 5 relevant to implementing conservation actions and monitoring outcomes, discussed in Required Elements 4 and 5 of the Northeast Lexicon (Crisfield 2013). When feasible, addressing these components can improve the likelihood of project success.

Fig. 4.1. Adaptive Management Cycle. Conservation Measures Partnership (CMP 2013).

A complete description of a proposed action (Crisfield 2013) includes:

- Who is responsible for the action?
- What will be done, with what benefits?
- When and where it will be done?
- How will the desired results be achieved?
- How will progress be measured?
- Why will the action be taken?

Throughout the discussions of conservation actions in this Plan we strive to provide this specificity. Fulfilling Required Element 4 (Conservation Actions), these conservation actions have been prioritized by species or taxonomic group (Chapter 1, Species; Appendix 1.4).

State Wildlife Action Plans encompass a wide range of species, habitats, and threats and such conservation action descriptions must be adaptable. All conservation actions can be classified and named using one naming convention, but not all conservation actions can be fully described using the prompts provided in the Northeast Lexicon (Crisfield 2013). Conservation actions often involve on-the-ground management practices, yet many conservation actions have been proposed that do not involve direct intervention. For example, incentives can be used to encourage proper land stewardship through voluntary participation by landowners in easement agreements. In other situations, outreach initiatives can inform the public and partners about species and their habitats. In some cases, lack of knowledge

about species' requirements inhibits planning or implementing more tangible actions, thus requiring research or survey actions to fill information gaps.

In this chapter, we describe conservation actions that may be implemented for this Plan. More thorough discussion of conservation actions for Species of Greatest Conservation Need (SGCN) and their Habitats, locations for implementing conservation actions, and prioritization are found in Chapter 1 and Appendix 1.4.

Conservation Action Classification System

The 2015 Pennsylvania Wildlife Action Plan adopts the Wildlife TRACS action classification system as described in the Northeast Lexicon, with a small number of amended categories. The Wildlife TRACS system is sufficiently broad in scope to incorporate the many actions required to address threats encountered in Pennsylvania and the northeast region, yet provide an appropriate level of detail to allow effective implementation. The system is hierarchical, with three tiers. The top two tiers are used in this Plan (Table 4.2). Additional conservation actions, though not eligible for State & Tribal Wildlife Grants funding, are included in this list because they are considered important for Plan implementation.

Table 4.2. Standardized Conservation Action codes and narrative description categories adapted from Wildlife TRACS (USFWS 2014; 2015; Salafsky 2008).

TRACS Level 1 Code	TRACS Level 1	TRACS Level 2 Code	TRACS Level 2
1	Coordination and Administration	1.1	Coordination and Administration
		1.2	Incentives
2	Direct Management of Natural Resources	2.1	Create new habitat or natural processes
		2.2	Dam and barrier removal
		2.3	Fire management
		2.4	Fish and wildlife habitat structures
		2.5	Grazing/farm management
		2.6	Hazard or infrastructure removal
		2.7	Instream modification
		2.8	Invasive species control
		2.9	Living shorelines
		2.10	Planting/seeding
		2.11	Vegetation management
		2.12	Water management
		2.13	Wildlife damage management
		2.14	Wildlife disease management

TRACS Level 1 Code	TRACS Level 1	TRACS Level 2 Code	TRACS Level 2
3	Data Collection and Analysis	3.1	Database development and management
		3.2	Research, survey or monitoring - fish and wildlife populations
		3.3	Research, survey or monitoring - habitat
		3.4	Research, survey or monitoring - utilization
		3.5	Techniques development
4	Education	4.1	Educator/Instructor training
5	Facilities and Areas	5.5	Cooperatively managed areas for hunting
		5.6	Fish passage facilities
		5.7	Fish screening and related facilities
		5.8	Hatcheries
		5.15	Wildlife Management Areas
6	Land and Water Rights Acquisition and Protection	6.1	Land acquisition
		6.2	Water rights acquisition
		6.3	Conservation area designation
		6.4	Private lands agreements
7	Law Enforcement	7.1	Law enforcement
8	Outreach	8.1	Partner/stakeholder engagement
9	Planning	9.1	Land use planning
		9.3	Species and habitat management planning
		9.4	State Wildlife Action planning
10	Species Reintroduction and Stocking	10.1	Native species restoration
		10.2	Production and stocking for recreational purposes
11	Technical Assistance	11.1	Environmental review
		11.2	Technical assistance
100[a]	Law and Policy	100.1	Legislation
		100.3	State Regulations
101[a]	Species Management	101.1	Species Management
102[a]	Partnerships	102.1	NGO

[a] Actions not part of Wildlife TRACS.

Conservation Action Description

The challenge of systematically labeling conservation actions is addressed through a set of descriptors in a conservation action template as discussed in the Northeast Lexicon (Crisfield 2013). For all conservation actions, the Northeast Lexicon recommends that states strive to provide, a name, objective, general strategy, and purpose (Table 4.3). This level of description is likely to be appropriate for all actions regardless of the readiness for implementation. For conservation action prioritization, the

purpose (identifying target species or habitats and threats), benefits, costs, urgency, and likelihood of success are common factors helpful for deriving maximum conservation benefit given limited funding. We included additional descriptors (e.g., reversibility, certainty) and provided the foundation for a detailed strategy (Chapter 1).

Table 4.3. Descriptors of conservation actions identified by Crisfield (2013) and used in Pennsylvania Wildlife Action Plan species accounts (Chapter 1, Appendix 1.4).

Lexicon Terminology	Content	Explanation
Name	The Action name is selected from Wildlife TRACS classification system (amended).	Uses the Wildlife TRACS classification system with hierarchical codes and includes amendments to incorporate actions from the IUCN system. Every action should be classified according to the amended Wildlife TRACS system at the most detailed a level possible.
Objective	Concise statement of the objective of the action.	An objective is "a specific, measurable, achievable, realistic, and time-limited statement that describes the desired short, medium, or long-term outcomes of a conservation action."
General Strategy	Concise description of the nature of the strategy for achieving the objective (This is analogous to Specific Action in the Species Accounts).	The strategy to address the objective should be described generally. (More detailed explanation can be provided in the answer to the question, "How?")
Purpose	Explains species or habitats that will benefit from the action and the threats mitigated.	Linking an action to a threat (Element 3), or action driver to the resource that will benefit such as target species (Element 1) or habitats (Element 2), provides a clear explanation of the motivation for the action and begins to reveal the results chain linking the strategy to the threat and the expected ecosystem response to mitigating the threat.
Benefits	Depending on the action, benefits may refer to habitat improvements, species' responses, reductions in threat risk, or public or stakeholder benefits.	These answers will likely be suggested by defining what the action is and why it is being taken. However, efforts to prioritize actions will probably require specific benefits to be considered. Answering this question clearly may also help define the measures of project success.

Estimated Costs	Several resources now are available to assist in estimating project costs. (One example is Naidoo et al. 2006.) States may, alternatively, use very coarse/relative estimates.	If action descriptions are intended to be used for action prioritization, cost estimates, even very rough ones, may be helpful. This should include total future costs in current dollar values, but not include any past expenses for infrastructure that will be used by proposed action. States may choose to simply categorize costs as High, Moderate, or Low. Estimates are available from business plans, Joint Ventures, and Partners in Flight. For prioritization purposes, states may choose to calculate cost/acre treated or cost/species to compensate for the fact that multi-species projects may be more expensive than single species projects. A very detailed process for action prioritization is described and evaluated in "Optimal Allocation of Resources among Threatened Species: a Project Prioritization Protocol" (Joseph et al. 2009).
Urgency	A relative estimate of the urgency of the action given the severity of the threats and the priority of the species or habitat.	The urgency of the action should be addressed by estimating the ideal timeframe for completing the action.
Likelihood of Success	• Has the action been implemented in other settings and with what results? • Is there uncertainty in the results chain? • Is there uncertainty in the cost? • Are there any risks or potential unintended consequences? • Are there constraints (e.g. political, land use)?	In general, this action description is meant to assess "feasibility" for the purposes of prioritization. This might identify areas where more information is needed to be sure that the action will work. It also can identify whether doing the action is a proven winner in other settings, but might be applied here.
Implementing Organization	Organizations or individuals responsible for implementing the action or partners who can assist.	If possible, an individual or agency responsible for managing the action could be identified. Partners that should be consulted or engaged could also be identified as could stakeholders.

Action Location	The location of the action may be described in terms of habitat types, conservation opportunity areas, geopolitical boundaries, watersheds, or more precise locations within these areas.	Aside from the habitat type, descriptions of where actions take place may include specific locations around the state, specific sites within a smaller locale, or any other geographical designation appropriate to the action. If the action requires monitoring, this description may complement the use of a standard protocol by defining the sampling strategy in a spatial context.

Best Practices for Conservation Actions

AFWA (2012) provides guidance to states on "best practices" to address each Required Element. For Conservation Actions, these include:

- Use the definitions and hierarchical classification in Salafsky et al.'s (2008) *A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions* to describe the general components of any given conservation project and categorize conservation actions.
- Use a hierarchical or tiered system to prioritize conservation actions.
- Design conservation actions to abate known threats and indicate metrics to measure effectiveness of conservation actions.
- Write conservation actions broadly enough to allow flexibility, yet with enough specificity to measure performance and engage partners.

In this Chapter, we use these "Best Practices" to describe the conservation actions in this Plan.

International Conservation Actions

Supporting sustainable populations of Pennsylvania's Species of Greatest Conservation Need (SGCN) requires partnerships and projects beyond the Commonwealth's state boundary. In the Northeast, this work has focused on Regional Species of Greatest Conservation Need (RSGCN) and their habitats, through support of initiatives such as the Regional Conservation Needs program and Landscape Conservation Cooperatives. Yet, many species, particularly birds, spend a majority of the year outside of the United States. This section, authored by Doug Gross (PGC), is an overview of Pennsylvania's conservation actions at the international scale to address full life-cycle conservation of these species.

Overview

A high percentage of birds, and to a lesser extent other animal taxa, migrate out of the states where they breed during some time of the year (Table 4.4). Birds typically move south to avoid the boreal winter, but species can exhibit other patterns. Thus, conservation actions taken only within a given state may not be adequate for long-term species conservation. States have considerable experience working with neighboring states on shared conservation issues, but fewer states have experience working with countries throughout the Western Hemisphere. Building international partnerships is crucial for addressing the conservation needs of migratory species throughout their annual cycle.

A quick perusal of the Eight Required Elements for State Wildlife Action Plans reveals our conservation strategies must extend beyond the boundaries of Pennsylvania for any Species of Greatest Conservation Need that is migratory. Species distribution (Element 1), conditions of key habitats (Element 2), descriptions of problems and priority research needs (Element 3), description of necessary conservation actions (Element 4), species and habitat monitoring needs (Element 5), plans for coordinating with federal agencies (Element 7), and plans for involving the public (Element 8) may involve not only other states, but also other countries. Generally, species are more concentrated on their wintering grounds than on their breeding grounds. Therefore, the loss of an acre (0.4 hectares) in Central America, South America, or the Caribbean region might be equivalent of losing 5 to 8 acres (2.0 to 3.2 hectares) in North American breeding habitat (Terborgh 1980). The many stressors for migratory birds have been well-discussed by scholars and researchers in popular scientific literature, alerting the interested public about issues facing both birds and people who live in the same habitats and rely on the same ecosystem functions (Terborgh 1989; Weidensaul 1999; Greenberg & Reaser 2007; Stutchbury 2007). For some SGCN, to protect our state investment, conservation will need to be accomplished outside of the country to address all the factors impacting them.

With advancing technologies, scientists are unraveling some of the mysteries of bird migration, including the connections between summer and wintering grounds, as well as the stopover points in-between. There are sometimes strong connections between summering grounds and wintering grounds, but not in all cases. Where there are stronger links between Pennsylvania and a wintering ground of a priority conservation species, there may be partnership opportunities to ensure successful implementation of conservation strategies. Focal areas for conservation can be prioritized and strategies devised as an international team. Appendix 4.1, Exhibit 1 outlines a procedure for bird species conservation outside the U.S. and provides examples of species appropriate for this approach.

Table 4.4. Migratory linkages for Pennsylvania Species of Greatest Conservation Need.

Common Name	Scientific Name	Wintering Range Destination or Origin of Passage for Winter Birds (Summer)
Lesser scaup	*Aythya affinis*	Canada (summer)
Long-tailed duck	*Clangula hyemalis*	Canada (summer)
Pied-billed grebe	*Podilymbus podiceps*	SE USA, Mexico, Central America
Horned grebe	*Podiceps auritus*	Canada (summer)
Red-necked grebe	*Podiceps grisegena*	Canada (summer)
American bittern	*Botaurus lentiginosus*	SE USA, Mexico, Central America
Least bittern	*Ixobrychus exilis*	SE USA, Middle America, Caribbean
Great egret	*Ardea alba*	SE USA, Middle America, Caribbean, South America
Black-crowned night-heron	*Nycticorax nycticorax*	S. USA, West Indies
Yellow-crowned night-heron	*Nyctanassa violacea*	S. USA, West Indies, Middle and South America
Osprey	*Pandion haliaetus*	West Indies, Central and South America

Common Name	Scientific Name	Wintering Range Destination or Origin of Passage for Winter Birds (Summer)
Broad-winged hawk	*Buteo platypterus*	Central America, but mostly NW South America
King rail	*Rallus elegans*	SE USA
Virginia rail	*Rallus limicola*	SE USA, Mexico
Sora	*Porzana carolina*	SE USA, Middle America, N. South America
Common gallinule	*Gallinula galeata*	SE USA, West Indies, Middle and South America
American coot	*Fulica americana*	S. USA, Middle America, West Indies
Piping plover (Great Lakes population)	*Charadrius melodus*	SE USA, West Indies
Spotted sandpiper	*Actitis macularius*	SE USA, Middle and South America
Upland sandpiper	*Bartramia longicauda*	Inland SE South America
Red knot	*Calidris canutusrufa*	Coast of South America
Wilson's snipe	*Gallinago delicata*	SE USA, Middle America, n. South America
American woodcock	*Scolopax minor*	SE USA
Black tern	*Chlidonias niger*	N. Coastal South America
Common tern	*Sterna hirundo*	South America
Long-eared owl	*Asio otus*	Canada (summer)
Short-eared owl	*Asio flammeus*	Canada (summer)
Common nighthawk	*Chordeiles minor*	South America
Eastern whip-poor-will	*Antrostomus vociferus*	Central America, West Indies
Chimney swift	*Chaetura pelagica*	South America
Peregrine falcon	*Falco peregrinus*	West Indies, Central and South America
Olive-sided flycatcher	*Contopus cooperi*	N. and W. South America
Yellow-bellied flycatcher	*Empidonax flaviventris*	NE Mexico to Panama
Willow flycatcher	*Empidonax traillii*	Yucatan, Central America
Purple martin	*Progne subis*	South America, mostly Amazon
Bank swallow	*Riparia riparia*	Central South America
Brown creeper	*Certhia americana*	SE USA
Winter wren	*Troglodytes hiemalis*	SE USA
Sedge wren	*Cistothorus platensis*	SE USA, Mexico
Marsh wren	*Cistothorus palustris*	SE USA
Swainson's thrush	*Catharus ustulatus*	W. South America
Wood thrush	*Hylocichla mustelina*	Middle America, mostly Honduras and n. Nicaragua
Gray catbird	*Dumetella carolinensis*	Florida and West Indies, Central America
Louisiana waterthrush	*Parkesia motacilla*	Middle America, Caribbean, N. South America

Common Name	Scientific Name	Wintering Range Destination or Origin of Passage for Winter Birds (Summer)
Northern waterthrush	*Parkesia noveboracensis*	Middle America, NW South America
Golden-winged warbler	*Vermivora chrysoptera*	Central America and NW South America
Blue-winged warbler	*Vermivora cyanoptera*	S. Mexico to Panama
Black-and-white warbler	*Mniotilta varia*	Middle America, West Indies, NW South America
Prothonotary warbler	*Protonotaria citrea*	Yucatan, Central America, and N. South America
Nashville warbler	*Oreothlypis ruficapilla*	Mexico and N. Central America
Kentucky warbler	*Geothlypis formosa*	S. Mexico, Central America, NW South America
Hooded warbler	*Setophaga citrina*	E. Mexico through Panama
Cerulean warbler	*Setophaga cerulea*	NW South America
Blackburnian warbler	*Setophaga fusca*	Canada, N. USA (Summer), NW South America
Blackpoll warbler	Setophaga striata	NW South America
Black-throated blue warbler	*Setophaga caerulescens*	West Indies
Prairie warbler	*Setophaga discolor*	Florida, West Indies, Central America
Black-throated green warbler	*Setophaga virens*	West Indies, E. Mexico to NW South America
Canada warbler	*Cardellina canadensis*	NW South America
Yellow-breasted chat	*Icteria virens*	Middle America
Eastern towhee	*Pipilo erythrophthalmus*	Canada, N. USA (Summer)
Field sparrow	*Spizella pusilla*	SE USA, Mexico
Vesper sparrow	*Pooecetes gramineus*	SE USA, Mexico
Savannah sparrow	*Passerculus sandwichensis*	SE USA, Mexico, Bahamas, West Indies
Grasshopper sparrow	*Ammodramus savannarum*	SE USA, N. Central America
Summer tanager	*Piranga rubra*	Middle America, NW South America
Scarlet tanager	*Piranga olivacea*	W. South America
Dickcissel	*Spiza americana*	N. South America
Bobolink	*Dolichonyx oryzivorus*	S. South America
Eastern meadowlark	*Sturnella magna*	SE USA and Mexico
Rusty blackbird	*Euphagus carolinus*	Canada , N. USA (summer)
Red crossbill	*Loxia curvirostra*	Canada, N. USA (summer)
Pine siskin	*Spinus pinus*	Canada, N. USA (summer)

Regional Conservation Actions

Regional Conservation Needs Program

Adapted from Terwilliger Consulting & NEFWDTC (2013).

Shared responsibilities of species and habitat by northeastern states have engendered a culture of cooperative and complementary management approaches. The Northeast Association of Fish and Wildlife Agencies (NEAFWA) has traditionally supported a strong technical committee structure to advance regional wildlife conservation. These species- or habitat-focused groups, and technical committees, exchange ideas and develop common approaches to wildlife issues. Typically, actions are implemented by individual states using their own funds; however, in some cases, additional funding has been made available at the discretion of NEAFWA leadership (i.e., State Agency Directors).

This regional collaboration has been recognized formally, and is financially supported, through the Regional Conservation Needs (RCN) Program. This cooperative approach across multiple states addresses Species of Greatest Conservation Need (SGCN) concerns. The purpose of the RCN program is to develop, coordinate, and implement conservation actions that are regional/sub-regional in scope, and build upon the many regional current initiatives. Funding for the RCN program is generated by an annual 4% allocation of State Wildlife Grant Funds from all northeast states and the District of Columbia, creating a base funding for regional projects. This collaboration also is supported by the Landscape Conservation Cooperatives (LCCs), especially the North Atlantic LCC (NALCC), Appalachian LCC (APPLCC) and Upper Midwest Great Lakes LCC (UMGLLCC) within the northeast regional boundaries.

Since 2007, when the program was established, 37 RCN projects have been, or currently are, funded (www.RCNgrants.org). “Data Collection and Analysis” (TRACS Level 1 Code: 3) (Table 4.5) has been a conservation action towards which many regional projects have been directed. Emphasis on this conservation action has been driven by the need to more thoroughly evaluate critical processes and emerging issues, such as diseases and climate change, at the multi-state scale. Projects not encompassing the entire northeast region typically are designed for relevancy to states not specifically within the study area. Although “insufficient information” is not a threat specifically identified by Salafsky et al. (2008), we have noted it (Chapter 3) because “lack of data” can be an indirect threat to developing and implementing effective conservation actions. Thus, these projects help to address crucial data gaps.

Threats at the regional scale (Chapter 3) can imperil Pennsylvania’s SGCN and habitats. In Goal 3 of this Plan it is recognized that Pennsylvania has a regional responsibility for species occurring beyond its boundaries.

Table 4.5. Conservation actions and regional threats addressed through projects sponsored by the Regional Conservation Needs Grants Program, North Atlantic Landscape Conservation Cooperative (LCC) and Appalachian LCC. (Adapted from Terwilliger Consulting & NEFWDTC 2013).

TRACS Action Category Level 1	TRACS Action Level 1	Threat Code Level 1	Threat Description	Threat Addressed	Projects
3	Data Collection and Analysis	1; 4	Residential and Commercial Development; Transportation and Service Corridors	Land use-urban and industrial development	RCN Grant 2007-05; RCN Grant 2008-02; RCN Grant 2008-03 RCN Grant 2011-06; NALCC_2011_04
		7	Natural Systems Modifications	Water Quality, Water Quantity and Aquatic Connectivity	RCN Grant 2010-02; RCN Grant 2007-02.
		8	Invasive and Other Problematic Species, Genes and Diseases	Invasive Species	RCN Grant 2007-03
				Wildlife Diseases (e.g., White nose Syndrome, Ranavirus)	RCN Grant 2007-09; RCN Grant 2010-01; RCN Grant 2012-1
		11	Climate Change and Severe Weather	Climate Change-Vulnerability of species and habitats	NALCC_2011_05; NALCC_2010_02;
		4	Energy Production and Mining	Energy Development (e.g., biomass, off-shore wind)	RCN Grant 2007-07; NALCC_2011_07
				Insufficient Data (Species and Habitat Monitoring)	Monitoring and Performance Reporting 2008; RCN Grant 2007-05;
				Insufficient Data (Vernal Pool Mapping)	NALCC_2013_03
				Insufficient Data (Coastal Wetland Mapping)	NALCC_2012_05
				Insufficient Data (Landscape Permeability)	NALCC_2011_04
				Insufficient Data (Stream Temperature)	NorEast Stream Temperature Mapper (beta version)

For the 2015 Pennsylvania Wildlife Action Plan, it is difficult to anticipate specific conservation actions that may be implemented as part of regional initiatives during the next 10 years. Regional needs are identified by the Northeast Fish and Wildlife Diversity Technical Committee (NFWDTC) and approved by NEAFWA Directors, and thus are not under the direct control of Pennsylvania. Performance measures for conservation actions also may vary depending upon specific project requirements. Yet, all regional conservation actions would be expected to follow the Northeast Lexicon (Crisfield 2013) or update. Where projects involve Pennsylvania SGCN and habitats, we anticipate activities developed by the NEFWDTC will be aligned with Pennsylvania conservation actions, more fully described in this Plan. For those projects, where this consistency is not observed, we will use the most relevant regional conservation actions and associated performance measures. With direct importance to Pennsylvania's SGCN and habitats, we will continue to work with the NEFWDTC to develop and implement conservation actions in the northeast region. This regional collaboration will be conducted with input from multiple parties, especially federal partners, NEAFWA Directors, State Wildlife Action Plan coordinators and other members of the NEFWDTC, RCN project leaders, and relevant Non-governmental Organizations (NGOs).

Regional Action

The Regional Conservation Needs (RCN) Program formalizes a cooperative approach to address SGCN needs across multiple states. The purpose of the RCN program is to develop, coordinate, and implement conservation actions that are regional or sub-regional in scope, and builds upon many current regional initiatives. The RCN program uses a funding mechanism that is equitable to all northeast states and the District of Columbia, creating a funding base for regional projects.

This action will develop and implement conservation actions for issues, threats, and opportunities that are most effectively addressed at a regional and multi-state scale. These actions will include partners involved in creating and implementing State Wildlife Action Plans.

Anticipated Benefit(s):
The RCN program will provide information and support management activities to help secure Pennsylvania's Species of Greatest Conservation Need and Regional Species of Greatest Conservation Need (RSGCN).

Performance Measures:

- Number of conservation action/research projects selected and completed.
- Number of articles, publications, and technical reports developed annually from funded projects.
- Number of completed projects addressing specific information or management needs (i.e., needs identified by the NEFWDTC) for Regional Species of Greatest Conservation Need (RSGCN).

Action Leader(s):
Northeast Fish and Wildlife Diversity Technical Committee, USFWS, State Wildlife Action Plan coordinators and Natural Diversity Program leaders, Wildlife Management Institute.

Species associated with Regional Conservation Action:
This Regional Conservation Action will be directed to support the most current list of RSGCN.

Pennsylvania Conservation Actions

A broad range of conservation actions will be required to fully implement this Plan. This Section describes Level 1 and Level 2 Wildlife TRACS Conservation Action categories and additional IUCN conservation action categories not encompassed by Wildlife TRACS. These descriptions include:

- A description of the conservation action
- Why the conservation action would be taken
- Pennsylvania examples
- Anticipated benefits
- Measures of progress
- Partners that could lead this conservation action

Taxonomic or species-specific conservation actions, including species prioritization, and detailed descriptions of conservation actions are found in Chapter 1, Appendix 1.4 (Species Accounts). In this chapter, we include summary tables of species and associated Level 1 Conservation Action Categories (Appendix 4.2, Exhibits 1-7). Importantly, species beyond those identified in these tables may benefit from a conservation action. Further, environmental conditions and needs of species are likely to change during the next 10 years, and for its viability, this Plan must be adaptable. Therefore, conservation actions currently identified for specific SGCN may require review in the context of future conditions and species needs, to determine if additional or alternative conservation actions may be beneficial for SGCN and their habitats.

To illustrate potential use of these Conservation Action Categories we associated Level 2 Conservation Actions with the goals of the Plan (Table 4.6). Actual use of conservation actions to address the goals, objectives and strategies will be contingent on the target SGCN, habitats, purpose and intended outcome for specific projects.

This part of page intentionally blank.

Table 4.6. Projected relationship of conservation action categories to Goals of the 2015 Pennsylvania Wildlife Action Plan.

Action Category	Action Category	Goal[a]	1	2	3	4	5	6
Level 1	**Level 2**							
1 - Coordination and Administration	1.1 Coordination and Administration		●	●	●	●	●	●
	1.2 Incentives		●					
2 - Direct Management of Natural Resources	2.1 Create New Habitat or Natural Processes		●					
	2.2 Dam and Barrier Removal		●					
	2.3 Fire Management		●					
	2.4 Fish and Wildlife Habitat Structures		●					
	2.5 Grazing/Farm Management		●					
	2.6 Hazard or Infrastructure Removal		●					
	2.7 Instream Modification		●					
	2.8 Invasive Species Control		●					
	2.9 Living Shorelines		●					
	2.10 Planting/Seeding		●					
	2.11 Vegetation Management		●					
	2.12 Water Management		●					
	2.13 Wildlife Damage Management		●					
	2.14 Wildlife Disease Management		●					
3 - Data Collection and Analysis	3.1 Database Development and Management			●			●	
	3.2 Research, Survey or Monitoring-Fish and Wildlife Populations		●	●		●		
	3.3 Research, Survey or Monitoring - Habitat		●	●		●		
	3.4 Research, Survey or Monitoring-Utilization			●		●		
4 - Education	4.1 Educator/Instructor Training					●		●
5 - Facilities and Areas	5.5 Cooperatively Managed Areas for Hunting		●					
	5.6 Fish Passage Facilities		●					
	5.7 Fish Screening and Related facilities		●					
	5.8 Hatcheries		●					
	5.15 Wildlife Management Areas		●					
6 - Land and Water Rights Acquisition and Protection	6.1 Land Acquisition		●					
	6.2 Water Rights Acquisition		●					
	6.3 Conservation Area Designation		●					
7- Law Enforcement	7.1 Law Enforcement						●	
8 - Outreach	8.1 Partner/Stakeholder Engagement					●	●	●

Action Category	Action Category	Goal[a]	1	2	3	4	5	6
9 - Planning	9.1 Land-Use Planning						●	
	9.3 Species and Habitat Management Planning		●	●		●	●	
10 - Species Reintroduction and Stocking	10.1 Native Species Restoration		●					
	10.2 Production and Stocking for Recreational Purposes		●					
11 - Technical Assistance	11.1 Environmental Review		●					
	11.2 Technical Assistance		●			●		
100 - Law and Policy	100.1 Legislation					●		
	100.3 State Regulations					●		
101 - Species Management	101.1 Species Management		●					
102 - Partnerships	102.1 Non-Governmental Organizations (NGO)					●	●	●

[a]Goal 1. Conserve Pennsylvania's native wildlife and its habitat by implementing conservation actions in the Wildlife Action Plan.
Goal 2. Base wildlife conservation decisions on the best available science, with an emphasis on Species of Greatest Conservation Need and their habitat.
Goal 3. Contribute to range-wide conservation of Species of Greatest Conservation Need.
Goal 4. Strengthen the state's capacity to conserve Pennsylvania's native wildlife.
Goal 5. Continue to improve cooperation within and between public agencies and other partners in wildlife conservation planning and implementation.
Goal 6. Develop a knowledgeable citizenry that supports and participates in wildlife conservation.

1.0. Coordination and Administration

Action Level 2

1.1. Coordination and administration

The administrative structure for revising the 2005 Pennsylvania Wildlife Action Plan provides a framework to coordinate implementing the 2015 Pennsylvania Wildlife Action Plan, and its eventual revision by 2025. We anticipate the State Wildlife Action Plan Steering Committee, Advisory Committee and Pennsylvania Biological Survey Technical Committees (PABS) will remain engaged during Plan implementation. With species and habitats enduring dynamic ecological conditions, it also is foreseen that current *ad hoc* committees and, as needed, new committees, may be convened to provide technical support for current and emerging issues. Implementing and revising the 2015 Pennsylvania Wildlife Action Plan are expected to require coordination at multiple scales including; local, regional (Pennsylvania), statewide, northeast region, nationally, and internationally.

Coping with specific threats (Chapter 1, Appendix 1.4) is anticipated to involve multiple agencies (all levels), organizations, private partners and landowners. This coordination may be necessitated by environmental reviews, where the entities involved are anticipated to vary with specific issues. This coordination may include: workshops, meetings, site-visits, conference calls, and electronic correspondences.

Administratively, implementing the 2015 Pennsylvania Wildlife Action Plan will extend beyond the administrative structure for Plan revision and will include support from PGC and PFBC Federal Assistance staff. Administering grant programs and projects that support implementation will contribute to Plan success.

Anticipated Benefit(s):
Coordination and Administration activities will foster implementing Conservation Actions, Monitoring and other activities in this Plan.

Performance Measure(s):
- Number of meetings convened.
- Number of workshops held.
- Number of decisions that lead to identified outputs or outcomes.
- Number of grants administered.
- Number of grants completed.

Action Leader(s):
PGC, PFBC

1.2. Incentives

Programs that provide direct incentives are crucial for landowner participation in conservation initiatives. Historically, for receipt of an incentive, landowners have been required to alter land-use practices (e.g., change from row-crop to forested land use) for the benefit of habitats or species. Incentives also can include voluntary easements where the landowner grants partial property rights for the benefit of species and habitats. These voluntary programs vary in the types and amounts of incentives offered, habitat or species eligibility, duration of incentives, and types of incentives which may include direct cash payments or technical assistance. For example, PGC and PFBC programs offer technical assistance to landowners (Table 4.7) in support of their respective trust species and habitats. Other agencies, such as the U.S. Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS) and USDA-Farm Service Agency (FSA), offer both financial and technical incentives to landowners for numerous resource concerns. For example, $2.7 million was directed in 2013 for Wildlife Habitat Incentive Program activities.

In 2014, USDA-FSA (Pennsylvania) directed $2.1 million to the Conservation Reserve Enhancement Program (CREP) and $126,000 to the Conservation Reserve Program (James Gillis, USDA-NRCS personal communication). For the broad range of conservation programs it administers, in 2014, the Pennsylvania USDA-NRCS funded approximately $35 million in projects to address vital resource concerns (Barry Frantz, USDA-NRCS personal communication) (excludes Conservation Reserve Program-CRP and CREP administered by NRCS-FSA).

In the years this Plan will be implemented (2015-2025), these programs and their requirements will be subject to modification, and new programs may become available. Thus, it is expected that a current comprehensive list of programs would likely become out-of-date during the next 10 years. We therefore, provide examples of programs that currently support this conservation action (Table 4.7).

Through programs such as Working Lands for Wildlife (WLFW) and Wetlands Reserve Enhancement Program (WREP) the focus may be specific SGCN and their habitats. Other programs (e.g., Conservation Reserve Enhancement Program-CREP, Environmental Quality Incentives Program-EQIP) support habitat enhancements that may not directly target SGCN, yet provide environmental benefits, such as reduced soil erosion or enhanced habitats beneficial to SGCN.

Incentives supporting SGCN and their habitats may be offered by numerous agencies and non-governmental organizations, and the agencies mentioned here are not intended to be comprehensive for this conservation action. Rather, these examples demonstrate that incentives have been available from a variety of sources, and are expected to be an important conservation action for the 2015 Pennsylvania Wildlife Action Plan.

Anticipated Benefit(s):
Incentives, either through technical or financial assistance, support habitat improvements that can directly or indirectly benefit SGCN.

Performance Measure(s):
- Number of landowner agreements.
- Number of acres (river miles) managed through incentive programs.
- Target species population metrics (e.g., breeding pairs, relative abundance) on unmanaged and managed lands or waters, directly measured or modeled.

Action Leader(s):
PGC, PFBC, USDA-NRCS, USDA-FSA, USFWS, other federal and state agencies, NGOs, and private foundations.

This part of page intentionally blank.

Table 4.7. Examples of incentive programs important for Pennsylvania's Species of Greatest Conservaiton Need and habitats.

Program	Agency	Target(s)	SGCN Benefitting
Private Lands Assistance Program (PLAP)	PGC	Multiple (e.g., forests, grasslands, wetlands)	Multiple birds and mammals
Cooperative Habitat Improvement Program (CHIP) and Technical Assistance Program (TAP)	PFBC	Rivers and Streams	Multiple aquatic species
Conservation Reserve Enhancement Program (CREP)	USDA-FSA	Multiple (e.g., grasslands, forests riparian zones)	Multiple
Conservation Reserve Program (CRP)	USDA-FSA	Multiple (e.g., grasslands, forests riparian zones)	Multiple
Environmental Quality Incentives Program (EQIP)	USDA-NRCS	Water Quality and Wildlife Habitat	Eastern brook trout, Multiple
Wetland Reserve Enhancement Program (WREP)	USDA-NRCS	Wetlands	Bog turtle
Working Lands for Wildlife (WLFW)	USDA-NRCS	Habitat enhancement for targeted species	Golden-winged warbler, bog turtle

2.0. Direct Management of Natural Resources

Action Level 2

2.1. Create new habitat or natural processes

Creating new habitats can be a useful conservation action, but specific management actions will be contingent upon initial condition of the property, target species and their habitat needs. This conservation action may be applicable where native habitats have been degraded or eliminated as an outcome of the many threats identified in Chapter 3. Availability of this conservation action does not imply that habitats should be intentionally degraded with expectations they can be recovered. However, when habitats are degraded and opportunities are available for their enhancement, this conservation action may be an option.

For the 2005 Pennsylvania Wildlife Action Plan this conservation action was used to develop the Piney Tract Important Bird Area Grasslands Management Site (PGC 2011) and subsequent management of the acquired property. This property has been named a Globally Important Bird Area due to the large breeding populations of grassland birds supported by the site. These 2,254.62 acres (912.4 hectares) now support populations of Henslow's sparrow (*Ammodramus henslowii*), grasshopper sparrow (*Ammodramus savannarum*) and Savannah sparrow (*Passerculus sandwichensis*), is an occassional

breeding area for the state-listed short-eared owl (*Asio flammeus*) and upland sandpiper (*Bartramia longicauda*).

Anticipated Benefit(s):
Creating new habitats increases foraging, breeding, resting and nesting opportunities for SGCN. Specific SGCN benefitting will be contingent on the habitat type and quality, and availability of populations to expand to the newly created habitat.

Performance Measure(s):
- Number of acres or river miles converted from an initial habitat to a target habitat.
- Population metrics (e.g. population, nest success) of target species measured directly or modeled.
- Habitat metrics (e.g. quality, fragmentation) measured directly or modeled.

Action Leader(s):
PGC, PFBC, NGOs.

2.2. Dam and Barrier Removal

Dams, culverts and other manmade barriers contribute to habitat fragmentation for aquatic organisms. In Pennsylvania this fragmentation is extensive with an estimated 3,500 dams (PADEP 2015d). Yet Pennsylvania is among national leaders in dam removal with approximately 250 dams removed since 1996 resulting in the opening of over 1,000 miles of rivers and streams. Success of this effort is attributable to the enduring collaboration among federal, state and local agencies and non-profit partners, which has resulted in an efficient and effective dam-removal process, and the ability to provide technical and financial support to dam owners.

The PFBC takes into account several factors when considering a dam for removal, among them is recognition that owners of dams have sole discretion of removal, operation and maintenance of their dam. As a result, the PFBC must work opportunistically and proactively to identify dams with potential for removal and prioritize dam-removal projects that are developed. When a dam is identified for potential removal, staff and project partners work with the landowner to determine their level of interest.

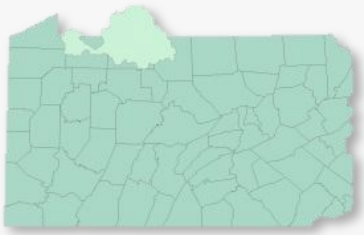
Decision-support tools available to the agency and the public help determine which projects are likely to achieve the greatest ecological benefits. The same support tools may be used to rank projects within the available opportunities. The Pennsylvania Dam Removal Program works proactively to develop the best projects, funds the most beneficial projects within the available dam removal opportunities, and declines assistance to projects that have limited potential benefit to aquatic resources.

Although the emphasis of this conservation action is dam removal, a compatible activity would be re-designing and installing culverts and other instream structures, to allow fish passage.

Pennsylvania Wildlife Action Plan

CASE STUDY: Dam Removal as a Habitat Restoration Tool

Ben Lorson, Fish Passage Biologist, Habitat Division
Pennsylvania Fish and Boat Commission



Project Location

Skinner Creek, Tributary to the Upper Allegheny River, McKean County, Pennsylvania.

Purpose

Remove the obsolete Old Skinner Dam that interrupted natural stream function, degraded instream habitat, and blocked fish movement.

Species of Greatest Conservation Need

Burbot (*Lota sp. of lota*) (Allegheny), eastern brook trout (*Salvelinus fontinalis*).

Project Purpose

The Skinner Creek dam was one of four dams built during the Civilian Conservation Corps Era (1933-1942) and served as a public water supply to the Borough of Port Allegany. These dams were abandoned for that use in the 1970s due to bacterial contamination. Pre-project electrofishing (2011) yielded 9 fish species below the dam and 5 species above the dam. Eastern brook trout were collected both below and above the dam and 24 burbot were collected below the dam, but none above the dam. The project was completed in 2013 and follow-up fish sampling is anticipated for 2016 or beyond.

Credit: American Rivers, Lisa Hollingsworth-Segedy

Partners

- PFBC, American Rivers, PGC, Port Allegany Borough.
- The PFBC Fish Passage Biologist, funded through a State & Tribal Wildlife Grant Project (T-09), provided technical and administrative support, and general coordination to facilitate project implementation. Additional funding was provided by PFBC's Sinnemahoning Creek Watershed Restoration Grant Program.

Reference

Hollingsworth-Segedy 2013

Anticipated Benefit(s):

Dam and barrier removal reduces habitat fragmentation, improves physical habitat and water quality and enhances opportunity for SGCN movement in rivers and streams.

Performance Measure(s):

- Number of dams removed.
- Number of connected river miles.
- Target species population metrics (e.g., relative abundance) measured directly or modeled.

Action Leader(s):

PFBC, PADEP, USACOE, NGOs.

2.3. Fire Management

Prescribed burns (i.e., ecological restoration burns) are crucial to maintain oak forests, scrub oak-pitch pine communities, various barrens, savannas, open woodlands and native grass communities (Brose et al. 2014). Fire-dependent habitats, such as scrub-oak barrens, also can support rare animals and insects (Wagner et al. 2003; Orndorff and Coleman 2008; Leuenberger et al. 2016). Land managers employ fire in controlled situations to promote healthy natural systems; a series of low-intensity fires can thin crowded forests, resulting in less severe disease and pest outbreaks (TNC et al. 2015). Fire promotes native grasses and wildflowers and helps to regenerate oaks, which in turn increases wildlife populations. Controlled burns also reduce leaf litter and woody fuels that increase wildfire intensity. Fire, in the right place at the right time, is a land-management tool that can offer numerous benefits for wildlife.

Many plant and animal species respond favorably when fire is introduced into their habitat. Fire benefits upland oak-hickory forests, woodlands, and pine-oak savannahs by increasing the sunlight reaching the ground and promoting seed germination. Periodic fires reduce competition of fire-intolerant species such as maples, beech, and white pine. Over time, upland oaks and pines gradually disappear from the landscape unless this competition is reduced. Studies of forest history show fire- intolerant species were uncommon on these upland areas prior to fire suppression (TNC et al. 2015). Historical records also indicate some plants and animals difficult to find in the Appalachians today were once commonly found. When fire is reintroduced, plants sometimes reappear where they have not been recorded in decades.

The controlled use of fire, under the direction of skilled resource managers, promotes wildlife and healthy forests (TNC et al. 2015).

Pennsylvania Wildlife Action Plan

CASE STUDY: Habitat Restoration Using Prescribed Fire

Benjamin C. Jones, PhD
Chief, Habitat Planning & Development Division
Pennsylvania Game Commission

Project Location: Statewide on public and private lands

Species of Greatest Conservation Need/Priority Habitat affected

Fire exclusion/suppression was cited as a threat to six key habitats in Pennsylvania's 2005 State Wildlife Action Plan. The majority of bird and mammal SGCN are associated with one or several of these habitats. As such, pursuit of an active fire management program (i.e., prescribed fire) was a Level 1 Action, the highest priority level over the plan's first five years. Fire was discussed under the following key habitats for the listed reasons:

- ***Forest*** (Deciduous, Mixed, Conifer),

  The lack of fire, a natural and historic disturbance factor, was among a list of factors responsible for lack of forest regeneration, changes in forest species composition, and changing forest structure and forest health. All to the detriment of many species of greatest conservation need.

- ***Grasslands***

  Fire is an important disturbance factor for maintaining herbaceous openings and meadows, and prescribed fire can be an effective tool to prevent woody encroachment in grasslands. Used on a large scale, fire can be more cost-effective than mowing and herbicide treatments in the maintenance of grasslands.

- ***Barrens***

  Suppression of fire is a threat to these rare Pennsylvania habitats. Throughout the northeastern U.S., barrens habitats are in decline as a result of development, forest maturation, and fire suppression. Many of the species that depend on the barrens also are declining, including suites of shrubland birds and several mammals.

- ***Shrublands/Thickets***

  Fire control [and intensive trapping of beavers] in the remaining large patches of forest have been factors decreasing the amount of suitable habitat for shrubland and gap-associated SGCN.

Project Purpose

To restore fire, a natural disturbance factor, to key habitats so they can be reclaimed, improved, and maintained for the benefit of SGCN and other wildlife.

Project Description

When our first Wildlife Action Plan was published, there were managers who believed that fire's wildlife habitat benefits were applicable to Pennsylvania. Less than 1,000 acres of prescribed fire were being implemented statewide at that time with the greatest hurdle a state law defining criminal and civil liability for burn managers if a fire escaped. In 2006, scattered fire enthusiasts began to coalesce around an effort to change the law. With documented support from our Wildlife Action Plan, statements such as, "significant loss of this Commonwealth's biological diversity will occur if fire is excluded from fire-dependent and fire-adapted communities" found their way into the 2009 Prescribed Burning Practices Act. With the new law's liability protection, habitat managers began planning burns in areas that hadn't seen fire for many decades. The Wildlife Action Plan was relied upon in press releases and public meetings to bolster fire's role in wildlife habitat management.

Around the same time, the Game Commission partnered with The Nature Conservancy on a State Wildlife Grants project, *Management Guidelines for Barrens Communities in Pennsylvania* (February 2008). The document was clear in its fire prescription and the grim outlook under continued fire exclusion. Realizing that plans and guidelines alone wouldn't conserve key habitats and SGCN, program managers at the Game Commission and Nature Conservancy began devising an implementation plan. The outcome was an on-going partnership (financed through Pittman-Robertson funds) that has resulted in 16,700 acres burned since 2009, hundreds of trained burn-crew members, and a network of fire managers that extends beyond Pennsylvania up and down the Appalachians. With a strong fire program base established, we're striving to burn 20,000 acres annually by the year 2020. Of course, support through the 2015 Wildlife Action Plan revision will be imperative in this endeavor.

Project Partners

Project Partners include the Pennsylvania Game Commission, The Nature Conservancy, Fort Indiantown Gap National Guard Training Center, Pennsylvania Department of Conservation and Natural Resources, US Fish & Wildlife Service, the National Park Service and the Pennsylvania Prescribed Fire Council.

Before and After – This eastern Pennsylvania dry oak ridgetop habitat (left) with fire excluded for over 60 years is choked with fire intolerant trees and shrubs including red maple and mountain laurel, resulting in poor habitat. (Ben Jones PGC photo, December 2010). The same site (right), two years after a habitat restoration fire. A pitch pine-oak savanna with scrub oak rejuvenated. Excellent wildlife habitat! (Ben Jones PGC photo, May 2015).

Anticipated Benefit(s):
In areas where ecological succession is to be controlled, prescribed burning promotes healthy ecosystems for a wide range of forest, woodland, savannah and grassland SGCN.

Performance Measure(s):
- Number of acres burned annually by habitat type (e.g., oak-forest, barrens, grasslands).
- Difference in pre- and post-burn target species population metrics (e.g., species richness) measured directly or modeled.

Action Leader(s):
PGC, TNC, Department of Military and Veterans Affairs-Ft. Indiantown Gap, National Park Service, PADCNR-Bureau of Forestry, PADCNR-Bureau of State Parks, Pennsylvania Prescribed Fire Council.

2.4. Fish and Wildlife Habitat Structures

Loss of natural structures, or impediments to animal movement, can suppress wildlife populations. Artificial structures may replace or supplement available habitat. In some cases (e.g., bat gating), structures also provide protection from human intrusion or may protect against invasive species. Provided here are descriptions of commonly used structures that have been, and are anticipated to be, used to support SGCN. However, during Plan implementation, additional types of structures may be applied to address case-specific needs. Research also may find more effective structure design and, where applicable, these newer structures would also be implemented.

Anticipated Benefit(s) for Fish and Wildlife Habitat Structures described below:
Artificial structures augment natural habitats and, depending upon the type of structure, can offer species with improved mobility, increased opportunities for breeding (spawning) nesting, roosting or rearing young.

Passage ways
Tunnels for Amphibians and Reptiles: Roads are often an impediment to the movement of amphibians and reptiles and in places where critical habitat is fragmented. Tunnels may provide a safe alternative route. Tunnel design is important and should be based on species anticipated to use the structure (Jackson 2003). Where SGCN are involved, tunnels should be incorporated into all new road construction and road re-construction projects.

Performance Measure(s):
- Number of tunnels constructed.
- Relative number of animals using the structure compared to roadkills in the same area (pre- and post-construction).

Action Leader(s):
PFBC, Pennsylvania Department of Transportation (PennDOT), County and Township Transportation Committees.

Artificial Structures

Turtle basking structures
Adapted from Houser (2007)

Used primarily in lakes, reservoirs and wetlands, Pennsylvania Turtle Basking Platforms were originally designed for red-bellied turtles (*Pseudemys rubiventris*) at Lake Marburg, York County, in response to sighting of these rare animals. During initial evaluation of these structures at Lake Marburg, it was observed that the platforms were used by a variety of turtles. Many Pennsylvania reservoirs are deficient in woody debris appropriate for turtles and, without appropriate basking habitat; many turtle species are not able to properly adjust body temperature. This physiological adjustment promotes individual growth, aids digestion, reduces susceptibility to disease and improves overall health.

Sites selected for basking platforms are typically where turtles have been sighted and with little attention from humans during open-water periods. These sites are generally in bays and coves in upstream areas of impoundments. Typical placement density is 5 structures per acre.

Performance Measure(s):
- ❖ Number of basking structures installed.
- ❖ Number of target turtles using structures.

Action Leader(s):
PFBC, NGOs.

Bat houses:

Bats benefit from boxes designed to meet needs of shelter, particularly during the reproductive season. Bat houses benefit not only bats, but also communities, farmers, gardeners and the ecosystem as a whole. Bat houses give bats a home, primarily to shelter and raise young, and provide an alternative to our houses, thereby reducing the chance of human-to-bat contact. Bat populations have decreased significantly, particularly as a result of white nose syndrome (WNS), and bat houses can help provide secure habitat.

Many bat species would typically roost under the bark of a dead tree and other safe crevices. However, due to habitat degradation, this is often not an available resource. Bat houses provide a safe and secure home for bats to roost during the day, and to raise their young. With declines in bat populations attributable to WNS, establishing artificial structures is recommended to increase survival of the remnant population. Additional information may be found at www.batconservation.org.

Performance Measure(s):
- ❖ Number of bat boxes installed.
- ❖ Number of target bats using structures.

Action Leader(s):
PGC, USFWS

Exclusion Structures

Gating entrances to caves and mines is a long-standing tool used to limit human access to bat hibernacula. These structures: provide protection from disturbance of bats during periods of hibernation, exclude people from dangerous underground locations, and reduce unintended disturbance of species that may constitute "take" under the federal Endangered Species Act. Bat populations have been shown to respond favorably to this protection, increasing over-winter survival and building local populations. Such protections are particularly important in response to impacts of WNS.

Performance Measure(s):
- Number of caves gated.
- Difference in target species populations before and after installation of gates.

Action Leader(s):
PGC, USFWS

2.5. Grazing/farm management

As noted in Chapter 2 (Habitat), agriculture encompasses approximately 23% of land use in Pennsylvania. Thus, proper land, water, and nutrient management of this extensive geographic area can greatly benefit SGCN. For example, livestock grazing activities have been found to be beneficial for the bog turtle (*Glyptemys muhlenbergii*) (Tesauro 2001; Tesauro and Ehrenfeld 2007). Water-quality benefits have been observed with application of best-management practices (BMPs) such as streambank fencing and cattle crossings (USDA 2014; Table 4.8).

Detailed descriptions of best practices associated with grazing and farm management are beyond the scope of this plan and additional conservation practices may be applicable for this conservation action. Where grazing and farm management actions are required for SGCN and associated habitats, the USDA-Field Office Technical Guide (FOTG) provides general references, soil and site information, conservation management systems, practice standards and specifications, and conservation effects (USDA 2015b). This conservation action supports objectives for streams, wetlands, and forests (USDA-NRCS 2012). As noted in Conservation Action 1.2 (Incentives), conservation programs may be modified or updated during the next 10 years.

Anticipated Benefit(s):
Encompassing a broad range of conservation practices, the ecological benefits offered by these practices are similarly expansive (see purpose in Table 4.8). Enhancing the quantity and quality of habitats contributes to the well-being of SGCN, with the extent of benefits dependent upon the practices implemented and effected species.

Performance Measure(s):
- Number of acres or river miles with habitat enhancement practices.

- Number of SGCN using enhanced habitats.

Action Leader(s):

PGC, PFBC, USDA-NRCS, USDA-FSA, County Conservation Districts.

Table 4.8. Examples of USDA conservation practices potentially benefitting SGCN.

Conservation Practice	Code	Definition	Purpose
Stream Crossing	578	A stabilized area or structure constructed across a stream to provide a travelway for people, livestock, equipment, or vehicles.	Improve water quality by reducing sediment, nutrient, organic, and inorganic loading of the stream. Reduce streambank and streambed erosion. Provide crossing for access to another land unit.
Stream Habitat Improvement and Management	395	Maintain, improve or restore physical, chemical and biological functions of a stream, and its associated riparian zone, necessary for meeting the life history requirements of desired aquatic species.	Provide suitable habitat for desired fish and other aquatic species. Provide stream channel and associated riparian conditions that maintain stream corridor ecological processes and hydrological connections of diverse stream habitat types important to aquatic species.
Prescribed Grazing	528	Managing the harvest of vegetation with grazing and/or browsing animals.	Improve or maintain desired species composition and vigor of plant communities. Improve or maintain quantity and quality of forage for grazing and browsing animals' health and productivity. Improve or maintain surface and/or subsurface water quality and quantity. Improve or maintain riparian and watershed function. Reduce accelerated soil erosion, and maintain or improve soil condition.

Conservation Practice	Code	Definition	Purpose
			Improve or maintain the quantity and quality of food and/or cover available for wildlife. Manage fine fuel loads to achieve desired conditions.
Riparian Forest Buffer	391	An area dominated by trees and/or shrubs, located adjacent to and up-gradient from watercourses or water bodies.	Create shade to lower or maintain water temperatures to improve habitat for aquatic organisms. Create or improve riparian habitat for wildlife and provide a source of detritus and large woody debris. Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff. reduce excess nutrients and other chemicals in shallow groundwater flow. Reduce pesticide drift entering the water body. Restore riparian plant communities. Increase carbon storage in plant biomass and soils.
Wetland Wildlife Habitat Management	644	Retaining, developing or managing wetland habitat for wetland wildlife.	To maintain, develop, or improve wetland habitat for waterfowl, shorebirds, fur-bearers, or other wetland dependent or associated flora and fauna.
Prescribed Burning	338	Controlled fire applied to pre-determined area.	Control undesirable vegetation. Prepare sites for harvesting, planting or seeding. Control plant disease. Reduce wildfire hazards. Improve wildlife habitat. Improve plant production quantity and/or quality.

Conservation Practice	Code	Definition	Purpose
			Remove slash and debris. Enhance seed and seedling production. Facilitate distribution of grazing and browsing animals. Restore and maintain ecological sites.

2.6. Hazard or infrastructure removal

There is increasing interest, especially in stream systems, to remove obstructions to aquatic species movement. Many of these obstructions are included in Conservation Action 2.2-Dam and Barrier Removal. However, where other structures, such as shoreline armoring or piers are found and require removal, this conservation action would be implemented. This conservation action also may be applicable where infrastructure is impeding movement of terrestrial animals such as concrete barricades.

Anticipated Benefit(s):
Implementing this conservation action will foster SGCN movement and may allow re-establishment of, or access to, important habitats.

Performance Measure(s):

- Number of hazards removed.

Action Leader(s):
PFBC, PGC

2.7. Instream modification

Factors contributing to degraded physical habitats of streams, such as eroded streambanks, insufficient cover resulting from various disturbances (e.g., changing land use, loss of vegetative cover, scouring floods), and sedimentation can be addressed with several instream structures (Lutz 2007). The type and composition of structures developed for a site are contingent upon the stream size, habitat condition and habitat concern. Although initially designed for trout streams, these structures may be applicable in coolwater and warmwater streams, depending upon the ecological conditions of the stream and habitat requirements of the species (Table 4.9).

These devices can be combined with other practices such as dam or barrier removal, riparian habitat enhancements and grazing/farm management practices. Implementing these instream practices should be made with consideration for hydrogeomorphic processes and in a watershed context (TNC and Environmental Law Institute-ELI 2014).

Table 4.9. Instream habitat modification devices. Adapted from Lutz (2007).

Structure	Purpose(s)
Boulders	Fish cover
Half-log; Whole-log	Fish cover
Deflectors (stone, stone with single log, log-faced stone, log-frame, overhead cover, brush, stacked, root wad, single log vane, multi-log vane	Channel narrowing, fish habitat; streambank stability, sediment management, overhead cover.
Stone cross-vane Log cross-vane	Grade control, centering flow in the channel, plunge-pool habitat, streambank stability.
Mud sill crib, modified mud sill crib, bank cover crib	Fish overhead cover, streambank stability, streambank reclamation.
Channel blocks	Diverting flow to other channels.
Root Wad	Fish cover; flow diversion

Anticipated Benefit(s):
Instream habitat modifications provide cover and stabilizing features that reduce streambank erosion and thus, contribute to improved habitat quality for fish and aquatic invertebrates.

Performance Measure(s):
- ❖ Number of river miles with habitat enhancement practices.
- ❖ Number of SGCN using enhanced habitats.

Action Leader(s):
PFBC, County Conservation Districts, NGOs

2.8. Invasive species control

Invasive species pose a substantial, long-term threat to Pennsylvania's SGCN and their habitats (Chapter 3). Once established, invasive species removal can be difficult, expensive, and perhaps impractical, especially if the invader is found in an open system (e.g., a river, large lake with an outlet) and can rapidly colonize new habitats. A comprehensive approach, under the auspices of Pennsylvania Invasive Species Council (PISC) and its members has been developed to address this diverse and dynamic threat (Pennsylvania Invasive Species Management Plan) (PAISMP) (PISC 2009). The following PAISMP goals are relevant to the Pennsylvania Wildlife Action Plan and should be considered when SGCN and their habitats are impacted by invasive species.

- Prevention
- Early Detection and Rapid Response
- Survey and Monitoring

- Data Management
- Research
- Outreach
- Communication and Coordination

The goals and associated conservation actions of the Pennsylvania Invasive Species Management Plan (Chapter 3) will be integral to success of the Pennsylvania Wildlife Action Plan.

Anticipated Benefit(s):
The benefits of this conservation action will be contingent upon the types of invasive species to which activities are directed. Generally, prevention and management of invasive species will reduce competition and enhance habitats for SGCN, furthering their protection and recovery.

Performance Measure(s):
The Pennsylvania Invasive Species Management Plan (PAISMP) identifies actions; however, no performance measures were specified. For invasive species, when relevant, the following performance measures could be used for activities specifically developed to support the 2015 Pennsylvania Wildlife Action Plan. Other measures may be applicable.

- ❖ Number of newly reported invasive species locations (intent of this measure is to reduce number of new sightings to -0-).
- ❖ Number of new invasive species considered established (intent for this to become -0-).
- ❖ Number of established invasive species removed from the Commonwealth or managed to a target level.
- ❖ Number of invasive species surveys conducted.
- ❖ Number of Invasive Species Action Plans developed.
- ❖ Number of potential recreational users contacted.
- ❖ Number of active volunteers trained.
- ❖ Number of people trained to a specified competency.
- ❖ Number of rapid-response exercises (mock or actual) in reaction to new sightings.

Action Leader(s):
PISC members, PGC, PFBC

2.9. Living shorelines

Shorelines are the transition between aquatic and terrestrial conditions and therefore are crucial for many species with life-histories that require movement between these habitats. At this aquatic-terrestrial interface, shorelines are often subject to erosion. In rivers and streams, altered land use (e.g., increased impervious surfaces), along with intensive use of streambanks (e.g., livestock access), may be factors in streambank erosion. In lakes and wetlands, excessive wave action may contribute to the loss of vegetation or, where vegetation has already been lost; further degrade shoreline quality. Other disturbances (e.g., invasive species) may threaten the functions of these habitats. The Pennsylvania Department of Environmental Protection Erosion and Sedimentation Pollution Control Program Manual (PADEP 2012) describes “best practices” for establishing vegetation following disturbance along

shorelines. In Pennsylvania, regulations regarding erosion and sediment control are provided under Title 25 Pa. Code Chapter 102 (Pennsylvania Code 2013).

Anticipated Benefit(s):
Re-establishing living shorelines can provide transitional corridors for SGCN (e.g., amphibians) and further protect these habitats from erosion and invasive plant species. These habitats also may support birds and invertebrates.

Performance Measure(s):
- ❖ Linear distance of shoreline restored with native plant species.

Action Leader(s):
PFBC, PGC, County Conservation Districts, NGOs

2.10. Planting/seeding

Planting vegetation is a particular form of 'habitat creation' in which natural processes are directed with select plants. This is typically done in combination with other related actions. Plantings are used to provide a particular vegetative structure, food or host plants. Best-Management Practices have been established for plantings after various types of disturbances, such as rights-of-way. The PGC and PADCNR maintain nurseries to rear a variety of seedlings for establishing wildlife food and cover. Native plants are preferred as they are well-adapted to local site conditions and local fauna will derive the greatest benefit. Although intended primarily for terrestrial species, this activity could re-establish or augment vegetation in aquatic habitats.

Anticipated Benefit(s):
Plantings enhance the capacity of habitats to provide food and cover for SGCN.

Measure(s):
- ❖ Number of acres planted.
- ❖ Habitat quality metrics (e.g., number of native plants).
- ❖ Target species population metrics (e.g., relative abundance, reproductive success).

Action Leader(s):
PGC, PADCNR, PFBC, County Conservation Districts, Industry

2.11. Vegetation management

For the 2015 Pennsylvania Wildlife Action Plan, vegetation management is inclusive of activities to benefit Species of Greatest Conservation Need. Examples include forest management for Allegheny woodrat (*Neotoma magister*) habitat to promote soft-mast trees, or young forest structure enhancement through timber harvest for golden-winged warbler (*Vermivora chrysoptera*) conservation. Vegetation management is also required to enhance habitats for reptiles such as the timber rattlesnake (*Crotalus horridus*) and bog turtle (*Glyptemys muhlenbergii*). For these species, tree removal is often required to allow sunlight for basking areas. For the bog turtle, vegetation management may also be conducted by grazing cattle. For fish SGCN, such as the bridle shiner (*Notropis bifrenatus*), ironcolor

shiner (*Notropis chalybaeus*), and burbot (*Lota lota*), aquatic vegetation is a specific habitat requirement, although vegetation management is not expressly a conservation action noted for these species, in places where such management would be feasible, this could be an optional management tool.

Anticipated Benefit(s):
Vegetation management enhances habitat suitability for SGCN. The purpose(s) for this conservation action (e.g., food, cover) will be contingent upon the needs of target SGCN.

Measure(s):
- Number of acres managed.
- Habitat quality metrics (e.g., number of native plants).
- Target species population metrics (e.g., relative abundance, reproductive success).

Action Leader(s):
PGC, PFBC, DCNR-Bureau of Forestry and State Parks, USDA-Forest Service, The Nature Conservancy,

2.12. Water management

Water management can be a vital component of an overall habitat management strategy, especially in areas where water levels can affect breeding, resting or feeding activities of fish and wildlife. Proper water management can make available high-quality habitats for fishes, amphibians and birds. Wetlands and lakes (i.e., impoundments with control structures) are primary habitats where this conservation action may be implemented.

Anticipated Benefit(s):
Proper water management can help maintain or improve survival of SGCN by enhancing habitat suitability.

Measure(s):
- Number of acres managed to a target water level.
- Habitat quality as measured by relevant metrics (e.g., acres of aquatic vegetation, mudflats for shorebirds).
- Target species population metrics (e.g., relative abundance, reproductive success).

Action Leader(s):
PGC, PFBC, USACOE

2.13. Wildlife damage management

Adapted from Yarrow (2009), Clemson Cooperative Extension

Prevention and control methods to reduce wildlife damage can be delineated into the following categories: 1) exclusion of problem wildlife; 2) habitat modification; 3) frightening; 4) repellents; 5) toxicants; 6) fumigants; 7) trapping; 8) shooting; 9) non-traditional methods, such as homemade remedies; and 10) proactive land use/management planning that reduces the potential of certain features to attract pest wildlife species. The effectiveness of each control method depends upon the biology of the species, timing, and skill of application. Some techniques that are effective for one species

may be totally ineffective for other species. Additionally, it is important to consider that some techniques for certain wildlife may not be legal. Before attempting any control method it is vital to check federal and state regulations, as well as local ordinances, that govern the use of various control methods. Depending on the species, a depredation permit may be required from jurisdictional state authorities to remove problem wildlife. Species also may be protected from control measures by federal and/or state law. In these cases, the appropriate federal (e.g., USDA-Wildlife Services, USFWS) or state agency (i.e., PGC) should be contacted for assistance.

Anticipated Benefit(s):
Controlling wildlife damage enhances habitat suitability and potentially reduces direct impact on SGCN.

Measure(s):
- Number of interventions

Action Leader(s):
PGC, PFBC

2.14. Wildlife disease management

Wildlife diseases are found in all populations, but can become epidemic when introduced into populations or, as a result of other stressors (Chapter 3) for more explanation of diseases). These diseases may have the potential to quickly eliminate entire populations of wildlife. Some wildlife diseases are transferred between species including, from wild animals to humans and from humans to wild animals. Emerging infectious diseases, (i.e., zoonoses), are all stressors in the environment that make it increasingly challenging to conserve wild populations. Significant examples include white nose syndrome and chytrid fungus (Chapter 3) which, in the species infected, have resulted in the most dramatic population declines in our lives.

Anticipated Benefit(s):
Managing wildlife diseases can directly benefit SGCN populations through reduced mortality.

Measure(s):
- Number of interventions.
- Mortality rates attributed to the disease in-question.

Action Leader(s):
PGC, PFBC, USFWS, Southeastern Cooperative Wildlife Disease Study

3.0. Data Collection and Analysis

3.1. Database development and management

Recent technological advances in data storage and management have enhanced greatly decision-making processes that support SGCN and their habitats. In the northeast region, this technology is supporting the design and development of the Northeast Regional Database which will enhance species management and foster communication through use of standard terminology found in the Northeast Lexicon (Crisfield 2013). The system will allow all northeast State Wildlife Action Plan jurisdictions to

report on conservation actions conducted in support of regional SGCN. This database, which is under development at the writing of this plan, will be an important tool for comprehensive regional assessments. Within Pennsylvania and throughout the northeast region, increasing use of geospatial landscape-scale assessments has been achieved through technical advances, such as improved computational capabilities, better land-use coverages, and improved habitat modeling.

Used in implementing the 2005 Pennsylvania Wildlife Action Plan, this conservation action included developing a database for freshwater mussels (State & Tribal Wildlife Grant, T-26). As mussel data continues to be collected throughout Pennsylvania, this system functions as a single-source data repository and reporting system. Similar data-management systems support fishes (State & Tribal Wildlife Grant, T-2-16), and amphibians and reptiles (State and Wildlife Grant, T-2-14). As needs are identified, new databases may be developed or database management activities may be required for these systems to remain viable with changing technologies. As comprehensive sources, these systems can provide data for analytical functions, such as species and habitat modeling.

For the 2015 Pennsylvania Wildlife Action Plan, a substantial database initiative is expected to center on the Conservation Opportunity Areas decision-support tool (COAs). For this geospatial, web-based tool, we anticipate either developing a new platform or adapting existing systems to provide users with information on species, habitats threats and actions for their area of interest.

Anticipated Benefit(s):
These databases will expedite summarization and analyses for management decisions that may include implementing habitat conservation actions, or conducting research, surveys or monitoring.

Measure(s):
- Number of records added to each database.
- A functional web-based Conservation Opportunity Areas decision support tool.

Action Leader(s):
PGC, PFBC

3.2. Research, survey or monitoring - fish and wildlife populations
3.3. Research, survey or monitoring - habitat
3.4. Research, survey or monitoring – utilization

Note: Due to their similarity in topic, the 3 conservation actions related to research, survey, or monitoring are discussed in this section.

For the 2005 Pennsylvania Wildlife Action Plan, projects directed towards Wildlife TRACs Action "3.0 Data Collection and Analysis" comprised over 60% of the State Wildlife Grant funded projects (Introduction). The high proportion of projects dedicated to this conservation action, reflects the underlying need for basic information about SGCN and their habitats. Although great progress has been made in acquiring data, as exemplified by the number of species both removed and added to the Pennsylvania threatened, endangered, and candidate list, there are many additional species for which

sufficient data are unavailable to fully understand species range, life-history requirements and population dynamics. Therefore, it is anticipated that Data Collection and Analysis (TRACS Level 2 codes 3.2-Research, survey or monitoring-fish and wildlife populations; 3.3-Research, survey or monitoring-habitat; 3.4-Research, survey or monitoring-utilization) will remain a major component of implementing the 2015 Pennsylvania Wildlife Action Plan.

The types of projects conducted (e.g., research, survey or monitoring) and their focus on populations, habitat, or utilization will be contingent upon specific data gaps and may include more than one focus. Research projects may be directed at gathering data to help guide specific management actions, when such information is unavailable or insufficient. Examples of this research include management of bats with white-nose syndrome.

For purposes of this Plan, surveys are considered initial data-gathering or baseline events, to characterize existing biota, chemical or physical conditions for planning or future comparisons (*sensu* Roni 2005). Surveys may be designed to gather basic ecological data (e.g., species distribution, habitat associations, population structure, and life-history information). Based on best available information, SGCN are designated as such because they are imperiled or, are likely to become imperiled, without intervention. Often, these species are difficult to find because they are in low abundance, cryptic, or have life-histories that require specific environmental conditions for them to appear. For example, it has been found in West Virginia that the spadefoot toad (*Scaphiopus holbrookii*) requires specific levels of relative humidity and mean air temperature for emergence (Johnson 2003). For many of Pennsylvania's SGCN, insufficient funding has not allowed collection of more robust information. As funding becomes available, this information can be gathered.

Monitoring generally refers to systematically sampling in an effort to detect or evaluate a change, or lack of change in a physical, a chemical or a biological parameter (Roni 2005) and may involve a specific temporal frequency. In Pennsylvania, many years of surveys have contributed to the current status assessment of the timber rattlesnake (*Crotalus horridus)* and ultimately to a monitoring program for long-term population trend analysis (State &Tribal Wildlife Grant, F15AF00411). This monitoring program will develop statistically reliable trend data for detecting changes in populations.

Identifying species selected for these conservation actions will be, in part, highlighted through SGCN Prioritization (Chapter 1) and with consideration of emerging threats.

Anticipated Benefit(s):
Implementing these conservation actions will reduce data gaps that contribute to uncertainty when developing management recommendations, including listing of species as Pennsylvania Threatened, Endangered or Candidate (only PFBC uses candidate designation). These data will support effective conservation actions.

Measure(s):
- Number of surveys directed toward SGCN.
- Number of research projects directed toward SGCN.

Action Leader(s):
PGC, PFBC, USGS, USFWS, Pennsylvania Biological Survey, conservancies, land trusts, citizen scientists, and other conservation partners.

SGCN associated with Conservation Action Category 3.0, Data Collection and Analysis.

This Conservation Action category would be considered applicable to all species. For species lacking basic information, this may require surveys and, for species with adequate baseline data, may involve monitoring. Research may be required to investigate specific questions for management needs. The Conservation Opportunity Areas decision-support tool will require compilation of data, species and habitat modeling, and thus a substantive task associated with this conservation action.

4.0. Education

4.1. Educator/instructor training

Training is especially important for personnel safety and management activities that can have long-term implications for species and habitats. This may be especially relevant for conservation actions where safety may be a factor (e.g., installing instream structures, dam removal, prescribed fire management). Given these concerns, in this conservation action we include instructor training as well as staff training.

Anticipated Benefit(s):
Training can contribute to safe, effective application of conservation actions, thus benefitting SGCN and their habitats, and reducing potential negative effects on non-target species.

Measure(s):
- Number of practitioners trained with minimum certifications, as required.
- Number of training meetings, workshops, webinars.

Action Leader(s):
PGC, PFBC, federal and state agencies, NGOs, County Conservation Districts and other partners with expertise in specific management activities.

5.0. Facilities and Areas

5.5. Cooperatively managed areas for hunting

More than 13,000 landowners and tenants currently are taking advantage of the mutual benefits provided by the PGC's Hunter-Access Program. These properties, located in most of the state's 67 counties, cover more than 2.6 million acres (1.05 million hectares). The Hunter-Access Program requires a landowner to place under agreement, a project area of at least 50 acres (20.2 hectares) for 5 or more years. Cooperators must be in legal control of the enrolled property. The Hunter-Access Program, which is governed by a term-lease agreement, creates a partnership between the PGC and landowner whereby they will work to mutually improve public hunting opportunities and wildlife habitat on enrolled property. Cooperators are provided advice on habitat conservation practices.

Anticipated Benefit(s):
Management activities on Cooperatively Managed Areas for hunting are directed toward game species, but have the potential to support SGCN. SGCN supported will be contingent upon the management practices, available SGCN, and their habitat requirements.

Measure(s):
- Number of Wildlife Management Areas.
- Number of acres managed.

Action Leader(s):
PGC, Private Landowners

5.6. Fish-Passage Facilities

On rivers and streams, where Conservation Action 2.2 (Dam and Barrier Removal) is not a realistic management option, fish-passage structures may be an alternative practice. These structures, sometimes referred to as "fish ladders", are built at a gradient allowing fish to swim upstream and downstream of the dam or impediment. Site-specific characteristics (e.g., flow patterns downstream of a dam) and fish requirements (e.g., ability to locate and transcend the ladder) can influence the long-term effectiveness of these structures. In Pennsylvania, these structures have been used at dams on the mainstem Susquehanna River, Lehigh River, Schuylkill River, and other rivers to accommodate passage of American shad (*Alosa sapidissima*) and other species.

Alternative structures that currently support fish passage are "fish lifts". On the Susquehanna River, due to their large size, the first three (i.e., Conowingo, Holtwood and Safe Harbor) are currently equipped with these devices. The fourth dam, York Haven, is a low-head dam and operates a vertical slot fishway. The cumulative success of these structures, as noted in Chapter 3, is limited, allowing only approximately 2% of American shad to successfully reach above the fourth dam (York Haven) (Hendricks and Tryninewski 2011).

Trap and transport of adult American shad on the Susquehanna River was discontinued in the late 1990s, as a result of the construction and operation of fish passage facilities at each of the four hydropower dams. In recent years, migratory fish restoration can include large nature-like fishways, one of which is planned for construction and operation by 2021 at the York Haven dam. Decades of fish passage monitoring has demonstrated that single passage technology is broadly applicable with uniform success; each dam presents unique conditions for engineers, dam operators, fisheries managers, and fish movement. For the large hydroelectric plants on the Susquehanna River within Pennsylvania, present and future fish passage technologies will be bolstered by adaptive management and operational strategies driven by fish passage performance measures, as conditioned in State Water Quality Certifications.

Use of these structures is subject to many factors, including configuration of the dam to accommodate the design of a fish passage structure, willingness of the dam owner to allow the structure, and cost of design, installation and maintenance.

Anticipated Benefit(s):
Where feasible, fish passage facilities allow volitional upstream movement of fish. If sufficient passage can be achieved, reduced effort and associated costs may be directed toward assisted passage (i.e., hauling fish upstream).

Measure(s):
- ❖ Number of fish passage structures constructed.
- ❖ Relative number of fish found upstream of a dam compared to downstream.

Action Leader(s):
PFBC, USFWS

5.7. Fish screening and related facilities

Adapted from USDA (2007)

Fish entrainment into water diversions or pump intake structures also affects natural migration patterns – primarily for downstream movement, but sometimes for upstream movement.
Typically, fish screens are used to prevent adult and juvenile fish entrainment, or attraction into manmade diversion structures or other features (power or sewage treatment plant outfalls). Typical types of surface and subsurface diversion structures requiring fish screens include: municipal and irrigation water intakes, irrigation diversions, and pump stations. Protecting fish from entrainment at these structures may be achieved through use of the following features:

- physical barriers and screens
- behavioral guidance to direct swimming direction
- capture and release systems

Anticipated Benefit(s):
For Pennsylvania fish SGCN, reduced mortality would be achieved primarily at hydroelectric facilities, and where fish may move between dams. These screening structures would be especially important on rivers with migratory fishes such as American shad and American eel (*Anguilla rostrata*). Mussels may also benefit when fish mortality is reduced for glochidial hosts.

Anticipated Benefits(s):
- ❖ Number of facilities using fish screens where needed.
- ❖ Number of entrained fish at facilities with fish screens.
- ❖ Fish mortality.

Action Leader(s):
PFBC, owners of dams and hydroelectric facilities, Federal Energy Regulatory Commission (FERC)

5.8. Hatcheries

In Pennsylvania, the PFBC and cooperative nurseries are major providers of stocked fishes for recreational use, but for SGCN, hatcheries also can provide an important service by “head-starting”

species for re-introduction. For example, the 2005 Pennsylvania Wildlife Action, State & Tribal Wildlife Grant (T-13) supported rearing of paddlefish (*Polyodon spathula*) at the Linesville State Fish Hatchery for eventual stocking into the Allegheny River.

Another fish SGCN culturing effort included bridle shiner (*Notropis bifrenatus*) and ironcolor shiner (*Notropis chalybaeus*) (State & Tribal Wildlife Grant R-03, Job 6001). Methodologies for hatchery propagation of freshwater mussels have been demonstrated (Neves 2004) and although this action has been considered as a conservation action for Pennsylvania mussel SGCN, PFBC hatcheries are not currently used for mussel propagation.

Since 1976, American Shad (*A. sapidissma*) have also been reared at the Van Dyke Research Station for Anadromous Fishes as part of an effort to restore diadromous fishes to the Susquehanna River Basin. The objectives of the Van Dyke Station have been to research culture techniques for American shad and to rear juveniles for release into the Juniata and Susquehanna rivers (State & Tribal Wildlife Grant T-9, Fish Passage). The program goal has been to develop a stock of shad imprinted to the Susquehanna drainage, which will subsequently return to the river as spawning adults (Hendricks 2004).

Measure(s):

- Number of species "head-started".
- Number of newly established, self-sustaining populations.
- Number of populations enhanced to a target level.

Action Leader(s):

PFBC, USFWS

5.15. Wildlife management areas

Wildlife Management Areas are lands owned or leased for the protection and promotion of fish and wildlife resources. In Pennsylvania, lands owned by the PGC are called "State Game Lands" (SGL), and given a unique identification number. PFBC properties provide access for water-based resources. Sportsmen and sportswomen have funded the acquisition of a large portion of SGLs through license fees and a federal tax on sporting arms and ammunition. Thus, the management emphasis is towards game species with regulations to protect hunting on these lands. Further, as public property, these areas provide habitat and opportunities for the public to interact with a wide variety of wildlife species, and opportunities for the jurisdictional agency to conduct habitat management practices to benefit specific species. Management Plans have been developed for many SGLs; identifying particular habitat practices and target species.

Anticipated Benefit(s):

Management activities on Wildlife Management Areas are directed toward game species, but have the potential to support SGCN. SGCN supported will be contingent upon the management practices, available SGCN, and their habitat requirements.

Measure(s):
- Number of Wildlife Management Areas.

Action Leader(s):
PGC

6.0. Land and Water Rights Acquisition and Protection

6.1. Land acquisition

Fee and non-fee title purchases of property can be used to protect critical habitat threatened by development or other disturbances. This conservation action could be directed at the purchase of degraded properties with realistic restoration potential such as purchase of the Piney Tract (discussed in Conservation Action 2.1, Create New Habitat or Natural Process) which, when purchased, was abandoned mine lands. It is recommended that such investments be accompanied by a long-term management fund for implementing management actions. Although implied, importantly, this conservation action would be considered on a *willing-seller basis only* and not through eminent domain.

Anticipated Benefit(s):
Land acquisition provides long-term securement for SGCN and, if the habitat is degraded, opportunities for enhancement.

Performance Measure(s):
- Number acres protected.
- Number of SGCN in protected acres.

Action Leader(s):
PGC, PFBC, PADCNR Non-Governmental Organizations, Land Trusts USFWS

6.2. Water rights acquisition

The Pennsylvania Department of Environmental Protection (PADEP) regulates withdrawal of surface water by public water suppliers under the Water Rights Act (1939) (Bishop 2006) and water sources, both surface and groundwater, used by the natural gas industry under the Oil and Gas Act (Chapter 78) and the Clean Streams Law (DePhilip & Moberg 2013b). With current protections, it appears unlikely that this conservation action would be required, but is included in the event that such acquisitions may be necessary to support SGCN.

Anticipated Benefit(s):
Securing water rights could help SGCN survival by securing suitable habitats where water supplies may be over-exploited.

Performance Measure(s):
- Number of agreements.
- Appropriate metric for protected water (e.g., millions of gallons/day, acre-feet).

Action Leader(s): PFBC, PADEP

6.3. Conservation area designation

As a State Wildlife Action Plan "best practice," AFWA (2012) recommended states: "Identify and spatially depict priority areas on the landscape that offer the best opportunities and potential for SGCN conservation as determined by each state, and use the generic term Conservation Opportunity Areas (COAs) for these focal areas." In Pennsylvania, rather than selecting designated areas, we will develop a geospatial decision-support tool early in the implementation phase of this plan (Conservation Opportunity Areas). An example of this concept is HabiMap™Arizona. For Pennsylvania, the tool will allow users from across the state to identify potential locations for species (modeled probabilities), habitats, and conservation actions (e.g., habitat enhancements). We will review current species and habitat-data systems for potential adaptability to this application.

Anticipated Benefit(s):
This web-based decision-support tool will allow users of this Plan to interactively select areas and receive information on modeled SGCN occurrences, habitats, and potential actions to address the needs of the species.

Performance Measure(s):
- A functional Conservation Opportunity Area decision-support tool is anticipated by December 2018.

Action Leader(s):
PGC, PFBC

6.4. Private lands agreements

Private lands comprise 85% of Pennsylvania's landscape and therefore are critical for maintaining Pennsylvania's SGCN and habitats. Agreements with landowners can establish management guidance that mutually supports the interests of the landowner and SGCN. These agreements may provide monetary compensation, services such as implementing conservation actions or voluntary technical assistance.

Private Lands Agreements are exemplified by the popular and successful PGC Private Landowner Assistance Program (PLAP) in which regional habitat biologists provide technical assistance to private landowners for the benefit of SGCN and other wildlife. The PGC's goal with this program is to improve Pennsylvania's landscape for wildlife species of special concern by developing detailed plans for interested landowners who want to help these at-risk species. Although these plans focus on species of concern, a wide variety of species often benefit from these habitat plans once they are implemented.

Agreements with private landowners also can involve voluntarily entering into easements in which the landowner grants partial rights to the property for compensation by way of incentives. The scope of each agreement is based upon the landowner's interests and protection to be provided to species and habitats. Land trusts and other non-governmental organizations often provide this habitat protection package.

Anticipated Benefit(s):
Given the extensive area encompassed by privately owned lands, participation of private landowners in habitat-management practices will increase opportunities to further protect and enhance SGCN populations.

Measure(s):
- Number of agreements with private landowners.
- Number of acres encompassed by agreements.
- Number of SGCN on properties with agreements.

Action Leader(s):
PGC, PFBC, PADCNR, NGOs

7.0. Law Enforcement

7.1. Law enforcement
Law Enforcement can be a vital function for protecting SGCN and their habitats. Currently, use of State & Tribal Wildlife Grant funds for this conservation action is limited to 10% of projects costs, along with other restrictions. This conservation action is especially helpful for protecting species such as the bog turtle (*Glyptemys muhlenbergii*) which is vulnerable to illegal harvest (Chapter 3), as well as other highly sought species for the pet trade and other demands. Beyond illegal trade, conservation law enforcement officers often are called to investigate pollution events that may involve SGCN.

Supporting law enforcement officers with training in animal identification, anti-poaching procedures, protecting important sites (e.g., caves for hibernating bats), and enforcing laws, especially focused on SGCN, are activities that could be considered within this conservation action.

Anticipated Benefit(s):
Law enforcement can directly reduce loss of habitat or illegal harvest of SGCN.

Performance Measure(s):
- Number of officers trained.
- Number of enforcement incidents in response to specific reports of illegal harvest of SGCN or habitat destruction.

Action Leader(s):
PGC, PFBC, USFWS

8.0. Outreach

8.1. Partner and stakeholder engagement
Acknowledged throughout this Plan, successful implementation will require participation and recruitment of many partners and stakeholders. Discussed in Chapter 7 (Partners), we intend to

maintain the administrative framework used in Plan development, and regularly engage the Advisory Committee and Technical Committees for current, broad-based perspectives during plan implementation.

Considering the public as a partner in this Plan, outreach and education through timely and well-developed programs and products, can advance understanding of SGCN and their habitats. This conservation action was mentioned for a small number of SGCN (Chapter 1) yet could be applicable to many SGCN and the overall plan. The proposed communication strategy mentioned in (Chapter 8, Public Participation) will support this outreach to the public.

Anticipated Benefit(s):
Partnerships will allow greater participation and opportunities for success in implementing this Plan and to achieve its Goals, Objectives and Strategies.

Performance Measure(s):
- Number of meetings, workshops, conferences dedicated to the plan involving the partners, stakeholders and the public.
- Number of meeting, workshop, and conference attendees.
- Number of projects or plans develop and implemented in response outreach initiatives.

Action Leader(s):
PGC, PFBC

9.0. Planning

9.1. Land use planning

Land-use planning as a conservation action is most frequently considered as a broad initiative for open space, although mandated wetland conservation, or increasingly ecotourism, is occasionally the specific objective. Undoubtedly, local zoning and planning may offer significant benefits to wildlife habitat availability. Local governments can leverage various planning tools to preserve their municipality's natural assets and quality of life. These tools may include: setting specific preservation goals as part of a comprehensive planning process, or working with developers to achieve these goals step-by-step. Localities are granted authority by the state legislature to adopt and implement local planning policies, regulations, permit requirements and guidelines that shape the growth of their local community.

The Natural Heritage Areas developed by the Pennsylvania Natural Heritage Program (PNHP), largely through the County Natural Heritage Inventory initiative, are designed to inform residents about their natural heritage and provide a tool for planning the future of their municipalities. Detailed mapping for a significant subset of the SGCN identified in this plan are presented in this product and can help inform users in the process of detailed conservation planning.

Use of the Pennsylvania Natural Diversity Inventory (PNDI) Environmental Review Tool (Pennsylvania Natural Heritage Program-PNHP 2015) also may be beneficial during land use planning processes.

Anticipated Benefit(s):
Through early planning and coordination with municipal and township authorities, this conservation action can lead to habitat protection for SGCN.

Performance Measure(s):
- Number of green infrastructure ordinances developed.
- Acres designated for conservation with SGCN.

Action Leaders(s):
Pennsylvania Department of Commerce and Economic Development (PADCED), local municipalities, PGC, PFBC, PADCNR, Pennsylvania Land Trust Association (PALTA).

9.3. Species and habitat management planning

Effective species and habitat management implementation requires a well-planned approach, with goals, objectives and desired outcomes clearly identified through a planning process. We anticipate this conservation action to be used extensively throughout the implementation period of the 2015 Pennsylvania Wildlife Action Plan. The focus of this conservation action will be on species where detailed planning has yet to be conducted to secure their protection, or where such planning is necessary to update current plans. As noted in Conservation Action 9.1 (Land-Use Planning), detailed mapping for a significant subset of the SGCN identified in this Plan are presented in this product and can help inform users for detailed conservation planning.

This conservation action also may include species and habitat planning conducted by partners directed to support SGCN.

Anticipated Benefit(s):
Species and Habitat Management Planning will contribute to efficient and effective implementation of conservation actions that support SGCN.

Performance Measure(s):
- ❖ Number of Species Action (Management) plans developed.
- ❖ Number of Species Action (Management) plans implemented.
- ❖ Number of Species Action (Management) plans completed.

Action Leader(s):
PGC, PFBC, Non-Governmental Organizations, PALTA

9.4. State Wildlife Action Planning

This conservation action will be implemented when the 2015 Pennsylvania Wildlife Action Plan is amended or comprehensively revised. Details are more fully described in Chapter 6.

Anticipated Benefit(s):
Amending or comprehensively revising the 2015 Pennsylvania Wildlife Action Plan will provide a relevant plan that maintains the Commonwealth's federal eligibility for State &Tribal Wildlife Grants.

Performance Measure(s):

- A completed comprehensive revision of the 2015 Pennsylvania Wildlife Action Plan will be completed by 09.30.2025.

Action Leader(s):
PGC, PFBC

10.0. Species Reintroduction and Stocking

10.1. Native species restoration

In limited situations, when species are considered either extirpated but recoverable or low in abundance, the availability of suitable habitat may be an opportunity for reintroduction from captive breeding, hatcheries or through translocation. Prior to implementing this conservation action, protocols should be thoroughly reviewed to ensure re-introduced animals are healthy and genetically appropriate for stocking. The probable cause of population decline should be resolved before wildlife is released into the wild. Generally, animals should not be released into established populations. Restoration of the bald eagle (*H. leucocephalus*) was expedited by relocation of juvenile birds here in Pennsylvania and neighboring states, after the banning of DDT. Paddlefish (*P. spathula*) were stocked into the Allegheny River in an effort to re-establish reproducing populations. At the time this Plan was produced, success of this stocking program remained uncertain. For species requiring several years to reach reproductive maturity, long-term monitoring ($\geq$ 20 years) may be required to more fully understand stocking success.

Anticipated Benefit(s):
Re-establishing extirpated species into former distributions enhances species viability and can strengthen ecological functions (e.g., predator-prey relationships).

Measure(s):

- Number of self-maintaining species populations re-established.
- Number of attempted reintroductions.

Action Leader(s):
PGC, PFBC

10.2. Production and stocking for recreational purposes

This conservation action has limited application and, although used under the 2005 Pennsylvania Wildlife Action Plan, the intent of use was a driving factor. For example, the PFBC reared American shad (*A. sapidissima*) to stock in the Susquehanna, Schuylkill, and Lehigh rivers. Although these fishes may have been caught after leaving Pennsylvania waters, these stockings were intended to build the species' population and were not strictly to provide fish for recreational purposes. On the Susquehanna River, fishing for American shad is closed year-round. On the Lehigh and Schuylkill rivers and tributaries, no harvest is allowed, only catch and immediate release (PFBC 2015c).

By comparison, eastern brook trout (*Salvelinus fontinalis*) are reared in PFBC hatcheries for recreational purposes (i.e., stock-and-harvest), but are not stocked to enhance *native* eastern brook trout populations. Distinctions are made between native and hatchery-reared eastern brook trout, and for these stocked fish, the intended use is recreational. Although hatcheries are used to rear SGCN, propagation and stocking strictly for recreational purposes would be a limited conservation action.

This conservation action may apply to species with the potential for culturing in hatcheries or related facilities.

Anticipated Benefit(s):

For this conservation action, potential benefits could be achieved if a sufficient number of stocked animals survived harvest by recreational users, to produce offspring.

Measure(s):

- Stocked animal survival.
- Stocked animals successfully reproducing young.

Action Leader(s):
PFBC

11.0. Technical Assistance

11.1. Environmental review

Projects that disturb habitats or species must be evaluated through the Pennsylvania Natural Diversity Inventory-Environmental Review Tool (PNDI ER Tool). This tool enables the public to perform online searches for potential impacts to threatened, endangered, special-concern species and special-concern resources (Pennsylvania Natural Heritage Program-PNHP 2015). The PNDI ER Tool is used prior to submitting permit applications to PADEP, or for project pre-planning.

Environmental review personnel from each jurisdictional agency evaluate applications and determine potential impacts to species and habitats. Depending upon the project type, location and potential species impacted, this assessment may be conducted in the office or as a site-visit.

PNDI coordination should be completed prior to project development and submission of permit applications. When PNDI searches identify potential conflicts, early consultations should be made with the resource or jurisdictional agencies to minimize delays and costs, and facilitate integration of more effective conservation measures into project planning.

Anticipated Benefit(s):
When conducted to address SGCN, environmental reviews can diminish negative impacts from human activities and provide recommendations for unavoidable impacts.

Performance Measure(s):

- Number of consultations.
- Number of on-site visits.
- Number of SGCN element occurrences encompassed per environmental review.

Action Leader(s):
PGC, PFBC, PADCNR, PADEP, USFWS

11.2. Technical assistance

Technical Assistance can involve all SGCN and a broad range of activities (e.g., guidance on habitat encroachment, highway, airport, and mass-transit projects, pollution, herbicide & pesticide applications, habitat management) that protect environmentally sensitive habitats and species. For example, this support may include recommendations or assistance with implementing on-the-ground activities such as habitat enhancements provided through PGC's Private Landowner Assistance Program (PLAP) or PFBC's Technical Assistance Program (TAP) for streams and lakes. Other agencies (e.g., USDA-NRCS, County Conservation Districts) and organizations also may offer technical assistance for program needs.

Anticipated Benefit(s):
Trained professionals provide technical assistance to reduce or avoid potential habitat degradation or loss from disturbances. Technical assistance also may include advice that protects or improves habitats.

Performance Measure(s):

- Number of consultations, landowners contacted.
- Acres or miles of streams under habitat management guidance.
- Number of species or habitat management plans developed with partners.

Action Leader(s):
PGC, PFBC

100.0. Law and Policy

100.1. Legislation

Legislation, both state and federal, can greatly affect grant program administration, species listing status, habitat protection and funding to implement this Plan. It is therefore crucial for SGCN conservation and their habitats that legislative offices are informed about this Plan and relevant programs.

Potential Benefit(s):
Legislation can foster Plan implementation through funding or rules that are congruent with the goals, objectives or strategies.

Measure(s):
- ❖ Number of wildlife laws enacted that support goals of the Plan.

Action Leader(s):
PGC, PFBC, NGOs

100.3. State Regulations

Similar to Conservation Action 100.1 (Legislation), Conservation Action 100.3 (State Regulations) can greatly effect plan implementation. State regulations also may include state designation of species. Through meetings, field visits and other media, legislators and partners should be kept apprised of how regulations may impact SGCN and their habitats.

Potential Benefit(s):
State regulations allied with the Plan will foster implementation and thus SGCN and their habitats.

Measure(s):
- ❖ Number of new regulations supporting Plan implementation.

Action Leader(s):
PGC, PFBC, Partners and Stakeholders

101.0. Species Management

101.1. Species management

Harvest and trade of wildlife can influence their populations. Thus, 101.0 Species Management would be especially applicable for specific SGCN such as fishes (e.g., American shad, eastern brook trout) managed by the PFBC and birds (e.g., American black duck, ruffed grouse) managed by the PGC. Where federal jurisdiction applies such as with migratory birds, the USFWS also would be a leader in this action.

Potential Benefit(s):
Proper controls on harvest or trade can provide more stable and viable populations, thus reducing the potential for listing as a threatened, endangered or candidate species.

Measure(s):
- Number of conservation actions specifically directed to support managed SGCN.

Action Leader(s):
PGC, PFBC, USFWS

102.0. Partnerships

102.1. Non-governmental organizations (NGO)

Pennsylvania is fortunate to host diverse, motivated, and knowledgeable Non-Governmental Organizations (NGOs). NGOs were instrumental throughout development of the 2015 Pennsylvania Wildlife Action Plan, by serving on the Advisory Committee and numerous Technical Committees.

Similarly, given diverse and often intensive resource needs, the technical expertise of NGOs along with their staff capacity, will be essential for implementing the 2015 Plan. A communication strategy, discussed in Chapter 8 (Section-Support Conservation Outreach Initiatives) will foster this conservation action.

Potential Benefit(s):
Collaboration with NGOs enhances opportunities to implement more strategies and conservation actions in this Wildlife Action Plan.

Measure(s):
- Number of NGOs participating in projects that are directed towards Plan implementation.

Action Leader(s):
PGC, PFBC, NGOs

Conservation Opportunity Areas

Adapted from the prospectus by Catherine D. Haffner [PGC] & Diana M. Day [PFBC] 12 February 2015.

Introduction

As noted in Conservation Action 6.3 (Conservation Areas), designation of these areas in State Wildlife Action Plans is recommended as a "Best Practice" (AFWA 2012). Here we describe a process to identify conservation opportunity areas in Pennsylvania following approval of the 2015-2025 Pennsylvania Wildlife Action Plan.

Need

The 2005 Pennsylvania Wildlife Action Plan included more than 1,000 "prioritized implementation actions" but lacks spatial guidance for targeting these actions to maximize conservation benefits for Species of Greatest Conservation Need (SGCN) and their habitats. The lack of spatially explicit priority areas was an early criticism of the plan, and reinforced by over 50 statewide conservation partners at a 2012 Wildlife Diversity Forum, hosted by the Pennsylvania Game Commission (PGC). Many states across the country identified Conservation Opportunity Areas (COAs) in their 2005 State Wildlife Action Plan and the Association of Fish and Wildlife Agencies highlighted Conservation Opportunity Areas as a "best practice" for 2015 revisions (AFWA 2012). There appeared to be no consistent methodology for identifying these areas, thus leaving options for Pennsylvania's approach.

The 2015 Pennsylvania Wildlife Action Plan Steering Committee, composed of Pennsylvania Fish and Boat Commission (PFBC) and PGC program administrators, has committed to spatially depict priority areas for conservation action, or COAs, in the 2015 revision. The intent of these areas is to encourage efficiency and effectiveness of collaborative conservation efforts. We aim to provide a transparent and scientifically defensible approach to the development of spatial actions for the benefit of SGCN.

Decision Problem

Early in developing this approach we identified the problem that needed to be addressed. Essentially this centered on the question of:

> *Where to implement conservation actions (e.g., habitat protection, restoration, management) within the next 10 years to maximize benefits for species of greatest conservation need and their habitats?*

The delineation and use of COAs poses long-term resource-management implications, as well as potential social and political concerns. Thus, the PGC and PFBC determined that a formal process would be the best approach for understanding the implications and role of COAs in the 2015 Pennsylvania Wildlife Action Plan.

For this process, a team of resource professionals from federal & state agencies, institutions and non-governmental organizations was assembled to review this problem. A sub-group of these members developed a prototype decision format as the outcome of a multi-day facilitated workshop (*06.02.14 to 06.06.14 at the National Conservation Training Center in Shepherdstown, WV)*. Workshop participants

represented conservation partners who directly implement actions specified in the 2005 Pennsylvania Wildlife Action Plan and whose perspectives were critical to framing this problem for the 2015 Plan.

Through a progressive, evaluative discussion, the focus of the problem transitioned from identifying COAs as static units to developing a decision-support tool that could allow users to assess spatially refined management options for SGCN. From these discussions we identified the following Objectives:

1. Conservation of SGCN

The conservation of SGCN is the primary purpose of the 2015 Pennsylvania Wildlife Action Plan. This fundamental objective is pursued through maximizing quality habitat that supports SGCN.

- Maintain existing quality habitat through management or protection conservation actions.
- Improve marginal habitat to enhance SGCN populations through management and restoration.

2. Minimize Costs

Financial costs are an overarching constraint on the implementation of conservation actions.

- Minimize management costs (e.g., equipment, materials).
- Minimize personnel costs (e.g., staff time).
- Minimize human conflict.

3. Transparent, Spatially Explicit and Functional Tool

- Transparency is important for COA use; it can aid in promoting openness when COAs are updated with new information, and maintain support of partners and the general public.
- Active use of the decision support tool will rely on it being spatially explicit, flexible and broad-reaching so it can inform many funding and management decisions across habitats, scales and organizations.

Decision Analysis

The workshop participants recognized the significance of a decision support tool as means to effectively address the problem of identifying combinations of locations and ranked actions for Pennsylvania SGCN. The proposed approach would allow more versatility and functionality for a broad range of users and be less restrictive in the identifying the location for actions. Below are the steps for a preliminary draft approach for developing this decision support tool.

1. ***Valuing SGCN:*** The 2015 Pennsylvania Wildlife Action Plan prioritizes SGCN by hierarchical categories. To value conservation actions of differing benefits across species, we first need to know the relative value for species in each category. The actual species valuations for the 2015 Plan have not yet been determined. (Example: In the 2005 Plan, possible weighted values assigned to Tiers 1-5 respectively: 50, 25, 15, 10, 5).

2. ***Integrate species occurrence probabilities and SGCN weighted values:*** Species distribution models help determine the likelihood of a species occurrence. The relative value for each SGCN coupled with the probability of occurrence for that species at any location will help inform possible conservation actions at that location. Additively overlaying occurrence probabilities for each valued

SGCN will create a consolidated SGCN value map. This initial step can highlight areas of potential work (*e.g.*, SGCN hotspots).

3. ***Specify species-habitat associations:*** Species distribution and abundance are assumed to be influenced by habitat type and change in habitat condition.

4. ***Spatially depict current habitat cover types and habitat conservation actions:*** Habitats will shift temporally with some probability. Within the management decision timeframe, habitat changes due to alternative conservation actions are compared to the habitat change resulting from a "do nothing" option.

5. ***Identify alternative actions and consequences:*** Natural resource managers are faced with many possible actions within any landscape, ranging from "no action" to intensive management. Alternative actions for each habitat type and condition need to be identified, including the habitat (and condition) resulting from the specified action.

6. ***Evaluate trade-offs and optimize decision:*** The actions implemented can impact both SGCN and cost. SGCN consequences for an action will be evaluated based on the likelihood that it increases the presence of valued SGCN in the area, based on the previous information. Actions also should be compared using estimations of cost.

Summary

This conservation assessment tool will allow a broad range of partners to direct resources towards projects that are most relevant to their resource-management interests and financial capacities. It will provide guidance on the priority species and potential actions that may be most beneficial for the specific location.

COA Definitions and Considerations

Species of Greatest Conservation Need (SGCN): This is the focal group of species considered in this decision problem. SGCN are select, native species of birds, mammals, fishes, amphibians, reptiles and invertebrates included in the Pennsylvania Wildlife Action Plan based on global, national, northeast regional or state rarity, significant threats or declining populations in Pennsylvania. This categorization of species is non-regulatory; however, federal and state threatened and endangered species are included in this list.

Conservation action: This is the core issue of the decision problem. A conservation action can be broadly defined as "work conducted by state agencies, conservation partners, private landowners, industry and other stakeholders, for the benefit of SGCN and their habitats." Conservation actions are linked to current or future threats, and consider climate change impacts as a source of uncertainty. As discussed in this chapter, the 2015 Pennsylvania Wildlife Action Plan uses a common lexicon to categorize conservation actions (Salafsky *et al*. 2008). Examples of conservation actions include land protection

(*i.e*., acquisition, easements, preferred land management practices), habitat improvement and restoration, species reintroduction, land-use planning (*i.e*., ordinances, regulations).

Conservation Opportunity Area (COA): These are locations identified for implementation of a specific conservation action. A working definition of a COA is "an area that supports, or has the potential to support, SGCN and where conservation actions have the potential to improve the future state of the area for SGCN".

Efficient and effective conservation actions: The premise of this approach is to minimize costs of conservation actions while maximizing measurable conservation benefits to SGCN and their habitats.

Timing: We consider two timeframes for conservation actions while addressing this problem – the *management timeframe* and the *values timeframe*. With a 10-year planning horizon for the Pennsylvania Wildlife Action Plan (2015-2025), the *management timeframe* includes actions that can be accomplished within the next 5-10 years. However, these short-term actions should be directed toward the long-term *values timeframe* of the next 100 years.

Relevant Management or Implementation Plans

Introduction

The 2015 Pennsylvania Wildlife Action Plan is allied with other resource management plans implemented by federal, state and local partners throughout the Commonwealth and northeast region. Through Goal 5, *Continue to improve cooperation within and between public agencies and other partners in wildlife conservation planning and implementation, the* value of partnerships is clearly expressed. The management plans discussed here are of significant support to the 2015 Pennsylvania Wildlife Action Plan yet, given the numerous conservation organizations in Pennsylvania, do not represent all potential resource plans. With implementation of this Wildlife Action Plan, as projects are identified, we will engage potential partners and review their management plans for collaborative actions. Agency and resource management plans are dynamic and periodically updated and we will continue to evaluate these plans for their relevance to the 2015 Pennsylvania Wildlife Action Plan.

Invasive Species

The diverse and dynamic status of invasive species in Pennsylvania requires the comprehensive approach developed by the Pennsylvania Invasive Species Council (PISC) and discussed in Chapter 3. Many goals and actions in the Pennsylvania Invasive Species Management Plan (PAISMP) (PISC 2009) are aligned with Goals of the 2015 Pennsylvania Wildlife Action Plan (Table 4.10).

Once established, removal of an invasive species is difficult and expensive, and perhaps impractical, especially if an invasive species is found in an open system (e.g., a river, large lake with an outlet) and rapidly colonizes new habitats. Therefore, preventing entry and establishment of invasive species is crucial and measures should be conducted at the greatest practicable distance from a potential target area and at high-priority access points. Active public participation is necessary for prevention to be effective, and outreach needs to provide timely and relevant information to help keep invasive species

from becoming established and spreading. Additional actions identified in the Pennsylvania Invasive Species Action Plan would further address the threat of invasive species and support of the Actions below would greatly advance these efforts.

Table 4.10. Relationships between goals of the 2009 Pennsylvania Invasive Species Management Plan and 2015 Pennsylvania Wildlife Action Plan.

2009 Pennsylvania Invasive Species Management Plan	**2015 Pennsylvania Wildlife Action Plan** (# refers to goal number)
Control Restoration	1. Conserve Pennsylvania's native wildlife and its habitat by implementing conservation actions in the Wildlife Action Plan.
Prevention Early Detection and Rapid Response Survey and Monitoring Data Management Research	2. Base wildlife conservation decisions on the best available science, with an emphasis on Species of Greatest Conservation Need and its habitat.
Communication and Coordination	5. Continue to improve cooperation within and between public agencies and other partners in wildlife conservation planning and implementation.
Education and Outreach	6. Develop a knowledgeable citizenry that supports and participates in wildlife conservation.

The following goals and actions are adapted from the Pennsylvania Invasive Species Action Plan (PISC 2009) for their relevance to the 2015 Pennsylvania Wildlife Action Plan, and should be considered especially when SGCN and their habitats are impacted.

Control

Goal: Prioritize non-native invasive species on which to focus control efforts, and when feasible, control established non-native invasive species that have significant impacts in Pennsylvania.

Actions:

- Develop species-specific or location-specific action plans that include control measures.
- Support the development of control and containment techniques that include a comparison to the potential economic, environmental, and/or human health impacts of a “no action” alternative.

- Recommend a statewide strategy to facilitate coordination and cooperation on invasive species control among all stakeholders whose rights-of-way, or personal, business, or state-owned properties border highways, byways and riparian corridors.

Restoration
Goal: When feasible, integrate restoration efforts into control and management activities, as well as ecologically disruptive activities that may be conducive to invasive species colonization.

Actions:

- Review contracts, partnerships and projects to incorporate restoration measures wherever possible to prevent colonization by invasive species.
- Develop incentive programs for private landowners for the restoration of ecosystems vulnerable to invasion and make recommendations to establish/enhance these programs.
- To use their expertise and resources, create a master directory of existing efforts and key groups that focus on restoration of native habitats.

Prevention
Goal: Identify, evaluate, and address pathways used by non-native invasive species to minimize their introduction into and spread throughout the Commonwealth.

Actions:

- Establish a simple, coordinated reporting system for managing invasive species sightings and disseminating data to relevant agencies, partners, and stakeholders in a timely fashion.
- Establish a hotline or web site for the public to report sightings of suspected invasive species.
- Create watch lists of invasive species not yet known to occur or to be of limited distribution in the Commonwealth.
- Conduct surveys and monitoring to assess the threat to critical habitats and species from invasion and address their protection through policy when needed.

Early Detection and Rapid Response
Goal: Detect new introductions of non-native invasive species quickly and control or contain target species before they become permanently established in the Commonwealth or move into areas where they previously did not exist.

Actions:

- Develop specific action plans for species and locations.
- Identify and involve stakeholders in early detection and rapid-response planning efforts.
- Identify and support personnel training needs and interagency partnerships for successful early detection and rapid-response operations.
- Identify gaps in existing early detection efforts.

Survey and Monitoring
Goal: Expand survey and monitoring efforts of non-native invasive species in Pennsylvania.

Actions:

- Prioritize survey and monitoring efforts.
- Conduct surveys and monitoring to assess the threat to critical habitats and their species from invasion and address their protection through policy when needed.
- Incorporate long-term monitoring into eradication and control programs to ensure success.
- Encourage data-sharing.

Data Management

Goal: Develop a statewide non-native invasive species database clearinghouse or information sharing system linking data from various state, federal, and non-governmental entities.

Actions:

- Support the development of a central clearinghouse database, including geo-referenced data, technical information and contact information.
- Inventory the various databases that already exist within the Commonwealth.
- Facilitate the coordination of data management with federal, state, and non-government organizations.

Research

Goal: Support research efforts on non-native invasive species issues and impacts in Pennsylvania and work with partners to facilitate the dissemination of data generated from these efforts.

Actions:

- Encourage and support collaboration on scientific research between state and federal agencies, universities, and other non-governmental organizations.
- Facilitate the collection and dispersal of information, research and data about Pennsylvania invasive species.

Communication and Coordination

Goal: Facilitate communication and coordination across jurisdictional boundaries to ensure state policy effectively promotes the prevention, early detection, and control of non-native invasive species in Pennsylvania.

Actions:

- Develop a statewide strategy to facilitate coordination and cooperation for control activities among all stakeholders whose rights-of-way or personal business, or state-owned properties, border highways, byways and riparian corridors.
- Partner with neighboring states to share data and coordinate management activities.
- Partner with the National Invasive Species Council and regional invasive species panels to coordinate with national and regional programs and efforts.

Education and Outreach

Goal: Inform the general public and key target audiences about non-native invasive species issues so they do not facilitate the introduction and spread of these organisms through their activities.

Actions:

- Develop unified messages regarding invasive species prevention and control.
- Develop educational materials and create fact sheets specific to Pennsylvania on invasive species and distribute them to target audiences.
- Support and encourage local, community-based programs that target invasive species.
- Encourage the development of training modules for volunteer programs that can assist with invasive species prevention, identification, monitoring, and control with the appropriate oversight.
- Encourage citizen groups in Pennsylvania to become active in outreach and education about invasive species.
- Support the development of training programs to certify field staff in identification and reporting of invasive species; eventually, require this training for all appropriate state agency field staff.
- Provide briefings on the threats, economic impacts and solutions to decision-makers, legislators and advisory councils; keep them abreast of invasive species issues and concerns.

The potential harm to native habitats and species is highlighted by examples of resources provided by agencies and organizations that also are directing work to prevent and control this threat (Table 4.11).

Table 4.11. Examples of additional resources on invasive species.

PADCNR Invasive Plant Management Tutorial	http://www.dcnr.state.pa.us/forestry/plants/invasiveplants/index.htm
*i*MapInvasives database hosted by Western Pennsylvania Conservancy	http://imapinvasives.org/
PFBC-Aquatic Invasive Species Action Plans, Biosecurity measures	http://fishandboat.com/ais.htm
USDA-National Agricultural Library, Manager's Tool Kit	http://www.invasivespeciesinfo.gov/toolkit/pa.shtml

State Game Lands Management (PGC)

Benjamin Jones, PGC

Pennsylvania's State Game Lands (SGL) System is one of few public land bases owned and operated solely by a state wildlife agency. With 1.5 million acres (0.6 million hectares) spread across 330 tracts, a SGL is within a 30-minute commute of most Pennsylvanians. This distribution and quantity of SGLs provides unique opportunities "…to create and maintain public hunting and fur-taking, game or wildlife propagation areas, farms or facilities for the propagation of game or wildlife, special preserves or other uses incidental to hunting, fur-taking and game or wildlife resource management" [Title 34, §722(a)].

Although wildlife conservation is a primary focus, other pressures on the state's natural resources including oil, mineral, coal and gas extraction, public access, recreation, and rights-of-way are routinely addressed on SGLs. In addition, invasive species, declining trends in some wildlife populations, and pursuit of alternative energy sources present new challenges. Within the agency, maintaining public confidence and managing budget constraints also play important roles in SGL conservation.

In January 2006, the PGC began developing a comprehensive game lands planning process. Input was solicited from conservation partners, PGC field staff and bureaus during development. Comprehensive planning takes advantage of interdisciplinary expertise, updated inventory programs and technological advances to create game lands management plans. Ultimately, management planning streamlines field operations, facilitates cost-benefit analysis of activities, and update best management practices. The PGC ensures sound SGL stewardship with an adaptive resource management approach that addresses numerous pressures and adjusts to yet unforeseen challenges.

Pennsylvania's SGLs offer unique opportunities to actively manage for SGCN, a luxury not afforded to most states. The Game Lands planning process facilitates SGCN conservation by first listing, then prioritizing actions for SGCN. This puts a SGCN-focus within each management plan (individual plans are written for each tract). Most importantly, these site-specific implementation plans include timelines and real actions for habitat conservation and improvement.

Pennsylvania Game Commission, State Game Lands (SGL) Comprehensive Plan Structure

Chapter/Section/Subsection

I. Supporting Materials
- A. Introduction
  - 1. Size
  - 2. Location
  - 3. History
- B. Current Game Lands Use and Accessibility
  - 1. Public access to SGL
  - 2. Hunting and fur-taking opportunities
  - 3. Other lawful recreation
  - 4. Unlawful activities
- C. Wildlife Resources
  - 1. Mammals

2. Important Mammal Areas
3. Birds
4. Important Bird Areas
5. Threatened and endangered species
6. Additional species

D. Current Habitat Condition
1. Soils
2. Water resources
3. Operability
4. Plant community types
5. Critical and unique habitats
6. Invasive species

E. Land Uses
1. Oil, minerals, coal and gas
2. Leases and cooperative agreements
3. Rights-of-way
4. Infrastructure

F. Landscape Context
G. Acquisitions
H. Alternate Funding Opportunities
I. Management Opportunities
1. Game species
2. Threatened and endangered species
3. Species of greatest conservation need

II. Comprehensive Game Lands Plan
A. Desired Future Resource Condition
1. Goals
2. Strategies
3. Implementation
4. Monitoring

B. Management Timeline

While the entire plan is relevant to SGCN conservation because it is comprehensive (e.g., Table 4.12), the following sections and subsections specifically address Habitat, Threats, and Species identified in this Wildlife Action Plan revision.

SGL Plan Sections and Guidance Directly Relevant to the Wildlife Action Plan

C. Wildlife Resources

Pennsylvania is home, either seasonally or permanently, to a diverse list of wildlife species. However, subsets of Pennsylvania wildlife are found on specific SGLs, depending on habitat and geographic location. Determining which species may benefit from various SGL management scenarios is an integral part of the planning process. Professional judgment of local managers and biologists will be vital. Several databases provide additional insight, including the Pennsylvania State Wildlife Action Plan, the Pennsylvania Breeding Bird Atlas, Pennsylvania Biological Survey, Partners in Flight Prioritization Lists, Pennsylvania GAP Analysis Project, and the Pennsylvania Natural Heritage Program. Based on the Wildlife Action Plan and professional experience, Bureau of Wildlife Habitat Management (BWHM) and

Bureau of Wildlife Management (BWM) created a species-habitat matrix that will help assess presence or absence of SGCN.

1. Mammals
Based on habitat condition, site visits, professional judgment and local knowledge, indicate notable mammals for the SGL. Notable mammals include game species, species of greatest conservation need, or others of conservation significance. In most cases, ubiquitous mammals need not be mentioned (e.g., eastern chipmunk, white-footed mouse, groundhog).

2. Important Mammal Areas (IMA)
Indicate adjacent or inclusive Important Mammal Areas (IMAs) designated by the Important Mammal Area Project. Discuss conservation significance of the IMA and the SGL's role in that context.

3. Birds
Based on habitat condition, site visits, professional judgment and local knowledge, indicate notable birds for the SGL. Notable birds include game species, species of greatest conservation need, or others of conservation significance. In most cases, ubiquitous birds need not be mentioned (e.g., northern cardinal, black-capped chickadee, American robin).

4. Important Bird Areas
Indicate adjacent or inclusive Important Bird Areas (IBA) designated by the Important Bird Area program. Discuss conservation significance of the IBA and the SGL's role in that context.

5. Threatened and Endangered Species (T&E)
Identify species and location of PNDI "hits" for all Threatened or Endangered species. If presence of a T&E species is suggested by PNDI, submit the search receipt and initiate an information request to the appropriate agency. Note the submittal date and response (or lack thereof) in the plan.

6. Additional Species
Many plant and animal species that are not under PGC jurisdiction may have implications for SGL management. Indicate species not under PGC jurisdiction for which there may be critical and unique habitats on the game lands. Examples are known timber rattlesnake dens or bog turtle habitat.

D. Current Habitat Condition

Previous sections paint a general picture of the SGL and recreational activities thereon. This chapter describes the SGL in greater detail and provides a record of current soil and cover types. Updated cover maps created by regional forestry and land management personnel will provide the majority of information used to assess current condition. The Bureau of Wildlife Habitat Management developed the *Manual of Procedure for State Game Lands Cover Typing* as a guide to land classification on SGLs. The cover-typing system is based on terrestrial- and palustrine-plant communities of Pennsylvania (Fike 1999). This "inventory" of habitats is a critical step in SGL planning. Using the new cover typing system,

describe acreage and proportion of the SGL within each terrestrial-, palustrine-, and aquatic-community type, as well as each anthropogenic type. The most recent U.S. Geological Survey soil survey should be used to describe soils.

1. Water Resources
Describe the watershed in which the SGL is included. List streams by order (from PADEP, Chapter 93 classifications) and describe specific conservation values such as wild trout fisheries. Discuss how water resources influence habitats and management.

2. Operability
Indicate operational zones per the *Manual of Procedure for State Game Land Cover Typing*. Describe how operability influences wildlife-habitat management on the SGL. Are all areas easily accessible? What are specific challenges? Set the stage for management potential. Include appropriate table(s) or figure(s) in the Appendix.

3. Plant Community Types
This section describes current habitat conditions on the SGL. Habitats on SGLs are represented by plant community types and their successional stages. Describe plant community types, their structure, age, and spatial configuration from a habitat perspective. In the Appendix, include a map indicating spatial distribution of habitats. Also, include other appropriate tables or figures in the Appendix.

4. Critical and Unique Habitats
Identify other critical and unique habitats on the SGL. Critical and unique habitats may be relative to the specific SGL and surrounding landscape. Include maps in the Appendix.

5. Invasive Species
List invasive species occurring on the SGL, including control measures taken to date. Proposed actions should be included in Chapter I., Sections A and B.

E. Land Uses

Numerous land uses and natural-resource-extraction activities, such as right-of-way permitting and oil, gas, and mineral exploration and extraction occur on SGLs. These activities have affects (both positive and negative) on wildlife and their habitats. In this chapter, describe past, current, and potential future land-use activities on the SGL under consideration.

1. Oil, minerals, coal, and gas.
Describe past and current mining projects, acreage impacted, and current and potential reclamation on the SGL. Also describe status of oil, mineral, and gas ownership and how it may affect future extraction activities.

2. Leases and Cooperative Agreements

Indicate current easements, leases, or other agreements that influence SGL management. Examples include timber reserves, active coal extraction leases, and share-crop agreements. The written agreement may be included and referenced as an appendix.

3. Rights-of-way
Describe rights-of-way such as oil/gas lines, utility lines, and/or access routes that currently exist on the SGL. Also, describe potential for future right-of-way permitting and how such license applications will be assessed relative to wildlife habitat and hunting opportunities.

4. Infrastructure
Describe location and condition of buildings, equipment sheds, access roads, bridges, culverts, dams and other existing infrastructure. Indicate maintenance schedules and associated costs, if known. Examples: Do certain roads flood frequently, and how much stone is required annually for repair? When is the boundary scheduled for marking, and how much paint is required? A table and a map should be included as visual aids.

F. Landscape Context
Wildlife does not adhere to jurisdictional boundaries; therefore, land use on the surrounding landscape provides important management context. In this section, describe general land use/land cover of the area within a 2-mile radius of the SGL boundary. This information should not be as detailed as the SGL site description included in Section D. Rather, include information such as proportion of forest, agriculture, and developed area. Include adjacency to other public landowners such as the Allegheny National Forest and/or a State Forest. Include adjacency to Conservation Reserve Enhancement Program properties, PGC Hunter-Access properties, 400 Areas, and other conservation easements. Provide additional detailed information on surrounding land cover and land uses as available.

G. Acquisitions
One of the greatest conservation efforts undertaken by PGC is acquisition of new lands into the State Game Lands System. Considering landscape context and habitat value, discuss properties that might be pursued for acquisition (i.e., indentures, adjacent properties, access routes).

H. Alternate Funding Opportunities
Numerous opportunities exist for funding of habitat management projects on SGL.

I. Management Opportunities
With numerous birds and mammals in the Commonwealth and a diversity of habitat conditions on game lands, it is impossible to manage for all species on every SGL. The information collected to this point should narrow appropriate management opportunities. Based on that information, discuss management opportunities for the SGL. Considerable overlap will likely occur among the following categories:

1. Game Species
Discuss opportunities to manage habitats for huntable species on the SGL.

2. Threatened and Endangered Species
If threatened and endangered species occur, discuss management implications including opportunities to improve their habitats.

3. Species of Greatest Conservation Need
Based on species and key habitats identified in the State Wildlife Action Plan, discuss opportunities to manage for species of greatest conservation need.

Table 4.12. Relationship between select goals of the Game Commission's 2010-2020 State Game Lands Comprehensive Management Plan and 2015 Pennsylvania Wildlife Action Plan.

2010-2020 State Game Lands Comprehensive Management Plans (Section/Subsection)	**2015 Pennsylvania Wildlife Action Plan Goal # (Objective #)**
Chapter I	
Game Land Use and Accessibility • Public Access, Hunting opportunities, Non-hunting recreation, • Illegal activities	2 (2.4)
Wildlife Resources • Mammals, IMA, Birds, IBA, T&E Species, Additional Species	1 (1.1)
Current Habitat Condition • Water resources, Plant community types, Critical & unique habitats • Invasive Species	1 (1.1), 2 (2.3)
Land Uses • Oil, minerals, coal, and gas, rights-of-way, infrastructure	1 (1.1) 2 (2.3)
Landscape Context	2 (2.5, 2.6)
Acquisitions	1 (1.2)
Alternate Funding Opportunities	4 (4.1, 4.3)
Management Opportunities • Species of Greatest Conservation Need, Threatened & Endangered species	1 (1.1, 1.2) 2 (2.6) 5 (5.4)
Chapter II	
Strategies and Implementation	1 (1.1, 1.2)
Monitoring	1 (1.3), 2 (2.1, 2.2)

State Forest Management (PADCNR)

With approximately 2.1 million acres (0.85 million hectares) of state forest land comprising 12% of Pennsylvania's forested habitat, management activities by the Pennsylvania Department of Conservation and Natural Resources (PADCNR) on these lands can affect a broad range of forest-dependent SGCN. For these lands, the 2003 Pennsylvania Forest Management Plan (PADCNR 2003),

Pennsylvania Forest Strategies (PADCNR 2010a) and Pennsylvania Statewide Forest Resource Assessment (PADCNR 2010b) provide guidance to manage and protect this crucial habitat for SGCN. In both the Pennsylvania Forest Strategies (PADCNR 2010a) and Pennsylvania Statewide Forest Resource Assessment (PADCNR 2010b), resource concerns of Land Use, Forest Health, Forest Management, Climate Change, Communicating Natural Resource Values, Energy Development also are relevant to the 2015 Pennsylvania Wildlife Action Plan.

The Pennsylvania Forest Management Plan (PADCNR 2003) focuses on several issues or themes, policies and goals congruent with the 2015 Pennsylvania Wildlife Action Plan. For example, select goals and policies under themes of *Ecological Considerations*, *Water Resources* and *Faunal Resources*, highlighted below, will support a biologically diverse landscape and are aligned with goals of 2015 Pennsylvania Wildlife Action Plan (Table 4.13). Other goals and policies within the 2003 Pennsylvania Forest Management Plan may be relevant, but these are provided to demonstrate the linkages between these plans.

Adapted from PADCNR (2003)

Ecological Considerations

Policy: The Bureau of Forestry will use ecological units in inventory, planning, and conservation and management efforts.

Goal . To participate in the continued refinement of the Pennsylvania community classification effort.

Policy: The maintenance and restoration of ecoregional biological diversity will be a key consideration in resource management efforts on state forest lands.

Goal. To conserve or enhance ecoregional biological diversity through the management of state forest lands.

Policy: The state forest bioreserve system will contribute to the long-term survival of species occurring on state forest lands by conserving populations of rare, unique and endangered species, as well as other ecologically significant populations and examples of all native plant communities, including old-growth communities.

Goal 1. To establish and maintain a bioreserve system within the state forests.

Goal 2. To monitor and update the state forest bioreserve system portfolio periodically in conjunction with the forest management planning process.

Policy: The Bureau [of Forestry] will protect selected areas of special scientific, scenic or ecological significance through the establishment of natural and wild areas.

Goal 1. To protect areas of scenic, historic, geologic or ecological significance through establishment of natural areas that will remain in an undisturbed state, with development and maintenance limited to that required for public health and safety.

Goal 2. To set aside certain areas of land known as wild areas where development or disturbance of a permanent nature will be prohibited, thereby preserving the wild character of the area.

Policy: Old-growth systems will be protected and promoted on State Forests.

Goal 1. To protect existing old-growth systems on State Forests.

Goal 2. To develop and implement a strategy to promote future old-growth systems on State Forest.

Policy: Forest fragmentation, connectivity and patch distribution will be considered in management decisions affecting State Forest resources.

Goal. To reduce and limit forest fragmentation and promote connectivity of high-canopy forests by maintaining fluid corridors throughout the State Forests.

Water Resources

Policy: Water Resources Management involves all water resources, values, uses, functions, and delineations. The Bureau of Forestry will manage water resources within the context of ecosystem management, considering the wide range of potential impacts, issues, and opportunities relating to water resources.

Goal 1. Protect and enhance water resources to produce the highest-quality water possible from State Forests.

Goal 2. Protect, manage, and enhance riparian ecosystems.

Goal 3. Protect, manage, and enhance aquatic ecosystems.

Goal 4. Manage water resources for "in-stream" values and functions such as recreation, aesthetic enjoyment, and habitat for aquatic ecosystems.

Faunal Resources

Policy: State Forests will be managed to ensure the conservation of a diversity of native forest animals and the provision of suitable habitats for these creatures.

Goal 1. Manage the forests to provide diverse and productive wildlife habitats and habitat components.

Goal 2. Protect species of special concern and promote their recovery to viable levels.

Goal 4. Provide for the conservation of "keystone" and other specific animal species or habitats by designating special management areas and developing specific strategies for the management of these resources.

Goal 5. Identify and manage faunal resources on State Forests that are imperiled by invasive plant or animal species.

Table 4.13. Relationship between select goals of the 2003 Pennsylvania Forest Management Plan (PADCNR 2003) and 2015 Pennsylvania Wildlife Action Plan.

2003 Pennsylvania Forest Management Plan	2015 Pennsylvania Wildlife Action Plan Goal # (Objective #)
Ecological Considerations	
To participate in the continued refinement of the Pennsylvania community classification effort.	2 (2.8)
To conserve or enhance ecoregional biological diversity through the management of State Forests.	1 (1.2)
To establish and maintain a bioreserve system within the State Forests.	1 (1.2)
To monitor and update the State Forest bioreserve system portfolio periodically in conjunction with the forest management planning process.	2 (2.2, 2.4)
To protect areas of scenic, historic, geologic or ecological significance through the establishment of natural areas that will remain in an undisturbed state, with development and maintenance being limited to that required for public health and safety.	1 (1.1)
To set aside certain areas of land known as wild areas where development or disturbance of a permanent nature will be prohibited, thereby preserving the wild character of the area.	1 (1.1)
To protect existing old-growth systems on State Forests.	1 (1.1, 1.2)
To develop and implement a strategy to promote future old-growth systems on State Forests.	5 (5.5)
To reduce and limit forest fragmentation and promote connectivity of high-canopy forests by maintaining fluid corridors throughout the State Forests.	2 (1.2)
Water Resources	
Protect and enhance water resources to produce the highest-quality water possible from State Forests.	1 (1.2)
Protect, manage, and enhance riparian ecosystems.	1 (1.2)
Protect, manage, and enhance aquatic ecosystems.	1 (1.2)

Manage water resources for "in-stream" values and functions such as recreation, aesthetic enjoyment, and habitat for aquatic ecosystems.	1 (1.1)
Faunal Resources	
Manage the forests to provide diverse and productive wildlife habitats and habitat components.	1 (1.1, 1.2)
Protect species of special concern and promote their recovery to viable levels.	1 (1.1, 1.2)
Provide for the conservation of "keystone" and other specific animal species or habitats by designating special management areas and developing specific strategies for the management of these resources.	1 (1.2)
Identify and manage faunal resources on State Forests that are imperiled by invasive plant or animal species.	2 (2.5)

This part of page intentionally blank.

In PADCNR (2010b), Issues, Threats, and Opportunities identified for plants and wildlife, include:

- Climate change
- Invasive species
- Identifying keystone habitats
- Habitat fragmentation and conversion of native cover types
- Decline of critical tree species
- Degradation and conversion of wetlands, riparian corridors and other aquatic habitats
- Diseases

All of these topics are considered crucial issues in the 2015 Pennsylvania Wildlife Action Plan. A detailed discussion of these documents is beyond the scope of this Plan, but readers are encouraged to review them when working on these topics.

Specific strategies identified for Climate Change and Plant and Animal Habitat in PADCNR (2010a) are particularly relevant to this Wildlife Action Plan (Table 4.14). Other strategies discussed in PADCNR (2010a) also can influence SGCN, but these are particularly germane to the 2015 Pennsylvania Wildlife Action Plan.

Table 4.14. Relationship between select strategies of the 2010 Pennsylvania Forest Strategies (PADCNR 2010a) and 2015 Pennsylvania Wildlife Action Plan.

2010 Pennsylvania Forest Strategies	**2015 Pennsylvania Wildlife Action Plan Goal # (Objective #)**
Climate Change	
Identify climate change impacts and prioritize research and survey efforts.	2 (2.5)
Promote resilience to climate change.	1 (1.2)
Identify species and resources vulnerable to climate change.	2 (2.5)
Plan for changes in forest composition.	5 (5.2)
Identify the range of conservation options.	5 (5.2)
Adapt monitoring programs.	2 (2.2, 2.4)
Coordinate with partners.	5 (5.3)
Educate the public.	6 (6.1)

Plant and Animal Habitat	
Identify plant and wildlife taxa and habitats of special concern that rely on private and state forest land.	1 (1.2)
Develop regional or landscape level plans to promote protection and restoration of contiguous forest landscapes.	5 (5.2)
Conserve wetland and aquatic habitats on private and state forest lands.	1 (1.1., 1.2)
Assist in developing effective identification, tracking, and management of invasive species impacts to plant and animal habitats and provide training about habitat specific concerns related to invasive species to technical service providers, land managers, and landowners.	2 (2.5)
Identify plant and wildlife species and habitat types vulnerable to climate change impacts.	2 (2.5)
Develop an effective "bioreserve" network across public and private forest.	1 (1.2)
Maintain forest canopy diversity.	1 (1.2)
Restore and manage forest understory vegetation.	1 (1.2)
Adapt monitoring programs.	2 (2.2, 2.4)
Coordinate and collaborate with partners.	5 (5.3)
Educate the public about forest habitat values.	6 (6.1)

Eastern Hemlock Management Plan

Eastern hemlock (*Tsuga canadensis*), Pennsylvania's state tree, was initially recognized for its commercial value to tanneries, but ecologically it has become known as a critical component in many riparian areas of the state. As a foundational species for these areas, eastern hemlock influences stream quality and site conditions, and provides habitat for a wide range of plants and animals (PADCNR 2014). This important tree, as noted in Chapter 3, is threatened by the invasive hemlock woolly adelgid (HWA) (*Adelges tsugae*) and additional threats are posed by climate change, especially with warmer winters that may allow expansion of HWA throughout the range of eastern hemlock (Paradis et al. 2008; Dukes et al. 2009). Numerous other diseases including; elongate hemlock scale (*Fiorinia externa*), cryptomeria scale (*Aspidiotus cryptomeriae*), shortneedle evergreen scale (*Nuculaspis tsugae*) and hemlock looper (*Lambina fiscellaria*) also threaten this tree (PADCNR 2014). [Note: Additional pests were mentioned, but these are a few examples to illustrate threats.]

Two conservation Strategies for eastern hemlock focus on addressing diseases and climate-change adaptation. For diseases, multiple control measures (e.g., chemical, biological), and implication of silvicultural practices, such as establishing alternative species, are discussed.

Climate change has two potential pathways to threaten eastern hemlock. First, increasing winter temperatures may allow HWA to survive and thus inflict further losses of trees. The other pathway is through general increases in temperatures that may reduce habitat suitability for this tree (PADCNR 2014). For climate change, identifying and maintaining refugia, adapting control measures such as increased insecticide applications if HWA continues to expand, and adaptive tree replacement (i.e., promoting alternative tree species) are potential measures. The following Focus Areas for hemlock protection were chosen primarily because of their populations of old-growth hemlock.

Tionesta Scenic and Research Areas in the Allegheny National Forest.

- Cook Forest State Park is located in northwestern Pennsylvania.
- Heart's Content Scenic Area in the Allegheny National Forest.
- Bear Meadows Natural Area is an 890-acre (360 ha) National Natural Landmark in Rothrock State Forest.
- Alan Seeger Natural Area also is located in Rothrock State Forest.
- Snyder Middleswarth Natural Area.

Agricultural Land Management

*Adapted from 2011 -2015 USDA-NRCS Strategic Plan for Pennsylvania (*USDA-NRCS 2012).

Working with producers to improve natural resources and moderate impacts of major agricultural and forestry practices is a significant focus of 2011-2015 Strategic Plan for Pennsylvania (USDA-NRCS 2012). In this plan, major agricultural land uses and habitats are described and include resource concerns and conservation actions. Although this strategic plan is scheduled to expire 09.30.15, the Pennsylvania USDA-NRCS Office fully anticipates that key activities of this document will continue to be implemented in subsequent years. The 2011-2015 USDA-NRCS Strategic Plan for Pennsylvania prioritized its efforts based on five major land uses that included:

- Livestock Production Areas
- Cropland
- Grazing and Forage Lands
- Streams and Wetlands
- Forests

Agricultural activities in each of these habitats can influence environmental conditions and ultimately the status of SGCN. Here we highlight habitats such as Grazing and Forage Lands, Streams and Wetlands, and Forests, that are relevant to the 2015 Pennsylvania Wildlife Action Plan. As noted in Chapter 2, agricultural practices encompass approximately 23% of Pennsylvania's landscape and, conservation practices directed by the 2011-2015 USDA-NRCS Strategic Plan for Pennsylvania (USDA-NRCS 2012), provide crucial management and protection across multiple habitats within the 2015 Pennsylvania Wildlife Action Plan. Readers are encouraged to review the entire USDA-NRCS Strategic Plan for specific actions implemented by the USDA-NRCS (Pennsylvania office) to achieve these objectives and strategies.

Streams, Wetlands and Watersheds

Recognizing that streams are threatened by excessive sediments, nutrients and high temperatures, objectives and strategies in the 2011-2015 USDA-NRCS Strategic Plan for Pennsylvania are directed to actions that will ameliorate these impacts to this habitat on agricultural lands (USDA-NRCS 2012). In streams, conservation practices are focused to protect and improve stream habitat and water quality, with a special emphasis on native eastern brook trout (Strategy A4) (Table 4.15). Key to implementing these strategies and actions, the USDA-NRCS is working to:

1. Establish and maintain riparian forest buffers.
2. Stabilize severely eroded streambanks.
3. Reduce impacts of legacy sediments.
4. Increase in-stream habitat for fish.

The anticipated outcomes of these activities are wetlands, floodplains, riparian areas, and streams restored to healthy functioning condition, and improved water quality.

Wetlands offer a broad range of ecological services (e.g., nutrient cycling, hydrological control) and in southeastern Pennsylvania, in cropland and pasture areas, management activities can create and improve habitat for the federally threatened bog turtle (*Glyptemys muhlenbergii*). Through Working Lands for Wildlife (WLFW), the USDA-NRCS, along with USFWS, PFBC and Mid-Atlantic Center for Herpetology and Conservation have directed considerable financial and technical resources in support of this species. In northwestern Pennsylvania, wetland management activities are directed to enhancing habitats for the Pennsylvania endangered eastern massasauga (*Sistrurus catenatus catenatus*). The anticipated outcome of this work is healthy wetlands in cropland and pasture areas.

Working at the watershed scale offers a holistic approach to address threats. The emphasis of the USDA-NRCS watershed-based initiatives are flood-control through dams, although Strategy C2 is directed towards outreach and partnerships with messaging on sustainability. Avoiding or lessening the effects of catastrophic events, such as dam failures, or impacts of major weather events (e.g., tropical storms, hurricanes), can help protect critical habitats for SGCN.

Table 4.15. Relationship between objectives and strategies in the 2011-2015 USDA-NRCS Strategic Plan (USDA-NRCS 2012) for Pennsylvania for streams, wetlands and watersheds, and goals and objectives of the 2015 Pennsylvania Wildlife Action Plan.

2011-2015 USDA-NRCS Strategic Plan (PA) Objectives and Strategies	2015 Pennsylvania Wildlife Action Plan Goal # (Objective #)
Streams	
Objective A: Protect and Improve Streams in Cropland and Pasture Areas	1 (1.1, 1.2)
Strategy A1: Increase the establishment of riparian forest buffers by 10% and maintain waterways protected by existing riparian forest buffers.	1 (1.1, 1.2)
Strategy A2: Stabilize 90% of severely eroded streams whose natural flows were disrupted by natural disasters.	1 (1.1, 1.2)
Strategy A3: Reduce the impact of legacy sediments by developing one demonstration project to remove sediment trapped by a mill dam or other structure and restore the stream and floodplain to a stabilized healthy condition.	1 (1.1, 1.2)
Strategy A4: Increase stream habitat conditions for eastern brook trout by 5%.	1 (1.1, 1.2)
Wetlands	
Objective B: Protect and Improve Wetlands in Cropland and Pasture Areas	1 (1.1, 1.2)
Strategy B1: Create, enhance, and protect an additional 5% of known or potential wetlands targeting bog turtle and eastern massasauga wetland habitat.	1 (1.1, 1.2)
Strategy B2: Restore 5% of degraded wetlands and adjacent plant communities to improve plant community structure and composition, control invasive species, and improve plant productivity and health.	1 (1.1, 1.2)
Watersheds	
Objective C: Watershed Operation, Rehabilitation, Emergency Streams Restoration	
Strategy C2: Increase outreach efforts to develop and support partnerships that will encourage the protection and sustainable uses of a watershed's natural resources.	6 (6.1, 6.3)

Forests

Among forest-dwelling species, the golden-winged warbler (*Vermivora chrysoptera*) and Indiana bat (*Myotis sodalis*) have been the focus of objectives and strategies in the 2011-2015 USDA-NRCS Strategic Plan for Pennsylvania (Table 4.16). In recent years, substantial funding for conservation practices and technical assistance, especially for golden-winged warblers, has been directed by the USDA-NRCS Pennsylvania office through the Working Lands for Wildlife program.

The USDA-NRCS also directs support to improve the health of forests and woodlands by increasing implementation of forest management plans. A Forest Management Plan is a site-specific plan that addresses resource concerns where forestry-related conservation activities will be applied. A Forest Management Plan includes: types and amount of practices to be implemented, schedule for implementation, and appropriate specifications for each practice.

Table 4.16. Relationship between objectives and strategies in the 2011-2015 USDA-NRCS Strategic Plan for Pennsylvania for Forests and goals and objectives in the 2015 Pennsylvania Wildlife Action Plan.

2011-2015 USDA-NRCS Strategic Plan (PA) Objectives and Strategies	2015 Pennsylvania Wildlife Action Plan Goal # (Objective #)
Forests	
Objective A: Increase Habitat for At-Risk and Declining Wildlife Species (specifically golden-winged warblers (*Vermivora chrysoptera*) and Indiana bats (*Myotis sodalis*).	1 (1.1, 1.2)
Strategy A1: Increase adequate size habitat and connected corridors by 5% for golden-winged warblers and other at-risk species by creating "young forest" (i.e., early successional) habitat.	1 (1.1, 1.2)
Strategy A2: Create, enhance, and protect an additional 5% habitat for the Indiana bat in the Healthy Forest Reserve Program (HFRP) targeted area.	1 (1.1, 1.2)
Objective B: Improve the health of Forests and Woodlands	1 (1.1, 1.2)
Strategy B1: Increase the number of implemented forest management plans that minimize invasive species, increase populations of declining species, and address water quality issues.	1 (1.1, 1.2)

Grasslands

Objectives and strategies for grasslands have a desired outcome of healthy perennial vegetative cover that can have important conservation benefits, such as preventing soil erosion, improving water quality and enhancing wildlife habitat (Table 4.17). From its beginning in 2000, the Conservation Reserve Enhancement Program in Pennsylvania has provided incentives to landowners who establish perennial grasses and legumes, and maintain perennial cover. Grasslands for agriculture, including grazing of livestock, mowing for hay and as a renewable biomass energy source also can be habitat for wildlife when conducted in a sustainable manner and with appropriate safeguards, such as timing of these activities.

Table 4.17. Relationship between objectives and strategies in the 2011-2015 USDA-NRCS Strategic Plan for Pennsylvania for Grasslands and goals and objectives in the 2015 Pennsylvania Wildlife Action Plan.

2011-2015 USDA-NRCS Strategic Plan (PA) Objectives and Strategies	**2015 Pennsylvania Wildlife Action Plan Goal # (Objective #)**
Grasslands	
C. Objective: Improve the Health of Permanent Grasslands (Hay, Biomass and Meadows)	1 (1.1, 1.2)
Strategy C2: Restore and protect an additional 5% of native cool and warm season grassland communities to improve biodiversity and habitat for grassland bird wildlife and produce renewable energy biomass feedstock.	1 (1.1, 1.2)

Anadromous Fishes

Atlantic States Marine Fisheries, Delaware River Basin

Adapted from Delaware River Basin Fish & Wildlife Management Cooperative (2011).

Within the Delaware River Basin, the Delaware River Basin Fish and Wildlife Management Cooperative (Cooperative) is responsible for the management of American shad (*A. sapidissima*), a Pennsylvania SGCN. The Cooperative is seeking sustainability of the Delaware River American shad stock at current levels of recreational and commercial usage. Through extensive data review and analysis, the Cooperative has identified several indices for monitoring the Delaware stock with associated benchmarks. The Cooperative will judge these fisheries as sustainable provided the indices of stock condition remain within the defined benchmarks.

Exploitation of the Delaware River shad stock occurs in several fisheries within the Basin. Commercial harvest is permitted by New Jersey and Delaware, generally during the spring spawning migration from late February into May. Historically, a substantial recreational fishery for shad existed in the non-tidal

reaches of the Delaware River; however, participation in this fishery is declining. The current recreational harvest is unknown. Most shad anglers practice catch-and-release fishing. The mortality associated with catch-and-release of shad in the Delaware River is unknown, but considered to be minimal.

The Cooperative's plan identifies monitoring benchmarks for populations. If the benchmarks are exceeded, options for management actions, especially regulation changes, then will be considered. Pennsylvania (PFBC) is a member of this Cooperative and the Atlantic States Marine Fisheries Commission.

Pollinator Conservation

Monarch Butterfly Conservation Strategy

Adapted from USDA-FS (2015).

The significant ecological services provided by pollinators, coupled with their general decline, have contributed to the increasing interest in this group. Among the more well-known pollinators is the monarch butterfly (*Danaus plexippus*), a 2015 Pennsylvania SGCN that is among 64 pollinators (Chapter 1, Appendix 1.1) identified by Leppo et al. (2015). The concern for these animals is illustrated by a June 2014 Presidential Memorandum directing Executive Departments and Agencies to develop a National Pollinator Health Strategy (Pollinator Health Task Force 2015). This strategy establishes specific goals for honey bees, monarch butterflies and pollinator acreage. Further, the U.S. Forest Service identified research, habitat management, public outreach needs, and development of public-private partnerships as major needs (USDA-FS 2015).

Climate Change

Adapting to Climate Change: Getting Started

Adapted from Staudinger et al. (2015c). *Scale-Appropriate Adaptation Strategies and Actions in the Northeast and Midwest United States; Chapter 4 in* Staudinger et al. (2015a).

Adaptation Concepts

Overview of Climate-Change Adaptation

Climate-change adaptation, a growing field within conservation and natural resource management, is focused on preparing for, and responding to, the current and future impacts of climate change and reducing related vulnerabilities (IPCC 2007a; Parry et al. 2007; Heller & Zaveleta 2009; Glick et al. 2011). Ecological systems are subject to natural variability over short and long timescales, but climate change is increasingly pushing species and systems beyond historical ranges of fluctuations. Therefore, managers must embrace a new paradigm of managing for change, rather than persistence (Milly et al. 2008). This requires goals and actions that consider not only how a system or population already has changed, but what conditions it is expected to experience as climate change continues to develop (Stein et al. 2013). Additionally, it is increasingly necessary that conservation and management initiatives act across the

landscape to increase connectivity among refugia and protected habitats, and sustain ecological functioning and processes (Stein et al. 2013).

Climate-change adaptation is largely about balancing goals and trade-offs, and there are many lessons to be drawn from ecosystem-based management approaches, which have been challenged with similar complex issues (Larkin 1996). Climate change also introduces high uncertainty to the decision-making process. This uncertainty is highlighted by the inability to exactly predict future climate conditions, how species and systems will respond to climate change and other stressors that act synergistically or cumulatively, as well as human response and behavior. Therefore, managers are considering actions and making informed decisions encompassing a range of possible futures and associated risks. Fortunately, planning approaches have been developed to help managers account for uncertainty (e.g., scenario planning) and are noted later in this section. Finally, managers may consider their available resources and weigh decisions and actions that have the greatest chance of success under future climate conditions.

To sustain fish and wildlife populations and their habitats, climate change adaptation requires evaluation over multiple temporal and spatial scales. Over short-term and small geographic scales, regardless of whether further assessment and information are needed, actions can be taken now to minimize effects of climate change on both ecosystems and humans. Over long-term and large geographic scales, responses to climate change should take advantage of existing and emerging knowledge to identify areas that are more resilient, more likely to adapt, or conversely, that are at highest risk. Efficient and effective adaptation plans and actions should engage and form collaborations among government agencies, non-governmental organizations, planners, researchers and municipalities to achieve common goals (NH Fish and Game Department 2013).

Broad recommendations for adapting ecosystems to climate change have previously been suggested and synthesized (Heinz Center 2008; Heller & Zaveleta 2009; Millar et al. 2007; Ogden & Innes 2008). Readers should review Staudinger et al. (2015c) for highlights of goals, approaches, processes, and actions considered and implemented across the northeast and midwest United States as illustrated through case studies at landscape, ecoregional, state, and local scales. Case studies highlight how different researchers and organizations are confronting complex issues related to climate change. Because of the relatively nascent status of adaptation development and regional programs that support adaptation, many of the highlighted initiatives are ongoing. The intention is to increase awareness of these initiatives and facilitate connections between researchers and managers across the region that may have specific interests in the process or outcomes of these projects. These examples may provide guidance for developing adaptation plans that incorporate effects and ecological responses to climate change, as well as associated uncertainty.

Principles of Adaptation

Considerable efforts have been directed to provide conceptual frameworks (e.g., Millar et al. 2007; Peterson et al. 2011), compile adaptation strategies (e.g., Heinz Center 2008; Heller & Zavaleta 2009;

Ogden & Innes 2008), and tools to support management decision-making (e.g., Cross et al. 2012; Morelli et al. 2012b; Swanston & Janowiak 2012). Along with these materials, basic principles (Table 4.18) can serve as a starting point for incorporating a climate-change adaptation perspectives into an existing management framework (Joyce et al. 2008; Millar et al. 2007; Swanston & Janowiak 2012; Wisconsin Initiative on Climate Change Impacts 2011).

Table 4.18. Climate-Adaptation Principles for management frameworks. Source: Staudinger et al. (2015c).

Climate-Adaptation Principle	Description
Prioritization and triage	It will be increasingly important to prioritize actions for adaptation based both on the vulnerability of natural resources and on the anticipated effectiveness of actions that attempt to reduce vulnerability.
Flexible and adaptive management	Adaptive management provides a decision-making framework that maintains flexibility and incorporates new knowledge and experience over time.
"No regrets" decisions	Actions that result in a wide variety of benefits under multiple scenarios and have little or no risk may be initial places to consider re-prioritization and look for near-term implementation.
Precautionary actions	Where vulnerability is high, precautionary actions to reduce risk in the near term, even with existing uncertainty, may be extremely important.
Variability and uncertainty	Climate change is much more than increasing temperatures; increasing climate variability will lead to equal or greater impacts that will need to be addressed.
Integrating mitigation	Many adaptation actions complement actions to mitigate climate change; for example, adapting forests to future conditions can help maintain and increase their ability to sequester carbon.

This part of page intentionally blank.

Developing Adaptation Strategies and Actions: Broad Goals to Specific Tactics

Climate-change adaptation strategies and approaches for natural resources can be regarded as a continuum of potential actions (Fig. 4.2). At the highest level, are the broad and largely conceptual *Options* of resistance (forestall change in ecosystems), resilience (enhance resilience of ecosystems to change), and transition (transition ecosystems into alignment with anticipated future conditions) (Millar et al. 2007). Adaptation *Strategies* and *Approaches* provide intermediate "stepping stones" that enable managers to translate broad concepts into targeted and prescriptive *Tactics* for implementing adaptation (Janowiak et al. 2010; Swanston & Janowiak 2012).

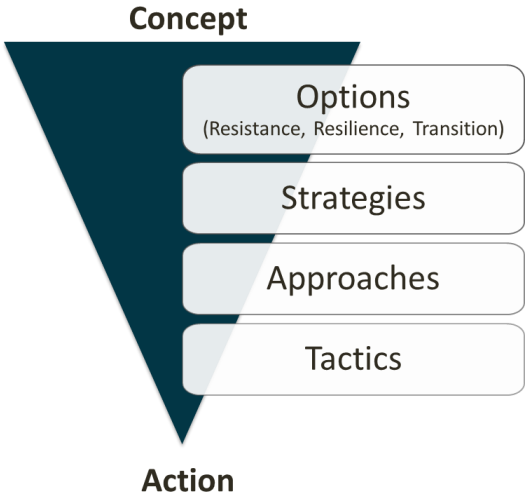


Fig. 4.2. Conceptual approach to climate change adaptation. Adaptation actions become increasingly specific along a continuum of options, strategies, approaches and tactics. Source: Janowiak et al. 2014b; Staudinger et al 2015a. *Used with permission by the DOI Northeast Climate Science Center and Northern Institute of Applied Climate Science.*

Options or Goals – The options of resistance, resilience, and response serve as the broadest and most widely applicable level of a continuum of management responses to climate change (Janowiak et al. 2011).

- **Strategies** – Adaptation strategies begin to illustrate the ways that adaptation options could be employed, and are abundant in recent literature and reports. Strategies, however, are still very broad, and can be applied in many ways across a number of landscapes and species.
- **Approaches**– Approaches provide greater detail on how managers may be able to respond, and differences in application among specific species and habitat types. Management goals start to become evident.
- **Tactics –** Tactics are the most specific adaptation response on the continuum, providing prescriptive direction in how actions can be applied on the ground.

Examples of 10 strategies and 39 specific approaches were synthesized from scientific papers that discussed adaptation actions at various scales and locations (Butler et al. 2012; extracted strategies are listed in Staudinger et al. 2015a, Appendix 4.1). Although originally focusing on forest ecosystems in northern Wisconsin, these strategies and approaches have proven to be broadly applicable to terrestrial ecosystem types across the Midwest and Northeast. By stating an intention to promote options of resistance, resilience, or response and explicitly linking strategies and approaches to on-the-ground tactics, managers are better able to specify how they will meet management goals through adaptation.

Processes for Adaptation Planning and Implementation

Processes with frameworks and structured steps can enhance transparency and participation in planning and decision-making, and directly address sources of uncertainty from climate change (e.g., possible future conditions, model projections), human response behaviors, and other sources (e.g., land-use change). Among those discussed by Staudinger et al. (2015c) include:

- The Adaptation Workbook (Swanston and Janowiak 2012)
- Climate-Change Vulnerability Assessments (CCVAs)
- Structured Decision-Making (SDM) (Hammond et al. 1999)
- Adaptive Resource Management (ARM) (Williams and Brown 2012)
- Scenario Planning

Readers should review Staudinger et al. (2015c) for a more detailed discussion and application of these decision-making processes and tools that may be pertinent to their specific needs and objectives. Additionally, the expanding availability of web-based tools may further support decision-making processes and are highlighted by Staudinger et al. (2015c, in Appendix 4.2 of that report). In Pennsylvania, Structured Decision Making was used in developing the concepts for Conservation Opportunity Areas (COAs) and also could be a useful approach to more thoroughly evaluate our approach to climate change.

Regional Adaptation Strategies: Case Studies

Staudinger et al. (2015c) illustrated application of adaptation strategies, approaches, and tactics implemented at the ecoregion, state, and local scales. Many of the projects highlighted are being conducted by the Northeast Climate Science Center (NE CSC) and diverse partners. At the local scale, examples include ongoing or recently completed projects focused on aquatic systems, forests, terrestrial wetlands, coastal, and tribal lands. Additionally, Staudinger et al. (2015c; Appendix 4.1) synthesized over 900 adaptation strategies by scale (e.g., national, ecoregional, state, and local), target resource (e.g., major taxonomic group or habitat type), and climate stressor (e.g., temperature, precipitation, sea-level rise) from nine regional adaptation studies. Each of the adaptation strategies listed in Staudinger et al. (2015c; Appendix 4.1) also is organized by the seven overarching goals listed in the National Fish, Wildlife and Plants Climate Adaptation Strategy (NFWPCAP 2012). These materials provide searchable examples ranging from large scale, broad goals to local scale, species or habitat-specific actions and implementation.

Provided below are regional case studies more fully described by Staudinger et al. (2015c).

Landscape and Ecoregion

- Landscape Conservation Cooperatives and Landscape Conservation Design
- USDA Northern Forests Sub Hub
- Northern Institute of Applied Climate Science
- Climate Change Resource Center (CCRC)
- Climate Change Response Framework (CCRF)
- Southeast Conservation Adaptation Strategy

- Conservation Opportunity Areas

Local

Aquatic Systems

- Landscape scale decision-making for headwater stream ecosystem conservation
- Assessing aquatic vulnerability through storm transposition

Forests

- ❖ Modeling effects of climate change on spruce-fir forest ecosystems and associated priority bird populations

Terrestrial Wetlands

- ❖ Novel management approaches for a vernal pool breeding salamander (marbled salamander, *Ambystoma opacum*).

National Adaptation Strategies

Adapted from the National Fish, Wildlife, and Plants Climate Adaptation Strategy (NFWPCAP 2012).

In 2009, Congress requested the Council on Environmental Quality (CEQ) and U.S. Department of Interior (DOI) to develop a national, government-wide strategy for fish, wildlife and plant climate adaptation. From this Congressional request, the *National Fish, Wildlife and Plants Climate Adaptation Strategy (Strategy)* (NFWPCAP 2012) was developed and became the first joint effort of federal, state, and tribal governments, with primary authority and responsibility for the living resources of the United States, to identify steps to help these resources become more resilient, adapt to, and survive, a warming climate. The Strategy is designed to inspire and enable natural resource managers, legislators, and other decision-makers to take effective steps towards climate-change adaptation for up to 10 years. As a framework, the Strategy can be used by agencies and organizations as they develop and implement state and local adaptation measures. We provide here an overview of the guiding principles and goals of this Strategy and how it relates to the 2015 Pennsylvania Wildlife Action Plan. For details, readers are encouraged to review the Strategy.

Strategy development was guided by 9 principles (Table 4.19), including coordination and communication among federal, state and tribal governments, conservation organizations, industry groups, and private landowners. Among these principles it also was deemed important to work with other sectors such as agriculture and energy, and to engage the public. The best available science must be applied – and it is important to identify where science and management capabilities must be improved or enhanced. When adaptation steps are taken, it will be crucial to carefully monitor actual outcomes and, where needed, make adjustments for more effective future actions; an iterative process called adaptive management (NFWPCAP 2012).

Table 4.19. Principles guiding development of the National Fish, Wildlife, and Plants Climate Adaptation Strategy. Source: NFWPCAP (2012).

Principle	Description
Build a national framework for cooperative response	Provide a nationwide framework for collective action that promotes collaboration across sectors and levels of government so they can effectively respond to climate impacts across multiple scales.
Foster communication and collaboration across government and non-government entities	Create an environment that supports the development of cooperative approaches among government and non-government entities to adapting to climate change while respecting jurisdictional authority.
Engage the public	To ensure success and gain support for adaptation strategies, a high priority must be placed on public outreach, education, and engagement in adaptation planning and natural resource conservation.
Adopt a landscape/seascape based approach that integrates best available science and adaptive management	Strategies for natural resource adaptation should employ: ecosystem-based management principles; species-habitat relationships; ecological systems and function; strengthened observation, monitoring, and data-collection systems; model-based projections; vulnerability and risk assessment; and adaptive management.
Integrate strategies for natural resources adaptation with those of other sectors	Adaptation planning in sectors including agriculture, energy, human health, and transportation may support and advance natural resource conservation in a changing climate.
Focus actions and investments on natural resources of the United States and its Territories	With this focus it also is important to acknowledge the importance of international collaboration and information- sharing, particularly across our borders with Canada and Mexico. International cooperation is important to conservation of migratory resources over broad geographic ranges.
Identify critical scientific and management needs	These may include new research, information technology, training to expand technical skills, or new policies, programs, or regulations.
Identify opportunities to integrate climate adaptation and mitigation efforts	Strategies to increase natural resource resilience while reducing greenhouse gas (GHG) emissions may directly complement each other to advance current conservation efforts, as well as to achieve short- and long-term conservation goals.
Act now	Immediate planning and action are needed to better understand and address the impacts of climate change and to safeguard natural resources now and into the future.

As discussed in Chapter 3, Pennsylvania's fish and wildlife already are burdened with several non-climate stressors such as pathogens, invasive species, habitat loss and fragmentation, and pollution. Climate change can intensify further the impacts of these stressors (NFWPCAP 2012), but the effects will vary regionally and by ecosystem across the United States (NFWPCAP 2012). Observed and projected ecological changes at the national scale highlight potential concerns within major Pennsylvania ecosystems from increasing temperatures (Table 4.20), precipitation (Table 4.21) and carbon dioxide (CO_2) (Table 4.22).

Table 4.20. Observed and projected ecological effects on United States ecosystems and species from temperature changes associated with increasing levels of greenhouse gases (GHGs). Adapted from Table 1 in NFWPCAP (2012).

Major Change	Forests	Shrublands	Grasslands	Inland Waters	Coastal
Increased Temperature	Increase in forest pest damage	Increased fire frequency may favor grasses over shrubs	Spread of non-native plants and pests	Expansion of warm-water species	Increase of salt marsh/forested wetland vegetation
	Changing fire patterns	Increased evapotranspiration and intensified water stress	Changing fire patterns	Stress on cold-water species.	Distribution shifts
	Higher evapotranspiration and drought stress	Spread of non-native species		Increased disease and parasite susceptibility	Phenology changes (e.g., phytoplankton blooms)
				More algal blooms	Altered ocean currents and larval transport into and out of estuaries
Melting sea ice, snowpack, snow melt	Longer frost-free periods	Reduced snowpack leads to hydrological changes (timing and quantity)	Reduced snowpack leads to hydrological changes (timing and quantity)	Snowpack loss changes the temperature, amount, duration, distribution and timing of runoff	Loss of anchor ice and shore-line protection from storms/waves

Major Change	Forests	Shrublands	Grasslands	Inland Waters	Coastal
	Increase in freeze-thaw events that can lead icing on winter forage			Effects on coldwater and other species.	Loss of ice habitat
	Decreased survival of insulation – dependent species			Loss of lake ice cover	Salinity shifts
Rising Sea Levels				Inundation of freshwater areas	Inundation of coastal marshes and low islands
				Groundwater contamination	Higher tidal and storm surges
				Higher tidal/ storm surges	Geomorphology changes
					Loss of nesting habitat
					Beach erosion
Changes in circulation patterns				Altered productivity and distribution of fish and other species with changes in lake circulation patterns	Altered productivity, survival, and/or distribution of fish and other estuarine dependent species
				Loss of anchor ice and shore-line protection from storms and waves	
				Loss of ice habitat	

Major Change	Forests	Shrublands	Grasslands	Inland Waters	Coastal
				Salinity shifts Inundation of coastal marshes and low islands	

This part of page intentionally blank.

Table 4.21. Observed and projected ecological effects on United States ecosystems and species from precipitation changes associated with increasing levels of greenhouse gases. Adapted from Table 1 in NFWPCAP (2012).

Major Change	Forests	Shrublands	Grasslands	Inland Waters	Coastal
Changing precipitation patterns	Longer fire season	Dry areas getting drier	Invasion of nonnative grasses and pests	Changing lake levels	Changes in salinity, nutrient, and sediment flows
	Changes in fire regime	Changing fire regimes	Species range shifting	Changes in salinity flow	Changing estuarine conditions may lead to hypoxia/anoxia
	Both wetter and drier conditions projected		Changes in fire regime		New productivity patterns
Drying conditions and drought	Decreased forest productivity and increased tree mortality	Loss of prairie pothole wetlands	Loss of nesting habitat	Loss of wetlands and intermittent streams	Changes in salinity, nutrient and sediment flows
	Increased fire	Loss of nesting habitat	Invasion of nonnative grasses	Lower summer base flows	Shifting freshwater input to estuaries
		Increased fire	Increased fire	Decreased lake levels	
More extreme rain and weather events	Increased forest disturbance	More variable soil water content	Changing pest and disease epidemiology	Increased flooding	Higher waves and storm surges
	More young forest stands			Widening floodplains	Loss of barrier islands
				Altered habitat	Beach erosion
				Spread of invasive species and contaminants	New nutrient and sediment flows

Major Change	Forests	Shrublands	Grasslands	Inland Waters	Coastal
					Salinity shifts. Increased physical disturbance

Table 4.22. Observed and projected ecological changes on United States ecosystems and species from carbon dioxide (CO_2) changes associated with increasing levels of greenhouse gases. Adapted from Table 1 in NFWPCAP (2012).

Major Change	Forests	Shrublands	Grasslands	Inland Waters	Coastal
Increase in atmospheric CO_2	Increase forest productivity and growth in some areas Insect pests may be affected Changes in species composition	Spread of exotic species Impacts on insect pests Changes in species composition	Declines in forage quality from increased Carbon: Nitrogen ratios Insect pests may be affected Changes in species composition	Increased growth of algae and other plants Changes in species composition and dominance	Increased terrestrial, emergent, and submerged plant productivity
Ocean acidification					Declines in shellfish and other species Impacts on early life stages

Goals, Strategies and Actions

The National Fish, Wildlife, Plants Climate Adaptation Strategy was developed by diverse teams of federal, state, and tribal technical and management experts, based on research and understanding regarding the needs of these resources under climate change. The resulting 7 goals, associated strategies and actions are considered broadly applicable to the 8 major United States ecosystem types within the Strategy. The goals are not prioritized, although actions within goals are ordered sequentially. These goals are relevant to the 2015 Pennsylvania Wildlife Action Plan (Table 4.23).

Table 4.23. Relationship between goals of the National Fish, Wildlife, Plants Climate Adaptation Strategy (Adapted from NFWPCAP 2012) and 2015 Pennsylvania Wildlife Action Plan.

Goal (NFWPCAP 2012) (# refers to goal number)	**Overview (NFWPCAP 2012)**	**Goal 2015 Pennsylvania Wildlife Action Plan** (# refers to goal number)
1. Conserve habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate.	Sustaining diverse, healthy populations requires conserving a sufficient variety and amount of habitat, and building a well-connected network of conservation areas to allow the movement of species in response to climate change.	1. Conserve Pennsylvania's native wildlife and its habitat by implementing conservation actions in the Wildlife Action Plan.
2. Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, recreational, and commercial use in a changing climate.	Incorporating climate change information into fish, wildlife, and plant management efforts is essential to safeguarding these valuable natural resources.	1. Conserve Pennsylvania's native wildlife and its habitat by implementing conservation actions in the Wildlife Action Plan.
3. Enhance capacity for effective management in a changing climate.	Climate change adaptation requires new ways of assessing information, new management tools and professional skills, increased collaboration across jurisdictions, and a review of laws, regulations, and policies.	4. Strengthen the state's capacity to conserve Pennsylvania's native wildlife.
4. Support adaptive management in a changing climate through integrated observation and monitoring and use of decision-support tools.	Coordinated observation, information management, and decision-support systems can help management strategies to be adaptive and adjust to changing conditions.	2. Base wildlife conservation decisions on the best available science, with an emphasis on Species of Greatest Conservation Need and their habitat.
5. Increase knowledge and information on impacts and responses of fish, wildlife, and plants to a changing climate.	Research must be targeted to address key knowledge gaps and needs, and findings must be rapidly incorporated into decision support tools available to natural resource managers and other decision makers.	2. Base wildlife conservation decisions on the best available science, with an emphasis on Species of Greatest Conservation Need and their habitat.

6. Increase awareness and motivate action to safeguard fish, wildlife, and plants in a changing climate.	Climate change adaptation efforts will be most successful if they have broad popular support and if key groups and people (such as private landowners) are motivated to take action.	5. Continue to improve cooperation within and between public agencies and other partners in wildlife conservation planning and implementation. 6. Develop a knowledgeable citizenry that supports and participates in wildlife conservation.
7. Reduce non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate.	Reducing existing threats such as habitat degradation and fragmentation, invasive species, pollution, and over-use can help fish, wildlife, plants, and ecosystems better cope with the additional stresses caused by a changing climate.	1. Conserve Pennsylvania's native wildlife and its habitat by implementing conservation actions in the Wildlife Action Plan.

Across these 7 goals, 23 strategies and 154 conservation actions were identified. To provide greater focus on this threat and potential actions, the 2015 Pennsylvania Wildlife Action Plan Climate-Change Committee prioritized these strategies and actions relevant to Pennsylvania's SGCN. This prioritization is a climate adaptation principle. From this prioritization, 9 Strategies and 42 actions were identified (Appendix 4.3, Exhibit 1). Of these prioritized actions, over 25% (11) Actions were in NFWPCAS Goal 1 (conserve habitat), and 19% (8) in NFWPCAS Goal 7 (reduce non-climate stressors). Notably, by implementing conservation actions in Goal 7 and addressing non-climate threats (e.g., invasive species) these actions can provide multiple benefits while supporting adaptation and resiliency for species and their habitats.

Pennsylvania's Adaptation Strategy

Recommendations

Beyond direct adaptation strategies for fish, wildlife and plants, the national strategy (NFWPCAP 2012) also discusses approaches for climate-adaptation measures across multiple sectors, including agriculture, energy, housing and urbanization, transportation and infrastructure, and water resources. Thus, the national strategy is commensurate with Pennsylvania's Climate Change Strategy (PADEP 2014b), which also encompassed multiple sectors including: Infrastructure, Public Health and Safety, Natural Resources, and Tourism and Outdoor Recreation. For each of these sectors, a work group developed climate-change adaptation recommendations. Cross-cutting issues with natural resources resulted in recommendations from multiple work groups.

Directly related to fish and wildlife management are recommendations to "conserve wildlife and fish habitat by building resilience to the impacts of climate change," use of riparian stream buffers, increase in native plantings, small dam removal, and providing refuge and connecting corridors to foster

movement of wildlife. Many of these activities are directly, or indirectly, relevant to goals in the 2015 Pennsylvania Wildlife Action Plan (Table 4.24).

Table 4.24. Select climate change adaptation recommendations from the Pennsylvania Climate Adaptation Planning Report (PADEP 2014b) and relationship to 2015 Pennsylvania Wildlife Action Plan goals.

Recommendation	Working Group	Relevant 2015 Pennsylvania Wildlife Action Plan Goal #
View existing actions through lens of climate change.	Natural Resources	1
Integrate climate change strategies into plans and budgets.	Natural Resources	5
Develop an integrated monitoring system.	Natural Resources	2
Create a consortium to promote collaborative research, monitoring and data sharing.	Natural Resources	5
Promote sustainable land-use planning and development.	Natural Resources	5
Focus on building resilience into conservation networks.	Natural Resources	1
Expand education and coordinate outreach on current and expected impacts and emphasize practical responses.	Natural Resources	6
Conserve fish habitats by removal of small dams.	Tourism & Outdoor Recreation	1
Increase use of green infrastructure, (e.g., native grasses).	Tourism & Outdoor Recreation	1
Support storm water, land use and flood management to prioritize natural function and minimize hazards to existing structures.	Infrastructure	1

Habitats

Forests

Adapted from Ross et al. (2013) and Shortle et al. (2009, 2015)

For Pennsylvania's forests, management actions for adapting to climate change are increasingly becoming important. Pennsylvania's private forests are in the possession of about 500,000 owners (Butler 2008) and thus communicating with this large number of people, and supporting proper management of these lands, will be daunting tasks. A key challenge in the coming decades will be maintaining forest habitat connectivity. In the more heavily forested parts of the Marcellus Shale region, natural-gas development has contributed to expansion of existing roads and development of new roads and pipeline corridors. On ridgetops, wind-energy development (Chapter 3) has further fragmented the landscape.

Climate change presents an overarching threat, impacting a broad range of non-climate stressors (e.g., invasive species, diseases) associated with forests. If Pennsylvania's forests are to remain resilient in the face of climate change, forest managers and policymakers must address other major threats to forest health and diversity. Noted by Shortle et al. (2009), strategies to address these threats should:

- Control insect pests, diseases, invasive plants, and animals

  Aggressively combat invasive species to eliminate them where possible, or at least reduce their expansion.

- Manage overabundant deer populations

  Maintain deer populations at a level commensurate with the forest's ability to provide forage for a healthy deer population.

- Reduce air pollution and atmospheric deposition of pollutants

  Air pollution (e.g., acidification, nitrogen deposition, ozone) along with forest stand characteristics (e.g., age, density) were the most important drivers of tree mortality (Dietze and Moorcroft 2011; Ross et al. 2013).

- Enhance forest connectivity for wildlife

  Minimize forest loss and maintain, or increase, the connectivity of the forests for movement of wildlife. This can be achieved by maintaining or restoring corridors; increasing number and proximity of high-quality core habitats, increasing the suitability of areas between core habitats to foster colonization (Krosby et al. 2010).

Addressing non-climate stressors is consistent with Goal 7 of the National Fish, Wildlife, and Plants Climate Adaptation Strategy (NFWPCAP 2012) and recommendations of the Pennsylvania Climate-Change Adaptation Plan (PADEP 2014b). Strategies for adapting Pennsylvania's forests to a changing climate have also been developed by the Pennsylvania Department of Conservation and Natural

Resources (PADCNR 2003). All of these problems are interrelated and must be considered holistically with the goal of maintaining, restoring, and creating healthy forest ecosystems (Shortle et al. 2009).

Aquatic resources

Adapted from Shortle et al. (2009); Ross et al. (2013); Shortle et al. (2015)

Pennsylvania's aquatic systems are impacted by numerous threats, such as pollution, invasive species, hydrologic modifications and other factors that affect water quality and associated biotic communities (Chapter 3). As in other ecosystems, climate change can intensify the impacts of these threats.

For Pennsylvania's aquatic systems, Shortle et al. (2009; 2015) recommended the following strategies to enhance climate change resiliency:

- Protect existing stream and wetland habitats, especially intact habitats for identified species of interest, such as eastern brook trout (EBTJV 2008).
- Maintain riparian forests to moderate stream temperature and treatment of run-off from adjoining lands.
- Restore aquatic ecosystems such as streams and wetlands wherever possible.
- Minimize groundwater pumping for irrigation, human consumption, etc., that removes water from highly important aquatic and wetland ecosystems .
- Focus on flood preparedness, reducing vulnerabilities and increasing resilience in more extreme and frequent flooding scenarios (high priority).
- Initiate programs for monitoring, assessing, estimating and abating stream bank erosion (for water quality and stream ecosystem health).

Knowledge gaps remain in understanding the potential impacts of climate change on Pennsylvania's natural resources. Prominent in these gaps is insufficient monitoring of hydrological variables (e.g., streamflow, groundwater, water quality) and lack of statewide modeling studies along with sufficiently detailed spatially-distributed data for developing projected climate (Ross et al. 2013). Specifically, for aquatic systems, there is need to assess:

- Current conditions of streams, lakes and wetlands.
- Projected increases in stream temperatures, flow rates and hydroperiods.
- Nutrient retention and export.
- The role of humans in water resource use and potential impacts on wetlands and streams.

Although these recommendations are not specific in approach or location, they provide a framework for partners to develop or expand information systems to fill data gaps and implement on-the-ground actions. Building resilience into conservation networks is consistent with recommendations of the Pennsylvania Climate-Adaptation Planning Report (PADEP 2014b). These recommendations would be beneficial in any context, but they can serve an even greater role by supporting resiliency and adaptive capacity for species dependent upon these habitats.

Appendix 4.1

Exhibit 1. International Bird Conservation

Adapted from D. Hahn, Southern Wings Coordinator, Association of Fish and Wildlife Agencies
Doug Gross, Nongame & Endangered Bird Section Supervisor, Pennsylvania Game Commission

Species of Greatest Conservation Need migrating out of Pennsylvania

Seventy-four Species of Greatest Conservation Need migrate outside of Pennsylvania during some season. Most of these species spend the winter in the West Indies, Central America, or South America. However, several species also spend the winter, or pass through, Pennsylvania on their way to more northerly breeding grounds in Canada. Consequently, the Commonwealth also has connections with its neighbor to the north, which hosts a vast number of birds in its boreal forests (Wells 2010).

Birds connect our state to many other states and countries with migration from, through, and to Pennsylvania being truly hemispheric in scope. Species like the common tern travel thousands of miles in their nearly continual migrations. The migrations of many species are extraordinary with the blackpoll warbler as the prime example, migrating over the Atlantic Ocean in a non-stop flight from the northeastern United States to South America. Many species of songbirds migrate nonstop over the Gulf of Mexico or the Caribbean on their way to their wintering ground (Table 4.4).

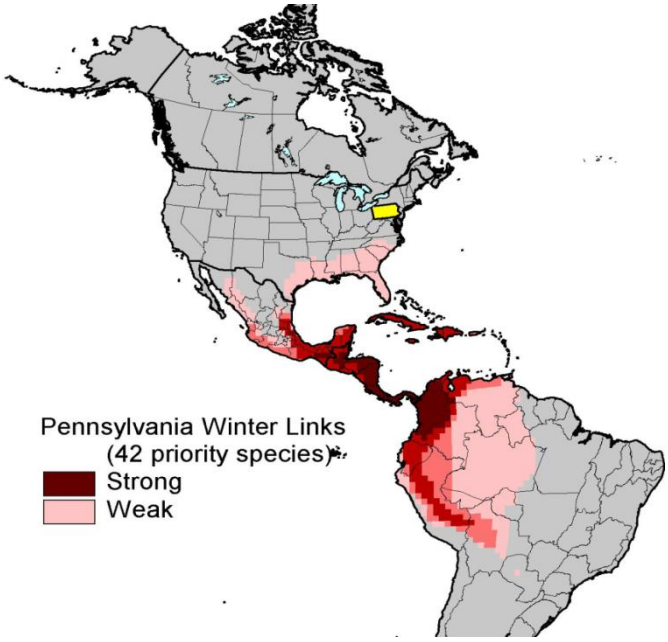


Exhibit 1-Fig. 4.1. Pennsylvania has weak-to-strong links with countries in Central America, the Caribbean, and South America, in sharing migrating bird species.

General rationale – core threats, habitats, geographic areas

For most species, we do not know if populations are limited during the breeding season, wintering period or migratory periods (Rappole and McDonald 1994; Sherry and Holmes 1995; Latta and Baltz 1997; Berlanga et al. 2010; Faaborg et al. 2010; but see DeSante et al. 2015). Thus, it is wise to undertake surveys, research, partnership building, and conservation actions throughout the species' annual cycle until we can comprehensively "…identify factors which may assist in restoration and improved conservation of these species and habitats." (Element 3)

Multiple species and overlap

Although it may be effective to pursue single-species conservation activities, it is more likely that Pennsylvania will be engaged in multi-species conservation actions. Pennsylvania will have more than one species of concern in a given area, and partners outside the U.S. are more apt to engage in multi-

species conservation as a general operating principle. Thus, it may be necessary to produce hotspot maps that show the degree of overlap of various species during the period when they are outside Pennsylvania or to consider the conservation of habitats for more than one species. Even with a high priority conservation species focus, it is strategically appropriate to recognize that any winter or passage migration location may have a role in the life cycle of multiple species.

Identifying species distributions

Good information on the distribution of the species during the season when it is outside Pennsylvania is obviously critical. For many species, including invertebrates, there are excellent maps available at NatureServe© Explorer (www.natureserve.org). Maps tend to be most useful for well-known taxa such as birds. These maps show countries where the species occur, although they do not provide information on relative abundance or habitat use, even for well-known species. For birds, there also is excellent distribution information, including maps, in the Birds of North America accounts (http://bna.birds.cornell.edu/bna/) as well as other references (DeGraaf and Rappole 1995; Stotz et al. 1996).

Besides knowing the winter (or summer) distribution of a migratory species, more detailed information on local habitat use and abundance is needed to take the most effective conservation actions. The emphasis in international approaches to connectivity is for species that breed in Pennsylvania and migrate to another location during the winter. There is no single source for this information for all taxa, although NatureServe© can serve as the initial resource. More detailed information has been assembled by Partners in Flight, BirdLife International, Bat Conservation International, The Xerces Society, and in Shorebird Conservation Plans (www.whsrn.org). Valuable information can be gleaned from the primary literature and, most importantly, from in-country partners (see Partners below).

Mapping tools

Partners in Flight (PIF) and Pennsylvania State University have developed a mapping tool to identify where state priority birds overwinter. This tool (http://www.cei.psu.edu/pif/) allows users to define a list of birds in a state, or a portion of a state, in several different ways. It then produces a hotspot map to guide the user to most likely important geographic region for conservation work. Once identified, communication and collaboration with in-country partners is needed to develop the most effective projects. In addition, the Institute for Bird Populations recently published temporal and spatial capture-mark-recapture and constant-effort capture-rate data from the Monitoring Avian Productivity and Survivorship (MAPS) program to estimate vital rates and demographic parameters for 158 species. (DeSante et al. 2015; http://www.vitalratesofnorthamericanlandbirds.org/).

Locating in-Country Partners

When one or more countries has been identified as likely locations for conservation work outside of Pennsylvania and outside the United States, it is critical to identify and communicate with in-country partners. They can confirm the presence of Species of Greatest Conservation Need in the identified region. This may be most easy for birds because the network of partners in the Western Hemisphere, and even beyond, is well developed. The major bird conservation initiatives (Partners in Flight, the U.S.

Shorebird Conservation Plan, and Waterbirds for the Americas) have contacts in all countries of interest and can suggest contacts.

Construction of a catalog of non-governmental organizations that work on bird conservation is currently underway; the catalog will be organized by country and electronically searchable. Other sources for conservation partners are in the American Bird Conservancy, Eco-index, the Western Hemisphere Migratory Species Initiative, Bat Conservation International, the Butterfly Conservation Initiative, the North American Monarch Conservation Plan, the Xerces Society and web sites for global conservation organizations, such as the Rainforest Alliance, Birdlife International, the Peregrine Fund, and The Nature Conservancy. The peoples of Latin America and the Caribbean can have deep connections with the native birds and their habitats, especially the forests where they live (Bonta 2003; Silvius et al. 2004). If asked, even uneducated rural and aboriginal people value nature, even as they fight poverty. Sustainable development, agriculture, and tourism have long been subjects of conservation literature and ongoing partnerships (e.g., Primack et al. 1998; Nations 2006). There are other reasons to enable and foster sustainable agriculture, especially forest management including preserving traditions and enabling self-sufficiency that inadvertently support bird habitat for migrants. For example, the Mayan forest garden approach to forest management at El Pilar, Belize, supports habitat where wood thrushes and other Nearctic migrants are abundant (D.Gross, personal observation). Such approaches are the basis for rustic cacao, cardamine, coffee, and other shade-grown forest crops that are reputed to be better habitat for birds than slash and burn or industrial agriculture. These natural, local connections can be exploited with care by enabling partnerships across borders.

Partners also can be located through a simple web search. Partners across the Western Hemisphere are very quick to use the internet for communication because it may often be superior to other mechanisms. If the search results in a non-English web page, tools such as Google Translate can quickly provide translations good enough to tell you whether you are on the right track or not.

Some state wildlife agencies already have experience engaging other countries in conservation activities. Some examples include Arizona (Mexico); Texas (Mexico); Florida (The Caribbean); Wisconsin (Costa Rica. To date, the only tool that has been developed to meet this need is for birds, developed by Belize (Ecuador, Colombia, Panama); Missouri (Nicaragua and Mexico); Vermont (The Caribbean); Alaska (Argentina); Oregon (Argentina); Oklahoma (Mexican grasslands). This is not a comprehensive list but simply an idea of other states that could be contacted to gather information. Finally, both the Sonoran Joint Venture (JV) and the Rio Grande JV encompass northern Mexico and projects are routinely done with in-country JV partners. If your conservation needs include those regions, the JVs are a great place to start the conversation. For the federal agencies, the U.S. Fish and Wildlife Service, U.S. Forest Service, and National Park Service all have international programs.

There are established nature study, birding, and bird conservation programs in many South and Central American countries that actively engage citizens and tourists in birding and conservation activities. Examples include Pronatura, the Belize Audubon Society, the Panama Audubon Society, and Fundación ProAves of Columbia. These organizations also publish important ornithological literature including checklists, field guides, Important Bird Area and biological reserve publications, and educational

literature, such as children's books about birds and nature, sometimes with North American partners such as the U.S. Forest Service or The Nature Conservancy. The work of these partners affords opportunities for connections with Pennsylvania's bird conservation community. Pennsylvania has been working with partners through the Partners in Flight and Southern Wings programs, but more connections could be made by the state and by non-government organizations, in concert or independently.

Southern Wings Program

State fish and wildlife agencies spend considerable time, money and effort providing high-quality bird habitat. Southern Wings is a partnership of state agencies that support the common vision of providing a funding mechanism for bird conservation projects in Latin America and the Caribbean.

Southern Wings provides a funding mechanism that: 1) is solidly based on the biology of birds that occur in the states and also spend time on Latin American /Caribbean (LAC) wintering grounds; 2) allows for relatively easy and seamless financial participation by interested states; 3) requires progress and accomplishment reports to the states, and achieves the benefits of match and leveraging of state funds.

The Western Association of Fish and Wildlife Agencies (AFWA), Southeastern Association of Fish and Wildlife Agencies and Midwest Association of Fish and Wildlife Agencies are pooling money for their respective member states. The American Bird Conservancy pools money for states in other areas of the country that wish to participate.

Missouri, Arizona, Wisconsin, South Dakota, Oklahoma, Arkansas, Pennsylvania, Iowa, Minnesota, Tennessee, and the Northeast AFWA participated in the Southern Wings program in 2010-2011. From 2011, Pennsylvania has supported the Nicaragua program at El Jaguar Reserva in the mountainous Jinotega province. The support has enabled workshops for landowners and the establishment tree nurseries for reforestation of agricultural areas. This project area has populations of wintering black-billed cuckoo, eastern wood-pewee, yellow-bellied flycatcher, wood thrush, blue-winged warbler, golden-winged warbler, cerulean warbler, worm-eating warbler, Louisiana waterthrush, hooded warbler, scarlet tanager, rose-breasted grosbeak, indigo bunting, and Baltimore oriole. The project particularly emphasizes golden-winged warbler and wood thrush research and conservation. We partner with other organizations at El Jaguar, including the American Bird Conservancy and North Carolina Audubon. There are other Southern Wings projects that are compatible with Pennsylvania and other Appalachian Mountain states including projects in, Osa Peninsula, Costa Rica; Izabal, Guatemala; Guanacaste National Park, Costa Rica; and the Cerulean Warbler Conservation Corridor, Colombia.

Neotropical Migratory Bird Conservation Act

The Neotropical Migratory Bird Conservation Act established a matching-grant program to fund projects that promote the long-term conservation of Neotropical migratory birds in the United States, Canada, Mexico, Latin America and the Caribbean. Projects may include activities to benefit bird populations and habitats, research and monitoring, law enforcement, and outreach and education.

In September 2006, Congress reauthorized the Act and allowed an incremental increase to its appropriations from $5 million to $6.5 million over five years, beginning with the fiscal year 2007 grants.

Since 2002, when the grants program began, partners have received more than $30.3 million to support 295 projects in more than 30 countries. An additional $134 million in matching funds and $6.6 million in other partner contributions have been contributed to these projects--a partner-to-grant fund match of more than 4:1. To-date, approximately 2 million acres (0.809 million hectares) of migratory bird habitat have been positively affected. Many of the projects take place in more than one state or country; others include the entire Neotropical region.

Migratory Bird Conservation Resources

- Partners in Flight: www.partnersinflight.org
- Partners in Flight Tri-National Vision for Landbird Conservation: http://www.savingoursharedbirds.org/
- Waterbird Conservation for the Americas: www.waterbirdconservation.org
- U.S. Shorebird Plan: www.fws.gov/shorebirdplan/
- North American Waterfowl Management Plan: www.fws.gov/birdhabitat/NAWMP/index.shtm
- U.S. NABCI Committee: www.nabci-us.org
- Migratory Connectivity Project: http://www.migratoryconnectivityproject.org/

Pennsylvania Landbird Examples

High-priority species with high percentages of their population breeding in Pennsylvania can be found by querying the Partners in Flight (PIF) Landbird Populations Estimates Database maintained by the Rocky Mountain Bird Observatory. Range maps for those species can then be obtained from NatureServe© Explorer and the Birds of North America series on-line. There are several examples of species for which connectivity can be made and partners can found within the migratory pathway and on wintering grounds. With advancing technology, we will certainly learn more about the connections between our state and the wintering grounds of several species in the future (Boulet & Norris 2006; McKinnon et al. 2013).

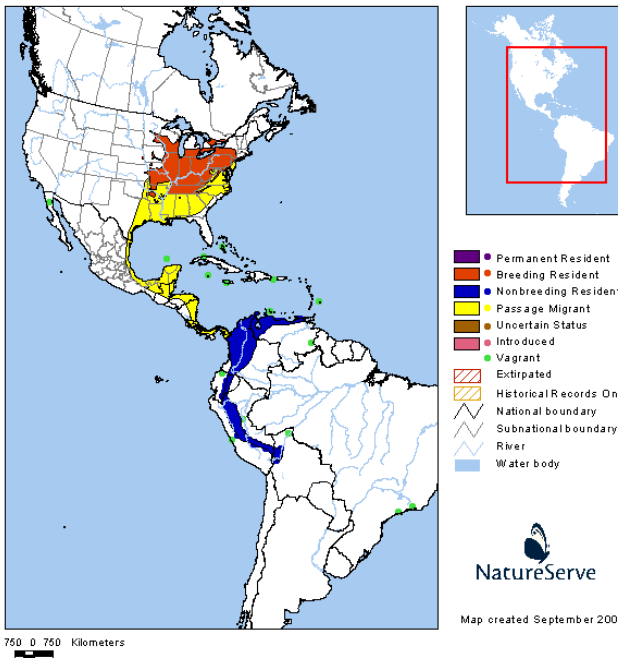


Exhibit 1-Fig. 4.2. Cerulean warbler (*Setophaga cerulean*) breeding, migratory, and wintering distributions. Source: NatureServe©.

Cerulean Warbler *(Setophaga cerulean)*

A very good example of a conservation linkage for Pennsylvania is the cerulean warbler. Partners in

Flight (PIF) estimates that over 8% of the global population of this species, or over 43,000 individuals, breed in Pennsylvania. This species is on the PIF Watch List and has a relatively high Combined Score of 16 (Rich et al. 2004). Cerulean warblers winter in the Andes of South America, especially in Columbia (Exhibit 1-Fig. 4.2). This warbler has become the icon for the conservation of long-distance migrants. An effective international working group, El Grupo Ceruleo, is in place and implementing conservation actions.

Purple Martin *(Progne subis)*

There is a connection between Pennsylvania's purple martin population and the Amazon rainforest of northern Brazil (Brown 1997; Fraser et al. 2012; Exhibit 1-Fig. 4.3). Purple martins have multiple roosting locations on their wintering grounds. There are two organizations operating in the state working together and with many volunteers to study these linkages and working with partners in South America to study and protect purple martin roosts. These are the Purple Martin Conservation Association, based in Erie, and the Stutchbury Lab of Behavioral and Conservation Ecology, York University, Toronto, Ontario, that has a field station, Hemlock Hill Research Area, Cambridge Springs, Crawford County.

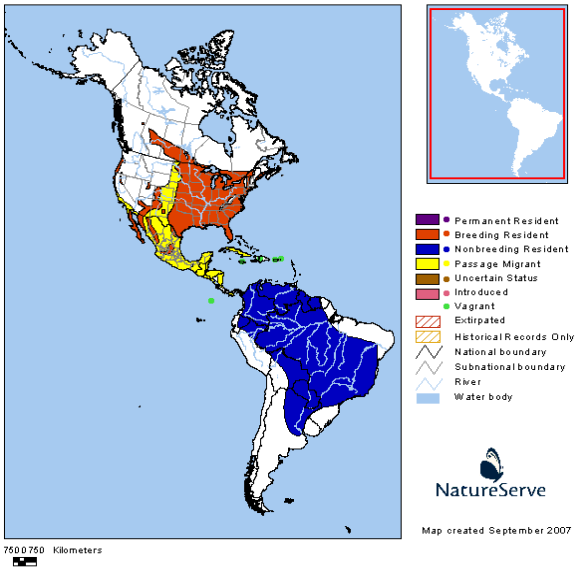


Exhibit 1-Fig. 4.3. Purple martin (*Progne subis*) breeding, migratory, and wintering distributions. Source: NatureServe©.

Broad-winged Hawk *(Buteo platypterus)*

Pennsylvania has had an international connection to raptor migration study for many years through the Hawk Mountain Sanctuary and Hawkwatch International, including the River of Raptors Project at Veracruz, Mexico . The broad-winged hawk migrates along the Texas coast, down the Gulf Coast of Mexico especially through the narrow gap of Veracruz, through Central America to northwestern South America (Exhibit 1-Fig. 4.4). Since 90% of the broad-

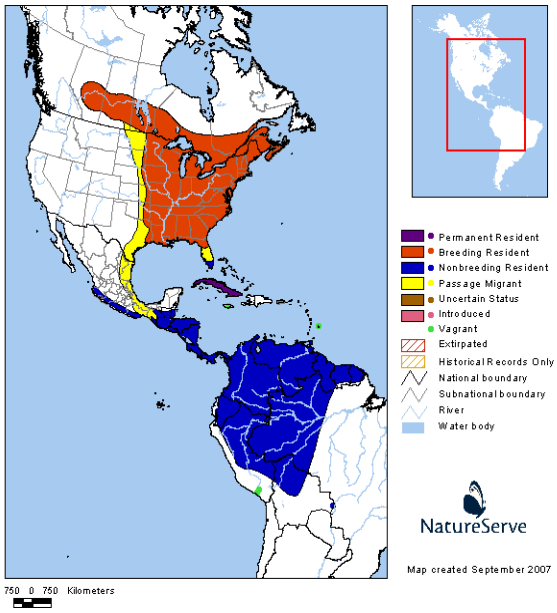


Exhibit 1-Fig. 4.4. Broad-winged hawk (*Buteo platypterus*)breeding, migratory, and wintering distributions. Source: NatureServe©.

winged hawk population migrates through Veracruz, this narrow corridor is essential to the species and it is necessary to partner with the local conservation organization. Hawk Mountain Sanctuary has been working for several years with Pronatura Veracruz to monitor raptors at Veracruz and to increase awareness and knowledge of this migration event. At least 4.5 million raptors migrate through Veracruz each fall migration, representing at least 12 species of diurnal raptor. The partnership not only conducts scientific monitoring and research, but also important outreach, education, and ecotourism. Pronatura Veracruz is dedicated to several bird habitat projects.

Wood Thrush *(Hylocichla mustelina)*

The wood thrush provides Pennsylvania with several opportunities for research and conservation partnerships. It winters from northeast Mexico south through eastern Mexico, especially Chiapas and the Yucatan Peninsula, through Central America (Evans et al. 2011; Exhibit 1-Fig. 4.5). The summer range of this species is much larger than the winter range. The **International Wood Thrush Conservation Alliance,** of which PGC is a part, is now working to forge partnerships across the range of this species. As part of the Chiapas Appalachian Pacific partnership, Pennsylvania is involved with a significant part of the wintering range of this species. Recent research has revealed there is a strong linkage between Pennsylvania wood thrush populations and the eastern part of the winter range, mostly the forests of eastern Honduras and northern Nicaragua. There also was a band recovery of a wood thrush banded at El Jaguar Reserve, Jinotega, Nicaragua, in Bucks County, demonstrating a tangible link between that location and our state. This eastern wintering ground region supports over half of the species' population so deserves to be a high conservation priority (Stanley et al. 2014). Although it still has a high forest cover, tropical deforestation is particularly high in this region. The stressors affecting wood thrush are probably affecting other nearctic migrants and residents that use the same forested habitats. Several migrant songbirds overlap considerably with wood thrush winter ground range and habitat, including the Pennsylvania endangered yellow-bellied flycatcher, which has similar threats (Gross & Lowther 2012). Forest conservation is accomplished through protected parks and sustainable forest agriculture (rustic shade coffee, cacao, and others). Research conducted in the Veracruz region showed that wood thrushes have higher survival in mature forest (Winker et al. 1990). This region also has experienced significant deforestation. So, the connection between our state and the Pronatura Veracruz is important for this species as well as migrant raptors.

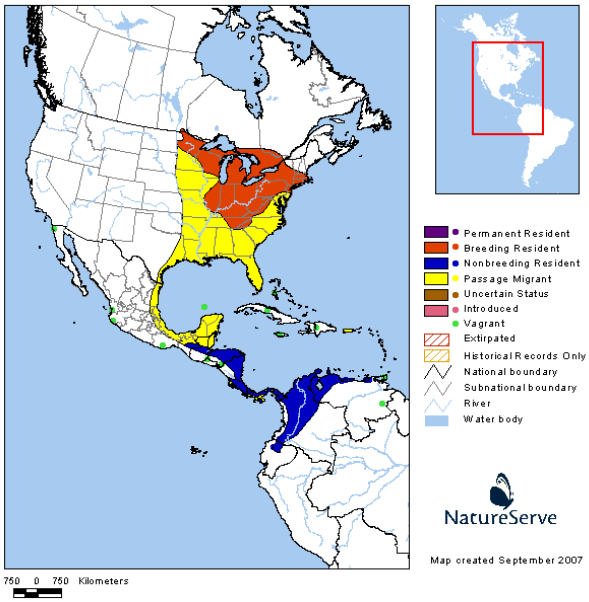


Exhibit 1-Fig. 4.5. Wood thrush *(Hylocichla mustelina)* breeding, migratory, and wintering distributions. Source: NatureServe©.

Louisiana Waterthrush *(Parkesia motacilla)*

Pennsylvania has a high responsibility for Louisiana waterthrush, a species associated with forested high-quality streams. The Louisiana waterthrush winters along the Mexico coasts, Central America, the Caribbean islands, and northwestern South America, mostly in lower elevation forests (Mattson et al. 2009; Exhibit 1-Fig. 4.6). A unique aspect of the Louisiana waterthrush is that its wintering ground habitat preference strongly resembles its summer habitat (Master et al. 2005). Therefore, the potential partners for conservation of Louisiana waterthrush in Central America and South America may include organizations that have made watershed conservation, forest cover, and water quality a priority including headwaters that protect watershed integrity. Louisiana waterthrush occurs at El Jaguar Reserva, Nicaragua, for example, along its small streams with a high tree canopy and along many streams of Costa Rica (Master el al. 2005).

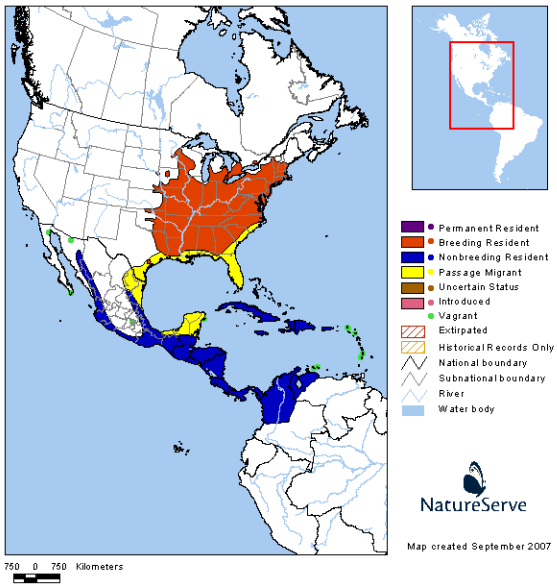


Exhibit 1-Fig. 4.6. Louisiana waterthrush *(Parkesia motacilla)* breeding, migratory, and wintering distributions. Source: NatureServe©.

Golden-winged Warbler *(Vermivora chrysoptera)*

The Golden-winged Warbler Working Group has developed many partnerships and products in its mission of "ensuring the conservation of golden-winged warbler populations through sound science, education, and management." This is one of the species that has been a focal point for international research and conservation (see Exhibit 1-Fig. 4.7).

There is an effective international working group, the Golden-winged Warbler Alliance, implementing conservation actions.

This involves multiple partners on the wintering grounds in Central America and northern South America, as well as in North America. For Pennsylvania, this means working

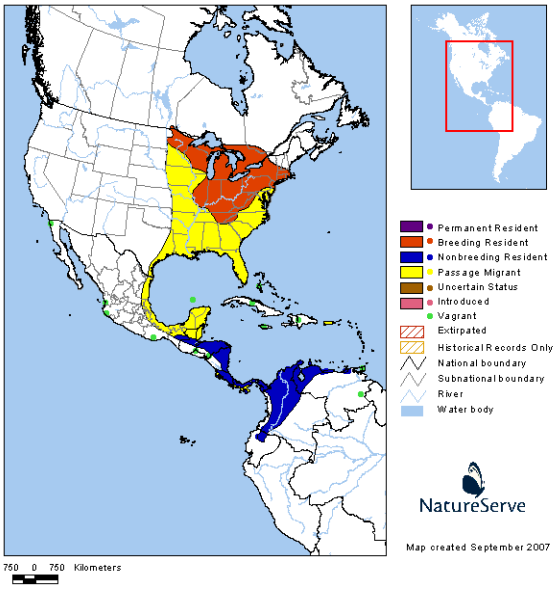


Exhibit 1-Fig. 4.7. Golden-winged warbler *(Vermivora chrysoptera)* breeding, migratory, and wintering distributions. Source: NatureServe©.

alongside of organizations like the American Bird Conservancy and North Carolina Audubon and institutions, such as the Michigan Technological University and the state's own Indiana University of Pennsylvania. There also are good potential partners in Columbia, such as Fundación ProAves.

Canada Warbler *(Cardellina canadensis)*

The Canada warbler is a priority species that breeds widely in the Pennsylvania forests, especially in mountain forests, and migrates to the Neotropics. It was named as a North American Bird Conservation Initiative Watch List species; moderately abundant and widespread with declines or high threats (NABCI 2014). Canada warblers migrate in a short period to their wintering grounds in northwestern South America. Their winter range includes Venezuela, Columbia, south through Ecuador and central Peru, but their largest numbers are in eastern Columbia (Conway 1999; Exhibit 1-Fig. 4.8). Its range overlaps considerably with two other conservation concern species in decline, the olive-sided flycatcher (Altman & Sallabanks 2012*),* cerulean warbler, and the golden-winged warbler, with which is shares some threats. The wintering ground habitat resembles the summer habitat in structure. Canada warblers live in dense undergrowth of submontane rain and cloud forests as well as coffee plantations, hedgerows and semi-open areas with a lot of undergrowth. Shade-grown coffee is one of the conservation initiatives that help this species. There was a special session for the Canada Warbler Initiative at the Partners in Flight International meeting at Snowbird, Utah, August, 2014. There, a Canada warbler group was established, including discussions of research and conservation opportunities on the winter ground, especially Columbia. An active International Canada Warbler Conservation Initiative communicates through Griffin Groups. There is a need for research on its proximate and ultimate causes for decline. There is a growing list of partners for Canada warbler including SELVA, Bogata, Columbia; ECOAN, Cuzco, Peru; and Pronatura Sur, Chiapas, Mexico. By working in partnerships, advances in research are being made (Bayly & Gonzales 2015).

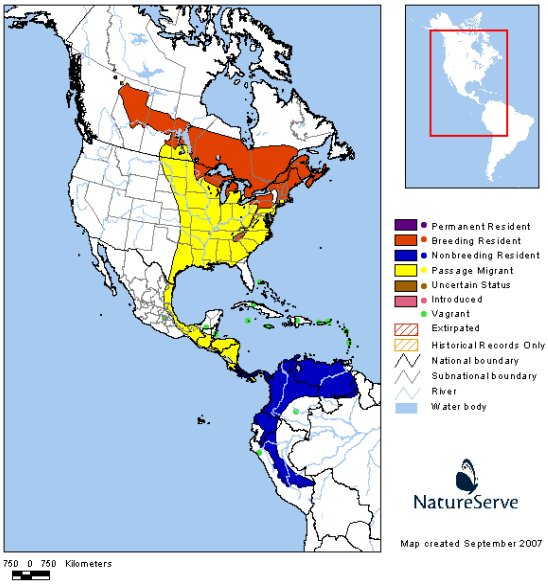


Exhibit 1-Fig. 4.8. Canada warbler *(Cardellina canadensis)* breeding, migratory, and wintering distribution. Source: NatureServe©.

Specific birds at the Nicaragua Site - black-billed cuckoo, eastern wood-pewee, wood thrush, blue-winged warbler, golden-winged warbler, cerulean warbler, worm-eating warbler, Louisiana waterthrush, hooded warbler, scarlet tanager, rose-breasted grosbeak, indigo bunting, Baltimore oriole.

Colombia - eastern wood-pewee, acadian flycatcher, golden-winged warbler, cerulean warbler, rose-breasted grosbeak, Baltimore oriole, Canada warbler.

International Partnerships

The Appalachian Mountain Joint Venture (AMJV), including the PGC, has joined with ProNatura Sur to promote bird conservation in Chiapas, Mexico. As part of the AMJV, Pennsylvania i has actively participated in the Chiapas Appalachian Pacific (CAP) partnership. Several AMJV and Pennsylvania priority species, including yellow-bellied flycatcher, wood thrush, Louisiana waterthrush, worm-eating warbler, and Kentucky warbler use significant portions of southern Mexico and northern Central America for wintering grounds. The highlands of Chiapas are an important migration corridor for raptors, including the broad-winged hawk. This is a significant region for bird conservation linkages. The Tri-national Committee of North American Bird Conservation Initiative (NABCI) has even identified a portion of this region, El Triunfo-Chiapas, as 1 of 5 "Continentally Important Areas" for bird conservation. The AMJV is working with the Chiapas Regional Alliance (CRA) in Mexico to develop a strategy for conserving shared birds species and their habitats.

Through the Southern Wings program, already discussed, Pennsylvania has partnered with El Jaguar Reserva, Jinotega Province, Nicaragua. There are other potential partners for the state through the Southern Wings program.

Volunteer Programs and Potential Opportunities for Partnerships

Volunteer programs allow individuals and groups to make tangible connections and contributions to Neotropical bird conservation. For example, Optics for the Tropics allows North Americans to contribute valuable optics where needed by researchers and students in the Neotropics. The American Bird Conservancy's Birders' Exchange program collects donated new and used birding equipment for distribution to bird research and conservation colleagues in Latin America and the Caribbean. Birders also can contribute to conservation through travel support. Projects also can be initiated by local bird organizations. For example, the Juniata Valley Audubon Society has initiated a golden-winged warbler conservation project to fund winter habitat in Honduras where many golden-winged warblers and other migrants spend the winter.

One notable international partnership program is the American Bird Conservancy's Conservation Through Birding, which connects birders to birding lodges in the Neotropics that including conservation in their itinerary. In this program, birders can visit important reserves that are associated with lodges. Indeed, birding lodges often are nexuses for local bird conservation since it is in the best interest of that business to conserve bird habitat for future consideration of that company and its customers. Organizations like the Jocotoco Foundation and associated ecotourism organizations, such as JOCOtours serve as examples of connecting ecological sustainability with tourism and local economies. Ecotourism is important in Costa Rica; Veracruz, Mexico; Belize; Panama; and many other areas where Pennsylvania birds spend the winter.

Appendix 4.2

Exhibit 1. Birds

Level 1 Conservation Action Categories (all priorities) for birds as identified in the species accounts (Appendix 1.4).

Common Name	Scientific Name	**1**-Coordination	**2**-Direct Management	**3**-Data Collection/Analysis	**5**-Facilities/Areas	**6**-Land & Water Rights	**7**-Law Enforcement	**8**-Outreach	**9**-Planning	**11**-Technical Assistance	**100**-Law & Policy	**101**-Species Management
Tundra Swan	*Cygnus columbianus*	●				●				●		
American Black Duck	*Anas rubripes*		●		●	●			●			●
Blue-winged Teal	*Anas discors*		●			●			●			●
Green-winged Teal	*Anas crecca*		●		●	●			●			●
Lesser Scaup	*Aythya affinis*					●						●
Long-tailed Duck	*Clangula hyemalis*		●	●								●
Ruffed Grouse	*Bonasa umbellus*	●	●	●				●		●		
Pied-billed Grebe	*Podilymbus podiceps*		●						●			●
Horned Grebe	*Podiceps auritus*											●
Red-necked Grebe	*Podiceps grisegena*											●
American Bittern	*Botaurus lentiginosus*		●								●	
Least Bittern	*Ixobrychus exilis*		●								●	
Great Egret	*Ardea alba*		●			●					●	

Common Name	Scientific Name	1-Coordination	2-Direct Management	3-Data Collection/Analysis	5-Facilities/Areas	6-Land & Water Rights	7-Law Enforcement	8-Outreach	9-Planning	11-Technical Assistance	100-Law & Policy	101-Species Management
Black-crowned Night-Heron	*Nycticorax nycticorax*		●			●					●	
Yellow-crowned Night-Heron	*Nyctanassa violacea*		●					●			●	●
Osprey	*Pandion haliaetus*		●					●		●		
Bald Eagle	*Haliaeetus leucocephalus*	●				●	●					●
Northern Harrier	*Circus cyaneus*	●	●						●		●	
Sharp-shinned Hawk	*Accipiter striatus*	●	●						●			
Northern Goshawk	*Accipiter gentilis*		●		●	●			●	●		
Broad-winged Hawk	*Buteo platypterus*		●			●			●			
Golden Eagle	*Aquila chrysaetos*								●	●		
King Rail	*Rallus elegans*		●								●	
Virginia Rail	*Rallus limicola*		●								●	
Sora	*Porzana carolina*		●			●						
Common Gallinule	*Gallinula galeata*		●		●							
American Coot	*Fulica americana*		●		●	●						
Piping Plover (Great Lakes)	*Charadrius melodus*		●				●	●		●		
Spotted Sandpiper	*Actitis macularius*		●					●	●			

Common Name	Scientific Name	1-Coordination	2-Direct Management	3-Data Collection/Analysis	5-Facilities/Areas	6-Land & Water Rights	7-Law Enforcement	8-Outreach	9-Planning	11-Technical Assistance	100-Law & Policy	101-Species Management
Upland Sandpiper	*Bartramia longicauda*		●			●						
Red Knot	*Calidris canutus*		●				●		●	●		
Wilson's Snipe	*Gallinago delicata*	●	●		●	●		●				
American Woodcock	*Scolopax minor*		●	●				●		●		
Black Tern	*Chlidonias niger*		●								●	
Common Tern	*Sterna hirundo*		●				●					
Barn Owl	*Tyto alba*	●	●					●				
Long-eared Owl	*Asio otus*		●			●			●	●		
Short-eared Owl	*Asio flammeus*		●			●		●	●			
Northern Saw-whet Owl	*Aegolius acadicus*		●	●					●			
Common Nighthawk	*Chordeiles minor*		●							●	●	
Eastern Whip-poor-will	*Antrostomus vociferus*	●	●			●			●			
Chimney Swift	*Chaetura pelagica*		●					●	●	●	●	
Red-headed Woodpecker	*Melanerpes erythrocephalus*		●				●	●				
American Kestrel	*Falco sparverius*	●	●			●		●				
Peregrine Falcon	*Falco peregrinus*							●	●		●	●
Olive-sided Flycatcher	*Contopus cooperi*		●									

Common Name	Scientific Name	1-Coordination	2-Direct Management	3-Data Collection/Analysis	5-Facilities/Areas	6-Land & Water Rights	7-Law Enforcement	8-Outreach	9-Planning	11-Technical Assistance	100-Law & Policy	101-Species Management
Yellow-bellied Flycatcher	*Empidonax flaviventris*		●			●			●	●		
Willow Flycatcher	*Empidonax traillii*		●						●		●	
Loggerhead Shrike	*Lanius ludovicianus*								●			
Purple Martin	*Progne subis*		●					●				●
Grasshopper Sparrow	*Ammodramus savannarum*		●						●			
Bank Swallow	*Riparia riparia*							●		●	●	
Brown Creeper	*Certhia americana*		●			●			●		●	
Winter Wren	*Troglodytes hiemalis*		●			●			●		●	
Sedge Wren	*Cistothorus platensis*	●	●				●	●				●
Marsh Wren	*Cistothorus palustris*		●								●	
Swainson's Thrush	*Catharus ustulatus*		●			●			●		●	
Wood Thrush	*Hylocichla mustelina*		●					●	●			
Gray Catbird	*Dumetella carolinensis*		●							●		
Louisiana Waterthrush	*Parkesia motacilla*		●			●			●		●	
Northern Waterthrush	*Parkesia noveboracensis*					●			●		●	●
Golden-winged Warbler	*Vermivora chrysoptera*		●	●					●			
Blue-winged Warbler	*Vermivora cyanoptera*		●									

Common Name	Scientific Name	1-Coordination	2-Direct Management	3-Data Collection/Analysis	5-Facilities/Areas	6-Land & Water Rights	7-Law Enforcement	8-Outreach	9-Planning	11-Technical Assistance	100-Law & Policy	101-Species Management
Black-and-white Warbler	*Mniotilta varia*	●	●						●		●	
Prothonotary Warbler	*Protonotaria citrea*		●		●	●	●					
Nashville Warbler	*Oreothlypis ruficapilla*	●	●									
Kentucky Warbler	*Geothlypis formosa*		●						●			
Hooded Warbler	*Setophaga citrina*	●						●	●		●	
Cerulean Warbler	*Setophaga cerulea*	●	●			●			●		●	
Blackburnian Warbler	*Setophaga fusca*		●						●		●	
Blackpoll Warbler	*Setophaga striata*		●						●	●		
Black-throated Blue Warbler	*Vermivora cyanoptera*		●						●	●	●	
Prairie Warbler	*Setophaga discolor*		●						●			
Black-throated Green Warbler	*Setophaga virens*		●			●			●	●	●	
Canada Warbler	*Cardellina canadensis*	●	●									
Yellow-breasted Chat	*Icteria virens*		●						●		●	
Eastern Towhee	*Pipilo erythrophthalmus*		●									
Field Sparrow	*Spizella pusilla*		●									
Vesper Sparrow	*Pooecetes gramineus*		●			●						
Savannah Sparrow	*Passerculus sandwichensis*		●			●						

Common Name	Scientific Name	1-Coordination	2-Direct Management	3-Data Collection/Analysis	5-Facilities/Areas	6-Land & Water Rights	7-Law Enforcement	8-Outreach	9-Planning	11-Technical Assistance	100-Law & Policy	101-Species Management
Henslow's Sparrow	*Ammodramus henslowii*		●			●						
White-throated Sparrow	*Zonotrichia albicollis*	●	●									●
Summer Tanager	*Piranga rubra*		●						●			
Scarlet Tanager	*Piranga olivacea*					●			●		●	
Dickcissel	*Spiza americana*					●						
Eastern Meadowlark	*Sturnella magna*		●						●			
Rusty Blackbird	*Euphagus carolinus*					●	●		●	●		
Red Crossbill	*Loxia curvirostra*		●						●	●		
Pine Siskin	*Spinus pinus*		●						●	●		

Exhibit 2. Mammals

Level 1 Conservation Action Categories (all priorities) for mammals as identified in the species accounts (Appendix 1.4).

Common Name	Scientific Name	1- Coordination	2-Direct Management	6-Land & Water Rights	7-Law Enforcement	8-Outreach	9-Planning	11-Technical Assistance	100-Law & Policy	101-Species Management
Eastern Fox Squirrel	*Sciurus niger vulpinus*									●
Northern Flying Squirrel	*Glaucomys sabrinus*						●			
Rock Vole	*Microtus chrotorrhinus*							●		
Allegheny Woodrat	*Neotoma magister*		●				●	●		
Prairie Deer Mouse	*Peromyscus maniculatus bairdii*		●				●			●
Appalachian Cottontail	*Sylvilagus obscurus*			●			●			●
North American Least Shrew	*Cryptotis parva*	●	●	●			●			
Long-tailed Shrew	*Sorex dispar*						●			
Northern Water Shrew	*Sorex palustris albibarbis*		●					●	●	
West Virginia Water Shrew	*Sorex palustris punctulatus*		●				●		●	
Maryland Shrew	*Sorex cinereus fontinalis*			●			●			
Big Brown Bat	*Eptesicus fuscus*		●				●			
Tricolored Bat	*Perimyotis subflavus*		●		●		●	●	●	
Northern Long-eared Bat	*Myotis septentrionalis*		●		●					
Eastern Small-footed Bat	*Myotis leibii*		●				●			●
Indiana Bat	*Myotis sodalis*		●	●	●		●			●
Little Brown Bat	*Myotis lucifugus*		●	●	●		●			●
Silver-haired Bat	*Lasionycteris noctivagans*			●					●	
Eastern Spotted Skunk	*Spilogale putorius*					●	●	●		

Exhibit 3. Amphibians

Level 1 Conservation Action Categories (all priorities) for amphibians as identified in the species accounts (Appendix 1.4).

Common Name	Scientific Name	1-Coordination	4-Educator/Instructor	7-Law Enforcement	8-Outreach	9-Planning	11-Technical Assistance
Eastern Hellbender	*Cryptobranchus alleganiensis alleganiensis*				●	●	
Mudpuppy	*Necturus maculosus*				●	●	
Jefferson Salamander	*Ambystoma jeffersonianum*			●		●	
Blue-spotted Salamander	*Ambystoma laterale*	●				●	●
Marbled Salamander	*Ambystoma opacum*			●		●	
Green Salamander	*Aneides aeneus*	●		●			●
Northern Ravine Salamander	*Plethodon electromorphus*					●	
Eastern Mud Salamander	*Pseudotriton montanus montanus*	●					●
Eastern Spadefoot	*Scaphiopus holbrookii*				●	●	●
Fowler's Toad	*Anaxyrus fowleri–PFBC*					●	
Northern Cricket Frog	*Acris crepitans*	●					●
Cope's Gray Treefrog	*Hyla chrysoscelis*					●	
Mountain Chorus Frog	*Pseudacris brachyphona*					●	
Upland Chorus Frog	*Pseudacris feriarum*					●	
New Jersey Chorus Frog	*Pseudacris kalmi*						●
Western Chorus Frog	*Pseudacris triseriata*					●	
Northern Leopard Frog	*Lithobates pipiens–PFBC*					●	
Southern Leopard Frog	*Lithobates sphenocephalus utricularius–PFBC*	●				●	●

Exhibit 4. Reptiles

Level 1 Conservation Action Categories (all priorities) for reptiles as identified in the species accounts (Appendix 1.4).

Common Name	Scientific Name	1-Coordination	2-Direct Management	7-Law Enforcement	9-Planning	10-Reintroductions	11-Technical Assistance
Eastern Mud Turtle	*Kinosternon subrubrum subrubrum*	●			●	●	●
Spotted Turtle	*Clemmys guttata*			●	●		
Wood Turtle	*Glyptemys insculpta*			●	●		
Bog Turtle	*Glyptemys muhlenbergii*		●	●	●		●
Blanding's Turtle	*Emydoidea blandingii*				●		
Eastern Redbelly Turtle	*Pseudemys rubriventris*				●		●
Eastern Box Turtle	*Terrapene carolina carolina*			●	●		
Eastern Fence Lizard	*Sceloporus undulatus*				●		
Northern Coal Skink	*Plestiodon anthracinus anthracinus*				●		
Broadhead Skink	*Plestiodon laticeps*	●			●		
Eastern Worm Snake	*Carphophis amoenus amoenus–PFBC*				●		
Kirtland's Snake	*Clonophis kirtlandii*				●		
Eastern Hognose Snake	*Heterodon platirhinos*			●	●		
Rough Green Snake	*Opheodrys aestivus*	●		●			●
Queen Snake	*Regina septemvittata*				●		
Eastern Ribbonsnake	*Thamnophis sauritus*				●		
Shorthead Garter Snake	*Thamnophis brachystoma*				●		
Eastern Smooth Earth Snake	*Virginia valeriae valeriae–PFBC*				●		
Mountain Earth Snake	*Virginia valeria pulchra–PFBC*				●		
Copperhead	*Agkistrodon contortrix*			●	●		
Timber Rattlesnake	*Crotalus horridus*			●			●

Common Name	Scientific Name	1-Coordination	2-Direct Management	7-Law Enforcement	9-Planning	10-Reintroductions	11-Technical Assistance
Eastern Massasauga	*Sistrurus catenatus catenatus*	●		●	●		●

Exhibit 5. Fishes

Level 1 Conservation Action Categories (all priorities) for fishes as identified in the species accounts (Appendix 1.4).

Common Name	Scientific Name	2-Direct Management	3.0Energy Production	5-Facilities/Areas	7-Law Enforcement	8-Outreach	9-Planning	10-Reintroductions	11-Technical Assistance	100-Law & Policy	101-Species Management
Ohio Lamprey	*Ichthyomyzon bdellium*						●				
Northern Brook Lamprey	*Ichthyomyzon fossor*	●								●	
Mountain Brook Lamprey	*Ichthyomyzon greeleyi*				●					●	
Least Brook Lamprey	*Lampetra aepyptera*						●			●	
Shortnose Sturgeon	*Acipenser brevirostrum*			●		●			●	●	●
Lake Sturgeon	*Acipenser fulvescens*	●		●							
Atlantic Sturgeon	*Acipenser oxyrhynchus*			●		●			●	●	●
Spotted Gar	*Lepisosteus oculatus*	●								●	
Bowfin	*Amia calva*								●	●	
American Eel	*Anguilla rostrata*			●						●	
Blueback Herring	*Alosa aestivalis*				●						●
Hickory Shad	*Alosa mediocris*			●							

Common Name	Scientific Name	2-Direct Management	3.0Energy Production	5-Facilities/Areas	7-Law Enforcement	8-Outreach	9-Planning	10-Reintroductions	11-Technical Assistance	100-Law & Policy	101-Species Management
Alewife	*Alosa pseudoharengus*				●						●
Northern Redbelly Dace	*Chrosomus eos*						●		●	●	
Southern Redbelly Dace	*Chrosomus erythrogaster*				●		●				
Redside Dace	*Clinostomus elongatus*						●		●	●	
Streamline Chub	*Erimystax dissimilis*						●				
Bigmouth Shiner	*Notropis dorsalis*						●		●		
Redfin Shiner	*Lythrurus umbratilis*	●					●			●	
Allegheny Pearl Dace	*Margariscus margarita*						●		●	●	
Hornyhead Chub	*Nocomis biguttatus*			●		●	●		●	●	
White Catfish	*Ameiurus catus*	●									
Bridle Shiner	*Notropis bifrenatus*						●			●	
Ironcolor Shiner	*Notropis chalybaeus*						●			●	
Blackchin Shiner	*Notropis heterodon*								●		
Longnose Sucker	*Catostomus catostomus*	●					●		●	●	
Spotted Sucker	*Minytrema melanops*	●									
Mountain Madtom	*Noturus eleutherus*						●				
Tadpole Madtom	*Noturus gyrinus*	●								●	
Margined Madtom	*Noturus insignis*										●
Brindled Madtom	*Noturus miurus*	●					●		●	●	
Northern Madtom	*Noturus stigmosus*						●				
American Shad	*Alosa sapidissima*			●							●
Brook Trout	*Salvelinus fontinalis*	●	●		●		●	●	●	●	
Central Mudminnow	*Umbra limi*						●			●	

Common Name	Scientific Name	**2**-Direct Management	**3**.0Energy Production	**5**-Facilities/Areas	**7**-Law Enforcement	**8**-Outreach	**9**-Planning	**10**-Reintroductions	**11**-Technical Assistance	**100**-Law & Policy	**101**-Species Management
Eastern Mudminnow	*Umbra pygmaea*						●		●	●	
Burbot	*Lota lota*	●								●	●
Allegheny Burbot	*Lota sp. cf lota*						●		●	●	
Brook Stickleback	*Culaea inconstans*						●			●	
Threespine Stickleback	*Gasterosteus aculeatus*			●			●			●	
Checkered Sculpin	*Cottus sp cf cognatus*						●			●	
Warmouth	*Lepomis gulosus*	●								●	
Longear Sunfish	*Lepomis megalotis*						●		●	●	
Eastern Sand Darter	*Ammocrypta pellucida*	●					●			●	
Iowa Darter	*Etheostoma exile*	●								●	
Tessellated Darter	*Etheostoma olmstedi*	●					●				
Chesapeake Logperch	*Percina bimaculata*						●	●		●	
Longhead Darter	*Percina macrocephala*								●	●	

Exhibit 6. Mussels

Level 1 Conservation Action Categories (all priorities) for mussels as identified in the species accounts (Appendix 1.4).

Common Name	Scientific Name	**1**-Coordination	**2**-Direct Management	**8**-Outreach	**11**-Technical Assistance
Dwarf Wedgemussel	*Alasmidonta heterodon*		●		●
Northern Riffleshell	*Epioblasma torulosa rangiana*	●	●		●
Snuffbox	*Epioblasma triquetra*		●		●
Eastern Pearlshell	*Margaritifera margaritifera*	●	●	●	
Round Hickorynut	*Obovaria subrotunda*	●	●		●
Sheepnose	*Plethobasus cyphyus*	●	●		●
Clubshell	*Pleurobema clava*	●	●		●
Rabbitsfoot	*Quadrula cylindrica cylindrica*		●		●
Pistolgrip	*Quadrula verrucosa*	●	●		●
Salamander Mussel	*Simpsonaias ambigua*	●			●
Rayed Bean	*Villosa fabalis*	●	●		●

Exhibit 7. Invertebrates

Level 1 Conservation Action Categories (Priorities 1-3) for invertebrates.

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Amphipods		●	●				●		
Bees		●			●				●
Butterflies and Skippers		●				●			
Caddisflies			●			●	●		
Craneflies		●				●	●		
Crayfishes									
Spinycheek Crayfish	*Orconectes limosus*	●	●						
Dragonflies and Damselflies									
Mottled Darner	*Aeshna clepsydra*	●						●	
Lance-tipped Darner	*Aeshna constricta*	●						●	
Variable Darner	*Aeshna interrupta*	●						●	
Comet Darner	*Anax longipes*	●						●	
Taper-tailed Darner	*Gomphaeschna antilope*	●						●	
Harlequin Darner	*Gomphaeschna furcillata*	●						●	
Cyrano Darner	*Nasiaeschna pentacantha*	●						●	
Spatterdock Darner	*Rhionaeschna mutata*	●						●	
River Jewelwing	*Calopteryx aequabilis*	●						●	
Superb Jewelwing	*Calopteryx amata*	●						●	

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Appalachian Jewelwing	*Calopteryx angustipennis*	●						●	
Sparkling Jewelwing	*Calopteryx dimidiata*	●						●	
Smoky Rubyspot	*Hetaerina titia*	●						●	
Seepage Dancer	*Argia bipunctulata*	●		●				●	
Blue-ringed Dancer	*Argia sedula*	●						●	
Taiga Bluet	*Coenagrion resolutum*	●						●	
River Bluet	*Enallagma anna*	●		●				●	
Boreal Bluet	*Enallagma boreale*	●						●	
Tule Bluet	*Enallagma carunculatum*	●						●	
Attenuated Bluet	*Enallagma daeckii*	●						●	
Turquoise Bluet	*Enallagma divagans*	●						●	
Atlantic Bluet	*Enallagma doubledayi*	●						●	
Big Bluet	*Enallagma durum*	●						●	
New England Bluet	*Enallagma laterale*	●						●	
Lilypad Forktail	*Ischnura kellicotti*	●						●	
Furtive Forktail	*Ischnura prognata*	●						●	
Rambur's Forktail	*Ischnura ramburii*	●						●	
Southern Sprite	*Nehalennia integricollis*	●						●	
Brown Spiketail	*Cordulegaster bilineata*	●		●				●	
Tiger Spiketail	*Cordulegaster erronea*	●		●				●	
Arrowhead Spiketail	*Cordulegaster obliqua*	●		●				●	
American Emerald	*Cordulia shurtleffii*	●						●	

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Petite Emerald	*Dorocordulia lepida*	●						●	
Slender Baskettail	*Epitheca costalis*	●						●	
Spiny Baskettail	*Epitheca spinigera*	●						●	
Uhler's Sunfly	*Helocordulia uhleri*	●						●	
Ski-tailed Emerald	*Somatochlora elongata*	●		●				●	
Forcipate Emerald	*Somatochlora forcipata*	●		●				●	
Incurvate Emerald	*Somatochlora incurvata*	●		●				●	
Mocha Emerald	*Somatochlora linearis*	●		●				●	
Brush-tipped Emerald	*Somatochlora walshii*	●		●				●	
Williamson's Emerald	*Somatochlora williamsoni*	●		●				●	
Lilypad Clubtail	*Arigomphus furcifer*	●						●	
Spine-crowned Clubtail	*Gomphus abbreviatus*	●						●	
Moustached Clubtail	*Gomphus adelphus*	●						●	
Beaverpond Clubtail	*Gomphus borealis*	●						●	
Midland Clubtail	*Gomphus fraternus*	●						●	
Splendid Clubtail	*Gomphus lineatifrons*	●						●	
Rapids Clubtail	*Gomphus quadricolor*	●						●	
Sable Clubtail	*Gomphus rogersi*	●						●	
Septima's Clubtail	*Gomphus septima delawarensis*	●						●	
Skillet Clubtail	*Gomphus ventricosus*	●						●	
Green-faced Clubtail	*Gomphus viridifrons*	●						●	
Extra-striped Snaketail	*Ophiogomphus anomalus*	●						●	

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Riffle Snaketail	*Ophiogomphus carolus*	●						●	
Pygmy Snaketail	*Ophiogomphus howei*	●						●	
Appalachian Snaketail	*Ophiogomphus incurvatus incurvatus*	●						●	
Maine Snaketail	*Ophiogomphus mainensis*	●						●	
Common Sanddragon	*Progomphus obscurus*	●						●	
Riverine Clubtail	*Stylurus amnicola*	●						●	
Elusive Clubtail	*Stylurus notatus*	●						●	
Russet-tipped Clubtail	*Stylurus plagiatus*	●						●	
Zebra Clubtail	*Stylurus scudderi*	●						●	
Emerald Spreadwing	*Lestes dryas*	●						●	
Amber-winged Spreadwing	*Lestes eurinus*	●						●	
Banded Pennant	*Celithemis fasciata*	●						●	
Martha's Pennant	*Celithemis martha*	●						●	
Seaside Dragonlet	*Erythrodiplax berenice*	●						●	
Little Blue Dragonlet	*Erythrodiplax minuscula*	●						●	
Blue Corporal	*Ladona deplanata*	●						●	
White Skimmer	*Ladona exusta*	●						●	
Crimson-ringed Whiteface	*Leucorrhinia glacialis*	●						●	
Belted Whiteface	*Leucorrhinia proxima*	●						●	
Golden-winged Skimmer	*Libellula auripennis*	●						●	
Bar-winged Skimmer	*Libellula axilena*	●						●	
Yellow-sided Skimmer	*Libellula flavida*	●						●	

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Needham's Skimmer	*Libellula needhami*	●						●	
Elfin Skimmer	*Nannothemis bella*	●		●				●	
Blue-faced Meadowhawk	*Sympetrum ambiguum*	●						●	
Saffron-winged Meadowhawk	*Sympetrum costiferum*	●						●	
Cherry-faced Meadowhawk	*Sympetrum internum*	●						●	
Band-winged Meadowhawk	*Sympetrum semicinctum*	●						●	
Allegheny River Cruiser	*Macromia alleghaniensis*	●						●	
Royal River Cruiser	*Macromia taeniolata*	●						●	
Gray Petaltail	*Tachopteryx thoreyi*	●		●				●	
Flatworms		●	●			●			
Freshwater Mussels									
	Margaritiferidae					●			
	Unionidae		●			●			
Freshwater Snails									
Blue Ridge Springsnail	*Fontigens orolibas*	●						●	
Great Pondsnail	*Lymnaea stagnalis*	●						●	
Moss Bladder Snail	*Aplexa hypnorum*	●						●	
Flexed Gyro	*Gyraulus deflectus*	●						●	
Sprite Elimia	*Pleurocera proxima*	●						●	
Three-ridge Valvata	*Valvata tricarinata*	●						●	
	Amnicola decisus	●						●	
Globe Siltsnail	*Birgella subglobosa*	●						●	

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Watercress Snail	*Fontigens nickliniana*	●						●	
Henscomb Hydrobe	*Littorinidops tenuipes*	●						●	
Woodland Pondsnail	*Lymnaea catascopium*	●						●	
Boreal Marstonia	*Marstonia lustrica*	●						●	
Vernal Physa	*Physa vernalis*	●						●	
Sharp Sprite	*Promenetus exacuous*	●						●	
Ohio Pebblesnail	*Somatogyrus integra*	●						●	
Shale Pebblesnail	*Somatogyrus pennsylvanicus*	●						●	
Grasshoppers									
Appalachian Grasshopper	*Appalachia hebardi*		●		●				●
Ground Beetles									
Pennsylvania Cave Beetle	*Pseudanopthalmus sp. nov.*			●	●				●
Isopods		●			●		●		
Mayflies			●			●	●		
Moths, Clear-winged									
Doll's Merolonche	*Acronicta dolli*	●			●				
Lilac borer	*Podosesia syringae*	●			●		●		
Moths, Erebid									
Twin-dotted Macrochilo	*Macrochilo hypocritalis*	●			●				
Masked Parahypenodes	*Parahypenodes quadralis*	●			●				
Pine Barrens Zanclognatha	*Zanclognatha martha*	●			●				

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Moths, Flannel									
Black-waved Flannel Moth	*Lagoa crispata*	●			●				
Moths, Geometrids									
A Geometer Moth	*Apodrepanulatrix liberaria*	●			●				
Southern Pine Looper Moth	*Caripeta aretaria*	●			●				
A Geometrid Moth	*Cyclophora nanaria*	●			●				
Broad-lined Erastria Moth	*Erastria coloraria*	●			●				
Blueberry Gray	*Glena cognataria*	●			●				
Rare Spring Moth	*Heliomata infulata*	●			●				
Esther Moth	*Hypagyrtis esther*	●			●				
Straw Wave Moth	*Idaea eremiata*	●			●				
A Wave Moth	*Idaea violacearia*	●			●				
Barrens Itame (Cf I. Inextricata)	*Itame sp. 1 nr. inextricata*	●			●				
Twilight Moth	*Lycia rachelae*	●			●				
Promiscuous Angle	*Macaria promiscuata*	●			●				
Barrens Metarranthis Moth	*Metarranthis apiciaria*	●			●				
Early Metarranthis Moth	*Metarranthis sp. near duaria*	●			●				
Tuscarora Emerald	*Nemoria tuscarora*	●			●				
Purple Plagodis	*Plagodis kuetzingi*	●			●		●		
Shiny Gray Carpet Moth	*Stamnodes gibbicostata*	●			●				

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Moths, Giant Silkworm and Royal									
Barrens Buckmoth	*Hemileuca maia*	●			●				
Spiny Oakworm Moth	*Anisota stigma*	●			●				
Pine Devil	*Citheronia sepulcralis*	●			●				
Moths, Noctuid									
Yankee Dart	*Abagrotis brunneipennis*	●			●				
A Noctuid Moth	*Acronicta lanceolaria*	●			●				
A Cutworm Moth	*Apamea burgessi*	●			●				
Crested Apamea	*Apamea cristata*	●			●				
A Noctuid Moth	*Apharetra dentata*	●			●				
A Noctuid Moth	*Aplectoides condita*	●			●				
A Noctuid Moth	*Bagisara gulnare*	●			●				
Straight Lined Mallow Moth	*Bagisara rectifascia*	●			●				
Boreal Fan Moth	*Brachionycha borealis*	●			●				
Curved Halter Moth	*Capis curvata*	●			●				
A Bird-dropping Moth	*Cerma cora*	●			●				
A Sallow Moth	*Chaetaglaea cerata*	●			●				
Barrens Chaetaglaea	*Chaetaglaea tremula*	●			●				
Marvel Moth	*Chytonix sensilis*	●			●				
Grote's Sallow	*Copivaleria grotei*	●			●		●		
The Pink Streak	*Dargida rubripennis*	●			●				
Red Dart Moth	*Diarsia rubifera*	●			●				
A Midget Moth	*Elaphria georgei*	●			●				

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Pointed Sallow	*Epiglaea apiata*	●			●				
Sundew Cutworm Moth	*Hemipachnobia monochromatea*	●			●				
Hop Vine Borer	*Hydraecia immanis*	●			●				
Figwort Borer Moth	*Hydraecia stramentosa*	●			●				
Fingered Lemmeria	*Lemmeria digitalis*	●			●				
A Moth	*Lithomoia solidaginis germana*	●			●				
Thaxter's Pinion Moth	*Lithophane thaxteri*	●			●				
Northern Brocade Moth	*Oligia hausta*	●			●				
Ash-tip Borer	*Papaipema furcata*	●			●		●		
Buffalo Moth	*Parapamea buffaloensis*	●			●				
An Oak Moth	*Phoberia ingenua*	●			●				
A Noctuid Moth	*Platyperigea meralis*	●			●				
A Noctuid Moth	*Properigea costa*	●			●				
Pink Sallow	*Psectraglaea carnosa*	●			●				
Aureolaria Seed Borer	*Rhodoecia aurantiago*	●			●				
A Noctuid Moth	*Richia acclivis*	●			●				
A Noctuid Moth	*Richia grotei*	●			●				
	Sideridis maryx	●			●				
Private Sallow Moth	*Sutyna privata*	●			●				
Pirate Looper Moth	*Syngrapha epigaea*	●			●				
Southern Variable Dart Moth	*Xestia elimata*	●			●				
Broad Sallow Moth	*Xylotype capax*	●			●				

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Moths, Notodontid									
A Hand-maid Moth	*Datana ranaeceps*	●			●				
Moths, Other									
The Angel	*Olceclostera angelica*	●			●		●		
Splendid Palpita	*Palpita magniferalis*	●			●		●		
Gold-Spotted Ghost Moth	*Sthenopis auratus*	●			●				
Moths, Papaipema									
A Borer Moth	*Papaipema aerata*	●			●				
Yellow Stoneroot Borer Moth	*Papaipema astuta*	●			●				
Indigo Stem Borer	*Papaipema baptisiae*	●			●				
Dark Stoneroot Borer Moth	*Papaipema duplicata*	●			●				
Joe-Pye-Weed Borer	*Papaipema eupatorii*	●			●				
Vernonia Borer Moth	*Papaipema limpida*	●			●				
Loosestife Borer	*Papaipema lysimachiae*	●			●				
Brick-red Borer Moth	*Papaipema marginidens*	●			●				
Maritime Sunflower Borer Moth	*Papaipema maritima*	●			●				
Sunflower Borer Moth	*Papaipema necopina*	●			●				
Coneflower Borer	*Papaipema nelita*	●			●				
Turtlehead Borer	*Papaipema nepheleptena*	●			●				
Mayapple Borer	*Papaipema rutila*	●			●				
Flypoison Borer Moth	*Papaipema sp. 1*	●			●				
Ostrich Fern Borer	*Papaipema sp. 2 nr. pterisii*	●			●				

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Moths, Sac-Bearers									
Melsheimer's Sack Bearer	*Cicinnus melsheimeri*	●			●				
Moths, Sphinx									
Graceful Clearwing	*Hemaris gracilis*	●			●				
Ash Sphinx	*Manduca jasminearum*	●			●		●		
Great Ash Sphinx	*Sphinx chersis*	●			●				
Franck's Sphinx Moth	*Sphinx franckii*	●			●				
Apple Sphinx	*Sphinx gordius*	●			●				
Moths, Tent Caterpillar & Lappet									
Dot-lined White Moth	*Artace cribraria*	●			●				
Tolype Moth	*Tolype notialis*	●			●				
Moths, Tiger									
Packard's Lichen Moth	*Cisthene packardii*	●			●				
Lead Colored Lichen Moth	*Cisthene plumbea*	●			●				
Pure Lichen Moth	*Crambidia pura*	●			●				
Phyllira Tiger Moth	*Grammia phyllira*	●			●				
Joyful Holomelina Moth	*Holomelina laeta*	●			●				
Blackish Tiger Moth	*Virbia nigricans*	●			●				
Moths, Underwing									
Angus' Underwing	*Catocala angusi*	●			●				
Dejected Underwing	*Catocala dejecta*	●			●				
Sweet Underwing	*Catocala dulciola*	●			●				
A Noctuid Moth	*Catocala miranda*	●			●				

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Precious Underwing Moth	*Catocala pretiosa pretiosa*	●			●				
Robinson's Underwing	*Catocala robinsoni*	●			●				
Pine Woods Underwing	*Catocala sp. 1 nr. jair*	●			●				
Shadow Underwing	*Catocala umbrosa*	●			●				
Moths, Zale									
Black-eyed Zale	*Zale curema*	●			●				
Oblique Zale Moth	*Zale obliqua*	●			●				
Pine Barrens Zale	*Zale sp. 1 nr. lunifera*	●			●				
Gray-banded Zale	*Zale squamularis*	●			●				
Gray Spring Zale	*Zale submediana*	●			●				
Other Beetles									
Six-banded Longhorn Beetle	*Dryobius sexnotatus*		●	●					●
American Burying Beetle	*Nicrophorus americanus*		●		●				●
Sawflies									
Black-headed Ash Sawfly	*Tethida barda*	●			●		●		
Spiders									
	A Ghost Spider	●	●		●				
	Anyphaenida				●				●
	Linyphiidae			●	●				●
	Lycosidae	●	●						
Springtails									
Heller Cave Springtail	*Typhlogastrura helleri*			●	●			●	

Taxonomic Group Common Name	Scientific Name	**2.0**-Direct Management	**3.0**-Data Collection	**6.0**-Land & Water Rights	**8.0**-Outreach	**9.0**-Planning	**10.0**-Reintroductions	**11.0**-Technical Assistance	**100.0**-Law & Policy
Stoneflies			●			●	●		
Terrestrial Snails		●	●						
Tiger Beetles		●	●						●
True bugs									
Fringetree Lace Bug	*Leptoypha mutica*	●					●		●

Appendix 4.3
Exhibit 1

Highest priority strategies and actions in the National Fish, Wildlife, Plants, Climate Adaptation Strategy (NFWPCAS), as identified by the 2015 Pennsylvania Wildlife Action Plan, Climate Change Committee. Strategies and Actions adapted from NFWPCAP (2012).

NFWPCAS Strategies	NFWPCAS Actions
1.1: Identify areas for an ecologically-connected network of terrestrial, freshwater, coastal, and marine conservation areas that are likely to be resilient to climate change and to support a broad range of fish, wildlife, and plants under changed conditions.	1.1.1: Identify and map high priority areas for conservation using information such as species distributions (current and projected), habitat classification, land cover, and geophysical settings (including areas of rapid change and slow change). 1.1.3: Assess the potential of species to shift ranges, and prioritize conservation efforts taking into account range shifts and accounting for ecosystem functions and existing and future physical barriers.
1.2: Secure appropriate conservation status on areas identified in action 1.1.1 to complete an ecologically connected network of public and private conservation areas that will be resilient to climate change and support a broad range of species under changed conditions.	1.2.1: Conserve areas identified in action 1.1.1 that provide high-priority habitats under current climate conditions and are likely to be resilient to climate change and/or support a broad array of species in the future. 1.2.2: Conserve areas representing the range of geophysical settings, including various bedrock geology, soils, topography, and projected climate, to maximize future biodiversity. 1.2.4: Work with partners at landscape scales to strengthen and maximize use of existing conservation programs, particularly the conservation title of the Farm Bill, conservation easement tax incentives, the private lands programs focused on endangered species, and other federal and state private lands incentive programs to conserve private lands of high conservation value, to enhance habitat values and maintain working landscapes under climate change.
1.3: Restore habitat features where necessary and practicable to maintain ecosystem function and resiliency to climate change.	1.3.1: Develop and implement restoration protocols and techniques that promote ecosystem resilience and facilitate adaptation under a range of possible future conditions. 1.3.3: Restore or enhance areas that will provide essential habitat and ecosystem services during ecosystem transitions under a changing climate. 1.3.4: Restore disturbance regimes as appropriate to emerging conditions, including instituting human-assisted disturbance where necessary (e.g., prescribed fire).
1.4: Conserve, restore, and as appropriate and practicable, establish new ecological connections among conservation areas to	1.4.1: Identify species with special connectivity needs (i.e., those that are area-limited, resource-limited, dispersal-limited, or process-limited).

facilitate fish, wildlife, and plant migration, range shifts, and other transitions caused by climate change.	1.4.2: Assess and prioritize critical connectivity gaps and needs across current conservation areas, including areas likely to serve as refugia in a changing climate. 1.4.3: Conserve corridors and transitional habitats between ecosystem types through both traditional and non-traditional (e.g., land exchanges, rolling easements) approaches.
2.1: Update current or develop new species, habitat, and land and water management plans, programs and practices to consider climate change and support adaptation.	2.1.1: Incorporate climate change considerations into new and future revisions of species and area management plans (e.g., State Wildlife Action Plans, agency-specific climate change adaptation plans) using the best available science regarding projected climate changes and trends, vulnerability and risk assessments, scenario planning, and other appropriate tools as necessary. 2.1.2: Develop and implement best-management practices to support habitat resilience in a changing climate. 2.1.3: Identify species and habitats particularly vulnerable to transition under climate change (e.g., wetlands, coolwater to warmwater fisheries) and develop management strategies and approaches for adaptation. 2.1.7: Review existing management frameworks and identify ways to increase the ability of stakeholders to adapt their actions to climate variability and change while preserving the integrity and sustainability of natural resources, habitats, and ecosystems.
2.3: Conserve genetic diversity by protecting diverse populations and genetic material across the full range of species occurrences.	2.3.1: Develop and implement approaches for assessing and maximizing the potential for maintaining genetic diversity of plant and animal species. 2.3.2: Protect and maintain high quality native seed sources including identifying areas for seed collection across latitudinal ranges of target species.
3.1: Increase the climate-change awareness and capacity of natural resource managers and other decision-makers and enhance their professional abilities to design, implement, and evaluate fish, wildlife, and plant adaptation programs.	3.1.1: Build on existing needs assessments to identify gaps in climate change knowledge and technical capacity among natural resource professionals. 3.1.8: Develop training materials to help managers and decision-makers apply climate knowledge to the administration of existing natural resource and environmental laws and policies.

3.2: Facilitate a coordinated response to climate change at landscape, regional, national, and international scales across state, federal, and tribal natural resource agencies and private conservation organizations.	3.2.1: Use regional venues, such as LCCs, to collaborate across jurisdictions and develop conservation goals and landscape/ seascape scale plans capable of sustaining fish, wildlife, and plants.
3.4: Optimize use of existing fish, wildlife, and plant conservation funding sources to design, deliver, and evaluate climate-adaptation programs.	3.4.1: Prioritize funding for land and water protection programs that incorporate climate-change considerations.
4.1: Support, coordinate, and, where necessary, develop distributed, but integrated, inventory, monitoring, observation, and information systems at multiple scales to detect and describe climate impacts on fish, wildlife, plants, and ecosystems.	4.1.2: Use available long-term monitoring programs at appropriate scales (local to international) as baselines for population and migration changes that could be affected by climate change (e.g., International Waterfowl Surveys). 4.1.3: Work through existing distributed efforts (e.g., NCA, National Estuarine Research Reserve System's system-wide monitoring program, State Natural Heritage Programs, National Wildlife Refuge System and National Park Service inventory and Monitoring Programs) to support integrated national observation and information systems that inform climate adaptation. 4.1.4: Expand and develop as necessary a network of sentinel sites (e.g., tribal lands, National Estuarine Research Reserves, National Wildlife Refuges, state lands) for integrated climate change inventory, monitoring, research, and education. 4.1.9: Collaborate with the National Phenology Network to facilitate monitoring of phenology; create an analogous National Population Network to catalog changes in distribution and abundance of fish, wildlife, and plants that have been identified as most vulnerable to climate change.
4.2: Identify, develop, and employ decision-support tools for managing under uncertainty (e.g., vulnerability and risk assessments, scenario planning, strategic habitat conservation approaches, forecasting, and adaptive management evaluation systems) via dialogue with scientists, managers (of natural resources and other sectors), economists, and stakeholders.	4.2.1: Develop regional downscaling of Global Climate models to conduct vulnerability assessments of living resources.

5.1: Identify knowledge gaps and define research priorities via a collaborative process among federal, state, tribal, private conservation organization, and academic resource managers and research scientists.	5.1.1: Increase coordination and communication between resource managers and natural and social scientists through existing forums (e.g., National Science Foundation (NSF), USGCRP, NCA, USDA, Cooperative Ecosystem Studies Units, CSCs, LCCs, JVs, RISAs, Associations of Fish and Wildlife Agencies, State Wetlands Managers, State Floodplain Managers, Coastal States Organization, National Estuarine Research Reserve Association, and others) to ensure research is connected to management needs. 5.1.2: Bring managers and scientists together at the appropriate scales to prioritize research needs that address resource management objectives considering a changing climate. 5.1.5: Based on priority conservation needs identified by resource managers, (develop national, and as appropriate,) regional research agendas identifying key high-level questions for which more fundamental research is needed to enable development of management applications or decision support tools; and facilitate consultation among major science funding agencies to maximize incorporation of these needs into funding opportunities and work plans.
5.2: Conduct research into ecological aspects of climate change, including likely impacts and the adaptive capacity of species, communities and ecosystems, and their associated ecosystem services, working through existing partnerships or new collaborations as needed (e.g., USGCRP, NCA, CSCs, RISAs, and others).	5.2.1: Produce regional to sub-regional projections of future climate-change impacts on physical, chemical, and biological conditions for U.S. ecosystems. 5.2.3: Identify and address priority climate-change knowledge gaps and needs (e.g., species adaptive capacity, risk and rewards of assisted relocation, climate-change synergy with existing stressors).
6.1: Increase public awareness and understanding of climate impacts to natural resources and ecosystem services and the principles of climate adaptation at regionally- and culturally-appropriate scales.	6.1.5: Increase public awareness of existing habitat conditions and the benefits of building resiliency of those habitats.
6.2: Engage the public through targeted education and outreach efforts and stewardship opportunities.	6.2.4: Make research and monitoring information regarding climate impacts to species and natural systems accessible and easily understood to the public and other partners (e.g., commercial fisheries, etc.). 6.2.7: Develop core messaging and recommended strategies to communicate the Strategy within participating organizations, local associations and clubs (e.g., garden clubs), and with the public.

7.1: Slow and reverse habitat loss and fragmentation.	7.1.1: Work with local land-use planners, flood-plain administrators, and others to identify shared interests and potential conflicts in reducing and reversing habitat fragmentation and loss through established planning and zoning processes. 7.1.8: Minimize impacts from alternative energy development by focusing siting options on already disturbed or degraded areas.
7.2: Slow, mitigate, and reverse, where feasible, ecosystem degradation from anthropogenic sources through land/ocean-use planning, water resource planning, pollution abatement, and the implementation of best-management practices.	7.2.8: Reduce groundwater and surface water withdrawals in areas experiencing drought and/or increased evapotranspiration. 7.2.12: Consider the impact of logging practices on fire risk and ecosystem diversity and function.
7.3: Use, evaluate, and as necessary, improve existing programs to prevent, control, and eradicate invasive species and manage pathogens.	7.3.1: Use, integrate, and implement existing pest and pathogen risk assessment methodologies for imported organisms and establish appropriate regulations to prevent deliberate importations of pests, pathogens, or other species that are predicted to be harmful or invasive. 7.3.4: Apply risk assessment and scenario planning to identify actions and prioritize responses to invasive species that pose the greatest threats to natural ecosystems. 7.3.6: Assess risks and vulnerability to identify high priority areas and/or species for monitoring of invasive species and success of control methods.
7.4: Reduce destructive capture practices (e.g., fisheries bycatch, destructive fishing gear), over-harvesting and illegal trade to help increase fish, wildlife, and plant adaptation.	7.4.4: Determine sustainable harvest levels in changing climate, and design, implement, and evaluate management plans and practices to eliminate over-harvest of fish, wildlife, and plants.