
CHAPTER 1

DELAWARE'S WILDLIFE SPECIES OF GREATEST CONSERVATION NEED



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Introduction

The Delaware Wildlife Action Plan (DEWAP) provides information on the distribution and abundance of species, including low population and declining species, which is indicative of the diversity and health of wildlife in a state. The DEWAP Revision process began with a review of national, regional and statewide current, available information on the diverse array of Delaware's fish and wildlife. In this chapter, we describe the process used to determine these species of greatest conservation need (SGCN) and then list and describe these species. Following chapters describe the habitats these species rely on (Chapter 2), the threats facing the species and their habitats (Chapter 3), and conservation actions that can minimize the impact of the threats and support the species' populations (Chapter 4).

Regional Context

Very few species live strictly within a single state. The vast majority of species are found in habitats across multiple states, or migrate annually and use habitats in many places. The Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) of the Northeast Association of Fish and Wildlife Agencies (NEAFWA), works to address conservation needs for regional species.

A comprehensive list of all SGCN included in the northeastern state Wildlife Action Plans (WAPs) in 2005 (compiled by Whitlock 2006) included 87 mammals, 263 birds, 65 reptiles, 73 amphibians, 299 fish, 27 tiger beetles, and 101 freshwater mussel species and subspecies. These numbers represent a significant percentage of the total numbers of northeastern species in all seven of these taxonomic groups (Table 1.1). The large number of species (915) included in these lists reflects the magnitude of the threats facing fish and wildlife species in the Northeast, as well as the commendable efforts of the individual northeastern states to ensure that their WAPs were comprehensive in their coverage of species in major taxonomic groups.

To determine which of these state SGCN should receive attention at the regional scale, the NEFWDTC identified regional species of greatest conservation need (RSGCN). A total of 1,260 species of seven major taxonomic groups (mammals, birds, reptiles, amphibians, fish, tiger beetles, and freshwater mussels) were evaluated by the NEFWDTC. Of these, almost 30% (367 species) were identified as RSGCN based on a species' conservation status and listing in state WAPs, as well as the percentage of the species' United States (U.S.) range that occurs in the Northeast (see Table 1.1 for a breakdown of RSGCN by major taxonomic groups). The RSGCN list will be reviewed periodically and will evaluate additional taxa. For example, only two major invertebrate groups (freshwater mussels and tiger beetles) were reviewed for the 2013 RSGCN list. Considerable additional information is available to assess invertebrates, and many states have expanded their treatment of

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invertebrates in 2015 state WAPs. The development of the RSGCN list supports earlier findings that a significant percentage of the wildlife species in the Northeast are in urgent need of dedicated conservation attention, with Stein et al. (2000) and The Heinz Center for Science Economics and Environment (The Heinz Center 2002; 2008) suggesting that approximately 33% of animal species in the U.S. are at elevated risk for extinction.

Major taxonomic groups with the highest percentage of RSGCN in the Northeast include amphibians (40%), reptiles (39%), and tiger beetles (39%) (Table 1.1). Threats to amphibians and reptiles from disease, water quality impairment, and habitat loss are well known and are discussed further in this document. Some tiger beetles are associated with early successional habitats or areas such as beaches that are prone to human disturbance, and thus are at elevated risk from human activities (Knisley and Schultz 1997). Of the 356 RSGCN analyzed in Table 1.1 (analysis excludes the 11 additional federally listed invertebrates not evaluated through the RSGCN process), approximately 16% are considered to be of high regional responsibility (meaning that they are found in 50% or more of the northeastern states) and high regional concern (based on the best available information about population status and trends and inclusion in northeastern states' WAPs). Tiger beetles have the highest percentage of species ranked high in both regional responsibility and high regional concern (21%). The next closest group, reptiles, had 8% of species in this category. Additionally, almost 30% of the RSGCN are listed under the Federal Endangered Species Act (ESA) as endangered, threatened or candidate species for listing). Mammals had the highest percentage of species with federal listing status, with 27% of the total number of species occurring in the Northeast.

One third (230) of Delaware's SGCN are currently included on the RSGCN list. This means that Delaware can work collaboratively with other states and regional conservation partners to share information, management plans, and even conservation funds to protect these species. Conversely, Delaware may have distinct responsibility for SGCN that are not found on the RSGCN list.

Table 1. 1 Regional Species of Greatest Conservation Need: Summary Statistics

Taxonomic Group	Total Number of Species in NE Region ¹	Northeastern State SGCN		Regional SGCN (RSGCN)		High Responsibility, High Concern		Federal Status	
		Number of State SGCN ²	Percent of Total	Number of RSGCN ³	Percent of Total	Number of High Responsibility, High Concern Species ³	Percent of Total	Number of Species with Federal Status ³	Percent of Total
Mammals	128	87	68%	45	35%	8	6%	34	27%
Birds	387	263	68%	110	28%	12	3%	34	9%
Reptiles	74	65	88%	29	39%	6	8%	11	15%
Amphibians	91	73	80%	36	40%	3	3%	4	4%
Fish	441	299	68%	101	23%	16	4%	11	2%
Tiger Beetles	28	27	96%	11	39%	6	21%	2	7%
Freshwater	111	101	91%	23	21%	7	6%	4	4%

Sources: NatureServe and NALCC

¹From Northeast Partners for Amphibian and Reptile Conservation (NEPARC) website and the comprehensive lists of vertebrate species, tiger beetles, and freshwater mussels on the NatureServe Explorer website.

²From Whitlock (2006) comprehensive list of SGCN for all northeastern states.

³From most recent version of RSGCN list, produced by NEFWDTC and partners.

Delaware's Animal Biodiversity

Delaware is home to thousands of animal species, ranging from microscopic marine plankton to great white sharks, and from miniscule land insects to large, familiar mammals and birds such as white-tailed deer and wild turkey. The overall number of species that occur in the state remains uncertain, since so few of the invertebrate groups have been well surveyed.

The functional roles played by Delaware's wildlife species are also highly diverse, including groups with such critical roles as pollinators, insectivorous predators, decomposers of wood and plant matter, filter feeders that remove nutrients from water, and foundation species that create structured habitats used by numerous other species. Biodiversity is critical to maintaining ecosystem function (Hooper et al. 2005).

Analysis of functional diversity often provides insights into ecosystem health that are not available from examination of species diversity alone (Cadotte et al. 2011). Protecting functional diversity should be an important goal of statewide conservation planning, especially since some studies have suggested that this type of diversity may be underrepresented in protected areas (Devictor et al. 2010).

Another critical component of Delaware's wildlife diversity is beta diversity, the change in species composition between places. Impacts of stressors can result in either decreases (homogenization) (Vellend et al. 2007) or increases (Hawkins et al. 2014) in beta diversity in a given area. Tracking these patterns in beta diversity and incorporating them into conservation planning along with changes in species and functional diversity is needed in order to adequately conserve Delaware's wildlife diversity in the long term.

State of Knowledge of Delaware's Species

Delaware's fish and wildlife species and their natural history have been described extensively in the published literature. A literature search was conducted to review the most current and relevant, scientific information available on the full array of Delaware's fish and wildlife. Some important monographic resources include: *Living Resources of the Delaware Estuary* (Dove et al. 1995), *Delaware's Fresh and Brackish Water Fishes* (Raasch 1997), *The Birds of Delaware* (Hess et al. 2000), *Reptiles and Amphibians of the Delmarva Peninsula* (White and White 2007), and *Ecology of Estuarine Fishes: Temperate Waters of the Western North Atlantic* (Able and Fahay 2010).

DNREC programs, especially the Division of Fish and Wildlife (DFW)'s Species Conservation & Research Program (SCRIP), conduct inventories, monitoring, and research to guide the preservation,

conservation, and management of the state's flora and fauna. These reports, as well as publications produced by academia and industry, contain extremely important, but often difficult to locate, sources of species distribution data (Boakes et al. 2010). Delaware has a significant volume of this kind of species information. Many studies have been produced in response to development of Delaware’s Coastal Zone since the 1960s. Much of this literature has been foundational for wildlife studies in Delaware, e.g., Wang and Kernehan (1979).

Museums are also extremely important sources of species information, especially for historical occurrence data. Repositories at the University of Delaware, Delaware Museum of Natural History, American Museum of Natural History, and National Museum of Natural History (Smithsonian) are of particular significance to the knowledge of Delaware’s fish and wildlife.

A pervasive problem in biodiversity conservation is a lack of capacity for species identification and research resulting in a lack of biological knowledge of many species. Often, the more poorly-known species are of conservation concern. For example, Bland et al. (2014) found that as many as 64% of terrestrial mammals considered by IUCN to be “Data Deficient” may be at risk of extinction. Delaware's SGCN list now includes a Data Needs Tier to help highlight the species for which Delaware data is insufficient. Conservation actions have been developed to address these important needs and can be found in Chapter 4.

Delaware’s Wildlife and SGCN - presented by Taxonomic Group

This Wildlife Action Plan chapter presents a summary of each major taxonomic group (Mammals, Birds, Amphibians, Reptiles, Fish and Invertebrates) and then focuses on each group’s SGCN in Delaware. The number of Delaware’s wildlife and SGCN are listed by taxonomic group in table 1.2, followed by descriptions of their tiered SGCN status ranks. A detailed description of the SGCN selection and ranking processes and criteria follows in this chapter (see [Update and Revision of Delaware’s Wildlife Species of Greatest Conservation Need List](#)).

Table 1. 2 Number of Wildlife Species and SGCN by Taxonomic Group in Delaware. Source: NatureServe 2015, Dillon et al. 2013, T. Pearce, pers. comm., Anderson et al. 2011

Taxonomic Group	Estimated Total # Species in DE	Total SGCN	Tier 1 SGCN	Tier 2 SGCN	Tier 3 SGCN	Data Needs SGCN	Extirpated SGCN
Mammals	60	23	10	3	6	3	1

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Taxonomic Group	Estimated Total # Species in DE	Total SGCN	Tier 1 SGCN	Tier 2 SGCN	Tier 3 SGCN	Data Needs SGCN	Extirpated SGCN
Birds	410	184	49	69	62	3	1
Amphibians	28	18	5	7	6	0	0
Snakes and Lizards	24	14	3	9	1	1	0
Turtles	16	10	8	2	0	0	0
Fishes	177	105	30	31	42	2	0
Freshwater Mussels	14	11	6	4	0	0	1
Marine/Estuarine Invertebrates	335+	7	1	3	3	0	0
Freshwater and Terrestrial Invertebrates	1700+	289	82	96	27	80	4
Freshwater and Terrestrial Snails	96 +	26	4	20	2	0	0
Other Invertebrates	Unknown *	Un- known					
TOTALS *	2,860+ known	688	198	245	149	89	7

* Insufficient information exists to estimate numbers of additional invertebrate species occurring in Delaware

Delaware's 2015 SGCN Status Rank Tier Definitions

The Association of Fish and Wildlife Agencies (AFWA) identified the need for prioritization of SGCN in the Best Practices for State Wildlife Action Plans (AFWA 2012) at the national level. The 14 Northeast states and DC furthered this approach by developing a lexicon which provided regionally consistent terms and criteria to facilitate the SGCN selection and ranking processes (Crisfield and

NEFWDC 2013). Delaware took this a step further and developed a more state specific approach with Tiers, similar to the 2007 WAP, but with major advancements and updated data. A detailed description of both the SGCN selection and prioritization processes and criteria are presented at the end of this chapter. Changes since the 2007 list are also provided (see [Update and Revision of Delaware's Wildlife Species of Greatest Conservation Need List](#)).

In order to improve prioritization of Delaware's SGCN, the number of tiers was expanded from two (in 2007) to three (in 2015), and additional Data Needs and Extirpated tiers were added. Criteria for assignment to each tier are detailed in [SGCN Prioritization Methods](#) below.

TIER 1

Tier 1 species are in the highest need of conservation action. These include the rarest species in the state, species that are highly globally imperiled, and species with regionally important Delaware populations that are also under high threat from climate change.

TIER 2

Tier 2 species are of moderate conservation concern in Delaware. These include species that have rare to uncommon breeding populations in the state, species with broad distributions that are threatened by climate change, and species for which Delaware has high responsibility within the Northeast region.

TIER 3

These species are for the most part still relatively common in Delaware, but are listed as SGCN for various reasons, including documented population declines, high responsibility of the Northeast region for the global population, or continued need for monitoring and/or management. This tier also includes non-breeding species that are uncommon in Delaware.

Data Needs

These are species in need of monitoring efforts to determine their conservation status in Delaware.

Extirpated

These species once occurred in Delaware, but have been determined through extensive survey effort to no longer occur in the state. The extirpated species included as SGCN have some possibility of reintroduction (i.e., suitable habitat may occur in the state and potential source populations may exist).

Mammals

Mammal Diversity of Delaware

Delaware is home to a wide variety of mammals. An important source of information about mammal populations that are hunted is the Delaware DNREC DFW. Species that are managed by the agency and hunted or trapped, including coyote, beaver, and white-tailed deer, are monitored through DNREC DFW management programs. Population and harvest data on many hunted, trapped, and other common mammal species are collected and evaluated annually in order to effectively monitor and manage these important, more common species in Delaware. The most current, available scientific data were reviewed on Delaware's mammals in order to determine those Species in Greatest Conservation Need. Sixty species are native to Delaware: 38 species of terrestrial mammals, 16 species of marine mammals and six species have been extirpated from the state. An additional five species are considered non-native or invasive to the state

Delaware SGCN Mammals

SGCN mammals include three carnivores, four small mammals, nine bats, and seven marine mammals. All but three of Delaware's mammal SGCN (mink, long-tailed weasel, evening bat) are among the forty-five species of mammals designated as RSGCN in the Northeast. Two of Delaware's SGCN are considered to have high regional responsibility and very high regional concern: eastern small-footed myotis and Delmarva fox squirrel. These high-priority mammals, along with many of the other mammalian SGCN, are threatened by residential and commercial development causing forest habitat conversion and predation by domestic pets and subsidized predators.

Carnivores

Carnivore guilds in eastern North America are taxonomically and functionally depleted when compared to the 17th and early 18th centuries, and even more so when compared with the Late Pleistocene (Dalerum et al. 2009). Ecologically functional populations of apex carnivores provide critical ecosystem services including herbivore and mesopredator suppression via trophic cascades. In Delaware, the native apex carnivores were likely one or more species of wolves (*Canis* sp.), the eastern cougar (*Puma concolor cougar*), and to a lesser extent, the black bear (*Ursus americanus*). Both wolves and cougars were extirpated from the state in the 1700s. Recently, eastern coyotes (*Canis latrans*), a mesopredator in areas with wolf populations, have begun to colonize the state and may assume an apex predator role in the near future. Delaware is also one of the only states in the continental US without a population of bobcat (*Lynx rufus*), although this species occurs across the bay in New Jersey and suitable habitat is present, especially in southern Delaware (Table 1.3).

Table 1. 3 Delaware Carnivorous Mammal SGCN

Carnivore SGCN (3)		
<i>Neovison vison</i>	Mink	Tier 2
<i>Mustela frenata</i>	Long-tailed Weasel	Tier 3
<i>Lynx rufus</i>	Bobcat	Extirpated

Mustelids (mink and weasels) are apparently now uncommon in Delaware, but that has not always been the case. Mink (*Neovison vison*) was noted by state wildlife managers in 1942 as having been “restricted by intensive trapping to a point of extinction” in the state, with “only a very few places in Delaware where they are to be found” (Delaware Board Game and Fish Comm. 1942). The same report refers to the long-tailed weasel (*Mustela frenata*, at the time called *Mustela noveboracensis*) as “not considered scarce” in Delaware, being found in New Castle and scattered areas of Kent and Sussex counties in “open mixed forests adjoining farm communities where streams are numerous”. Both of these reports suggest that mustelids have experienced significant declines in Delaware during the 20th century. Studies in the southeast suggest that environmental contaminants may play an important role in mustelid population declines, especially on the coastal plain (Osowski et al. 1995).

Small Mammals

The conservation status of many small mammals in Delaware is poorly known, and further survey work is warranted. Several species are apparently restricted to the Piedmont, but their population status there is uncertain. Increased survey efforts are needed to determine species abundance and distributions for SGCN listed here as well as other species whose conservation status is less well known. Four small mammal species are considered SGCN (Table 1.4).

Table 1. 4 Delaware Small Mammal SGCN

Small Mammal SGCN (4)		
<i>Sciurus niger cinereus</i>	Delmarva Fox Squirrel	Tier 1
<i>Cryptotis parva</i>	North American Least Shrew	Tier 2
<i>Condylura cristata</i>	Star-nosed Mole	Tier 3
<i>Sorex cinereus fontinalis</i>	Maryland Shrew	Data Needs

Delmarva Fox Squirrel

The Delmarva fox squirrel (*Sciurus cinereus niger*, Figure 1.1), once found in mature mixed oak-pine forests throughout the Delmarva Peninsula, was listed as Endangered by the U.S. Fish and Wildlife Service (USFWS) in 1967, at which time the range had been reduced to 10% of the original size. The species had been extirpated from Delaware prior to 1920 (USFWS 2012). Between 1984 and 1987, translocated populations were established at two sites in Sussex County, Delaware (Prime Hook National Wildlife Refuge and



Figure 1. 1 Delmarva Fox Squirrel (*Sciurus niger cinereus*). Photo: USFWS

Assawoman Wildlife Area) and the Delaware Assawoman population was designated a nonessential experimental population (US Fish and Wildlife Service 1993). The Prime Hook population has persisted without supplementation, while the Assawoman population has been lost (US Fish and Wildlife Service 2012). By 2007, a new population was identified in the Nanticoke Wildlife Management Area in southwestern Sussex County. This was the first population found in Delaware since the time of listing that was not a result of a translocation (US Fish and Wildlife Service 2007).

In 2014, the Delmarva fox squirrel was proposed for delisting from protection under the Endangered Species Act, and a draft *Postdelisting Monitoring Plan* (US Fish and Wildlife Service 2014) was completed. According to this plan, DNREC DFW will continue to list the Delmarva fox squirrel as a State Endangered species. DNREC DFW prepared a Draft *Delaware Delmarva Fox Squirrel Conservation Plan* in 2014 (DNREC DFW 2014).

Bats

Delaware's SGCN bats are divided into two main groupings based on life history. "Cave bats" spend their winters hibernating in caves, and often form colonies to roost and raise their young in the summer. Colonies can be found in hollow trees, or buildings and other man-made structures. "Tree

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bats” are generally more solitary in nature, roost under pieces of bark alone or in small groups and spend their time foraging in and near forests. All these things make tree bats difficult to study. Nine bat species are considered SGCn in Delaware (Table 1.5).

Table 1. 5 Delaware Bat SGCN

Cave Bats (5)		
<i>Myotis leibii</i>	Eastern Small-footed Myotis	Tier 1
<i>Myotis lucifugus</i>	Little Brown Bat	Tier 1
<i>Myotis septentrionalis</i>	Northern Long-eared Bat	Tier 1
<i>Perimyotis subflavus</i>	Tricolored Bat	Tier 2
<i>Eptesicus fuscus</i>	Big Brown Bat	Tier 3
Tree Bats (4)		
<i>Nycticeius humeralis</i>	Evening Bat	Tier 2
<i>Lasiurus borealis</i>	Eastern Red Bat	Tier 3
<i>Lasionycteris noctivagans</i>	Silver-haired Bat	Data Needs
<i>Lasiurus cinereus</i>	Hoary Bat	Data Needs

Fourteen species of bats are listed as northeast RSGCN. One species, the eastern small-footed myotis (*Myotis leibii*) is recognized as high responsibility and high concern throughout the Northeast. Many of the northeastern species of bats are acutely threatened by white-nose syndrome (WNS), a fungal disease that alters the torpor cycle and metabolism of overwintering bats and leads to significant mortalities. Delaware is part of a nation-wide team of state and national biologists tracking WNS. Bats hibernating at Fort Delaware and Fort DuPont State Parks were confirmed to have WNS in 2012 and the fungus that causes the disease was documented in bats returning to summer sites in 2010.

The northern long-eared bat (*Myotis septentrionalis*) is one of the species of bats most impacted by WNS. Due to declines caused by the disease, as well as continued spread of WNS, the northern long-eared bat was listed as Threatened under the Endangered Species Act (USFWS 2015). Delaware listed both northern long-eared bats and little brown bats as state Endangered in 2014.

Delaware is collecting information on the size and location of bat maternity colonies and hibernation sites statewide, including through a volunteer “bat spotters” program. Acoustic monitoring is also conducted across Delaware in summer via acoustic transects using car-mounted detectors. Migrating bats are being studied via stationary acoustic monitoring stations and both

passive and acoustic monitoring is taking place throughout the state to document species locations and status.

Marine Mammals

Of the 16 species of marine mammals occurring in Delaware, seven are considered SGCN, including six species of whales, as well as harbor porpoise (*Phocoena phocoena*) (Table 1.6).

Table 1. 6 Delaware Marine Mammal SGCN

Marine Mammal SGCN (7)		
<i>Balaenoptera borealis</i>	Sei Whale	Tier 1
<i>Balaenoptera musculus</i>	Blue Whale	Tier 1
<i>Balaenoptera physalus</i>	Fin Whale	Tier 1
<i>Eubalaena glacialis</i>	North Atlantic Right Whale	Tier 1
<i>Megaptera novaeangliae</i>	Humpback Whale	Tier 1
<i>Physeter macrocephalus</i>	Sperm Whale	Tier 1
<i>Phocoena phocoena</i>	Harbor Porpoise	Tier 3

Conservation of whales in the Northeast has been a significant concern since the depletion of local populations due to whaling by the late 19th century. Right whale populations were severely depleted in the 17th and 18th centuries. Sperm whaling increased in the 18th century, and was becoming less economically viable by the second half of the 19th century when the focus of the New England whaling industry shifted to blue and fin whales.

Some northeastern whale species (e.g., humpback, fin) have shown signs of recovery since a global whaling ban was imposed in 1985. In 1972 Canada stopped whaling and the U.S. passed the Marine Mammal Protection Act, which banned all taking of marine mammals or importing of marine mammal products. Other northeastern whales, such as the North Atlantic right whale, have recovered much more slowly from heavy harvest pressure. New potential threats include shipping activity, entanglement in fishing gear, and offshore energy development.

Multiple agencies have jurisdiction over the conservation of marine mammals, including DNREC DFW, and the National Oceanographic and Atmospheric Administration (NOAA). Since whale populations range over such vast areas, the jurisdiction of any individual state comprises a very small proportion of a species’ range, making coordination between states, regions, and federal agencies critical to the conservation of the species in this group.

Birds

Avian Diversity of Delaware

The Delaware State List of Bird Species includes 410 species that have been accepted by the Delaware Bird Records Committee (DBRC) of the Delmarva Ornithological Society (DOS). This official state list includes accidental and vagrant species as well as more regularly occurring species. Of these, 184 species are considered SGCN, including one extirpated species.

The DOS publishes an annual journal, *The Delmarva Ornithologist* (1964-present), which contains articles related to avian research and observation conducted by members in the region. DOS also conducts an annual spring count that provides data on abundance and diversity of birds in the state during early May.

National monitoring programs have helped contribute to knowledge of Delaware's avifauna. This includes the annual Christmas Bird Count, coordinated by the National Audubon Society and compiled locally by DOS and the Sussex Bird Club. There are currently seven Christmas Bird Count circles (plots) in Delaware that provide consistent data on wintering bird populations in the state.

The North American Breeding Bird Survey (BBS) is a cooperative effort between the United States Geological Survey (USGS) and Canadian Wildlife Service. The BBS monitors the status and trends of North American bird populations by collecting data at point counts along randomly established roadside routes. There are currently ten BBS routes in Delaware spanning all three counties.

The first standardized project to document the state's breeding avifauna occurred from 1983-1987 and resulted in the *Birds of Delaware* (Hess et al. 2000), which included the results and became the state's first breeding bird atlas. Results of this effort indicated that at the time of publication four species that historically bred in the state had been extirpated, while an additional 11 were not found breeding during the survey period. Twenty-four breeding species had estimated populations of less than 20 pairs, putting them at high risk of future extirpation. Twenty-one breeding birds and 16 migrants or winter visitors were of management concern due to having low or declining populations or being dependent on severely degraded habitat. As a whole, 93 species of Delaware birds were declining.

A second Delaware Breeding Bird Atlas (DEBBA) was conducted from 2008-2012. Publication of the results of this project is underway, and raw occurrence data are available. The Atlas found breeding evidence for 171 total species, 147 of which were confirmed in at least one block (BBA Explorer 2015).

Between the two atlas periods (1987-2008) the SCRP (formerly Delaware Natural Heritage Program) incorporated breeding bird surveys into a routine inventory of state and federal natural areas. The

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results from several surveys were published in DNREC publications and in the *Delmarva Ornithologist*.

All but one of the 21 species listed as Endangered in Delaware are known to have bred in the state. These species are listed in Table 1.7 below.

Table 1. 7 Endangered Breeding Birds of Delaware

Pied-billed Grebe	<i>Podilymbus podiceps</i>
Northern Harrier	<i>Circus cyaneus</i>
Broad-winged Hawk	<i>Buteo platypterus</i>
Black-crowned Night-heron	<i>Nycticorax nycticorax</i>
Yellow-crowned Night –Heron	<i>Nyctanassa violacea</i>
American Kestrel	<i>Falco sparverius</i>
Piping Plover	<i>Charadrius melodus</i>
Short-eared Owl	<i>Asio flammeus</i>
American Oystercatcher	<i>Haematopus palliatus</i>
Black Rail	<i>Laterallus jamaicensis</i>
Upland Sandpiper	<i>Bartramia longicauda</i>
Black Skimmer	<i>Rhyncops niger</i>
Henslow’s Sparrow	<i>Ammodramus henslowii</i>
Common Tern	<i>Sterna hirundo</i>
Forster’s Tern	<i>Sterna forsteri</i>
Least Tern	<i>Sterna antillarum</i>
Cerulean Warbler	<i>Setophaga cerulean</i>
Hooded Warbler	<i>Setophaga citrine</i>
Swainson’s Warbler	<i>Limnothlypis swainsonii</i>
Sedge Wren	<i>Cistothorus platensis</i>

The distributions of breeding birds were modeled for Delaware, Maryland, and New Jersey by McCorkle et al. (2006) in the Maryland, Delaware, and New Jersey GAP Analysis Project, conducted by the USFWS Delaware Bay Estuary Project, the USGS, and the University of Maryland Eastern

Shore. Bird SGCN with less than 1% of their predicted distributions occurring within protected natural lands (GAP Status 1 or 2) in the three state region include: American kestrel (*Falco sparverius*), short-eared owl (*Asio flammeus*), royal tern (*Sterna maxima*), and common nighthawk (*Chordeiles minor*) (McCorkle et al. 2006).

Regional, National, and International Perspectives

Regional Species of Greatest Conservation Need (RSGCN)

One hundred and ten species of birds were identified as RSGCN in the Northeast. Of these, 10 species were ranked by the NEFWDC as “very high” concern and “high” responsibility for the Northeast. Thirty-five of the 110 RSGCN birds occur along the northeastern region’s coast, either in salt marshes, beaches, dunes, or offshore islands. Throughout the Northeast, these habitats have been heavily altered by long-term human activities, including development and stabilization, pollution, marsh filling and draining, pesticide spraying, and recreational use.

Audubon Important Bird Areas

Important Bird Areas, or IBAs, are sites that provide essential habitat for one or more species of bird. IBAs include sites for breeding, wintering, and/or migrating birds. IBAs may be a few acres or thousands of acres, but usually they are discrete sites that stand out from the surrounding landscape. IBAs may include public or private lands, or both, and they may be protected or unprotected (Table 1.8).

Table 1. 8 Important Bird Areas (IBAs) in Delaware

IBA Name	IBA Priority	Acreage
White Clay Creek State Park	State	5,001
Red Clay Valley	Continental	_____
Delaware Coastal Zone	Global	270,009
Pea Patch Island	State	311
Great Cypress Swamp Conservation Area	State	12,400

Bird Conservation Regions

North American Bird Conservation Initiative (NABCI) Bird Conservation Regions (BCRs) are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues. Started in 1999, the U.S. [NABCI](#) Committee is a coalition of government agencies, private organizations, and bird initiatives in the United States working to ensure the long-

term health of North America's native bird populations. Delaware's coastal plain is within BCR 30 (New England/Mid-Atlantic Coast), and the Delaware piedmont is within BCR 29 (Piedmont).

BCR 30: New England/Mid-Atlantic Coast

BCR 30 has the densest human population of any BCR in the country. Much of what was formerly cleared for agriculture is now either in forest or residential use. Coastal wetland and beach habitats support the highest priority species, including saltmarsh, Nelson's, and seaside sparrows, piping plover, American oystercatcher, American black duck, and black rail. The region includes critically important migration sites for red knot, ruddy turnstone, sanderling, semipalmated sandpiper, and dunlin. Terns and gulls nest in large numbers and large mixed colonies of herons, egrets, and ibis occur on islands in the Delaware and Chesapeake Bay regions.

Estuarine complexes and embayments created behind barrier beaches in this region are extremely important to wintering and migrating waterfowl, including approximately 65% of the total wintering American black duck population along with large numbers of greater scaup, tundra swan, gadwall, Atlantic brant, and canvasback.

BCR 29: Piedmont

BCR 29 is transitional between the mountainous Appalachians and the flat coastal plain, and is dominated in the north by oak-hickory hardwoods. Interior wetlands, reservoirs, and riverine systems provide migration and wintering habitat for waterfowl and some shorebirds. The fragmented patchwork of pasture, woodlots, and suburban sprawl that now dominates most of this region creates significant bird conservation challenges, particularly since upland conservation is not as well funded as wetland conservation in the Joint Venture (see next section).

The Piedmont Bird Conservation Plan (Watson 2014) identifies priority species and habitats. Fifty-seven species were identified as priority, mostly associated with grasslands/early-successional habitats, forests, and forested wetlands and freshwater emergent wetlands. Primary efforts in this BCR will focus on conservation of existing forests and grasslands, particularly on private lands, and maintaining or establishing habitat corridors between priority conservation areas.

The Atlantic Coast Joint Venture

The [Atlantic Coast Joint Venture \(ACJV\)](#) is a partnership focused on the conservation of habitat for native birds in the Atlantic Flyway of the United States from Maine south to Puerto Rico. The ACJV includes 17 states and commonwealths and key federal and regional habitat conservation agencies and organizations in the joint venture area (Figure 1.2).



Figure 1. 2 Map of North American Bird Habitat Joint Ventures, showing the Atlantic Coast Joint Venture (ACJV) area in light blue

Regional Initiatives for Specific Groups of Birds

Regional initiatives and conservation plans for specific bird taxa are discussed within the relevant sections for each group below.

Delaware SGCN Birds

Of the total bird diversity in the state, 184 species have been determined to be SGCN. The process of identifying SGCN is discussed at the end of this chapter and the entire list of Delaware SGCN can be found in Appendix 1.A and Appendix 1.B. The 2015 plan employed a different prioritization process than was used in 2007, resulting in the removal of several species and the addition of others. In general, the 2015 list includes many more species found in Delaware only as migrants or wintering birds, as well as additional pelagic species. These migrant species, like resident species, are threatened by habitat loss and fragmentation, predation by pets and subsidized predators, and invasive species and diseases.

Waterbirds

The *North American Waterbird Conservation Plan*, a project of the Waterbird Conservation for the Americas Initiative (www.waterbirdconservation.org), assessed the abundance and distribution of 210 waterbird species in North America and found that one-third of colonial nesting waterbirds are at risk of serious population declines. Eleven pelagic seabirds are imperiled, while seven wading birds and 36 pelagic and coastal seabirds are of high conservation concern. Only 17% of 166 colonial waterbird species are exhibiting apparent or biologically significant population increases, while another 15% of these species are lacking information to estimate population trends (Kushlan et al. 2002).

The Mid-Atlantic/New England Maritime Regional Working Group for Waterbirds (MANEM) is a regional partnership working to conserve waterbirds in the Northeast. The MANEM Waterbird Conservation Plan is being implemented within the context and framework of the North American Waterbird Conservation Plan. Thirty-two percent of waterbirds occurring in the MANEM region are declining at the continental scale, with Audubon’s shearwater, black rail, and king rail experiencing the greatest declines (MANEM Waterbird Working Group 2006).

Migratory Shorebirds

Nineteen species of migratory shorebirds were identified as SGCN in Delaware (Table 1.9).

Table 1. 9 Delaware Migratory Shorebird SGCN

Migratory Shorebird SGCN (19)		
<i>Arenaria interpres</i>	Ruddy Turnstone	Tier 1
<i>Calidris alba</i>	Sanderling	Tier 1
<i>Calidris alpina</i>	Dunlin	Tier 1
<i>Calidris canutus</i>	Red Knot	Tier 1

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<i>Calidris pusilla</i>	Semipalmated Sandpiper	Tier 1
<i>Limnodromus griseus</i>	Short-billed Dowitcher	Tier 1
<i>Tringa flavipes</i>	Lesser Yellowlegs	Tier 1
<i>Tringa melanoleuca</i>	Greater Yellowlegs	Tier 1
<i>Calidris fuscicollis</i>	White-rumped Sandpiper	Tier 2
<i>Limosa fedoa</i>	Marbled Godwit	Tier 2
<i>Limosa haemastica</i>	Hudsonian Godwit	Tier 2
<i>Numenius phaeopus</i>	Whimbrel	Tier 2
<i>Pluvialis squatarola</i>	Black-bellied Plover	Tier 2
<i>Recurvirostra americana</i>	American Avocet	Tier 2
<i>Tryngites subruficollis</i>	Buff-breasted Sandpiper	Tier 2
<i>Calidris melanotos</i>	Pectoral Sandpiper	Tier 3
<i>Phalaropus tricolor</i>	Wilson's Phalarope	Tier 3
<i>Pluvialis dominica</i>	American Golden-Plover	Tier 3
<i>Tringa solitaria</i>	Solitary Sandpiper	Tier 3



Figure 1.3 Red knots (*Calidris canutus*) need to encounter favorable habitat, weather conditions, and food (such as the horseshoe crabs they feed upon in Delaware) within narrow seasonal windows during their migration stopovers. Photo: Harold A. Davis

The Delaware Bay hosts one of the largest concentrations of migrating shorebirds in the Western Hemisphere (Senner and Howe 1984; Myers et al. 1987). Delaware Bay is the most important spring stopover site for semipalmated sandpiper (*Calidris pusilla*), ruddy turnstone (*Arenaria interpres*), sanderling (*Calidris alba*), and red knot (*Calidris canutus*, Figure 1.3). The *rufa* subspecies of red knot has been the focus of regional conservation measures and has recently been listed as threatened under the ESA (USFWS 2014). In Delaware Bay, tide cycles have great influence on the distribution of shorebirds in beach and marsh environments. Factors that threaten this globally important site include horseshoe crab overharvest, direct development, human disturbance, and effect of toxic accidents (Clark et al. 1993).

In 1974, Manomet Bird Observatory initiated the International Shorebird Survey (ISS), which was the first attempt to survey shorebird populations by focusing on migratory stopover sites. In 1986, Delaware Bay became the first Western Hemisphere Shorebird Reserve Network (WHSRN) Site of Hemispheric Importance for migrating shorebirds.

There is limited information on population sizes and trends for most species of shorebirds in North America, but the available information suggests that 46% of the 72 species in North America are declining. Population trend estimates are uncertain for another 53% of the species, and only two species have populations that are apparently increasing (Brown et al. 2001). Recognition of the need for more systematic surveys of shorebirds to effectively track populations led to the development of the *United States Shorebird Conservation Plan* and the Program for Regional and International Shorebird Monitoring (PRISM). These efforts are designed to estimate breeding population sizes and trends, spatial distribution and abundance at stopover sites, and to assess habitat use patterns for 72 species of shorebirds nesting in North America (Bart et al. 2005). More importantly, results from this research can be used to develop effective conservation strategies and action plans to help stabilize shorebird populations.

The Northern Atlantic Regional Shorebird Plan (Clark and Niles 2001) was produced at the regional level from the U.S. Shorebird Conservation Plan, developed with the purpose of creating conservation goals, identifying critical habitat, and promoting education and outreach programs to facilitate shorebird conservation. Several shorebird plans have also been developed that provide species-specific conservation actions including those for the American oystercatcher (Schulte et al. 2007) and red knot (Niles et al. 2010).

The DNREC DFW runs the Delaware Shorebird Project that works to mitigate the threat to the state's shorebirds. Since 1997, the project team has conducted research and monitoring on populations and health of migratory shorebirds while coordinating with an international network that directs shorebird habitat protection and management plans.

Even though coastal habitats are regulated by the Coastal Resources Management Council (CRMC), dredging projects, development, human disturbance, and more recently, rising sea levels threaten prime shorebird habitat. Delaware shorebirds need protection, as do the few remaining coastal habitats that can support them.

The [Atlantic Flyway Shorebird Conservation Business Strategy](#) defines focal species of shorebirds along with strategies and specific objectives for their conservation. The Strategy involves numerous federal, state, provincial, and local governments, conservation groups, universities, and individuals.

Beach-nesting Birds

Five species of beach-nesting birds were identified as SGCN in Delaware (Table 1.10).

Table 1. 10 Delaware Beach-nesting Bird SGCN

Beach-nesting Bird SGCN (5)		
<i>Charadrius melodus</i>	Piping Plover	Tier 1
<i>Haematopus palliatus</i>	American Oystercatcher	Tier 1
<i>Rynchops niger</i>	Black Skimmer	Tier 1
<i>Sterna hirundo</i>	Common Tern	Tier 1
<i>Sternula antillarum</i>	Least Tern	Tier 1

Annual surveys are presently conducted by DNREC DFW for colonial nesting birds (e.g., egrets, gulls, terns) and piping plover. Piping plover (Figure 1.4), which was listed as threatened under the federal Endangered Species Act (ESA) in 1986, has been managed by DNREC since 1990 under a binding agreement between DNREC and the USFWS and subsequent species management plan. Piping plover nesting areas at Cape Henlopen State Park are closed annually to the public to protect the birds from disturbance during their March to September nesting season. The closure, which must include feeding habitat as well as nesting areas, has been successful, increasing the number of piping plover nesting pairs from a low of two pairs to a high of nine pairs.

Beach and dune habitats of Delaware also support several other specialist species, including least tern (*Sterna antillarum*), common tern (*Sterna hirundo*), American oystercatcher (*Haematopus palliatus*), and black skimmer (*Rhynchops niger*). As with the piping plover, remaining populations of these species depend heavily upon active protection and management. Least terns typically nest in scrapes in sand with shells or pebbles and occasionally in construction sites or on flat rooftops.

In 2001, the American oystercatcher was identified in the U.S. Shorebird Conservation Plan (Brown et al. 2001) as a species warranting special attention because of its small and declining population. As a result, the American Oystercatcher Working Group was formed to devise and implement a regional research, monitoring, and conservation strategy for the oystercatcher along the Atlantic and (to a lesser extent) Gulf Coasts of the United States. This working group, along with the National Fish and Wildlife Foundation (NFWF) produced the [American Oystercatcher Business Plan](#) in 2008. Under the plan, Delaware is a Tier 2 state, due to its relatively small numbers of oystercatchers.



Figure 1. 4 The piping plover (*Charadrius melodus*) population has been on the rise since the early 1990s, but this is due to sustained management initiatives, upon which populations remain dependent. Photo: Harold A. Davis

Colonial Waterbirds

Nineteen species of colonial waterbirds were identified as SGCN in Delaware (Table 1.11).

Table 1. 11 Delaware Colonial Waterbird SGCN

Colonial Waterbirds – Cormorants (1)		
<i>Phalacrocorax auritus</i>	Double-crested Cormorant	Tier 2
Colonial Waterbirds – Pelicans (1)		
<i>Pelecanus occidentalis</i>	Brown Pelican	Tier 3
Colonial Waterbirds – Herons (9)		
<i>Bubulcus ibis</i>	Cattle Egret	Tier 1
<i>Egretta thula</i>	Snowy Egret	Tier 1

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<i>Egretta tricolor</i>	Tricolored Heron	Tier 1
<i>Nyctanassa violacea</i>	Yellow-crowned Night-Heron	Tier 1
<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron	Tier 1
<i>Plegadis falcinellus</i>	Glossy Ibis	Tier 1
<i>Ardea alba</i>	Great Egret	Tier 2
<i>Egretta caerulea</i>	Little Blue Heron	Tier 2
<i>Ardea herodias</i>	Great Blue Heron	Tier 3
Colonial Waterbirds - Saltmarsh Nesting (4)		
<i>Sterna forsteri</i>	Forster's Tern	Tier 1
<i>Larus argentatus</i>	Herring Gull	Tier 2
<i>Larus marinus</i>	Great Black-backed Gull	Tier 2
<i>Leucophaeus atricilla</i>	Laughing Gull	Tier 2
Colonial Waterbirds – Non-breeding Terns (4)		
<i>Sterna dougallii</i>	Roseate Tern	Tier 1
<i>Chlidonias niger</i>	Black Tern	Tier 2
<i>Gelochelidon nilotica</i>	Gull-billed Tern	Tier 2
<i>Thalasseus sandvicensis</i>	Sandwich Tern	Tier 2

Hérons

One mile northeast of Delaware City, the 310-acre Pea Patch Island hosts a nationally significant breeding colony for nine species of herons and ibis. Pea Patch Island is an ideal nesting ground for these birds because of the types and arrangement of trees on the island, and its proximity to the rich food sources in the coastal marshes and agricultural areas of Delaware and New Jersey. On the island, both mixed hardwoods and the *Phragmites* marsh are utilized for nesting, depending on the species. This colony is the only known breeding location in the state for little blue heron and cattle egret, and the largest heron rookery on the Atlantic coast north of Florida.

While some of the nine species may be found nesting in other, smaller rookeries throughout the region, Pea Patch Island is the only site known to support all of these species. The species nesting at Pea Patch include the great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), cattle egret (*Bubulcus ibis*) black-crowned night-

heron (*Nycticorax nycticorax*), tricolored heron (*Egretta tricolor*), yellow-crowned night-heron (*Nyctanassa violaceus*, Figure 1.5), and glossy ibis (*Plegadis falcinellus*).

In 1993 the heronry hosted 12,000 pairs of nesting herons. The island's location also posed some significant issues for the health of the heron nesting colony: among them, rapidly expanding suburban development and changes to habitat quality, agricultural pesticides and industrial contaminants, human disturbance, and oil spills and other industrial accidents. Researchers in the 1990s noticed issues with heron health (including lesions and low nestling survival) and had documented declines in the numbers of nesting birds (around 6,000 pairs by 1997). Because of its interconnectedness with the river and surrounding areas, a single cause of the declining health of the colony could not be identified.

The Pea Patch Island Heronry Region Special Area Management Plan was developed as a way to address the diverse range and complex nature of the issues affecting the health of the Pea Patch Island Heronry and its surrounding habitats. The development of this plan involved stakeholders from state, local, and federal government agencies, universities, industry, citizens, and not-for profit organizations. Participants in the planning process developed 28 strategies through a consensus building process. These strategies were finalized in the 1998 [Pea Patch Island Heronry Region Special Area Management Plan](#). An Implementation team was formed when the planning process was complete; their job was to coordinate with each other, prioritize strategies, and find resources to implement the actions outlined within the strategies. By June of 2001, 21 of the 28 strategies had been implemented. Projects conducted as part of the Pea Patch Island Heronry Region Special Area Management Plan are outlined in the [2001 Progress Report](#).

Today, the Pea Patch Island Heronry continues to be an active and important regional heron nesting colony, but populations of nesting birds remain significantly lower than the 12,000 pairs documented in 1993. Nevertheless, the diversity of species continues to make Pea Patch Island one of the most unique and important bird nesting areas on the East Coast. The DNREC Division of Parks and Recreation (DPR) continues to manage Pea Patch Island Heronry as a Nature Preserve and entry to the area is prohibited. The DPR conducts monthly flight surveys, with the assistance of volunteers, during the nesting season to monitor and track population numbers.



Figure 1. 5 Yellow-crowned night heron (*Nyctanassa violacea*). Photo: Harold A. Davis

Saltmarsh Nesting Colonial Waterbirds

Three species of saltmarsh-nesting gulls and terns have historically nested on the marsh islands of Rehoboth Bay, while a fourth, the great black-backed gull, began to expand its breeding range southward into Delaware in the late 1980s. The expansion of large and aggressive *Larus marinus* into Inland Bays colonies may have potential negative effects on the other species in this group, as was the case in mixed species colonies in Maine (Ellis and Good 2006).

Colonial saltmarsh birds nest on the ground or in low vegetation of the marsh platform and are sensitive to disturbance and predation, especially by mammals. Primary conservation activities for these species include consistent monitoring and efforts to reduce disturbance. Foraging habitats, usually salt marshes adjacent to nesting sites, are also important habitat components that will be threatened by rising sea levels.

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Waterfowl

Nineteen species of waterfowl were identified as SGCN in Delaware (Table 1.12).

Table 1. 12 Delaware Waterfowl SGCN

Bay Waterfowl (8)		
<i>Branta bernicla</i>	Brant	Tier 2
<i>Oxyura jamaicensis</i>	Ruddy Duck	Tier 2
<i>Aythya affinis</i>	Lesser Scaup	Tier 3
<i>Aythya americana</i>	Redhead	Tier 3
<i>Aythya marila</i>	Greater Scaup	Tier 3
<i>Aythya valisineria</i>	Canvasback	Tier 3
<i>Bucephala albeola</i>	Bufflehead	Tier 3
<i>Bucephala clangula</i>	Common Goldeneye	Tier 3
Marine Waterfowl (5)		
<i>Clangula hyemalis</i>	Long-tailed Duck	Tier 1
<i>Melanitta americana</i>	American Scoter	Tier 2
<i>Melanitta perspicillata</i>	Surf Scoter	Tier 2
<i>Melanitta fusca</i>	White-winged Scoter	Tier 3
<i>Somateria mollissima</i>	Common Eider	Tier 3
Freshwater Waterfowl (7)		
<i>Branta canadensis</i>	Canada Goose (Atlantic migratory population only)	Tier 1
<i>Anas acuta</i>	Northern Pintail	Tier 2
<i>Anas americana</i>	American Wigeon	Tier 2
<i>Anas discors</i>	Blue-winged Teal	Tier 2
<i>Anas platyrhynchos</i>	Mallard	Tier 2
<i>Cygnus columbianus</i>	Tundra Swan	Tier 2
<i>Lophodytes cucullatus</i>	Hooded Merganser	Tier 2

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The United States Fish and Wildlife Service Waterfowl Population Status Report (USFWS 2014) includes the most current breeding population and production information available for waterfowl in North America and is a result of cooperative efforts by the USFWS, the Canadian Wildlife Service (CWS), various state and provincial conservation agencies, and private conservation organizations.

The North American Waterfowl Management Plan (NAWMP), first published in 1986, and most recently updated in 2012, aims to protect continental habitat conditions that could sustain and improve waterfowl populations (USFWS and CWS 2012). The plan calls for the protection of North America's remaining wetlands and restoration of waterfowl populations through habitat protection, restoration, and enhancement activities.

The Atlantic Coast Joint Venture (ACJV), a partnership of government agencies and conservation partners, has designated four Waterfowl Focus Areas in Delaware in the *ACJV Waterfowl Implementation Plan* (2005): Bayshore, Blackbird, Inland Bays, and Nanticoke. This plan steps down continental and regional waterfowl population and habitat goals from the NAWMP 2004 update to the ACJV area. The ACJV facilitates implementation of these goals through the Delaware Bay Partnership (New Jersey, Pennsylvania, and Delaware) and the Chesapeake Bay Waterfowl Working Group (Maryland, Delaware, Virginia, and West Virginia). Species-specific efforts are also being conducted, including the [Black Duck Joint Venture](#) and the [Atlantic Brant Management Plan](#) (2002).

Marine Waterfowl

The five Delaware SGCN regularly occur in varying numbers off the Atlantic Coast of Delaware during migration and winter. In recent years a periodic seawatch has been conducted by the Delmarva Ornithological Society and Sussex Bird Club to help assess abundance of these and other species during migration.

The [Sea Duck Joint Venture](#) is a conservation partnership under the NAWMP. Its goal is increase knowledge and management of sea ducks so as to more effectively manage them. This project is a large-scale, multi-year, multi-partner satellite tracking program for sea ducks along the Atlantic coast and Great Lakes, with the following primary objectives:

- Fully describe the annual migration patterns for four species of sea ducks (surf scoter, black scoter, white-winged scoter, long-tailed duck) in the Atlantic flyway and Great Lakes by 2014.
- Map local movements and estimate length of stay during winter for individual radio-marked ducks in areas proposed for placement of wind turbines

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- Identify near-shore and offshore habitats of high significance to sea ducks to help inform habitat conservation efforts.
- Estimate rates of annual site fidelity to wintering areas, breeding areas, and molting areas for all four focal species in the Atlantic flyway.

Freshwater Waterfowl

Delaware DNREC DFW has conducted annual aerial waterfowl surveys throughout the state since 1974. These surveys help measure long-term trends in duck and goose populations. Flights are usually made in mid-October, mid-November, mid-December, and the second week in January. The January flight is part of the Midwinter Waterfowl Survey, a coast-wide effort to survey waterfowl throughout the Atlantic Flyway at approximately the same time. The state surveys cover the primary waterfowl habitat in Delaware, approximately the eastern half of the state, and are divided into 11 zones. Data are available at <http://www.dnrec.delaware.gov/fw/Hunting/Pages/WaterfowlSurveys.aspx>

Ducks Unlimited (DU) is a national conservation organization with a significant presence in Delaware. DU’s Delaware conservation program has restored, enhanced, or conserved 15,497 acres of wetlands and adjacent habitat. The goal of these projects has been to maximize quality and quantity of habitat for migratory and wintering waterfowl.

Several species of breeding freshwater ducks in Delaware, including gadwall and blue-winged teal, have experienced apparent declines in breeding success in the state based on comparison of data from the first to second atlas periods (DNREC DFW unpublished data).

Marine and Pelagic Birds

Eleven species of pelagic Birds were identified as SGCN in Delaware (Table 1.13).

Table 1. 13 Delaware Pelagic Bird SGCN

Pelagic Bird SGCN (11)		
<i>Oceanodroma castro</i>	Band-rumped Storm-Petrel	Tier 1
<i>Puffinus griseus</i>	Sooty Shearwater	Tier 2
<i>Morus bassanus</i>	Northern Gannet	Tier 3
<i>Onychoprion anaethetus</i>	Bridled Tern	Tier 3
<i>Pelagodroma marina</i>	White-faced Storm-Petrel	Tier 3
<i>Phalaropus lobatus</i>	Red-necked Phalarope	Tier 3
<i>Puffinus gravis</i>	Great Shearwater	Tier 3

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<i>Puffinus lherminieri</i>	Audubon's Shearwater	Tier 3
<i>Stercorarius longicaudus</i>	Long-tailed Jaeger	Tier 3
<i>Sterna paradisaea</i>	Arctic Tern	Tier 3
<i>Uria lomvia</i>	Thick-billed Murre	Tier 3

Pelagic birds are difficult to assess as they do not nest in state waters and because local populations vary temporally and spatially. However, such species are still at risk from a variety of threats, including loss of habitat or mortality from offshore wind turbines and oil spills, and as bycatch in fishing gear.

The offshore waters of Delaware are part of Pelagic Bird Conservation Region (PBCR) 78 (Northeast US Continental Shelf)

Not nearly enough is known about Atlantic seabirds and their vulnerability to a number of current and emerging threats while in their primary offshore habitats. Data on their pelagic distribution and abundance are critical for monitoring population trends, understanding their basic ecology and role in marine ecosystems, assessing actual or potential impacts from oil spills, fisheries bycatch, and offshore development (shipping, wind generation, gas and mineral exploration), identifying critical marine habitats, and educating the public about marine conservation issues. [The Northwest Atlantic Birds at Sea Conservation Cooperative](#) has formed and is committed to engaging resource agencies and partners in and outside its membership to develop new alliances to prioritize and implement research, management, policy, and educational actions needed to sustain marine birds in their offshore environments. [A Marine Bird Mapping and Assessment](#) project is currently being conducted by the North Atlantic Landscape Conservation Cooperative (NALCC) and multiple partners.

Marsh Birds

Twenty two species of marsh birds were identified as SGCN in Delaware (Table 1.14).

Table 1. 14 Delaware Marsh Bird SGCN

Freshwater Marsh Bird SGCN (g)		
<i>Botaurus lentiginosus</i>	American Bittern	Tier 1
<i>Himantopus mexicanus</i>	Black-necked Stilt	Tier 1
<i>Podilymbus podiceps</i>	Pied-billed Grebe	Tier 1

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<i>Rallus limicola</i>	Virginia Rail	Tier 1
<i>Actitis macularius</i>	Spotted Sandpiper	Tier 2
<i>Ixobrychus exilis</i>	Least Bittern	Tier 2
<i>Porzana carolina</i>	Sora	Tier 2
<i>Rallus elegans</i>	King Rail	Tier 2
<i>Gallinago delicate</i>	Wilson's Snipe	Tier 3
Saltmarsh Bird SGCN (13)		
<i>Ammodramus caudacutus</i>	Saltmarsh Sparrow	Tier 1
<i>Ammodramus maritimus</i>	Seaside Sparrow	Tier 1
<i>Ammodramus nelsoni</i>	Nelson's Sparrow	Tier 1
<i>Anas rubripes</i>	American Black Duck	Tier 1
<i>Asio flammeus</i>	Short-eared Owl	Tier 1
<i>Circus cyaneus</i>	Northern Harrier	Tier 1
<i>Cistothorus platensis</i>	Sedge Wren	Tier 1
<i>Laterallus jamaicensis</i>	Black Rail	Tier 1
<i>Melospiza georgiana nigrescens</i>	Coastal Plain Swamp Sparrow	Tier 1
<i>Rallus longirostris</i>	Clapper Rail	Tier 1
<i>Tringa semipalmata</i>	Willet	Tier 1
<i>Cistothorus palustris</i>	Marsh Wren	Tier 2
<i>Tyto alba</i>	Barn Owl	Tier 2

Since many marsh birds are nocturnal, survey data is limited. The publication of the North American Marsh Bird Monitoring Protocol (Conway 2009) and framework for monitoring site selection (Johnson et al. 2009) has greatly improved comparability of recent marsh bird survey data across studies and jurisdictional boundaries.

Freshwater Marsh Birds

The majority of Delaware's freshwater marsh habitat occurs within coastal impoundments that are highly threatened by sea level rise (SLR), making the outlook for these species in the state uncertain. Several SGCN utilize these freshwater emergent marsh habitats, including American bittern (*Botaurus lentiginosus*), king rail (*Rallus elegans*), and least bittern (*Ixobrychus exilis*).

Saltmarsh Birds

Salt marshes are universally considered to be among the most important wildlife habitats in North America, and Delaware's contribution to the regional distribution and conservation of this habitat is significant. Partners in Flight (PIF) identified maritime marshes as a habitat harboring the some of the largest number of high-priority species in the region. The saltmarsh sparrow (Figure 1.6) is considered by PIF to be the species of highest conservation priority in the region (Rosenberg and Dettmers 2000, Ruth 2006, PIF 2012).



Figure 1. 6 Saltmarsh sparrow (*Ammodramus caudacutus*). Photo: Harold A. Davis

Bird species inhabiting salt marshes are widely considered to be highly imperiled due to SLR. Delaware is responsible for approximately 10% of the northeastern region population of clapper rail (Shriver et al. 2014).

The Saltmarsh Habitat and Avian Research Program (SHARP) helps provide critical information for the long-term conservation of tidal-marsh birds. This collaborative research program focuses on monitoring the health of North America's tidal-marsh bird community in the face of SLR and upland development.

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Black rail populations have been declining in the eastern United States for over a century. This decline has resulted in a retraction of its breeding range, an overall reduction in the number of breeding locations within its core range, and a loss of individuals within historic strongholds. Over the past 10-20 years, some reports indicate that populations have declined 75% or greater and have become dangerously low (The Center for Conservation Biology 2014).

American black duck has experienced apparent declines in breeding in the state based on comparison of data from the first to second atlas periods (DNREC DFW unpublished data).

Landbirds

While best known for its waterbird habitat, Delaware also provides critical habitat for landbirds. Important groups for which Delaware has particularly high regional responsibility include Neotropical migrant songbirds that use the state for stopover habitat, migrating and wintering raptors, breeding birds of agricultural habitats (including horned lark and grasshopper sparrow), early successional habitat breeding birds, and forest breeding birds of southern affinities that are at or near their northern range limit in Delaware.

Grassland Birds

Eleven species of grassland birds were identified as SGCN in Delaware (Table 1.15).

Table 1. 15 Delaware Grassland Bird SGCN

Grassland Bird SGCN (11)		
<i>Ammodramus henslowii</i>	Henslow's Sparrow	Tier 1
<i>Bartramia longicauda</i>	Upland Sandpiper	Tier 1
<i>Falco sparverius</i>	American Kestrel	Tier 1
<i>Ammodramus savannarum</i>	Grasshopper Sparrow	Tier 2
<i>Dolichonyx oryzivorus</i>	Bobolink	Tier 2
<i>Eremophila alpestris</i>	Horned Lark	Tier 2
<i>Passerculus sandwichensis</i>	Savannah Sparrow	Tier 2
<i>Spiza americana</i>	Dickcissel	Tier 2
<i>Poocetes gramineus</i>	Vesper Sparrow	Tier 3
<i>Sturnella magna</i>	Eastern Meadowlark	Tier 3
<i>Lanius ludovicianus</i>	Loggerhead Shrike	Data Needs - Historical

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The *2009 State of the Birds* report concluded that grassland birds are among the fastest and most consistently declining groups of birds in North America, with 55% of species declining significantly (North American Bird Conservation Initiative 2009). According to the *Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape* (Anderson and Olivero Sheldon 2011), of the 22 bird species that preferentially breed in grasslands, fields, and field edges, 17 have experienced persistent, widespread declines. This trend probably reflects the expansion of these species' habitat during the period of widespread farming and pasturing followed by agricultural abandonment and a return of the land to forest.

Just as many forest-dependent birds are area-sensitive, many grassland birds also require large, contiguous habitat patches to maintain viable breeding populations. Breeding Bird Surveys (BBS) conducted by the Biological Resource Division of USGS and volunteers throughout the United States have shown alarming declines in the number of grassland birds nationwide. For instance, bobolinks have declined by 38% and grasshopper sparrows by 69% in the past 25 years.

Grassland habitat has experienced dramatic declines in Delaware since the 1980s and there is currently very little available habitat for these species (see Chapter 2 for a detailed analysis of grassland habitats). Corresponding with loss of suitable habitat, grassland-dependent bird species have declined precipitously in distribution in the state. Eastern meadowlark was found in only 30% blocks in the second DEBBA, down from 78% in the first atlas.

Throughout the Mid-Atlantic, those grasslands that do remain are largely located on unprotected private lands. There are several grassland bird species with less than 1% of their potential habitat falling within protected natural lands (GAP status 1 or 2) in Maryland, Delaware, and New Jersey. These include the upland sandpiper (*Bartramia longicauda*), grasshopper sparrow (*Ammodramus savannarum*), vesper sparrow (*Pooecetes gramineus*), savannah sparrow (*Passerculus sandwichensis*), Henslow's sparrow (*Ammodramus henslowii*), dickcissel (*Spiza americana*), bobolink (*Dolichonyx oryzivorus*), and eastern meadowlark (*Sturnella magna*) (McCorkle et al. 2006).

Conservation of grassland habitats and changes in management practices can maintain good quality habitat for these rare birds. Because farmland has become fragmented, most remaining grasslands have become smaller and isolated and are no longer suitable for many species requiring large tracts of grassland.

Upland Game Birds

With the notable exception of wild turkey, which uses more extensively forested habitats, upland game birds have declined sharply in Delaware.

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Of highest concern in the state, and rangewide, is the continued steep decline and range contraction of northern bobwhite (*Colinus virginianus*). Historically, this species did well in habitat mosaics of agricultural and natural cover, with hedgerows, fallow areas, and old fields interspersed with active cropland. With the industrialization of agriculture and a large increase in suburban development, bobwhites have lost most of their habitat in northern Delaware, retracting from their historic range north of the Chesapeake & Delaware (C&D) canal. DNREC DFW has developed a Northern Bobwhite Focus Area at Cedar Swamp Wildlife Area in order to provide habitat for this species. The [National Bobwhite Quail Initiative \(NBCI\)](#) is a unified range-wide strategy of 25 state wildlife agencies, with numerous conservation group and research institution partners, to achieve widespread restoration of native grassland habitats and huntable populations of wild quail (The National Bobwhite Technical Committee 2011). Recent studies indicate that northern bobwhite is useful as an “umbrella species” for other shrubland and grassland-associated birds, including grasshopper sparrow and dickcissel (Crosby et al. 2015).

American woodcock (*Scolopax minor*) also has a shrinking distribution in Delaware. An American woodcock nesting habitat model developed in a recent Pennsylvania study indicated that chosen nest sites were characterized by a significantly lower stem count of invasive species, compared to random sites. In addition, successful nest sites had mean invasive cover of 30%, while unsuccessful nests averaged 56% invasive cover. The birds in this study tended to nest most often in arrowwood (*Viburnum dentatum*) and spicebush (*Lindera benzoin*) cover, and avoided bush honeysuckles (*Lonicera* sp.) and multiflora rose (*Rosa multiflora*) (Miller 2011). The continued spread of invasive woody plants throughout Delaware, combined with the impending threat of the *Viburnum* leaf beetle, represent further threats to woodcock breeding in the state. A *Woodcock Management Plan* (<http://timberdoodle.org/>) has been developed for this species.

Shrubland Birds

Ten species of shrubland birds were identified as SGCN in Delaware (Table 1.16).

Table 1. 16 Delaware Shrubland Bird SGCN

Shrubland Bird SGCN (10)		
<i>Coccyzus erythrophthalmus</i>	Black-billed Cuckoo	Tier 2
<i>Colinus virginianus</i>	Northern Bobwhite	Tier 2
<i>Empidonax traillii</i>	Willow Flycatcher	Tier 2
<i>Scolopax minor</i>	American Woodcock	Tier 2
<i>Vermivora cyanoptera</i>	Blue-winged Warbler	Tier 2
<i>Icteria virens</i>	Yellow-breasted Chat	Tier 3

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<i>Pipilo erythrophthalmus</i>	Eastern Towhee	Tier 3
<i>Setophaga discolor</i>	Prairie Warbler	Tier 3
<i>Spizella pusilla</i>	Field Sparrow	Tier 3
<i>Toxostoma rufum</i>	Brown Thrasher	Tier 3

Shrubland birds have declined throughout the US during the past several decades. According to the Northeast RSGCN list, the only shrubland bird species for which the region has “high responsibility” is the blue-winged warbler, with 48% of the continental population in the Northeast. However, the fact that these species are largely dependent on anthropogenic, early successional habitats makes them a high management priority.

Forest Birds

Along with many other species groups, forest birds have been considered in several regional and national plans and programs. The Northeast RSGCN Prioritization Framework considered the wood thrush, scarlet tanager, and cerulean warbler to be high responsibility species for the region. These and many other forest species are known to be sensitive to fragmentation and edge effects, thus making human activities such as roads and development important threats. According to the *Conservation Assessment* (Anderson and Olivero Sheldon 2011) there have been substantial changes, both increases and declines, in forest bird abundances over the past 40 years. Species abundance changes have been correlated with degree of fragmentation, with the road-fragmented oak-pine forests showing declines in 11 species and increases in 10 species.

In fragmented landscapes and small habitat patches, direct threats such as predation and brown-headed cowbird (*Molothrus ater*) brood parasitism are higher, creating ecological sinks. Emerging threats include changes in forest composition that may result from invasive insects, diseases, and climate change. It is also important to note that forest birds have varying structural requirements with some requiring older or younger seral stages, or different levels of structural diversity. Twenty nine species of forest birds were identified as SGCN in Delaware (Table 1.17).

Table 1. 17 Delaware Forest Bird SGCN

Forest Bird SGCN (5)s		
<i>Vireo gilvus</i>	Warbling Vireo	Tier 2
<i>Colaptes auratus</i>	Northern Flicker	Tier 3
<i>Icterus galbula</i>	Baltimore Oriole	Tier 3

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<i>Myiarchus crinitus</i>	Great Crested Flycatcher	Tier 3
<i>Tyrannus tyrannus</i>	Eastern Kingbird	Tier 3
Forest Interior Bird SGCN (9)		
<i>Buteo platypterus</i>	Broad-winged Hawk	Tier 1
<i>Setophaga cerulea</i>	Cerulean Warbler	Tier 1
<i>Certhia americana</i>	Brown Creeper	Tier 2
<i>Pheucticus ludovicianus</i>	Rose-breasted Grosbeak	Tier 2
<i>Piranga olivacea</i>	Scarlet Tanager	Tier 2
<i>Setophaga dominica</i>	Yellow-throated Warbler	Tier 2
<i>Buteo lineatus</i>	Red-shouldered Hawk	Tier 3
<i>Piranga rubra</i>	Summer Tanager	Tier 3
<i>Vireo flavifrons</i>	Yellow-throated Vireo	Tier 3
Forest Interior Understory Bird SGCN (10)		
<i>Setophaga citrina</i>	Hooded Warbler	Tier 1
<i>Catharus fuscescens</i>	Veery	Tier 2
<i>Hylocichla mustelina</i>	Wood Thrush	Tier 2
<i>Setophaga ruticilla</i>	American Redstart	Tier 2
<i>Empidonax virescens</i>	Acadian Flycatcher	Tier 3
<i>Geothlypis Formosa</i>	Kentucky Warbler	Tier 3
<i>Helmitheros vermivorum</i>	Worm-eating Warbler	Tier 3
<i>Mniotilta varia</i>	Black-and-white Warbler	Tier 3
<i>Parkesia motacilla</i>	Louisiana Waterthrush	Tier 3
<i>Bonasa umbellus</i>	Ruffed Grouse	Extirpated
Forest Interior Wetlands Bird SGCN (3)		
<i>Limnothlypis swainsonii</i>	Swainson's Warbler	Tier 1
<i>Setophaga americana</i>	Northern Parula	Tier 2
<i>Protonotaria citrea</i>	Prothonotary Warbler	Tier 3
Pine Specialist Bird SGCN (2)		

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<i>Melanerpes erythrocephalus</i>	Red-headed Woodpecker	Tier 2
<i>Sitta pusilla</i>	Brown-headed Nuthatch	Tier 2

Forest Interior Birds

Bird species sensitive to forest fragmentation are sometimes referred to as forest interior-dwelling (FID) species or forest area-dependent (FAD) species. There are some species that are sensitive to forest patch isolation, requiring a large amount of overall forest cover, but which do not necessarily require forest interior, so FAD is a broader term that also includes these species. Data on forest area requirements of Mid-Atlantic bird species was summarized by Robbins et al. (1989).

For coastal Maryland, Bushman and Therres (1988) established a list of 19 forest interior-breeding birds, which was later supplemented by Jones et al. (2000), who increased the list to 25 species. McCorkle et al. (2006) identified 26 FAD breeding bird species that occur in the Delaware/Maryland/New Jersey area. Table 1.18 includes 32 Delaware species that have been identified by one or more of these sources. Of these, 24 species (75%) are listed as SGCN.

Table 1. 18 Forest Area-Dependent Birds in Delaware

Common Name	Scientific Name	Source	DE Breeding Status	DE SGCN Status
Red-shouldered Hawk	<i>Buteo lineatus</i>	ALL	Breeds	Yes
Broad-winged Hawk	<i>Buteo platypterus</i>	Jones et al.	Rarely Breeds	Yes
Whip-poor-will	<i>Caprimulgus vociferous</i>	Bushman & Therres, Jones et al.	Breeds	Yes
Canada Warbler	<i>Cardellina Canadensis</i>	McCorkle et al.	Migrant	Yes
Veery	<i>Catharus fuscescens</i>	Jones et al., McCorkle et al.	Breeds	Yes
Brown Creeper	<i>Certhia americana</i>	Jones et al., McCorkle et al.	Rarely Breeds	Yes

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Acadian Flycatcher	<i>Empidonax vireescens</i>	ALL	Breeds	Yes
Kentucky Warbler	<i>Geothlypis formosa</i>	ALL	Breeds	Yes
Worm-eating Warbler	<i>Helmitheros vermivorum</i>	ALL	Breeds	Yes
Wood Thrush	<i>Hyocichla mustelina</i>	Jones et al., McCorkle et al.	Breeds	Yes
Swainson's Warbler	<i>Limnothlypis swainsonii</i>	ALL	Rarely Breeds	Yes
Black-and-White Warbler	<i>Mniotilta varia</i>	ALL	Breeds	Yes
Louisiana Waterthrush	<i>Parkesia motacilla</i>	ALL	Breeds	Yes
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>	McCorkle et al.	Rarely Breeds	Yes
Scarlet Tanager	<i>Piranga olivacea</i>	ALL	Breeds	Yes
Summer Tanager	<i>Piranga rubra</i>	McCorkle et al.	Breeds	Yes
Prothonotary Warbler	<i>Protonotaria citrea</i>	ALL	Breeds	Yes
Northern Parula	<i>Setophaga americana</i>	ALL	Breeds	Yes
Black-throated Blue Warbler	<i>Setophaga caerulescens</i>	McCorkle et al.	Migrant	Yes
Cerulean Warbler	<i>Setophaga cerulea</i>	Jones et al., McCorkle et al.	Breeds	Yes
Hooded Warbler	<i>Setophaga citrina</i>	ALL	Breeds	Yes
American Redstart	<i>Setophaga ruticilla</i>	ALL	Breeds	Yes

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Black-throated Green Warbler	<i>Setophaga virens</i>	Jones et al.	Migrant	Yes
Yellow-throated Vireo	<i>Vireo flavifrons</i>	ALL	Breeds	Yes
Pileated Woodpecker	<i>Dryocopus pileatus</i>	ALL	Breeds	No
Northern Waterthrush	<i>Parkesia noveboracensis</i>	McCorkle et al.	Migrant	No
Hairy Woodpecker	<i>Picooides villosus</i>	ALL	Breeds	No
Blue-gray Gnatcatcher	<i>Polioptila caerulea</i>	McCorkle et al.	Breeds	No
Ovenbird	<i>Seiurus aurocapilla</i>	ALL	Breeds	No
White-breasted Nuthatch	<i>Sitta carolinensis</i>	McCorkle et al.	Breeds	No
Barred Owl	<i>Strix varia</i>	ALL	Breeds	No
Red-eyed Vireo	<i>Vireo olivaceus</i>	ALL	Breeds	No

Heckscher (2000) conducted point count surveys of birds in the Great Cypress Swamp, the largest remaining contiguous forest area in Delaware, finding a total of 73 species, of which seven of the top 10 most abundant species were forest-dependent Neotropical migrants. This study represents an important baseline survey breeding species of coastal plain forests.

Despite many forest area-dependent species still being relatively common, there has been a general decline of 63% of Neotropical migrant species since 1966 (USGS Breeding Bird Survey). Some flagship species for this decline include two that breed in Delaware: wood thrush (*Hylocichla mustelina*) and cerulean warbler (*Setophaga cerulea*).

Many species of FAD birds are Neotropical migrants. Other species include the Eastern whip-poor-will (*Caprimulgus vociferus*) as a well as several hawk and woodpecker species. Although there are survival pressures on these species throughout their annual cycle, habitat loss and forest fragmentation on their breeding grounds is certainly playing a critical role. Jones et al. (2000) outlines in detail conservation measures necessary to conserve the remaining forest interior habitats in this region.

Aerial Insectivores

Six species of aerial insectivores were identified as SGCN in Delaware (Table 1.19).

Table 1. 19 Delaware Aerial Insectivore SGCN

Aerial Insectivore SGCN (6)		
<i>Caprimulgus carolinensis</i>	Chuck-will's-widow	Tier 2
<i>Caprimulgus vociferus</i>	Eastern Whip-poor-will	Tier 2
<i>Chaetura pelagica</i>	Chimney Swift	Tier 2
<i>Chordeiles minor</i>	Common Nighthawk	Tier 2
<i>Petrochelidon pyrrhonota</i>	Cliff Swallow	Tier 2
<i>Riparia riparia</i>	Bank Swallow	Tier 2

Birds whose diet consists primarily of aerial invertebrates have declined dramatically, especially in the Northeast (Nebel et al. 2010). The reasons for this decline are not well understood, but potential climate change-related effects have been suggested as many of these species are long-distance migrants. Some of these species (common nighthawk, chimney swift) depend nearly exclusively on buildings and structures in urban areas for breeding sites, while others (cliff swallow, barn swallow, bank swallow, purple martin) depend to a large extent on anthropogenic nesting habitats.

Cornell’s Nestwatch program is tracking nesting success of aerial insectivores that use nest boxes or artificial structures rangewide through their volunteer network. The Nightjar Survey Network, a nationwide monitoring effort for nightjars, coordinates standardized survey routes for singing nightjars, but has no routes established in Delaware as of 2015.

Migrant Passerines

Eleven species of Neotropical passage migrant birds were identified as SGCN in Delaware (see Table 1.20).

Table 1. 20 Delaware Neotropical Passage Migrant SGCN

Neotropical Passage Migrant SGCN (11)		
<i>Catharus bicknelli</i>	Bicknell's Thrush	Tier 1
<i>Contopus cooperi</i>	Olive-sided Flycatcher	Tier 2
<i>Vermivora chrysoptera</i>	Golden-winged Warbler	Tier 2
<i>Cardellina canadensis</i>	Canada Warbler	Tier 3

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<i>Setophaga caerulescens</i>	Black-throated Blue Warbler	Tier 3
<i>Setophaga castanea</i>	Bay-breasted Warbler	Tier 3
<i>Setophaga fusca</i>	Blackburnian Warbler	Tier 3
<i>Setophaga tigrina</i>	Cape May Warbler	Tier 3
<i>Setophaga virens</i>	Black-throated Green Warbler	Tier 3
<i>Empidonax minimus</i>	Least Flycatcher	Data Needs - Historical (Breeder)
<i>Setophaga pensylvanica</i>	Chestnut-sided Warbler	Data Needs - Historical (Breeder)

Delaware provides critical stopover habitat for Neotropical and temperate passage migrant songbirds. An extensive point count study by McCann et al. (1993) was the first to quantify significantly higher abundance and species richness of migrants at bayshore sites as compared to inland or ocean shore areas. More recent studies by LaPuma et al. (2012) and Buler and Dawson (2014) using weather surveillance radar to assess stopover distributions of landbirds during fall, showed that a high density of birds consistently use significant portions of New Castle, Kent, and Sussex Counties for stopover between migratory flights. The Delaware Piedmont, coastal forests along the Delaware Bay, and the Nanticoke Watershed appear to be especially important stopover areas (Heckscher pers. comm.).

Migrant Raptors

Nine species of migratory and wintering raptors were identified as SGCN in Delaware (Table 1.21).

Table 1. 21 Delaware Migratory and Wintering Raptor SGCN

Migratory/Wintering Raptor SGCN(g)		
<i>Falco peregrinus</i>	Peregrine Falcon	Tier 1
<i>Accipiter striatus</i>	Sharp-shinned Hawk	Tier 2
<i>Aquila chrysaetos</i>	Golden Eagle	Tier 2
<i>Asio otus</i>	Long-eared Owl	Tier 2
<i>Accipiter gentilis</i>	Northern Goshawk	Tier 3
<i>Aegolius acadicus</i>	Northern Saw-whet Owl	Tier 3
<i>Buteo lagopus</i>	Rough-legged Hawk	Tier 3
<i>Falco columbarius</i>	Merlin	Tier 3

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<i>Haliaeetus leucocephalus</i>	Bald Eagle	Tier 3
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Large numbers of migrating raptors pass through Delaware each year, with especially large numbers observed in the fall. Two hawk watches in Delaware are operated by a collaboration between DNREC DFW, DNREC DPR, the DOS, and The Delaware Nature Society (DNS). The Ashland Hawk Watch is located at the DNS Ashland Nature Center in the Red Clay Valley of the Piedmont, and has documented large flights of broad-winged hawks during fall migration. The Cape Henlopen Hawk Watch is located along the Atlantic Ocean shore of Cape Henlopen State Park and documents numerous raptors crossing over Delaware Bay from Cape May, as well as those migrating down the western shore of the Bay.

SGCN migrant raptors include sharp-shinned hawk (*Accipiter striatus*), which has nested, albeit rarely, in the Delaware Piedmont, but which is much more frequent as a migrant; broad-winged hawk (*Buteo platypterus*), a Neotropical migrant raptor that concentrates heavily during migration, making it susceptible to stochastic events; red-shouldered hawk (*Buteo lineatus*); and golden eagle (*Aquila chrysaetos*). Major threats to these species include collisions with wind turbines and communications towers and loss of stopover foraging and roosting habitat.

Other Wintering Birds

Five species of wintering coastal birds were identified as SGCN in Delaware (Table 1.22).

Table 1. 22 Delaware Wintering Coastal Bird and Wintering Passerine SGCN

Wintering Coastal Bird SGCN (5)		
<i>Calidris maritima</i>	Purple Sandpiper	Tier 2
<i>Gavia stellata</i>	Red-throated Loon	Tier 2
<i>Gavia immer</i>	Common Loon	Tier 3
<i>Phalacrocorax carbo</i>	Great Cormorant	Tier 3
<i>Podiceps auritus</i>	Horned Grebe	Tier 3
Wintering Passerines (7)		
<i>Euphagus carolinus</i>	Rusty Blackbird	Tier 1
<i>Spinus pinus</i>	Pine Siskin	Tier 2
<i>Spizella arborea</i>	American Tree Sparrow	Tier 2
<i>Carpodacus purpureus</i>	Purple Finch	Tier 3
<i>Passerella iliaca</i>	Fox Sparrow	Tier 3

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<i>Plectrophenax nivalis</i>	Snow Bunting	Tier 3
<i>Sitta canadensis</i>	Red-breasted Nuthatch	Tier 3

Several SGCN birds are regular winter visitors in Delaware. Irruptive species such as pine siskin (*Carduelis pinus*), and red-breasted nuthatch (*Sitta canadensis*) are very abundant some years and absent, or nearly so, in others. These birds are grouped together here even though they may use different habitats because their seasonal presence in the state dictates different management actions than those for resident species.

Rusty blackbird (*Euphagus carolinus*, Figure 1.7), the only Tier 1 species in this group, is a boreal-breeding, forested wetland-dependent species that has declined 85-95% since the early 1900s (Greenberg and Droege 1999). Rusty blackbirds use Delaware's non-tidal freshwater wetlands and floodplain forests during migration and to a lesser extent in winter. [The International Rusty Blackbird Working Group \(IRBWG\)](#) was founded in 2005 to foster communications among researchers and develop cross-seasonal and comprehensive research projects.



Figure 1. 7 Rusty blackbird (*Euphagus carolinus*). Photo: Harold A. Davis

Reptiles and Amphibians

Reptile and Amphibian Diversity of Delaware

Evidence indicates that there are worldwide declines in amphibian (Stuart et al. 2004) and reptile populations and a need to identify the specific causes and impacts of these declines is warranted (Gibbons et al. 2000; LaRoe et al. 1995). There is a recognized national and regional need for advocacy focused on conservation of amphibians and reptiles and the use of an ecosystem approach to incorporate species protection into existing management plans (NEPARC 2004, NEPARC 2009). An estimated 35% of amphibians that are dependent on aquatic habitats are rare or imperiled nationally (TNC 1996; Abell et al. 2000). LaRoe et al. (1995) found that 45% of the nation's turtle species are in need of conservation action, with many species experiencing significant population and distribution declines over the last century. Moreover, vernal pools, the habitat for many amphibian species and some reptile species, are declining in the Northeast (Calhoun and Klemens 2002). Results from a long-term study of amphibian occupancy rates on National Wildlife Refuges, a place where anthropogenic threats should be minimal, documented a 3.7% overall decline in

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amphibian occupancy at study sites (Adams et al. 2013). With this level of decline, 50% of the sites would be expected to be unoccupied within 27 years.

A total of 63 amphibian and reptile species are native to Delaware. Of these, 11 are listed by the state as Endangered and five are also federally listed. The status of Delaware’s amphibian and reptile species remains poorly documented. White and White (2007) provided county-level occurrence and distributional maps. Threats to Delaware’s herps include habitat loss and fragmentation, disease, and climate change. The range, habitats, status, and ecology of Delaware’s herpetofauna are reviewed in White and White (2007).

Based on GAP analysis of habitat models, all herp taxa are poorly represented within protected natural areas in the Delaware, Maryland, and New Jersey region. Amphibians appear to be in the worst shape, with over 95% of amphibian species having less than 10% of their potential habitat occurring within protected natural lands (GAP Status 1 and 2) (McCorkle et al. 2006).

The northeastern region RSGCN list includes 29 reptile species: 14 turtles, two lizards, and 13 snakes. Of these species, northern diamondback terrapin and northern black racer are Delaware species considered to be of high regional responsibility for management as well as high or very high regional conservation concern. These high-priority reptiles, along with many of the other herptile SGCN, are threatened by habitat loss and fragmentation, pollution, disease, and illegal harvest.

Amphibians

Delaware is home to twenty-eight species of amphibians, of which eighteen (64%) meet the criteria for SGCN (Table 1.23). Notable ecological groups include ephemeral wetland obligate breeders and species associated strongly with groundwater-fed lotic habitats such as springs and seeps.

Table 1. 23 Delaware Amphibian SGCN

<u>Amphibian SGCN (18)</u>		
Ephemeral Wetland Obligate Amphibians		
<i>Ambystoma tigrinum</i>	Tiger Salamander	Tier 1
<i>Hyla gratiosa</i>	Barking Treefrog	Tier 1
<i>Ambystoma maculatum</i>	Spotted Salamander	Tier 2
<i>Ambystoma opacum</i>	Marbled Salamander	Tier 3
<i>Lithobates sylvaticus</i>	Wood Frog	Tier 3
Groundwater Lotic Amphibians		

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<i>Pseudotriton montanus</i>	Mud Salamander	Tier 1
<i>Eurycea longicauda</i>	Longtail Salamander	Tier 2
<i>Pseudotriton ruber</i>	Red Salamander	Tier 2
<i>Desmognathus fuscus</i>	Northern Dusky Salamander	Tier 3
Other Amphibians		
<i>Lithobates virgatipes</i>	Carpenter Frog	Tier 1
<i>Rana kauffeldi</i>	Atlantic Coast Leopard Frog	Tier 1
<i>Acris crepitans</i>	Northern Cricket Frog	Tier 2
<i>Hemidactylum scutatum</i>	Four-toed Salamander	Tier 2
<i>Hyla chrysoscelis</i>	Cope's Gray Treefrog	Tier 2
<i>Pseudacris kalmi</i>	New Jersey Chorus Frog	Tier 2
<i>Anaxyrus fowleri</i>	Fowler's Toad	Tier 3
<i>Eurycea bislineata</i>	Northern Two-lined Salamander	Tier 3
<i>Notophthalmus viridescens</i>	Eastern Newt	Tier 3

The RSGCN list for the Northeast includes 35 species of amphibians, of which 28 are salamanders, five are frogs, and two are toads. All but 3 of Delaware's SGCN Amphibians are included on the RSGCN list (spotted salamander, barking treefrog (Figure 1.8), and wood frog). Amphibian species in the Northeast are under many threats, including wetland loss, water pollution, groundwater contamination, exurban and suburban sprawl, increased habitat fragmentation from roads and new human developments, and exotic, non-native diseases.

The eastern spadefoot is facing population declines and loss of habitat in the Northeast. The northern leopard frog is also a regional species of concern that is exhibiting population declines in the Northeast, but is common elsewhere in the U.S.

In terms of rarity and vulnerability to human impacts, vernal pool-breeding amphibians represent an important species assemblage. Several species are of particular conservation concern, including the spotted salamander (*Ambystoma maculatum*), marbled salamander (*Ambystoma opacum*), tiger salamander (*Ambystoma tigrinum*), and barking treefrog (*Hyla gratiosa*), all of which depend upon forests and seasonal wetlands for their survival.

The Blackbird-Millington Corridor, which spans the boundary between Maryland and Delaware on the northern part of the Coastal Plain, includes the largest concentration of Coastal Plain seasonal ponds on the Delmarva Peninsula. These seasonal wetlands and the surrounding matrix of

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hardwood forest represented the most significant rare amphibian species hotspot in the Maryland, Delaware, and New Jersey GAP Analysis (MDN-GAP) project area, and much of the area remains unprotected (McCorkle et al. 2006). Because the topography of the area is very flat, its forests and seasonal wetlands are especially vulnerable to development. Despite the fact that significant portions of this corridor occur on state-owned forest land and wildlife management area land, all of the species mentioned above have less than 10% of their predicted distributions occurring within protected natural lands (GAP status 1 or 2) (McCorkle et al 2006).

Barking treefrog (*Hyla gratiosa*), Cope's gray treefrog (*Hyla chrysoscelis*), eastern narrowmouth toad (*Gastrophryne carolinensis*), and carpenter frog (*Rana virgatipes*) all have less than 5% of their predicted regional distributions occurring within protected natural lands (GAP status 1 or 2) (McCorkle et al. 2006).



Figure 1. 8 Barking treefrog (*Hyla gratiosa*) is a southeastern species that reaches the northern edge of its range in Delaware and is entirely dependent on Coastal Plain seasonal ponds for breeding habitat. Photo: Jim White

Upland forested buffers are extremely important for conservation of ephemeral wetland breeders. For example, adult salamanders of six *Ambystoma* species were found an average of 125 m from the

edge of aquatic habitats during the non-breeding portions of their life-cycles, such that a wetland buffer zone of 164 m (534 ft) could be expected to encompass the majority of the population of these salamanders during their entire life cycle (Semlitsch 1998). It also important to consider corridors to allow gene flow between populations, and when possible, to protect entire complexes of breeding wetlands as well as their forest matrix.

Several of Delaware’s amphibian SGCN are dependent on groundwater-fed, lotic habitats associated with springs, seeps, and stream headwaters. These include the long-tail salamander, mud salamander, northern dusky salamander, and red salamander.

Concern over declines in amphibian populations has prompted the initiation of amphibian monitoring programs throughout North America and around the world. Volunteers with the Delaware Amphibian Monitoring Program (DAMP), part of the North American Amphibian Monitoring Program (NAAMP), conduct nighttime surveys of calling frogs and toads around the state each year. Volunteers are assigned a driving route in one portion of the state, and conduct surveys along that route. DAMP volunteers have been surveying calling frogs and toads in Delaware since 1997.

Delaware frog call survey data from 2001 to 2011 were analyzed (along with data from several other states in the northeast) to detect population trends of frog species. Delaware results included significant increasing trends for green treefrog (*Hyla cinerea*), spring peeper (*Pseudacris crucifer*), and the gray treefrog complex (*Hyla versicolor/chrysosecelis*) and significant decreasing trends for the chorus-frog complex (*Pseudacris feriarum/ kalmi*) (Weir et al. 2014).

Snakes and Lizards

Twenty-four species of snakes and lizards (collectively known as scaled reptiles, or squamates) are known to occur in Delaware. Of these, fourteen species are considered SGCN in the state (Table 1.24). A subset of these species is found entirely or primarily in sandy habitats on the Coastal Plain.

Table 1. 24 Delaware Snake and Lizard SGCN

Sand Specialist Snake and Lizard SGCN (5)		
<i>Cemophora coccinea</i>	Scarletsnake	Tier 1
<i>Pantherophis guttatus</i>	Red Cornsnake	Tier 1
<i>Scincella lateralis</i>	Ground Skink	Tier 2
<i>Storeria occipitomaculata</i>	Red-bellied Snake	Tier 2
<i>Heterodon platirhinos</i>	Eastern Hog-nosed Snake	Tier 3
Other Snake and Lizard SGCN (9)		

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<i>Nerodia erythrogaster</i>	Plain-bellied Watersnake	Tier 1
<i>Agkistrodon contortrix</i>	Copperhead	Tier 2
<i>Lampropeltis getula</i>	Common Kingsnake	Tier 2
<i>Lampropeltis triangulum</i>	Milksnake	Tier 2
<i>Opheodrys aestivus</i>	Rough Greensnake	Tier 2
<i>Regina septemvittata</i>	Queen Snake	Tier 2
<i>Thamnophis sauritus</i>	Eastern Ribbonsnake	Tier 2
<i>Virginia valeriae</i>	Smooth Earthsnake	Tier 2
<i>Plestiodon laticeps</i>	Broad-headed Skink	Data Needs - Historical

Accurate population assessments are needed to determine the status of many of the species in this group.

Turtles

Sixteen species of turtles are known to occur in Delaware. Ten of these species are considered SGCN in the state (Table 1.25) including five sea turtles (Tables 1.25 and 1.26).

Table 1. 25 Delaware Turtle SGCN

Wetland and Riparian Turtle SGCN (2)		
<i>Clemmys guttata</i>	Spotted Turtle	Tier 1
<i>Glyptemys muhlenbergii</i>	Bog Turtle	Tier 1
River and Bay Turtle SGCN (2)		
<i>Malaclemys terrapin</i>	Diamondback Terrapin	Tier 2
<i>Pseudemys rubriventris</i>	Northern Red-bellied Cooter	Tier 2
Terrestrial Turtle SGCN (1)		
<i>Terrapene carolina</i>	Eastern Box Turtle	Tier 1



Figure 1. 9 Bog turtle (*Glyptemys muhlenbergii*). Photo: Jim White

The bog turtle (*Glyptemys muhlenbergii*, Figure 1.9) is a small, semi-aquatic turtle that inhabits freshwater wetland habitats that have soft muck and pedestal vegetation. Unfortunately, the species is in trouble due to loss of habitat, wetland alteration and illegal collection for the pet trade. The U.S. Fish and Wildlife Service listed the northern population as federally threatened in 1997, with a recovery plan prepared for the northern population in 2001 (USFWS 2001). There are only two known locations in Delaware where bog turtles are reproducing.

The DNREC DFW Wildlife Species Conservation & Research Program has been monitoring bog turtles since 1992 and monitors known sites with visual surveys, trapping and radio telemetry to keep track of population status and evaluates potential new habitats to see if bog turtles are present. DNREC DFW also works with landowners with bog turtle habitats to encourage bog turtle populations by maintaining optimal vegetation and habitat quality.

Like the bog turtle, the spotted turtle (*Clemmys guttata*) is associated with wetlands, and is generally found within 500 m of a wetland (Whitlock 1994). Although far more widespread in Delaware than bog turtles, spotted turtles remain a species of concern due to habitat loss and illegal collection for the pet trade.

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Diamondback terrapins, once a seasonal food item across Delmarva, are no longer routinely trapped for food, but continue to face beach development, bulk-heading and traffic as major threats to their breeding areas. The DNREC DPR and DFW erected turtle fencing to minimize road mortality during the nesting season along the busy barrier beach highway at Delaware Seashore State Park. Nesting habitat was also added to the bayside of the highway in an effort to deter females from crossing the road. A conservation assessment is currently underway for this species in the Northeast, funded by the Northeast Regional Conservation Needs program and recognized as a priority by the Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC).

All of Delaware’s SGCN turtles are listed as RSGCN except the Eastern box turtle. Although the Eastern box turtle was listed in nearly every northeastern state as SGCN, the region has low responsibility for this species.

Sea Turtles

All five species of sea turtles known from Delaware waters were identified as SGCN in Delaware (Table 1.26).

Table 1. 26 Delaware Sea Turtle SGCN

Sea Turtle SGCN (5)		
<i>Caretta caretta</i>	Loggerhead	Tier 1
<i>Chelonia mydas</i>	Green Turtle	Tier 1
<i>Dermochelys coriacea</i>	Leatherback	Tier 1
<i>Eretmochelys imbricata</i>	Hawksbill	Tier 1
<i>Lepidochelys kempii</i>	Kemp's Ridley Sea Turtle	Tier 1

Four species of marine sea turtles are included on the RSGCN list (loggerhead, green, leatherback, and Kemp’s ridley), all of which are protected under the ESA. Because of their broad distributions, but significant range-wide declines, these species are considered to be low regional responsibility, but of very high conservation concern in the Northeast. Information about their distribution, abundance (Figure 1.10), migratory movements, and population characteristics are collected by USFWS, National Marine Fisheries Service (NMFS), and other partners to implement actions identified in the species’ Federal Recovery Plans.

Sea turtles visit Delaware’s estuarine and marine waters during the warmer months (June through October). The Delaware Estuary has an abundance of benthic invertebrates, which are the primary

prey for loggerheads, Kemp's ridley, and juvenile green turtles. Because leatherbacks (*Dermochelys coriacea*) feed primarily upon jellyfish, their occurrence in Delaware waters is more pelagic although sightings in the lower Delaware Bay have occurred, likely tied to jellyfish blooms.

In Delaware Bay, loggerheads (*Caretta caretta*) occur in the greatest number, and the estuary provides important developmental habitat for juveniles. The estuary may be equally important for adults as evidenced by satellite-tagged individuals that travelled to Delaware Bay and set up "home ranges," some staying as long as several months before heading offshore or southward when water temperatures begin dropping in the fall (Martin 2010). Survey data compiled from 1996-1997 by J.R. Spotila indicate that a high density (21-33 animals/100 km²) of turtles, primarily loggerheads, are found in the Delaware Bay during the summer (Spotila et al. 2007).

Research indicates that loggerhead sea turtles have an apparent affinity for channel habitat in other estuarine and near shore habitats along the U.S. Atlantic Coast (PSEG 1997, Byles 1988). This makes them vulnerable to ship strikes and channel dredging activities. Baseline data is needed on sea turtles in Delaware, especially with regard to periods of peak abundance, population size and habitat usage.

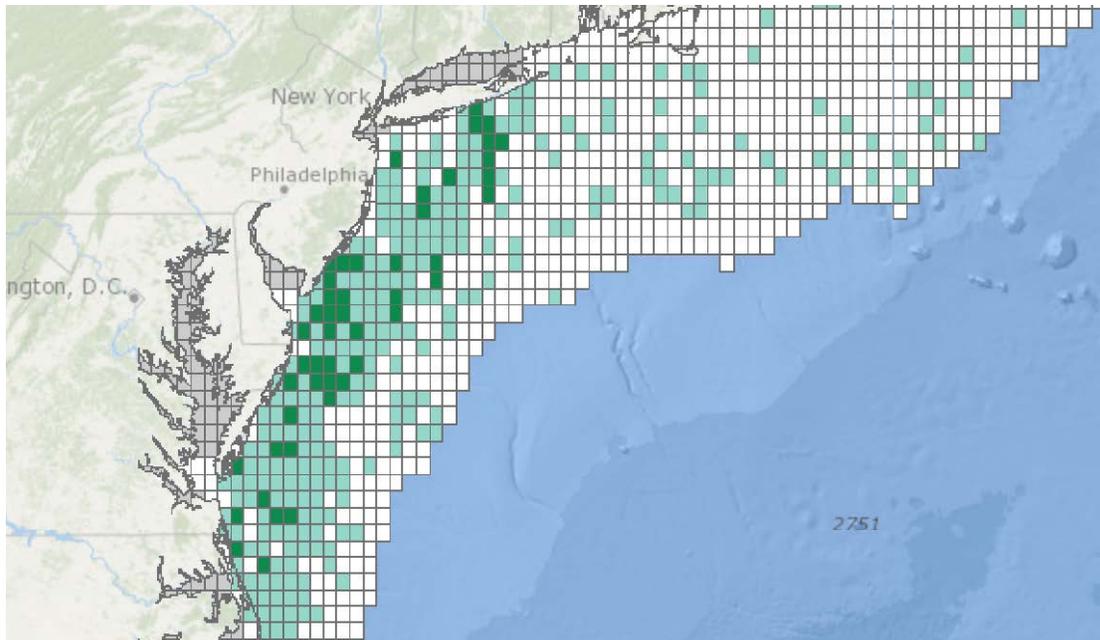


Figure 1. 10 Loggerhead, leatherback, and green sea turtle abundance. Dark green represents above average abundance for multiple species, light green represents above average abundance for one species. Source: Anderson et al. (2010), mapped by MARCO Mid-Atlantic Data Portal.

http://portal.midatlanticocean.org/static/data_manager/metadata/html/MigratoryPortfolio.html

Fish

Fish Diversity of Delaware

At least one hundred and seventy-seven species of fish have been documented in Delaware waters. One hundred and five of these are considered SGCN in the state (Table 1.28).

NOAA (2011) estimates that 130 species of fish use the estuarine habitats of the Delaware River and Bay. The shallow waters of Delaware's Inland Bays provide habitat for at least 112 species of fish (Delaware Center for the Inland Bays 2011). Five fish species may be extirpated from the Delaware River Basin: pirate perch (*Aphredoderus sayanus*), mud sunfish (*Acantharchus pomotis*), blackbanded sunfish (*Enneacanthus chaetodon*), swamp darter (*Etheostoma fusiforme*), and longnose gar (*Lepisosteus osseus*) (Cooper 1983; Horwitz et al. 2008).

One hundred and one fish species have been identified as Northeast RSGCN, making them one of the most numerous vertebrate groups listed. These fish taxa include representatives of all of the major fish families found in the Northeast, with certain families (Percidae, Cyprinidae, Salmonidae) particularly well represented.

NOAA's NMFS provides an [Essential Fish Habitat \(EFH\) Mapper](#) tool online for viewing the spatial representations of EFH for all 39 species under federal management in the Mid-Atlantic and Northeast, as well as links to supporting materials, including fishery management plans, and the ability to download GIS data. It was developed for general visualization and informational purposes only and does not necessarily represent the most important habitats. EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (16 U.S.C. 1802(10)). Species for which EFH has been mapped in Delaware River and Bay and the Delaware Inland Bays are listed in Table 1.27. A number of additional species have EFH mapped in the Atlantic Ocean offshore of Delaware.

The Atlantic States Marine Fisheries Commission (ASMFC) manages coastal (0-3 miles) inshore migratory species, and the Mid-Atlantic Fisheries Management Council (MAFMC) maintains jurisdiction from 3 to 200 miles off the coast. The MAFMC has Fishery Management Plans (FMPs) for Atlantic mackerel, squid and butterfish; bluefish; spiny dogfish (joint with the NEFMC); summer flounder, scup and black sea bass; and tilefish (available online at <http://www.mafmc.org/mid-atlantic/fmp/fmp.htm>). The ASMFC manages 22 species or groups of species for conservation, and has approved interstate FMPs for several of them (e.g., striped bass; available online at <http://www.asmfc.org>). All of these regional FMPs assess the abundance and distribution for each species and describe conservation measures to address any threats to the fish stocks.

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Table 1. 27 Species for which Essential Fish Habitat is mapped within Delaware Bay and the Delaware Inland Bays. Source: NOAA/TNC.

Species	Upper DE Bay	Lower DE Bay	Inland Bays
Black Sea Bass	JA	JA	JA
Cod			
Atlantic Herring			
Bluefish	JA	JA	JA
Clearnose Skate		A	A
Little Skate		A	A
Monkfish			
Red Hake		A	
Scup	JA	JA	JA
Spiny Dogfish			
Summer Flounder	JA	JA	LJA
Windowpane Flounder	ELJA	ELJA	ELJA
Winter Flounder	ELJA	ELJA	ELJA
Winter Skate		A	A
Butterfish	JA	LJA	JA
Longfin Inshore Squid	X	X	X
Rosette Skate			
Total Species	8	12	11

E = eggs; L = larvae; J = juveniles; A = adults; X = data not developed for individual life stages

The Atlantic Coastal Fish Habitat Partnership (ACFHP) developed a Conservation Strategic Plan for 2012-2016, which proposed key conservation strategies to address serious threats to fish habitats along the Atlantic coast (ACFHP 2011a). ACFHP also developed an accompanying 2012-2013 Implementation Plan, a subset of the Conservation Strategic Plan, which described specific objectives and actions to be accomplished during the 2012-2013 period (ACFHP 2012b). The AFWA published a National Fish Habitat Action Plan (AFWA 2006), which detailed specific actions for the restoration and conservation of fish habitat across the United States. The National Fish Habitat Partnership (NFHP) recently published a second edition of the habitat action plan (NFHB 2012) with new conservation and management actions and updates on progress since the first plan. In 2010,

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NFHP conducted the first ever national assessment of fish habitat, *Through a Fish's Eye: The Status of Fish Habitats in the United States* (NFHB 2010), which detailed the status of fish habitats across the country and served to accomplish one of the major goals of AFWA's 2006 Action Plan.

Human activities continue to impact aquatic systems across the Northeast, and fish populations face many threats. The recent American Fisheries Society and USGS analysis (<http://www.actionbioscience.org/biodiversity/walsh.html>) (Walsh et al. 2009) describes the most significant threats to freshwater fish. Destruction or modification of habitat, which can result in loss of populations and reductions in species range, includes dam construction, stream channelization, mining, conversion of forests to agriculture, and urban and suburban development. Pollution from point and non-point source contaminants in run-off reduces water quality to the point where only highly tolerant fish species survive. Sedimentation of fine particulates can also smother bottom substrates, causing declines in bottom-dwelling species that require clean substrates and good water quality.

Introduction of non-native species, which may result in hybridization, competition, and predation, has the potential to impact native species. Examples of aquatic invasive that may impact SGCN fishes include the northern snakehead (*Channa argus*) (found in the Nanticoke and Christina drainages) and the rusty crayfish (*Orconectes rusticus*). The Mid-Atlantic Panel on Aquatic Nuisance Species created a list of 49 "[Species of Interest](#)" for the region. Disease or parasitism such as whirling disease (introduced from Europe) has affected many wild and hatchery populations of trout and salmon species in the United States and Canada. Overharvesting for commercial, recreational, scientific, or educational purposes has also historically affected some species such as the federally endangered shortnose sturgeon and Atlantic sturgeon. Eutrophication and resulting hypoxia can create unsuitable conditions in summer months for sensitive species, especially in shallow estuarine waters.

Global climate change and associated changes in weather and rainfall patterns across the Northeast have the potential to alter water quality and quantity in many streams, lakes, and rivers, with resulting detrimental effects for many fish species. Climate change effects in estuarine and marine habitats can affect currents, water temperature, and many other factors that may result in impacts to SGCN. Climate change can also exacerbate the other threats listed above.

Freshwater Fish

Twenty-three species of freshwater fishes were identified as SGCN in Delaware (Table 1.28).

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Table 1. 28 Delaware Freshwater Fish SGCN

Freshwater Fish SGCN (23)		
<i>Cottus caeruleomentum</i>	Blue Ridge Sculpin	Tier 1
<i>Enneacanthus chaetodon</i>	Blackbanded Sunfish	Tier 1
<i>Etheostoma vitreum</i>	Glassy Darter	Tier 1
<i>Notropis bifrenatus</i>	Bridle Shiner	Tier 1
<i>Notropis chalybaeus</i>	Ironcolor Shiner	Tier 1
<i>Acantharchus pomotis</i>	Mud Sunfish	Tier 2
<i>Cottus bairdii</i>	Mottled Sculpin	Tier 2
<i>Enneacanthus obesus</i>	Banded Sunfish	Tier 2
<i>Lampetra aepyptera</i>	Least Brook Lamprey	Tier 2
<i>Lethenteron appendix</i>	American Brook Lamprey	Tier 2
<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	Tier 2
<i>Notropis amoenus</i>	Comely Shiner	Tier 2
<i>Noturus insignis</i>	Margined Madtom	Tier 2
<i>Percina peltata</i>	Shield Darter	Tier 2
<i>Amia calva</i>	Bowfin	Tier 3
<i>Cyprinella analostana</i>	Satinfin Shiner	Tier 3
<i>Etheostoma fusiforme</i>	Swamp Darter	Tier 3
<i>Exoglossum maxillingua</i>	Cutlip Minnow	Tier 3
<i>Hybognathus regius</i>	Eastern Silvery Minnow	Tier 3
<i>Lepomis auritus</i>	Redbreast Sunfish	Tier 3
<i>Notropis procne</i>	Swallowtail Shiner	Tier 3
<i>Semotilus corporalis</i>	Fallfish	Tier 3
<i>Umbra pygmaea</i>	Eastern Mudminnow	Tier 3

Cool-cold Headwater Species

Sculpin (Cottidae) often co-occur with brook trout, but may tolerate slightly warmer stream temperatures. Both slimy and mottled sculpin occur in Delaware and have been documented as potential host fish for several mussel species, including dwarf wedgemussel (*Alasmidonta heterodon*), brook floater (*Alasmidonta varicosa*), and creeper (*Strophitus undulatus*) (Nedeau et al. 2000; CTDEP 2003). Sculpin have small home ranges and need networks of connected headwaters and small streams to maintain genetic diversity and minimize the risk of localized extinction.

Transitional Cool and Warm Backwater Species

These species thrive in cool or warm sluggish headwater streams and in backwaters of small and large rivers. Bridle shiner (*Notropis bifrenatus*) were once abundant in the Delaware Basin but now are considered rare. Declines have been rapid and range-wide over the past 50 years (Cooper 1983; PNHP 2010). Recent surveys within the Delaware River basin have documented bridle shiners in small sluggish warm-water creeks, permanent backwaters within the floodplain, and in beaver ponds. They were often found swimming above and into patches of submerged aquatic vegetation, which are used for cover and during spawning (Horwitz et al. 2008).

While they were never abundant, ironcolor shiner (*Notropis chalybaeus*) distributions have also decreased. Only two populations have been documented recently in the Delaware River basin (Lellis and Johnson 2006; NYDEC 2011). Both shiners spawn over aquatic vegetation (Jenkins and Burkhead 1993). Possible causes of species decline include siltation, loss of aquatic vegetation, and a reduction in critical backwater habitat historically created by beavers (Horwitz et al. 2008; PNHP 2010). Eastern mudminnow (*Umbra pygmaea*) also thrives in vegetated backwater pools and wetlands within the floodplain of major tributaries and the mainstem river (Horwitz et al. 2008). Adjacent land cover, lateral connectivity, and groundwater contribution are important to maintaining vegetation, temperature, and dissolved oxygen in these habitats.

Nest Builders

Several freshwater species, including Delaware's four SGCN sunfish (Centrarchidae) species, as well as margined madtom (*Noturus insignis*) and fallfish (*Semotilus corporalis*) build nests in which to spawn. Some species such as banded (*Enneacanthus obesus*) and blackbanded sunfish (*Enneacanthus chaetodon*) prefer spawning habitat in shallow areas with low flow and aquatic vegetation. Margined madtom (*Noturus insignis*) prefer moderate to fast currents over sand and gravel substrates. They are important indicators of the persistence of shallow, fast water habitats and serve as host fish for several freshwater mussel species. Fallfish (*Semotilus corporalis*) also serves as a host fish for freshwater mussels (Strayer and Jirka 1997; CTDEP 2003).

Nest builders require maintenance of suitable nesting substrate and are sensitive to extreme high and low flow events that could impact eggs and fry. Changes to land cover, loss of baseflows, and high flow events during spawning could impact nesting success. Blackbanded sunfish (*Enneacanthus obesus*), while apparently never common, has now become extremely rare and is listed as Endangered in Delaware. A Conservation Action Strategy for this species on Delmarva was developed by Maryland DNR (Killian et al. 2013). Blackbanded sunfish is one of the species that likely used beaver dam habitat extensively in pre-colonial times. A full review of the associations of freshwater fish with beaver dams is provided by Pollock et al. (2003).

Diadromous Fish

The Delaware River Basin supports ten diadromous fish species, which migrate between freshwater and marine habitats during their life cycles (Cooper 1983; Greene et al. 2009; NOAA 2011).

Anadromous fish, including clupeids, American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), alewife (*A. pseudoharengus*), and blueback herring (*A. aestivalis*); Atlantic sturgeon (*Acipenser oxyrinchus*); and striped bass (*Morone saxatilis*) spend most of their adult lives at sea before returning to natal rivers to spawn.

Although often referred to as an anadromous species, shortnose sturgeon (*Acipenser brevirostrum*) in the Delaware River is more correctly referred to as an amphidromous species, as its individuals move between freshwater and the bay to feed, but not to spawn. Delaware’s catadromous species, American eel (*Anguilla rostrata*), migrates from the ocean into freshwater environments as juveniles. Once mature, they emigrate to spawn in marine environments.

Diadromous fish require connectivity between marine and freshwater habitats. The Delaware River is unique among major eastern rivers in that its mainstem is free of dams, allowing these species to access much of their historic spawning habitat. However, overfishing, pollution, and barriers on tributaries have negatively affected diadromous fish populations in the Delaware River Basin, with most populations currently at historic lows (ASMFC 2006; ASMFC 2007). A review of habitat conditions, threats, and recommendations for diadromous fish was completed for the Atlantic coast by Greene et al. (2009). Nine species of diadromous fishes were identified as SGCN in Delaware (see Table 1.29).

Table 1. 29 Delaware Diadromous Fish SGCN

Diadromous Fish SGCN (g)		
<i>Acipenser brevirostrum</i>	Shortnose Sturgeon	Tier 1
<i>Acipenser oxyrinchus oxyrinchus</i>	Atlantic Sturgeon	Tier 1
<i>Alosa aestivalis</i>	Blueback Herring	Tier 1

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<i>Alosa pseudoharengus</i>	Alewife	Tier 1
<i>Anguilla rostrata</i>	American Eel	Tier 1
<i>Alosa mediocris</i>	Hickory Shad	Tier 2
<i>Alosa sapidissima</i>	American Shad	Tier 2
<i>Morone saxatilis</i>	Striped Bass	Tier 2
<i>Clupea harengus</i>	Atlantic Herring	Tier 3

Historical information and restoration efforts for shad and other anadromous species in northern Delaware tributaries are detailed in Narvaez et al. (2010). American shad are historically known from the Brandywine and Christina watersheds, the Broadkill, and the Nanticoke. American shad from hatcheries have been stocked in the Nanticoke River. A state moratorium on the commercial and recreational harvest of American shad and hickory shad went into effect in February 2000.

Sturgeon populations remain at historic lows as well. The Delaware River spawning population of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is currently estimated at less than 300 adults, down from an estimated 180,000 prior to 1890 (NOAA NMFS n.d.) The New York Bight Distinct Population Segment (DPS) of Atlantic sturgeon (including the Delaware River spawning population) was one of 4 DPSs listed as federally Endangered in 2012 (USFWS 2012). Shortnose sturgeon (*Acipenser brevirostrum*) was listed as as federally Endangered in 1967 ([32 FR4001](#)), with a [recovery plan](#) published in December 1998.

Threats to both sturgeon species include vessel strikes and entrainment and impingement in cooling water withdrawal systems. Twenty-nine mortalities of Atlantic sturgeon believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. A recent study indicated that the loss of only a few adult female Atlantic sturgeon would impact recovery of Atlantic sturgeon in the Delaware River (NOAA NMFS n.d.). The effects of main channel deepening of the Delaware River (both dredging and increased vessel traffic) on sturgeon could be significant.

Estuarine and Marine Fish

The ecology of Delaware’s estuarine fishes was extensively reviewed by Able and Fahay (2010). Much foundational information on juvenile life stages was compiled by Wang and Kernehan (1979). Thirty-seven species of estuarine and marine fishes were identified as SGCN in Delaware (see Table 1.30).

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Table 1. 30 Delaware Estuarine and Marine Fish SGCN

Estuarine Fish SGCN (5)		
<i>Apeltes quadracus</i>	Fourspine Stickleback	Tier 2
<i>Fundulus luciae</i>	Spotfin Killifish	Tier 2
<i>Fundulus heteroclitus</i>	Mummichog	Tier 3
<i>Fundulus majalis</i>	Striped Killifish	Tier 3
<i>Menidia menidia</i>	Atlantic Silverside	Tier 3
Marine/Estuarine Fish SGCN (32)		
<i>Tautoga onitis</i>	Tautog	Tier 1
<i>Thunnus thynnus</i>	Atlantic Bluefin Tuna	Tier 1
<i>Ammodytes americanus</i>	American Sand Lance	Tier 2
<i>Brevoortia tyrannus</i>	Atlantic Menhaden	Tier 2
<i>Centropristis striata</i>	Black Sea Bass	Tier 2
<i>Cynoscion regalis</i>	Weakfish	Tier 2
<i>Opsanus tau</i>	Oyster Toadfish	Tier 2
<i>Stenotomus chrysops</i>	Scup	Tier 2
<i>Cynoscion nebulosus</i>	Spotted Seatrout	Tier 3
<i>Hemitripteris americanus</i>	Sea Raven	Tier 3
<i>Leiostomus xanthurus</i>	Spot	Tier 3
<i>Lophius americanus</i>	Goosefish	Tier 3
<i>Merluccius bilinearis</i>	Silver Hake	Tier 3
<i>Microgadus tomcod</i>	Atlantic Tomcod	Tier 3
<i>Micropogonias undulatus</i>	Atlantic Croaker	Tier 3
<i>Myoxocephalus octodecemspinosus</i>	Longhorn Sculpin	Tier 3
<i>Paralichthys dentatus</i>	Summer Flounder	Tier 3
<i>Paralichthys oblongus</i>	Fourspot Flounder	Tier 3
<i>Peprilus triacanthus</i>	Butterfish	Tier 3
<i>Pogonias cromis</i>	Black Drum	Tier 3

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<i>Pomatomus saltatrix</i>	Bluefish	Tier 3
<i>Prionotus carolinus</i>	Northern Searobin	Tier 3
<i>Prionotus evolans</i>	Striped Searobin	Tier 3
<i>Pseudopleuronectes americanus</i>	Winter Flounder	Tier 3
<i>Sciaenops ocellatus</i>	Red Drum	Tier 3
<i>Scomber scombrus</i>	Atlantic Mackerel	Tier 3
<i>Scomberomorus maculatus</i>	Spanish Mackerel	Tier 3
<i>Scophthalmus aquosus</i>	Windowpane	Tier 3
<i>Sphoeroides maculatus</i>	Northern Puffer	Tier 3
<i>Tautoglabrus adspersus</i>	Cunner	Tier 3
<i>Urophycis chuss</i>	Red Hake	Tier 3
<i>Zoarces americanus</i>	Ocean Pout	Tier 3

Steep declines in Atlantic bluefin tuna (*Thunnus thynnus*) between 1970 and 1992 led to the species' listing as Endangered by the IUCN, and listing as a NMFS Species of Concern in 2011.

The [International Commission for the Conservation of Atlantic Tunas \(ICCAT\)](#) scientific committee typically assesses the abundance of Atlantic bluefin tuna stocks every 2 to 3 years. According to the [2014 stock assessment](#), the western Atlantic bluefin tuna stock is no longer subject to overfishing. However, based on the information in the 2014 stock assessment and continued uncertainty about population estimates, NOAA Fisheries has determined that the western Atlantic bluefin tuna stock remains overfished. A recent satellite tagging study indicated a coastal core-use area centered near the shelf break of the Mid-Atlantic bight (Galuardi and Lutcavage 2012).

Tautog (*Tautoga onitis*) is listed as a Tier 1 species due to its IUCN status of Vulnerable. This important recreational fishery species experienced a 73% reduction in spawning biomass between 1986 and 2004 (Choat and Pollard 2010) and it continues to be classified as overfished in all stock assessment regions according to the most recent ASMFC stock assessment (ASMFC 2015). Fishing pressure on tautog is not as high in the Delmarva stock assessment region and overfishing is not currently occurring in this region (ASMFC 2015).

The Delaware Bay is an important spawning area for weakfish (*Cynoscion regalis*). Weakfish populations are currently very low compared with historic estimates of abundance, and juvenile weakfish rarely reach adulthood in Delaware's Inland Bays (Delaware Center for the Inland Bays

2011). Black drum (*Pogonias cromis*) and white perch (*Morone americana*) also use the bay for spawning, and juveniles use tidal creeks as nursery areas. Several flatfish are common in bay waters, including the SGCN summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudopleuronectes americanus*), and windowpane flounder (*Scophthalmus aquosus*).

Several common species are included as Tier 2 or Tier 3 species due to the high responsibility of the state and/or region for maintenance of healthy populations of these ecologically important species. Examples include mummichog (*Fundulus heteroclitus*), Atlantic silverside (*Menidia menidia*), and striped killifish (*Fundulus majalis*), common estuarine and nearshore fish that comprise an important part of the diet of many of the larger, commercially important species. Atlantic menhaden (*Brevoortia tyrannus*) and American sand lance (*Ammodytes americanus*) are also important in the marine ecosystem, serving as a food resource for many species of predatory fish.

Sharks, Rays and Skates

There are 32 species of sharks and 4 species of rays and skates considered SGCN in Delaware (Table 1.31). Global populations of sharks and other cartilaginous fishes have been severely reduced in recent decades through over-harvest for the commercial market. Many species of sharks of conservation concern use the waters of Delaware Bay and the Atlantic Ocean. A few of these species may be very uncommon as far north as Delaware, however, the high global concern for shark species and potential changes in distribution and abundance due to climate change warrants their listing even if they are currently uncommon or rare in Delaware waters.

Table 1. 31 Delaware Shark SGCN

Coastal Shark SGCN (20)		
<i>Carcharhinus plumbeus</i>	Sandbar Shark	Tier 1
<i>Carcharhinus signatus</i>	Night Shark	Tier 1
<i>Carcharias Taurus</i>	Sand Tiger	Tier 1
<i>Sphyrna lewini</i>	Scalloped Hammerhead	Tier 1
<i>Sphyrna mokarran</i>	Great Hammerhead	Tier 1
<i>Sphyrna zygaena</i>	Smooth Hammerhead	Tier 1
<i>Squalus acanthias</i>	Spiny Dogfish	Tier 1
<i>Carcharhinus brevipinna</i>	Spinner Shark	Tier 2
<i>Carcharhinus leucas</i>	Bull Shark	Tier 2
<i>Carcharhinus limbatus</i>	Blacktip Shark	Tier 2
<i>Galeocerdo cuvier</i>	Tiger Shark	Tier 2

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<i>Heptranchias perlo</i>	Sharpnose Sevengill Shark	Tier 2
<i>Hexanchus griseus</i>	Bluntnose Sixgill Shark	Tier 2
<i>Mustelus canis</i>	Smooth Dogfish	Tier 2
<i>Negaprion brevirostris</i>	Lemon Shark	Tier 2
<i>Carcharhinus isodon</i>	Finetooth Shark	Tier 3
<i>Rhizoprionodon terraenovae</i>	Atlantic Sharpnose Shark	Tier 3
<i>Sphyrna tiburo</i>	Bonnethead Shark	Tier 3
<i>Ginglymostoma cirratum</i>	Nurse Shark	Data Needs
<i>Squatina dumeril</i>	Angel Shark	Data Needs
Oceanic Shark SGCN (12)		
<i>Alopias superciliosus</i>	Bigeye Thresher Shark	Tier 1
<i>Alopias vulpinus</i>	Thresher Shark	Tier 1
<i>Carcharhinus longimanus</i>	Oceanic Whitetip Shark	Tier 1
<i>Carcharhinus obscurus</i>	Dusky Shark	Tier 1
<i>Carcharodon carcharias</i>	White Shark	Tier 1
<i>Cetorhinus maximus</i>	Basking Shark	Tier 1
<i>Isurus oxyrinchus</i>	Shortfin Mako Shark	Tier 1
<i>Isurus paucus</i>	Longfin Mako Shark	Tier 1
<i>Lamna nasus</i>	Porbeagle Shark	Tier 1
<i>Rhincodon typus</i>	Whale Shark	Tier 1
<i>Carcharhinus falciformis</i>	Silky Shark	Tier 2
<i>Prionace glauca</i>	Blue Shark	Tier 2
Skate and Ray SGCN (4)		
<i>Leucoraja ocellata</i>	Winter Skate	Tier 1
<i>Leucoraja erinacea</i>	Little Skate	Tier 2
<i>Dasyatis centroura</i>	Roughtail Stingray	Tier 3
<i>Leucoraja garmani</i>	Rosette Skate	Tier 3

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The shallow habitats of coastal Delaware Bay are important primary and secondary nursery habitat for sandbar shark (*Carcharhinus plumbeus*) (Merson and Pratt 2001; Rechisky and Wetherbee 2003; NMFS 2009). Sand tiger shark (*Carcharias taurus*), along with smooth (*Mustelus canis*) and spiny dogfish (*Squalus acanthias*) also use the Bay extensively. Researchers have conducted radio-tagging research on sand tiger sharks in Delaware Bay since 2007 as part of the Atlantic Cooperative Telemetry (ACT) Network, finding that this species leaves Delaware Bay in fall, with males moving south to Hatteras or beyond, and females moving to offshore waters near the shelf break (Fox et al. 2009, Teter et al. 2015). Several species of oceanic sharks [as classified by Camhi et al. (2009)] regularly visit the waters off Delaware. All shark species managed by the Atlantic States Marine Fisheries Commission (ASMFC) and with observations or potentially suitable habitat in Delaware and adjacent ocean waters are included as SGCN.

Invertebrates

Invertebrate Diversity of Delaware

Invertebrates account for an exceptionally large proportion of the biodiversity of Delaware. In Pennsylvania, where invertebrate species numbers have been quantified, Rawlins and Bier estimate that invertebrates make up 53.2% of the state's species diversity, with plants, algae, fungi, and lichens accounting for 40%, and vertebrate animals only 3.2%. Among invertebrates, the vast majority are insects (Rawlins and Bier, n.d.). Although published estimates do not exist for Delaware, the proportions are likely similar. Additional information needs have been recognized and presented as conservation actions in Chapter 4 to better quantify and understand Delaware's invertebrate fauna. Of the more than 1700 invertebrate species documented from the state, over 300 species are considered as SGCN.

Insects

There are more than 163,000 species of insects in the U.S. and Canada, but much of this incredible diversity is not yet understood. In adjacent Pennsylvania, insects alone make up an estimated 45.8% of all species in the state, plant or animal, and 76.3% of animal species (Rawlins and Bier, n.d.) The numbers are likely similar in Delaware. Despite this tremendous dominance in terms of biodiversity, the ecology, distribution, and habitat associations of most species remain poorly known.

Highly specialized relationships between insects and host plants can render some insects highly vulnerable to extinction should the host decline. It is presumed, for example, that at least two species of moths have become extinct due to the loss of the American chestnut (Dunn 2005). Similar risks exist for species dependent on plants threatened by invasive species, such as ashes (*Fraxinus* sp.), which may decline in Delaware in the near future as a result of emerald ash borer invasion. Pollinators are dependent on sufficient diversity and abundance of host plants for pollen and nectar, and these relationships are also becoming threatened due to development, invasive species, and other factors.

Dragonflies and Damselflies

Dragonflies and damselflies are relatively well-known in Delaware, thanks largely to the efforts of H.B. White, whose *Natural History of Delmarva Dragonflies and Damselflies* (2011) presents a series of essays on all species known to occur on the peninsula as well as a county distribution checklist.

The regional status and habitat associations of northeastern odonates were assessed by White et al. (2014). Two hundred twenty-eight species of odonates are known from the northeast region, an area that is widely considered to be a "hotspot" for odonate diversity, and 130 of those species are known to occur on the Delmarva Peninsula.

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Eighty-four species are included on the SGCN list for Delaware, ranging from common species for which the Northeast has high conservation responsibility, to rare species, as well as many species that are at the edge of their ranges in the state (Table 1.32). The elfin skimmer (Figure 1.11) is a state Endangered species.

Table 1. 32 Delaware Odonate SGCN

Dragonfly & Damselfly SGCN (84)		
<i>Aeshna tuberculifera</i>	Black-tipped Darner	Tier 1
<i>Argia bipunctulata</i>	Seepage Dancer	Tier 1
<i>Cordulegaster bilineata</i>	Brown Spiketail	Tier 1
<i>Cordulegaster erronea</i>	Tiger Spiketail	Tier 1
<i>Enallagma dubium</i>	Burgundy Bluet	Tier 1
<i>Enallagma pallidum</i>	Pale Bluet	Tier 1
<i>Epitheca spinosa</i>	Robust Baskettail	Tier 1
<i>Gomphaeschna antilope</i>	Taper-tailed Darner	Tier 1
<i>Gomphus apomyius</i>	Banner Clubtail	Tier 1
<i>Gomphus fraternus</i>	Midland Clubtail	Tier 1
<i>Gomphus rogersi</i>	Sable Clubtail	Tier 1
<i>Helocordulia selysii</i>	Selys' Sundragon	Tier 1
<i>Lanthus vernalis</i>	Southern Pygmy Clubtail	Tier 1
<i>Lestes eurinus</i>	Amber-winged Spreadwing	Tier 1
<i>Nannothemis bella</i>	Elfin Skimmer	Tier 1
<i>Rhionaeschna mutata</i>	Spatterdock Darner	Tier 1
<i>Somatochlora provocans</i>	Treetop Emerald	Tier 1
<i>Stylurus laurae</i>	Laura's Clubtail	Tier 1
<i>Aeshna verticalis</i>	Green-striped Darner	Tier 2
<i>Archilestes grandis</i>	Great Spreadwing	Tier 2
<i>Argia translata</i>	Dusky Dancer	Tier 2
<i>Brachymesia gravida</i>	Four-spotted Pennant	Tier 2
<i>Calopteryx dimidiata</i>	Sparkling Jewelwing	Tier 2
<i>Celithemis verna</i>	Double-ringed Pennant	Tier 2

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<i>Chromagrion conditum</i>	Aurora Damsel	Tier 2
<i>Cordulegaster diastatops</i>	Delta-spotted Spiketail	Tier 2
<i>Dromogomphus spinosus</i>	Black-shouldered Spinyleg	Tier 2
<i>Enallagma basidens</i>	Double-striped Bluet	Tier 2
<i>Enallagma daeckii</i>	Attenuated Bluet	Tier 2
<i>Enallagma durum</i>	Big Bluet	Tier 2
<i>Enallagma vesperum</i>	Vesper Bluet	Tier 2
<i>Enallagma weewa</i>	Blackwater Bluet	Tier 2
<i>Epitheca costalis</i>	Slender Baskettail	Tier 2
<i>Erythrodiplax berenice</i>	Seaside Dragonlet	Tier 2
<i>Erythrodiplax minuscula</i>	Little Blue Dragonlet	Tier 2
<i>Gomphaeschna furcillata</i>	Harlequin Darner	Tier 2
<i>Ischnura kellicotti</i>	Lilypad Forktail	Tier 2
<i>Lestes australis</i>	Southern Spreadwing	Tier 2
<i>Lestes congener</i>	Spotted Spreadwing	Tier 2
<i>Lestes forcipatus</i>	Sweetflag Spreadwing	Tier 2
<i>Lestes inaequalis</i>	Elegant Spreadwing	Tier 2
<i>Libellula auripennis</i>	Golden-winged Skimmer	Tier 2
<i>Libellula axilena</i>	Bar-winged Skimmer	Tier 2
<i>Libellula needhami</i>	Needham's Skimmer	Tier 2
<i>Macromia illinoensis</i>	Swift River Cruiser	Tier 2
<i>Macromia taeniolata</i>	Royal River Cruiser	Tier 2
<i>Nehalennia gracilis</i>	Sphagnum Sprite	Tier 2
<i>Nehalennia integricollis</i>	Southern Sprite	Tier 2
<i>Neurocordulia obsoleta</i>	Umber Shadowdragon	Tier 2
<i>Progomphus obscurus</i>	Common Sanddragon	Tier 2
<i>Somatochlora filosa</i>	Fine-lined Emerald	Tier 2
<i>Stylogomphus albistylus</i>	Eastern Least Clubtail	Tier 2

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<i>Stylurus plagiatus</i>	Russet-tipped Clubtail	Tier 2
<i>Stylurus spiniceps</i>	Arrow Clubtail	Tier 2
<i>Sympetrum semicinctum</i>	Band-winged Meadowhawk	Tier 2
<i>Telebasis byersi</i>	Duckweed Firetail	Tier 2
<i>Amphiagrion saucium</i>	Eastern Red Damsel	Tier 3
<i>Anax longipes</i>	Comet Darner	Tier 3
<i>Arigomphus villosipes</i>	Unicorn Clubtail	Tier 3
<i>Basiaeschna janata</i>	Springtime Darner	Tier 3
<i>Boyeria vinosa</i>	Fawn Darner	Tier 3
<i>Celithemis elisa</i>	Calico Pennant	Tier 3
<i>Cordulegaster maculata</i>	Twin-spotted Spiketail	Tier 3
<i>Didymops transversa</i>	Stream Cruiser	Tier 3
<i>Enallagma aspersum</i>	Azure Bluet	Tier 3
<i>Enallagma divagans</i>	Turquoise Bluet	Tier 3
<i>Enallagma geminatum</i>	Skimming Bluet	Tier 3
<i>Enallagma traviatum</i>	Slender Bluet	Tier 3
<i>Gomphus exilis</i>	Lancet Clubtail	Tier 3
<i>Gomphus lividus</i>	Ashy Clubtail	Tier 3
<i>Lestes rectangularis</i>	Slender Spreadwing	Tier 3
<i>Lestes vigilax</i>	Swamp Spreadwing	Tier 3
<i>Libellula cyanea</i>	Spangled Skimmer	Tier 3
<i>Libellula semifasciata</i>	Painted Skimmer	Tier 3
<i>Somatochlora linearis</i>	Mocha Emerald	Tier 3
<i>Somatochlora tenebrosa</i>	Clamp-tipped Emerald	Tier 3
<i>Sympetrum rubicundulum</i>	Ruby Meadowhawk	Tier 3
<i>Argia sedula</i>	Blue-ringed Dancer	Data Needs - Historical
<i>Celithemis fasciata</i>	Black Spotted Skimmer	Data Needs - Historical
<i>Celithemis martha</i>	Martha's Pennant	Data Needs - Historical
<i>Leucorrhinia intacta</i>	Dot-tailed Whiteface	Data Needs - Historical

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<i>Libellula flavida</i>	Yellow-sided Skimmer	Data Needs - Historical
<i>Nehalennia irene</i>	Sedge Sprite	Data Needs

A worldwide assessment of the conservation status of odonates conducted by Clausnitzer et al. (2009) found that only about 1 in 10 odonates was currently threatened with extinction according to IUCN criteria, a relatively low percentage compared to other taxa. However, 18% of the northeastern U.S. odonate fauna is imperiled. Peatlands, low gradient streams and seeps, high gradient headwaters, and larger rivers are habitats that harbor a disproportionate number of imperiled species in our region and should be considered priority habitat types for conservation, monitoring, and management (Figure 1.12) (White et al. 2014). In fact, Collins (2014) found that future climate change will significantly impact the range of all 15 northeastern lotic species in his climate modeling study, even assuming unlimited dispersal.



Figure 1. 11 Elfin skimmer (*Nannothemis bella*) is a state Endangered odonate restricted to Coastal Plain peatlands, especially sea level fens. Photo: Michael Moore

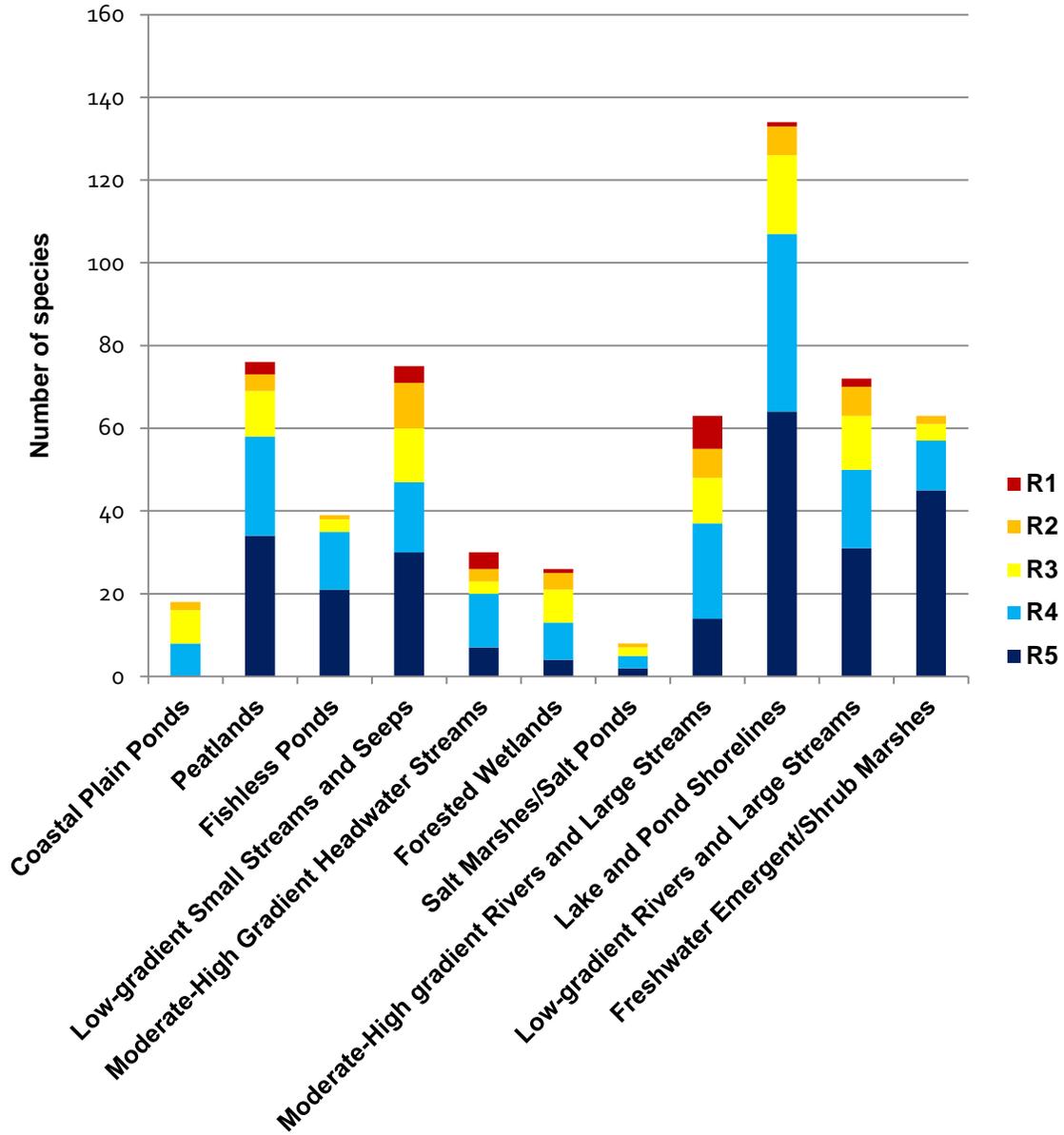


Figure 1. 12 Relative importance of habitat types to dragonflies and damselflies in the Northeast. From White et al. (2014). Regional ranks are depicted by colors, with R1 the most imperiled.

Lepidoptera: Butterflies and Moths

Butterflies and Skippers

Forty-one of the approximately 105 species of butterflies and skippers that occur or have occurred historically in Delaware are considered SGCN (Table 1.33). Many Delaware SGCN are associated with relatively rare small-patch habitats such as Piedmont seepage meadows and xeric sand ridge openings. A butterfly of herbaceous wetlands is the Baltimore checkerspot (Figure 1.13), a Tier 1 species.

Table 1. 33 Delaware Butterfly and Skipper SGCN

Butterfly & Skipper SGCN (41)		
Early Successional Herbaceous Butterflies		
<i>Danaus plexippus</i>	Monarch	Tier 1
<i>Anatrytone logan</i>	Delaware Skipper	Tier 2
<i>Boloria bellona</i>	Meadow Fritillary	Data Needs
<i>Erynnis baptisiae</i>	Wild Indigo Duskywing	Data Needs
<i>Pompeius verna</i>	Little Glassywing	Data Needs
<i>Pontia protodice</i>	Checkered White	Data Needs
<i>Speyeria idalia</i>	Regal Fritillary	Extirpated
Early Successional Shrubland Butterflies		
<i>Callophrys gryneus</i>	Juniper Hairstreak	Tier 2
Floodplain Forest Butterflies		
<i>Asterocampa celtis</i>	Hackberry Emperor	Tier 2
<i>Asterocampa clyton</i>	Tawny Emperor	Tier 2
<i>Libytheana carinenta</i>	American Snout	Tier 2
<i>Autochton cellus</i>	Gold-banded Skipper	Data Needs - Historical
Forest Butterflies		
<i>Erynnis martialis</i>	Mottled Duskywing	Tier 1
<i>Feniseca tarquinius</i>	Harvester	Tier 1
<i>Satyrrium liparops strigosum</i>	Striped Hairstreak	Tier 2

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<i>Polygonia progne</i>	Gray Comma	Data Needs - Historical
Forest Edge Butterflies		
<i>Erynnis icelus</i>	Dreamy Duskywing	Data Needs
<i>Poanes hobomok</i>	Hobomok Skipper	Data Needs
Forest Understory Butterflies		
<i>Celastrina neglectamajor</i>	Appalachian Azure	Tier 1
<i>Battus philenor</i>	Pipevine Swallowtail	Tier 2
<i>Callophrys henrici</i>	Henry's Elfin	Data Needs
Habitat Generalist Butterflies		
<i>Speyeria aphrodite</i>	Aphrodite Fritillary	Tier 1
Herbaceous Wetland Butterflies		
<i>Euphydryas phaeton</i>	Baltimore Checkerspot	Tier 1
<i>Euphyes conspicua</i>	Black Dash	Tier 1
<i>Euphyes dion</i>	Dion Skipper	Tier 1
<i>Poanes massasoit chermocki</i>	Chermock's Mulberry Wing	Tier 1
<i>Poanes massasoit massasoit</i>	Mulberry Wing	Tier 1
<i>Boloria selene myrina</i>	Myrina Fritillary	Tier 2
<i>Lycaena hyllus</i>	Bronze Copper	Tier 2
<i>Lethe eurydice</i>	Eyed Brown	Data Needs - Historical
Forested Wetland Butterflies		
<i>Atlides halesus</i>	Great Purple Hairstreak	Tier 1
<i>Callophrys hesseli</i>	Hessel's Hairstreak	Tier 1
<i>Satyrium kingi</i>	King's Hairstreak	Tier 1
<i>Wallengrenia otho</i>	Southern Broken-Dash	Tier 2
Tidal Wetland Butterflies		
<i>Problema bulenta</i>	Rare Skipper	Tier 1
Xeric Opening Butterflies		
<i>Atrytonopsis hianna</i>	Dusted Skipper	Tier 1

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<i>Callophrys irus</i>	Frosted Elfin	Tier 1
<i>Hesperia metea</i>	Cobweb Skipper	Tier 1
<i>Callophrys augustinus</i>	Brown Elfin	Data Needs
<i>Erynnis brizo brizo</i>	Sleepy Duskywing	Data Needs
<i>Hesperia sassacus</i>	Indian Skipper	Data Needs

The Northeast RSGCN list is dominated by two families, the skippers (family HesperIIDae) and the blues, coppers, and elfins (family LycaenIDae). Butterflies of the families HesperIIDae and LycaenIDae occur in large numbers on the regional and state SGCN lists because many species in these families are small-bodied, relatively weak fliers with very specific host plant requirements, or they have other narrow ecological specializations such as association with specific vegetation communities. In addition, the larvae of many species of LycaenIDae participate in symbiotic relationships with ants, so that both the larval host plant and suitable ant partners must be available in order for the species to thrive.



Figure 1. 13 Baltimore checkerspot (*Euphydryas phaeton*) is a declining SGCN found in Delaware only in Piedmont wetlands. This species may disappear from the state due to the combined effects of climate change and other factors. Photo: Jim White

Beginning in the 1990s, researchers have documented a steady decline in monarch butterfly (*Danaus plexippus*, Figure 1.14) numbers. A primary threat to the monarch butterfly is a decline in populations of milkweed, the primary food plant required by caterpillars. The decline in milkweed is partially due to the reduction of open habitats, but in the Midwest losses are mostly due to the dramatic increase in use of the herbicide Roundup (glyphosphate), which has been associated with the mass-planting of genetically modified herbicide resistant corn and soy (Pleasants and Oberhauser 2012). In addition, the widespread use of systemic insecticides such as neonicotinoids within the breeding range of the monarch poses a considerable threat; illegal logging of fir forests in Mexico has reduced wintering habitat; and extreme weather events in the eastern U.S. may be negatively impacting Monarchs.

In recognition of the decline in monarch butterflies, the Monarch Joint Venture (MJV) was initiated in December 2008 as a partnership of federal agencies, state agencies, non-governmental organizations, and academic programs working together to protect the monarch and its annual, long-distance migration. Guided by the North American Monarch Conservation Plan (2008), the MJV is taking a science-based approach to addressing monarch conservation issues. The MJV promotes monarchs as a flagship species whose conservation will sustain habitats for pollinators

and other plants and animals. For more information about MJV:

<http://www.monarchjointventure.org/>.



Figure 1. 14 Monarch (*Danaus plexippus*) populations have crashed rangewide in recent years. This migratory species depends on milkweeds (*Asclepias* spp.) as its larval host plant. Photo: Jenny Bothell

Moths

The nocturnal Macrolepidoptera ("larger moths") of Delaware have been studied in recent years by Heckscher, Gonzon, and others. Still, much of our data is based on regional sources. Important recent studies by Tuttle (2007), Schweitzer et al. (2011), and Wagner et al. (2011) have greatly improved the readily accessible body of knowledge on northeastern macromoth species of conservation interest. More than one thousand species of moths have been documented in Delaware, with some groups receiving greater attention than others. One hundred and six species of moths were identified as SGCN in Delaware (Table 1.34).

The larvae of moths in the genus *Papaipema* (family Noctuidae) bore into the stems and tubers of plants and many are specific to a particular species of plant. Host specificity has resulted in many species becoming rare due to the decline of their host plant. A recent survey of Brandywine Creek State Park (New Castle County) by Heckscher and Schweitzer (unpub. data) found that the meadow *Papaipema* fauna was largely intact while the forest understory fauna was mostly depauperate

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probably due to deer over-browse, alien earthworms, and alien plant species. The family of sphinx or hawk moths (family Sphingidae) includes several well-known agricultural pests as well as several rare and declining species. Certain hawk moths are diurnally active and many species can be important pollinators of flowers with long, tubular corollas.

Giant silkworm moths (family Saturniidae) are among the most colorful and spectacular species of Lepidoptera in the world and several of the largest and most beautiful species have recently declined across the Northeast. These declines have been anecdotally attributed to increased spraying of chemicals for mosquito and other pest control and to increased anthropogenic light pollution, which disrupts the normal nocturnal flight patterns of these insects. The buck moth (*Hemileuca maia*) is a diurnal silkworm moth closely associated with scrub oak that primarily occurs in serpentine barrens where this oak often dominates the understory. The buck moth has experienced notable declines in the northeast due to habitat loss.

The *Catocala* (underwing) moths are among the most impressive and most speciose Noctuidae groups in eastern North America. Many species are designated Delaware SGCN due to their dependency on specific host plants that may be uncommon. For example, several species are dependent upon shagbark hickory (*Carya ovata*) which is uncommon in the state outside the Red Clay Creek valley. Other reasons for rarity in this moth group include Delaware’s position at the northern or southern edge of the natural range of several species. Xeric or semi-xeric sand ridges and forests in Sussex County are scattered but highly threatened by development. These forests are often hickory-rich providing important concentrations of Coastal Plain *Catocala* populations. Similarly, mesic hardwood forests of the Piedmont often support a mix of several hickory species providing a rich *Catocala* fauna including some regionally uncommon species. Salicaceae feeding species may be threatened by SLR including *Catocala carissima*.

Summerville and Crist (2002) and Summerville (2004) in the U.S., along with Pavlikova and Konvicka (2011) in Europe, have shown that classification of moth functional groups by life form of the larval food source is useful in predicting responses to habitat change. The ecological groups below classify Delaware’s SGCN by broad habitat type and by larval host plant life form.

Table 1. 34 Delaware Moth SGCN

Moth SGCN (106)		
Dune Herb-feeding Moths (4)		
<i>Drasteria graphica</i>	Graphic Moth	Tier 1
<i>Melitara prodenialis</i>	Eastern Cactus-boring Moth	Data Needs - Historical
<i>Schinia spinosae</i>	A Noctuid Moth	Data Needs - Historical
<i>Sympistis perscripta</i>	A Noctuid Moth	Data Needs - Historical
Forest Herb-feeding Moths (7)		

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<i>Hadena ectypa</i>	A Noctuid Moth	Tier 1
<i>Lintneria eremitus</i>	Hermit Sphinx	Tier 1
<i>Papaipema astuta</i>	Yellow Stoneroot Borer	Tier 1
<i>Papaipema duplicatus</i>	Dark Stoneroot Borer Moth	Tier 1
<i>Papaipema pterisii</i>	Bracken Borer Moth	Data Needs - Historical
<i>Papaipema rutila</i>	Mayapple Borer Moth	Data Needs - Historical
<i>Papaipema lysimachiae</i>	Loosestrife Borer Moth	Data Needs
Forest Litter-feeding Moths (1)		
<i>Macrochilo louisiana</i>	Louisiana Macrochilo	Data Needs
Forest Tree Canopy-feeding Moths (17)		
<i>Catocala dejecta</i>	Dejected Underwing	Tier 1
<i>Catocala ulalume</i>	An Underwing Moth	Tier 1
<i>Catocala flebilis</i>	Mournful Underwing	Tier 2
<i>Catocala habilis</i>	Habilis Underwing	Tier 2
<i>Catocala lacrymosa</i>	Tearful Underwing	Tier 2
<i>Catocala nebulosa</i>	Clouded Underwing	Tier 2
<i>Catocala obscura</i>	Obscure Underwing	Tier 2
<i>Catocala residua</i>	Residua Underwing	Tier 2
<i>Lapara coniferarum</i>	Southern Pine Sphinx	Tier 2
<i>Zale metata</i>	A Noctuid Moth	Tier 2
<i>Zale metatoides</i>	Washed-out Zale Moth	Tier 2
<i>Catocala innubens</i>	The Betrothed Underwing	Tier 3
<i>Catocala cerogama</i>	Yellow Banded Underwing	Data Needs - Historical
<i>Catocala insolabilis</i>	Inconsolable Underwing	Data Needs - Historical
<i>Catocala minuta</i>	Little Underwing	Data Needs - Historical
<i>Sphinx franckii</i>	Franck's Sphinx	Data Needs - Historical
<i>Tolype notialis</i>	Small Tolype Moth	Data Needs - Historical
Forest Tree-feeding Moths (15)		
<i>Papaipema marginidens</i>	A Borer Moth	Tier 1
<i>Acronicta exilis</i>	Exiled Dagger Moth	Tier 2
<i>Catocala maestosa</i>	Sad Underwing	Tier 2
<i>Catocala umbrosa</i>	An Underwing Moth	Tier 2
<i>Lophocampa caryae</i>	Hickory Tussock Moth	Tier 2
<i>Acronicta lithospila</i>	Streaked Dagger Moth	Data Needs - Historical

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<i>Amorpha juglandis</i>	Walnut Sphinx	Data Needs - Historical
<i>Ceratomia undulosa</i>	Waved Sphinx	Data Needs - Historical
<i>Copivaleria grotei</i>	Grote's Sallow	Data Needs - Historical
<i>Haploa colona</i>	Colona Moth	Data Needs - Historical
<i>Heterocampa astarte</i>	A Notodontid Moth	Data Needs - Historical
<i>Manduca jasminearum</i>	Ash Sphinx	Data Needs - Historical
<i>Eacles imperialis</i>	Imperial Moth	Data Needs
<i>Papaipema furcata</i>	Ash Borer Moth	Data Needs
<i>Synanthedon castaneae</i>	Chestnut Clearwing Moth	Extirpated
Forest Understory-feeding Moths (16)		
<i>Catocala alabamae</i>	Alabama Underwing	Tier 1
<i>Papaipema araliae</i>	Aralia Shoot Borer Moth	Tier 1
<i>Catocala mira</i>	Wonderful Underwing	Tier 2
<i>Catocala praeclara</i>	Praeclara Underwing	Tier 2
<i>Manduca rustica</i>	Rustic Sphinx	Tier 2
<i>Xestia dilucida</i>	A Noctuid Moth	Tier 2
<i>Amphion floridensis</i>	Nessus Sphinx	Tier 3
<i>Acronicta rubricoma</i>	Ruddy Dagger Moth	Data Needs - Historical
<i>Catocala antinympa</i>	Sweetfern Underwing	Data Needs - Historical
<i>Deidamia inscriptum</i>	Lettered Sphinx	Data Needs - Historical
<i>Dolba hyloeus</i>	Pawpaw Sphinx	Data Needs - Historical
<i>Paonias astylus</i>	Huckleberry Sphinx	Data Needs - Historical
<i>Paratreia plebeja</i>	Plebian Sphinx	Data Needs - Historical
<i>Sphinx chersis</i>	Great Ash Sphinx	Data Needs - Historical
<i>Acronicta increta</i>	Southern Oak Dagger Moth	Data Needs
<i>Hemileuca maia maia</i>	Eastern Buckmoth	Data Needs
Freshwater Wetland Herb-feeding Moths (12)		
<i>Exyra fax</i>	Pitcher Plant Moth	Tier 1
<i>Papaipema appassionata</i>	Pitcher Plant Borer Moth	Tier 1
<i>Papaipema speciosissima</i>	Osmunda Borer Moth	Tier 1
<i>Tarache delecta</i>	A Noctuid Moth	Tier 1
<i>Cirrhophanus triangulifer</i>	A Noctuid Moth	Tier 2
<i>Papaipema stenocelis</i>	Chain Fern Borer Moth	Tier 2
<i>Apamea helva</i>	A Noctuid Moth	Tier 3
<i>Papaipema inquaesita</i>	Sensitive Fern Borer Moth	Tier 3

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<i>Papaipema birdi</i>	Umbellifer Borer Moth	Data Needs - Historical
<i>Parapamea buffaloensis</i>	Buffalo Moth	Data Needs - Historical
<i>Bellura gortynoides</i>	A Noctuid Moth	Data Needs
<i>Capsula subflava</i>	A Noctuid Moth	Data Needs
Freshwater Wetland Shrub-feeding Moths (2)		
<i>Darapsa versicolor</i>	Hydrangea Sphinx	Tier 2
<i>Argyrostromis quadrifilaris</i>	Four-lined Chocolate Moth	Data Needs - Historical
Freshwater Wetland Tree-feeding Moths (10)		
<i>Catocala marmorata</i>	Marbled Underwing	Tier 1
<i>Iridopsis pergracilis</i>	A Geometrid Moth	Tier 1
<i>Orgyia detrita</i>	A Tussock Moth	Tier 1
<i>Catocala carissima</i>	An Underwing Moth	Tier 2
<i>Pero ancetaria</i>	Hübner's Pero	Tier 2
<i>Acronicta connecta</i>	Connected Dagger Moth	Data Needs - Historical
<i>Catocala parta</i>	Mother Underwing	Data Needs - Historical
<i>Catocala unijuga</i>	Once-married Underwing	Data Needs - Historical
<i>Cerura scitiscrupta</i>	Black-Etched Prominent	Data Needs - Historical
<i>Gluphisia lintneri</i>	A Notodontid Moth	Data Needs - Historical
Lichen-feeding Moths (4)		
<i>Nigetia formosalis</i>	Thin-winged Owlet Moth	Tier 1
<i>Cisthene kentuckiensis</i>	Kentucky Lichen Moth	Data Needs - Historical
<i>Cisthene tenuifascia</i>	Thin-Banded Lichen Moth	Data Needs - Historical
<i>Parahypenodes quadralis</i>	A Noctuid Moth	Data Needs
Meadow Herb-feeding Moths (13)		
<i>Papaipema circumlucens</i>	Hop Borer	Tier 1
<i>Papaipema maritima</i>	Maritime Sunflower Borer Moth	Tier 1
<i>Papaipema nelita</i>	A Borer Moth	Tier 1
<i>Schinia septentrionalis</i>	A Noctuid Moth	Tier 1
<i>Azenia obtusa</i>	Obtuse Yellow	Tier 2
<i>Calyptra canadensis</i>	Canadian Owlet	Tier 2
<i>Grammia phyllira</i>	Phyllira Tiger Moth	Data Needs - Historical
<i>Papaipema baptisiae</i>	Wild Indigo Borer Moth	Data Needs - Historical
<i>Papaipema eupatorii</i>	Eupatorium Borer Moth	Data Needs - Historical
<i>Papaipema rigida</i>	A Borer Moth	Data Needs - Historical

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<i>Schinia trifascia</i>	Three-lined Flower Moth	Data Needs - Historical
<i>Agrius cingulata</i>	Pink-spotted Hawkmoth	Data Needs
<i>Hyles gallii</i>	Galium Sphinx	Data Needs
Pine-feeding Moths (2)		
<i>Zale squamularis</i>	A Noctuid Moth	Tier 1
<i>Caripeta aretaria</i>	A Geometrid Moth	Tier 2
Tidal Marsh Moths (1)		
<i>Pero zalissaria</i>	A Geometrid Moth	Tier 2
Undetermined (2)		
<i>Agnorisma bollii</i>	A Noctuid Moth	Tier 2
<i>Chloropteryx tepperaria</i>	Angle Winged Emerald Moth	Tier 2

Beetles

Tiger Beetles

Tiger beetles (e.g., Figure 1.15) are a group of highly active, predatory beetles that have been variously classified as either a subfamily (Cicindelinae) within the larger Family Carabidae, or a separate Family Cicindelidae. The Northeast RSGCN list includes 11 tiger beetle taxa, encompassing over half of the Northeast tiger beetle fauna. Several tiger beetle species remain common throughout the Northeast, including the six-spotted tiger beetle (*Cicindela sexguttata*), bronzed tiger beetle (*Cicindela repanda*), and punctate tiger beetle (*Cicindela punctulata*), which can be found in many urban and suburban areas. Fourteen species are considered SGCN in Delaware (Table 1.35).

Sympatric tiger beetle species (those that occur together in the same habitat) and their larvae are often closely associated with particular microhabitats, especially exposures of different soil types, such as sand or clay (Schultz 1989). Distinct thermal microhabitat preferences have also been described for oviposition (Hoback et al. 2000) and adult activity (Schultz 1998). These specializations make some species susceptible to habitat degradation that alters or eliminates their necessary microhabitats.

Several tiger beetle species are known to be in decline range-wide. These include *Cicindela patruela*, a pine barrens and ridge-top barrens species that has been lost from many historical sites in the Northeast states, as well as *Cicindela lepida*, a species that was formerly associated with sand dunes and other open sandy areas across the central and eastern states. Knisely et al. (2014) reviews the conservation status of U.S. tiger beetle species.

Certain guilds of tiger beetles are known to be at elevated risk for extirpation or even extinction. Population declines have been documented in many species of tiger beetles associated with ocean beaches, including two Northeast RSGCN, the federally listed *Cicindela dorsalis dorsalis* and its

southern counterpart *Cicindela dorsalis media*. Beach-nesting tiger beetles have been found to be sensitive to compaction of sands resulting from human disturbance (Cornelisse 2009), a factor that has probably contributed to the widespread decline of *Cicindela dorsalis*. Whereas other beach-dependent species such as piping plover (a shorebird) leave Delaware’s beaches during the winter, tiger beetles spend their entire lives in this habitat and are vulnerable to vehicular use at all seasons. *Cicindela dorsalis dorsalis* was federally listed as Threatened in 1990, with a Recovery Plan drafted in 1994 (USFWS 1994).



Figure 1. 15 The Eastern beach tiger beetle (*Cicindela dorsalis*) once occurred in Delaware but may no longer occur in the state. Its sandy beach habitats have been heavily impacted by destruction and disturbance of natural beach habitat from shoreline development, beach stabilization, and high levels of recreational use. Photo: Mike Drummond/USFWS

One of the tiger beetles on the RSGCN list is primarily nocturnal or crepuscular and thus is often overlooked in diurnal beetle surveys. *Cicindela unipunctata* was once thought to be uncommon to rare throughout its range, but pitfall trapping studies in the New Jersey Pine Barrens demonstrated that this species can occur in large numbers at sites where it is not observed during daylight hours (Boyd 1985).

Table 1. 35 Delaware Tiger Beetle SGCN

Tiger Beetle SGCN (14)		
<i>Cicindela dorsalis</i>	Eastern Beach Tiger Beetle	Tier 1

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<i>Cicindela dorsalis media</i>	White Tiger Beetle	Tier 1
<i>Cicindela lepida</i>	Ghost Tiger Beetle	Tier 1
<i>Cicindela patruela</i>	Northern Barrens Tiger Beetle	Tier 1
<i>Cicindela hirticollis</i>	Hairy-necked Tiger Beetle	Tier 2
<i>Cicindela marginata</i>	Margined Tiger Beetle	Tier 2
<i>Cicindela scutellaris</i>	Festive Tiger Beetle	Tier 2
<i>Cicindela unipunctata</i>	One-spotted Tiger Beetle	Tier 2
<i>Cicindela duodecimguttata</i>	Twelve-spotted Tiger Beetle	Data Needs
<i>Cicindela formosa generosa</i>	Big Sand Tiger Beetle	Data Needs
<i>Cicindela purpurea</i>	Cow Path Tiger Beetle	Data Needs
<i>Cicindela rufiventris</i>	Eastern Red-bellied Tiger Beetle	Data Needs
<i>Tetracha virginica</i>	Virginia Big-headed Tiger Beetle	Data Needs
<i>Cicindela patruela consentanea</i>	New Jersey Pine Barrens Tiger Beetle	Extirpated

Delaware's SGCN tiger beetle list could potentially be expanded, and populations of conservation importance located, with additional survey effort. For example, the tiny pine barrens specialist *Cicindela abdominalis* is found at relatively few sites across the entire Northeast, but has large populations in the New Jersey Pine Barrens and occurs on the Maryland portion of Delmarva. This species has been looked for by K. Heckscher in Sussex County, without success, but further inventory is warranted.

Fireflies

The study of fireflies has a rich history in Delaware, thanks largely to pioneering work by Frank A. McDermott, a chemist who spent his retirement studying this family and in the process became one of only a few North American experts on the taxon. McDermott discovered a new firefly species near the town of Bethany Beach in 1946 and named it *Photuris bethaniensis*, the Bethany Beach firefly (McDermott 1953). So far, this species has not been found outside the state of Delaware and is currently recognized as Delaware's only endemic species. Another Delaware species, *Photuris mysticalampas*, was discovered and described by Christopher M. Heckscher in 2013 (Heckscher 2013, Figure 1.16). Like *Photuris bethaniensis*, this species has not been found outside of Delaware;

however, it is assumed that it occurs in Maryland as much suitable habitat can be found in that state. Due to its history as an epicenter for the study of North American fireflies, the distribution and abundance of many Delaware species are fairly well known. Consequently, Delaware is likely the only Northeastern state to have evaluated the conservation status of its fireflies so thoroughly.

Three genera of nocturnal bioluminescent fireflies are widespread in North America: *Photuris*, *Photinus*, and *Pyrractomena*. Of the three, the *Photuris* are the best understood in Delaware, largely because of the work of McDermott and Heckscher, while elsewhere more is known about the distribution and abundance of *Photinus* than *Photuris*. From the collections of McDermott, *Pyrractomena dispersa* was described from the wetlands of the Beaver Valley of the upper Brandywine watershed (Green 1957). In addition, *Photuris bethaniensis* and *Photuris mysticalampas* were first described from Bethany Beach and Phillips Landing, respectively. *Photuris pennsylvanica* is thought to have been first collected and described from the marshes of Wilmington, Delaware (McDermott 1967). Thus, four species have their type locality in Delaware: *Pyrractomena dispersa*, *Photuris bethaniensis*, *Photuris mysticalampas*, *Photuris pennsylvanica*.



Figure 1. 16 A new species of firefly, *Photuris mysticalampas*, was recently described from Delaware. Photo: Christopher Heckscher

Most fireflies are associated with wetlands, as the soft-bodied larvae, better known as glowworms, might otherwise be susceptible to desiccation. Soil chemistry, microclimate (e.g., humidity, temperature), or prey items, might also limit the distribution of some species. Due to their affiliation with various threatened wetland types, several species are of high conservation concern. *Photuris bethaniensis* is restricted to rare and threatened interdunal wetlands that occur within the backdunes along Delaware's Atlantic coast (Heckscher and Bartlett 2004). Interdunal swales are threatened by SLR, coastal development, and invasive plant species. *Photuris mysticalampas* is associated with forested peatland floodplains of high ecological quality in Sussex County (Heckscher 2013). *Photuris pennsylvanica* is associated with freshwater emergent and shrub wetlands that are usually tidally influenced (Heckscher 2010). All tidal freshwater wetlands are becoming increasingly

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threatened by SLR. *Photuris salina* and *Pyralomima ecostata* are both restricted to salt and brackish coastal marshes and are therefore likely threatened by SLR, adulticides used for mosquito control, and the spread of the invasive *Phragmites australis* (Heckscher 2010; Heckscher and Lloyd, in press). All fireflies are suspected of being sensitive to pesticide application including those that occur in urban areas. In general, many species seem to be in regional decline especially representatives of the genus *Pyralomima* (Heckscher and Lloyd, in press). Thirteen species of fireflies were identified as SGCN in Delaware (see Table 1.36).

Table 1. 36 Delaware Firefly SGCN

Firefly SGCN (10)		
<i>Photinus floridanus</i>	A Firefly	Tier 1
<i>Photuris bethaniensis</i>	Bethany Beach Firefly	Tier 1
<i>Photuris cinctipennis</i>	A Firefly	Tier 2
<i>Photuris frontalis</i>	A Firefly	Tier 2
<i>Photuris hebes</i>	A Firefly	Tier 2
<i>Photuris pennsylvanica</i>	A Firefly	Tier 2
<i>Photuris pyralomimus</i>	A Firefly	Tier 2
<i>Photuris tremulans</i>	A Firefly	Tier 2
<i>Photinus ignitus</i>	A Firefly	Tier 3
<i>Pyralomima dispersa</i>	A Firefly	Tier 3
Forest Firefly SGCN (1)		
<i>Photuris mysticalampas</i>	A Firefly	Tier 1
Tidal Marsh Firefly SGCN (2)		
<i>Photuris salina</i>	A Firefly	Tier 2
<i>Pyralomima ecostata</i>	A Firefly	Tier 2

Water Beetles

Four species of freshwater beetles were identified as SGCN in Delaware (Table 1.37). Water beetles reach high levels of diversity in isolated wetlands, especially vernal pools and Coastal Plain seasonal ponds. With a high density of these habitat types, Delaware, and the Delmarva Peninsula as a whole, are likely a “hotspot” for water beetle diversity. The absence of fish is a major factor

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influencing community composition and abundance of water beetles in pond habitats (Fairchild et al. 2000).

The Seth Forest water scavenger beetle (*Hydrochus spangleri*), a globally critically imperiled beetle known from a single wetland in Maryland since the 1970s, was subsequently found to inhabit a handful of similar sites in the northern part of the Delmarva peninsula, including New Castle County, Delaware (Steiner et al. 2003). Surveys by McIntosh and Short (2012) revealed the continuing occurrence of the species in two small and densely forested vernal pools in northern Delaware.

The primary threat to water beetles is residential and commercial development of the unprotected, isolated wetlands in which they occur, as well as the surrounding forest matrix. In addition, climate change may affect these species due to their reliance on a shallow, ephemeral wetland habitat combined with apparently very limited dispersal ability. Many species are attracted to lights, so light pollution may be an additional threat for populations in fragmented habitats near residential and commercial areas.

Table 1. 37 Delaware Freshwater Beetle SGCN

Freshwater Beetle SGCN (4)		
<i>Hoperius planatus</i>	A Predaceous Diving Beetle	Tier 1
<i>Hydrochus spangleri</i>	Seth Forest Water Scavenger Beetle	Tier 1
<i>Agabetes acuductus</i>	A Predaceous Diving Beetle	Data Needs
<i>Helocombus bifidus</i>	A Water-scavenger Beetle	Data Needs

Other Beetles

Two other species of beetles were identified as SGCN in Delaware (Table 1.38). These two species historically occurred in Delaware but there are no recent records. American burying beetle is a federally-listed beetle that was once widespread throughout eastern North America but has declined precipitously as a result of habitat changes.

Table 1. 38 Delaware Other Beetle SGCN

Other Beetle SGCN (2)		
<i>Lucanus elaphus</i>	Giant Stag Beetle	Data Needs - Historical
<i>Nicrophorus americanus</i>	American Burying Beetle	Extirpated

Hymenoptera: Bees and Wasps

Considerable concern has been expressed about the conservation status and population trends of native pollinators across North America. Available evidence indicates that certain pollinator species have been declining in the U.S., and flower-visiting insects account for 50% of all known insect extinctions (NRCS 2007). Reduced pollinator populations can result in decreased pollination of plant species that require pollinators for fertilization and reproduction. Eleven of Delaware's more than 250 species of bees and wasps were identified as SGCN in Delaware (Table 1.39). This list could be expanded with increased knowledge of the distribution and conservation status of bees and wasps in the state.

Declines in pollinator populations are poorly understood in most cases, with potential contributing factors including intensification of agricultural practices, use of certain pesticides, and habitat loss and degradation. Some bumblebees, particularly *Bombus affinis* in the east, have experienced declines as a result of the apparent spread of parasites accidentally introduced from European bees used in hothouse tomato production. Climate change is also expected to pose additional challenges to pollinator populations, including decoupling of plant-pollinator interactions when plants and pollinators respond differently to climate cues.

Most pollinator species are invertebrates, mostly insects. Major pollinator groups in the Northeast include social and solitary bees, certain groups of solitary wasps, as well as many flies, beetles, butterflies, and moths. The Xerces Society has published a *Red List of Native Bees in Decline* (Xerces Society 2014). The Heinz Center (2013) has prepared guidance for incorporating information about the conservation of animal pollinators into Wildlife Action Plans.

Limited data on Delaware's native bee fauna is available as a result of survey work completed by the Delaware Department of Agriculture, Plant Industries Section during the early 2000s. Additional records from museum specimens and the literature were compiled by J. Ascher at the American Museum of Natural History. Parasitic bee groups, including the cleptoparasitic cuckoo bees (*Nomada*) and the nest parasite cuckoo bumble bees (*Bombus* subgenus *Psithyrus*) are now considered especially imperiled due to presumed baseline rarity and declines of their host species.

Although probably not significant pollinators, two Pompilidae (spider wasp) species occur on the SGCN list: *Psorthaspis sanguinea* and *P. mariae*. Both species are at or near the northern limit of their distribution and both appear to be dependent on specific edaphic features associated with xeric forests (Heckscher 2014). *Psorthaspis sanguinea* is known from Cape Henlopen State Park and this occurrence represents a disjunct population from the North Carolina coast and consequently the only known location in the northeast (Heckscher 2014).

Table 1. 39 Delaware Bee and Wasp SGCN

Bee & Wasp SGCN (11)		
Bumble Bees		
<i>Bombus affinis</i>	Rusty-patched Bumble Bee	Tier 1
<i>Bombus fraternus</i>	Southern Plains Bumble Bee	Tier 1
<i>Bombus pensylvanicus</i>	American Bumble Bee	Tier 1
<i>Bombus auricomus</i>	Black and Gold Bumble Bee	Tier 2
<i>Bombus vagans</i>	Half-black Bumble Bee	Tier 2
<i>Bombus ashtoni</i>	Ashton's Cuckoo Bumble Bee	Data Needs
<i>Bombus variabilis</i>	Variable Cuckoo Bumble Bee	Data Needs
Ground-nesting Bees and Wasps		
<i>Colletes aestivalis</i>	A Cellophane Bee	Tier 1
<i>Lasioglossum marinum</i>	A Sweat Bee	Tier 2
<i>Lasioglossum nymphale</i>	A Sweat Bee	Tier 2
<i>Nomada rubicunda</i>	A Cuckoo Bee	Tier 2

Aquatic Macroinvertebrate Insects

Delaware's aquatic macroinvertebrates have been surveyed extensively during water quality monitoring efforts, but in many cases these immature stages are not identified to species level. Twelve species of freshwater aquatic insects were identified as SGCN in Delaware (Table 1.40).

The Delaware Department of Natural Resources and Environmental Control assesses the water quality in its non-tidal, perennial streams using standard physical, chemical, and biological criteria (Barbour et al. 1999) on a regional basis: Piedmont and Coastal Plain on alternating years. Semiquantitative macroinvertebrate samples are taken during fall low-flow conditions using a D-net (approximately 6 m² per sample), and subsampled to a 200 count.

Limited species-level survey work on adult caddisflies (Trichoptera) and stoneflies (Plecoptera) was conducted in the early 1980s (Lake 1980, 1984) in Delaware and these published records form the basis for the state lists for those orders.

Aquatic macroinvertebrates have also been separated ecologically into lotic-erosional (running water riffles), lotic-depositional (running water pools and margins), lentic-limnetic (standing water), lentic-littoral (standing water, shallow shore areas), lentic-profunda (standing water, basin), and beach zone groups (Wallace and Anderson, 1996).

Several species of hydropsychid caddisflies are some of the most imperiled freshwater invertebrates in Delaware. This family consists of mostly lotic-erosional species (Merritt et al. 2008). The caddisfly diversity of Delaware includes at least 143 species (Lake 1984).

Table 1. 40 Delaware Freshwater Aquatic Insect SGCN

Freshwater Aquatic Insect SGCN (12)		
<i>Agarodes libalis</i>	Spring-loving Psiloneuran Caddisfly	Tier 1
<i>Beraea fontana</i>	A Caddisfly	Tier 1
<i>Beraea nigrifera</i>	A Caddisfly	Tier 1
<i>Cheumatopsyche wabasha</i>	A Caddisfly	Tier 1
<i>Hydropsyche hoffmani</i>	A Caddisfly	Tier 1
<i>Hydropsyche impula</i>	A Caddisfly	Tier 1
<i>Hydropsyche ophthalmica</i>	A Caddisfly	Tier 1
<i>Neophylax delicatus</i>	A Caddisfly	Tier 1
<i>Ostrocerca prolongata</i>	Bent Forestfly	Tier 1
<i>Polycentropus chenoides</i>	A Caddisfly	Tier 1
<i>Anisocentropus pyraloides</i>	A Caddisfly	Tier 2
<i>Cheumatopsyche virginica</i>	A Caddisfly	Tier 2
<i>Helicopsyche borealis</i>	A Caddisfly	Tier 2

Mollusks

Freshwater Mussels

The ecology and habitat associations of North American freshwater mussels were recently reviewed by Haag (2012). As some of the least mobile and longest-living freshwater aquatic organisms, mussels provide a lens to evaluate long-term trends and conditions (Grabarkiewicz and Davis 2008). As filter-feeding bivalves, they are important links in the food chain, filtering bacteria and suspended materials from the water. Their reproduction is complex, relying on species-specific host fish for successful completion of the life cycle.

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The RSGCN list for the northeastern states includes 23 freshwater mussel species, including seven taxa that are high regional responsibility as well as high or very high conservation concern. Six of these species are or were present historically in Delaware: dwarf wedgemussel (*Alasmidonta heterodon*), brook floater (*Alasmidonta varicosa*), northern lance (*Elliptio fisheriana*), yellow lampmussel (*Lampsilis cariosa*), tidewater mucket (*Leptodea ochracea*), Eastern pondmussel (*Ligumia nasuta*), triangle floater (*Alasmidonta undulata*), and alewife floater (*Anodonta implicata*).

Freshwater mussels are highly imperiled in Delaware. Of the thirteen species known from the state, eleven are considered SGCN (Table 1.41). Six species are listed on the Delaware Endangered Species List and four of these are extirpated or historical in the state.

Dwarf wedgemussel (*Alasmidonta heterodon*) was federally listed as Endangered in 1993 (55 FR 9447; U.S. Fish and Wildlife Service 1993).

Table 1. 41 Delaware Freshwater Mussel SGCN

Freshwater Mussel SGCN (11)	
<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel
<i>Alasmidonta undulata</i>	Triangle Floater
<i>Alasmidonta varicosa</i>	Brook Floater
<i>Anodonta implicata</i>	Alewife Floater
<i>Elliptio complanata</i>	Eastern Elliptio
<i>Elliptio fisheriana</i>	Northern Lance
<i>Lampsilis cariosa</i>	Yellow Lampmussel
<i>Lampsilis radiata</i>	Eastern Lampmussel
<i>Leptodea ochracea</i>	Tidewater Mucket
<i>Ligumia nasuta</i>	Eastern Pondmussel
<i>Strophitus undulatus</i>	Creeper

Primarily Riverine Species

A few of the Delaware’s freshwater mussel species are closely associated with riverine habitats, including brook floater (*Alasmidonta varicosa*), dwarf wedgemussel (*Alasmidonta heterodon*), and creeper (*Strophitus undulatus*). These three species are long-term brooders, requiring suitable spawning conditions in the summer and fall, and access to host fish in the spring and early summer.

Host fish include darter, sculpin, and minnows. Dwarf wedgemussel occurs in small rivers, major tributaries, and on the mainstem near islands on low gradient reaches (Cole et al. 2008).

Semi-riverine Species

These species include alewife floater (*Anodonta implicata*), triangle floater (*Alasmidonta undulata*), yellow lampmussel (*Lampsilis cariosa*), and Eastern elliptio (*Elliptio complanata*). They are found in a variety of habitats, including small streams, large rivers, and lakes. Yellow lampmussel and Eastern elliptio are associated with larger-bodied, mobile host fish. Alewife floater is also associated with highly mobile host fish, possibly including American shad and blueback herring, in addition to alewife (Nedeau et al. 2000). Because their host fish are highly mobile, species recruitment is directly related to longitudinal connectivity. Alewife floater populations have expanded in direct response to the installation of fish passage (Smith 1985).

Freshwater mussels have declined due to the cumulative impact of numerous threats, including dams, pollution, and declines in host fish populations. Future concerns include potential water temperature and oxygenation effects of climate change, as well as physical impacts of floods and increased severe precipitation events. Some species will be subject to increased salinities from saltwater intrusion related to SLR.

In 2007, the Partnership for the Delaware Estuary (PDE) launched the [Freshwater Mussel Recovery Program](#) (FMRP), aimed to conserve and restore native freshwater mussels in the Delaware Estuary. The FMRP is part of PDE's watershed-based shellfish restoration strategy. DNREC DFW has conducted freshwater mussel surveys, finding the state's highest species diversity in the Chesapeake drainages of Deep Creek (Nanticoke River watershed) and the Choptank River (Heckscher and Bennett 1999).

Land Snails

From 1997 to 2001 then Delaware Museum of Natural History Curator of Mollusks Dr. Tim Pearce conducted research (funded by the National Science Foundation) on land snails of Delmarva, compiling an unpublished preliminary list of 75 species for Delaware (Pearce, pers. comm.) Twenty one species of land snails were identified as SGCN in Delaware (Table 1.42).

Table 1. 42 Delaware Land Snail SGCN

Land Snail SGCN (21)		
<i>Anguispira fergusonii</i>	Coastal-plain Tigersnail	Tier 1
<i>Catinella hubrichti</i>	Snowhill Ambersnail	Tier 1
<i>Glyphyalinia picea</i>	Rust Glyph	Tier 1
<i>Oxyloma effusum</i>	Coastal-plain Ambersnail	Tier 1

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<i>Anguispira alternata</i>	Flamed Tigersnail	Tier 2
<i>Carychium exiguum</i>	Obese Thorn	Tier 2
<i>Discus catskillensis</i>	Angular Disc	Tier 2
<i>Euconulus dentatus</i>	Toothed Hive	Tier 2
<i>Gastrocopta armifera</i>	Armed Snaggletooth	Tier 2
<i>Haplotrema concavum</i>	Gray-foot Lancetooth	Tier 2
<i>Philomycus flexuolaris</i>	Winding Mantleslug	Tier 2
<i>Punctum vitreum</i>	Glass Spot	Tier 2
<i>Pupoides albilabris</i>	White-lip Dagger	Tier 2
<i>Stenotrema hirsutum</i>	Hairy Slitmouth	Tier 2
<i>Triodopsis tridentata</i>	Northern Threetooth	Tier 2
<i>Ventridens intertextus</i>	Pyramid Dome	Tier 2
<i>Vertigo ovata</i>	Ovate Vertigo	Tier 2
<i>Vertigo pygmaea</i>	Crested Vertigo	Tier 2
<i>Vertigo teskeyae</i>	Swamp Vertigo	Tier 2
<i>Vertigo tridentata</i>	Honey Vertigo	Tier 2
<i>Zonitoides nitidus</i>	Black Gloss	Tier 2

Land snail species richness is significantly higher in high-base sites (Nekola 2005) and it is likely that Delaware land snails are disproportionately diverse in basic mesic forests, as was the case in the coastal Carolinas in Nekola's study. Species within a region also cluster at the landscape scale according to habitat type, soil surface architecture, geography, moisture levels, and presence of anthropogenic disturbance (Nekola 2003). Land snails are not included in the Species-Habitat Associations compiled in Appendix 2.C due to insufficient knowledge of their habitat relationships in Delaware. However, most land snails are associated with natural, forested habitats.

Freshwater Snails

Twenty-one species of freshwater gastropods are known from Delaware based on work by Dillon et al. (2013). Of the 21 species known from the state, 5 were included as SGCN in this revision. *Physa carolinae*, a southern species reaching the northern edge of its known distribution in Delaware, was recently described (Wethington et al. 2009) (Table 1.43).

Dillon et al. (2013) visited the Dover laboratories of DNREC in January of 2013 and reviewed macrobenthic samples from three years: 2006 (Piedmont), 2010 (Coastal Plain), and 2011 (Piedmont). Approximately 40-50 sites were sampled each of these years, yielding a total of 198 freshwater gastropod records. Supplementing this were specimens from the following institutions: U.S. National Museum in Washington, the Academy of Natural Sciences of Philadelphia, the Carnegie Museum of Natural History in Pittsburgh, and the Delaware Museum of Natural History in Wilmington and personal collections made by the authors within Delaware.

Table 1. 43 Delaware Freshwater Snail SGCN

Freshwater Snail SGCN (5)		
<i>Littoridinops tenuipes</i>	Henscomb Hydrobe	Tier 2
<i>Physa carolinae</i>	Carolina Physa	Tier 2
<i>Pomatiopsis lapidaria</i>	Slender Walker	Tier 2
<i>Gyraulus deflectus</i>	Flexed Gyro	Tier 3
<i>Promenetus exacuus</i>	Keeled Promenetus	Tier 3

Estuarine and Marine Invertebrates

Benthic marine habitats of the Mid-Atlantic Bight contain over 2000 species of invertebrates such as marine worms, sponges, shrimp, crab, clams, scallops, snails, sea stars, and anemones (Mid-Atlantic Regional Council on the Ocean (MARCO). The invertebrate fauna of the Delaware Bay is also highly diverse. A current effort to inventory and develop a digital field guide to zooplankton of Delaware Bay is being conducted by University of Delaware researcher Jonathan Cohen. Only a small number of well-known or economically important estuarine and marine invertebrates have received conservation attention. Seven species of estuarine and marine invertebrates were identified as SGCN in Delaware (Table 1.44).

Table 1. 44 Delaware Estuarine and Marine Invertebrate SGCN

Estuarine/Marine Invertebrate SGCN (7)		
<i>Limulus polyphemus</i>	Horseshoe Crab	Tier 1
<i>Callinectes sapidus</i>	Blue Crab	Tier 2
<i>Crassostrea virginica</i>	American Oyster	Tier 2
<i>Geukensia demissa</i>	Ribbed Mussel	Tier 2
<i>Busycon carica</i>	Knobbed Whelk	Tier 3

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<i>Busycotypus canaliculatus</i>	Channeled Whelk	Tier 3
<i>Homarus americanus</i>	American Lobster	Tier 3

The horseshoe crab is perhaps Delaware’s most iconic invertebrate. Horseshoe crabs (*Limulus polyphemus*) concentrate in the Delaware Bay to spawn on the sandy beaches fringing its shorelines. The vast quantities of eggs the crabs deposit on these beaches serve as an important food resource for migrating shorebirds. Horseshoe crab population indices in the Delaware Bay declined dramatically (by approximately 90%) from the early 1990s to the mid-2000s (Niles 2009). While the ASMFC has worked via an adaptive management framework to set harvest limits on bait harvest of horseshoe crabs in Delaware Bay for a number of years, these limits (generally an annually-set, male-only harvest quota apportioned by state) are resulting so far in only modest increases in previously depleted horseshoe crab populations, which is perhaps unsurprising due to the long generation time of the species. While some evidence of horseshoe crab increase is available, the greatly shifted baseline from which current populations are recovering makes restoring the species to historic population levels difficult in the near-term.

Blue crabs (*Callinectes sapidus*) are a ubiquitous, ecologically and commercially important species found throughout the waters of the estuary. Oysters (*Crassostrea virginica*) play an important role in the bay, both as filter-feeders, and because oyster reefs provide essential habitat for numerous other estuarine species.

The filtration capacity of ribbed mussels (*Geukensia demissa*) in Delaware Bay tidal marshes has been estimated to exceed that of oysters and other native bivalves. Ribbed mussels are foundation species in salt marshes, helping the marsh edge resist erosion and generating waste accumulations that help the marsh build elevation.

Knobbed and channeled whelk fishery landings are increasing, and evidence suggests that low fecundity and long development time of these species may be cause for conservation concern as fishing pressure increases (Peemoeller et al. 2013). On May 6, 2014, Governor Jack Markell signed House Bill No. 199, making the shell of the channeled whelk (*Busycotypus canaliculatus*) the official state shell of the State of Delaware. The bill states that the channeled whelk shell “contributes to the beauty of our seashores, as well as to the marine economy of the State of Delaware.”

Plants

Delaware’s plant species play a key role in supporting wildlife diversity. Delaware is home to over 2,300 plant taxa, of which about 69% are native to the state. Thirty-seven percent of our native taxa are restricted to the Coastal Plain, while only about 14% are restricted to the Piedmont. The remaining 49% of taxa are found in both physiographic provinces. Delaware’s native flora is highly threatened by the same stressors that affect wildlife species (see Chapter 3).

The Flora of Delaware Online Database (McAvoy 2015) is a web-based reference containing basic information on the status, habitat, and distribution of plants in Delaware (Table 1.45). The database contains a wealth of information about each species listed and is available to planners, wildlife and land managers, stewardship ecologists, restoration ecologists, research biologists, landscapers, naturalists, educators, and home gardeners.

Table 1. 45 Conservation Status of Delaware's Plant Species

State Conservation Status Rank	Number of Species	% of Native Flora
S1 and S2 (rare, extant)	384	24
SH and SX (historical and extirpated)	192 (142 SH, 50 SX)	12
S3 (uncommon)	152	9
SU (status undetermined)	128	8
Globally Rare (G1, G2, G3)	33	2
Federally Listed (LE, LT, C)	9	1

Plants comprise a significant proportion of Delaware’s biodiversity, but this large taxon is not directly eligible for State Wildlife Grants (SWGs) and has therefore been less represented in the WAPs. Stein and Gravuer (2008) recommended adding plant-specific components to existing Wildlife Action Plans. This DEWAP applies the Northeast Terrestrial Wildlife Habitat Classification System (NETWHCS) (Gawler 2008) using plants to define habitats, together with the *Northeast Habitat Guides* (Anderson et al. 2013), which provide a list of representative plant species and a list of rare plants for each habitat type. Therefore plants are included here as candidates for SGCN. Further, Chapter 4 recommends a conservation action to establish a plant taxa team to identify plant SGCN in the next revision using a process consistent with the other taxa.

An assessment of plant populations is important information to consider when determining the condition of the habitats in which these plants are found. This information is presented in Chapter 2

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in the context of habitats. Threats to plants are similar to those affecting animals, especially in community types that have limited distributions in the state, such as small freshwater wetlands, coastal plain seasonal ponds, xeric inland sand forest, and tidal marshes. SLR and other climate change impacts have emerged as issues affecting many of Delaware's plant communities.

Appendix 2.D provides a list of plant species (both common and scientific names) that were mentioned in the DEWAP (primarily Chapter 2). It is not indicative of those species' canditure, only a reference resource as often scientific names were not provided in the chapters.

Update and Revision of Delaware's SGCN List

As part of the federal requirement to address conservation of the broad array of wildlife in Delaware, 459 SGCN were identified in Delaware's 2006 WAP. Beginning in March 2014, the criteria and SGCN list were reevaluated resulting in a list of 688 species and subspecies of mammals, birds, amphibians, reptiles, fishes, and invertebrates for the 2015 Wildlife Action Plan Revision.

Summary of SGCN List Changes since 2006

This revision benefited from the availability of more recent and complete data for many of Delaware's wildlife species. The 2015 DEWAP process applied recent national (AFWA and Service) guidance as well as regional (Lexicon) criteria for SGCN selection and ranking. These important updates were used to assess the status of the full array of Delaware's wildlife species, including reevaluating the status of each of the 2006 SGCN. The 2015 list development applied these updates and then developed an enhanced DEWAP set of SGCN selection and ranking criteria, followed by an inclusive screening by species experts and partners.

After screening using the decision framework shown in Figure 1.18 Box 2, several accidental and extralimital taxa were removed from the list. The results of this exercise were then compared to the SGCN list from 2006. Overall, the 2015 SGCN list of 688 species reflects a comprehensive approach to identifying species of conservation concern across many taxa, including many representatives of historically underrepresented taxonomic groups.

Additions since 2006

The updated process resulted in the addition of 255 previously unlisted taxa and a net addition of 231 taxa to the SGCN list. These additions are the result of several factors. The primary driver is the inclusion in the 2015 list of a regional perspective. Incorporating Northeast Regional Species of Greatest Conservation Need (vertebrates) and Regional Odonates of Conservation Concern as listing criteria generated a number of Delaware SGCN that were not previously listed.

In addition, a much larger number of marine fish and sharks are included in the 2015 list, primarily because all ASMFC-managed species known or likely to occur offshore from Delaware or within Delaware waters were included. A number of invertebrate species were also added, based on work completed in Delaware since 2006 that has led to S-ranking of additional species, especially moths, odonates, and caddisflies.

Removals since 2006

Twenty species included as SGCN in the 2006 DEWAP did not meet the 2015 SGCN inclusion criteria, and thus were removed from the Draft SGCN list. An additional three taxa that were

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included in the 2006 plan as both the full species and a named subspecies were edited to remove erroneous taxonomic duplicates. One species was removed because its presence on the 2006 SGCN list was based on an erroneous record and the species does not occur in Delaware. These 24 species and the reasons for their removal are presented in Table 1.46.

Table 1. 46 SGCN Not Meeting 2015 Criteria

Group	Scientific Name	Common Name	2006 SGCN Tier	Reason Removed
Birds	<i>Accipiter cooperii</i>	Cooper's Hawk	Tier 1	No longer meets Criterion #4 (S Rank) due to rank change
Birds	<i>Anas clypeata</i>	Northern Shoveler	Tier 2	Decision Tree #3, rare breeding attempts outside of core range.
Birds	<i>Charadrius wilsonia</i>	Wilson’s Plover	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	<i>Coragyps atratus</i>	Black Vulture	Tier 2	No longer meets Criterion #4 (S Rank) due to rank change
Birds	<i>Coturnicops noveboracensis</i>	Yellow Rail	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	<i>Fulica americana</i>	American Coot	Tier 2	Decision Tree #3, rare breeding attempts outside of core range.
Birds	<i>Hydrocoloeus minutus</i>	Little Gull	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	<i>Pandion haliaetus</i>	Osprey	Tier 1	Original listing justification “Sensitive/Significant Population – Indicator Species” no longer considered valid criterion

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Group	Scientific Name	Common Name	2006 SGCN Tier	Reason Removed
Birds	<i>Pelecanus erythrorhynchos</i>	American White Pelican	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	<i>Rhodostethia rosea</i>	Ross's Gull	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	<i>Strix varia</i>	Barred Owl	Tier 2	No longer meets Criterion #4 (S Rank) due to rank change
Fishes	<i>Pristis pectinata</i>	Smalltooth Sawfish	Tier 1	No valid Delaware records
Fishes	<i>Ameiurus natalis</i>	Yellow Bullhead	Tier 1	Original listing justification "Sensitive/Significant Population – Restricted Range" no longer considered valid criterion
Insects	<i>Amblyscirtes aesculapius</i>	Lace-winged Roadside-Skipper	Tier 2	Decision Tree #5 (very rare or casual visitor)
Insects	<i>Amblyscirtes carolina</i>	Carolina Roadside-Skipper	Tier 2	Decision Tree #5 (very rare or casual visitor)
Insects	<i>Boloria selene</i>	Silver-bordered Fritillary	Tier 2	Full species removed, subspecies <i>myrina</i> retained
Insects	<i>Catocala palaeogama</i>	Oldwife Underwing	Tier 2	No longer meets Criterion #4 (S Rank) due to rank change
Insects	<i>Celithemis ornata</i>	Banded Pennant	Tier 2	Record of species in Delaware is erroneous.
Insects	<i>Drasteria graphica atlantica</i>	Atlantic graphic moth	Tier 2	Subspecies <i>atlantica</i> removed, full species retained.
Insects	<i>Ladona deplanata</i>	Blue Corporal	Tier 2	No longer meets Criterion #4 (S Rank) due to pending S-rank change

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Group	Scientific Name	Common Name	2006 SGCN Tier	Reason Removed
Insects	<i>Satyrium liparops</i>	Striped Hairstreak	Tier 2	Full species removed, subspecies <i>strigosum</i> retained
Insects	<i>Sympetrum ambiguum</i>	Blue-faced Meadowhawk	Tier 2	No longer meets Criterion #4 (S Rank) due to pending S-rank change
Mammals	<i>Canis latrans</i>	Coyote	Tier 2	Now considered a non-native species by Delaware Division of Fish and Wildlife
Reptiles	<i>Pituophis melanoleucus</i>	Pinesnake	Tier 2	No valid Delaware records

SGCN Selection Process

A multistep system was used to generate and evaluate species for SGCN status. The data sources in Table 1.47 were used in conjunction with criteria shown in Figure 1.17 Box 1 below to generate the draft list via a database query process. This list was then screened using the decision framework shown in Figure 1.18 Box 2 below. Additional sources of data, including but not limited to those shown in Table 1.47, were used to help ensure completeness of the list.

Table 1. 47 Additional Data Sources Reviewed to Generate SGCN Candidates

Data Source	Date of Last Revision
Delaware Elements List from Biotics Database	May 2014
Regional Species of Greatest Conservation Need (RSGCN) List for the Northeast States	2013
Delaware Endangered Species List	July 2013
Federal Endangered, Threatened, Candidate Species	May 2014
IUCN Red List	May 2014
Northeast Odonate Conservation Status Assessment	2014
Atlantic States Marine Fisheries Commission Managed Species	2014
NOAA NMFS Species of Concern	Nov 2013
American Fisheries Society Freshwater and Diadromous Fishes at Risk of Extinction	2008
Bird Conservation Region (BCR) 29 – Piedmont Priority Species	2014
Bird Conservation Region (BCR) 30 – Atlantic Coastal Plain Priority Species	2008
NEPARC Northeast Amphibian and Reptile Species of Regional Responsibility and Conservation Concern	2010
Partners in Flight Databases	2013
North Atlantic Regional Shorebird Plan	n.d.
North American Waterfowl Management Plan	2012
U.S. Shorebird Conservation Plan	2000

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Data Source	Date of Last Revision
Population Estimates of North American shorebirds (Andres et al 2012)	2012
State of the Birds Report 2014	2014
Xerces Society Red List of Aquatic Invertebrates	n.d.
Xerces Society Red List of Bees	n.d.
Xerces Society Red List of Butterflies and Moths	n.d.
US Fish and Wildlife Species of Conservation Concern	2008
Sea Duck Joint Venture Strategic Plan 2014-2018	2014

Figure 1. 17 Box 1: SGCN Criteria for Delaware Wildlife Action Plan 2015

Species were considered a *candidate* for GCN status if they **occur in Delaware** AND they met any one of the following criteria:

1. Federally Endangered, Threatened, or Candidate status
2. State Legal Status of Endangered
3. Global Rank of G₃ or higher, or any combination rank that includes G₃
4. S-Rank of S₂ or higher, SH, or SX for Breeding, Nonbreeding or Both
5. Regional Species of Greatest Conservation Need (RSGCN) for the Northeast
6. IUCN Red List Status of Near Threatened or higher
7. Taxon-specific Conservation Concern. Included at the following levels on the following taxon-specific plans:

Birds: Mid-Atlantic Bird Conservation Initiative BCR 29 or BCR 30 "Highest Priority" and "High Priority" Species

Fishes and Marine Invertebrates: National Oceanic and Atmospheric Administration (NOAA) NMFS Species of Concern (NOAA 2010), American Fisheries Society (2001) Marine, Estuarine, and Diadromous Fish Stocks at Risk of Extinction in North America (Exclusive of Pacific Salmonids), American Fisheries Society (2008) List of imperiled North American freshwater and diadromous fishes, Atlantic States Marine Fisheries Commission (ASMFC) Managed Species

Reptiles & Amphibians: NEPARC (2010) Northeast Amphibian and Reptile Species of Regional Responsibility and Conservation Concern

Odonates: White, et al. (2014) A conservation status assessment of Odonata for the northeastern United States. New York Natural Heritage Program, Albany, NY.

8. Endemic, Near-Endemic, or Disjunct. (Species which, according to the best available data are endemic or near-endemic to the Delmarva Peninsula, or whose Delaware populations are widely disjunct: 200+ miles from the species main range of distribution)
9. Scientific Data and Expert Consensus

Taxa that do not meet other SGCN criteria that can be demonstrated by scientific evidence or expert consensus to have at least a moderate risk of extinction in the future, or that have especially significant Delaware populations. This may include taxa that are data deficient, have demonstrated population declines, rarity or limited habitat requirements, need direct species management in order to persist, have at-risk populations, or are likely to be significantly negatively impacted by climate change or other specific and imminent threats.

Figure 1. 18 Box 2: Decision Tree for Screening SGCN from SGCN Candidate List

1. Is the species native or thought to be native to Delaware or adjacent waters (including North American native species whose range has expanded naturally into the region)?

YES: continue NO: not SGCN

2. Is Delaware within, or presumed to be within, the species' regularly occurring range, now or at some time in the past? Accidental and vagrant species should not be included, even if there are multiple records. Disjunct populations should be considered part of the regularly occurring range.

YES: continue NO: not SGCN

3. If the species is included solely on the basis of a breeding season S-rank, does that rank reflect only sporadic, accidental breeding attempts well outside the usual breeding range of the species? (Any evidence of continued breeding or establishment of a breeding population should be considered.)

YES: not SGCN NO: continue

4. If the species is considered extirpated from Delaware (SX), is there some possibility that the species could either recolonize naturally or be intentionally reintroduced in the foreseeable future?

Yes: SGCN NO: Not SGCN

5. Is the species a rare or casual migrant or rare seasonal visitor in Delaware such that threats and conservation actions present /conducted over the next 10 years in Delaware are unlikely to have a measurable impact on the species' population?

The database query process using Criteria 1-7 from Figure 1.17 Box 1 generated an initial list of taxa for consideration. Additional taxa that were not picked up by the initial database query were added to the draft list based on Criteria 8 or 9. Some of these taxa, such as the firefly *Photuris mysticalampas* and the frog *Rana kauffeldi* are newly recognized species that will likely meet both State and Global Rank Criteria once they are officially ranked. Several native bee species are not yet S-ranked, but are globally or regionally rare and were added on the basis of rangewide declines and

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historical occurrence in Delaware. It is likely that more species of native bees will be added during further review of that group. One species of butterfly, the monarch (*Danaus plexippus*) was added on the basis of current critical rangewide declines that are not yet reflected in state or global ranks. A few species, including two species of spider wasps (*Psorthaspis* sp.) were added based on disjunct distribution as described in Criterion 8. Two species, the blue crab (*Callinectes sapidus*) and the American oyster (*Crassostrea virginica*) were added based on Criterion 9 due to their dependence on management activities to build and maintain populations. A handful of other species were added based on anticipated S rank changes to be updated during the course of the WAP process (some fireflies, bats, etc.) A complete list of species added since 2006, along with their corresponding criteria met, is included as Appendix 1.B.

After screening and applying the decision framework to remove several accidental and extralimital taxa, the final SGCN list contains 688 taxa (Table 1.48).

SGCN Prioritization Methods

The AFWA identified the need for greater prioritization of SGCN in the Best Practices for State Wildlife Action Plans (AFWA 2012) and the Northeast regional lexicon (Crisfield and NEFWDC 2013) advanced this by providing consistent terminology and process recommendations. DEWAP took that a step further by applying these criteria and customizing it to Delaware and its conservation partners who were included in the prioritization process.

Once the SGCN list was updated using the selection criteria described above, taxonomic experts for each group were again asked to review the SGCN list for their taxa and provide data on regional and state level responsibility and concern for each species. The answers to these evaluations were used, along with S-ranks, G-ranks, and other available information to group SGCN into Tiers.

Data Gaps and Uncertainty

For many species, reliable data may not be available. In some cases, particularly with invertebrates, some or all aspects of basic life history may be unknown. In dealing with data deficiencies, gaps, and complete unknowns, the DEWAP process endeavors to:

- a. Use expert opinion based on the current scientific literature and your understanding of the taxon;
- b. Use information and data from related taxa; and
- c. Document level of certainty and what information decisions were based on.

Tier Definitions and Criteria

Each SGCN was assigned a status rank or tier, which denotes the degree of conservation need for that species. The 2015 Tier system is similar to the 2006 system but was improved and updated to include additional tiers for greater prioritization.

TIER 1

Tier 1 species are in the highest need of conservation action. These include the rarest species in the state, species that are highly globally imperiled, and species with regionally important Delaware populations that are also under high threat from climate change.

A species was assigned to Tier 1 if it met one or more of the following criteria:

1. Federally Listed Species (USFWS, NOAA NMFS) (regardless of rank), or;
2. State Endangered Species (regardless of rank), or;
3. Rounded Global Rank of G1, G2, or G3, or;

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4. State Rank of S₁ (rounded S rank) or S₁B*, *and* rounded Global Rank of G₄; or
5. IUCN Status of Vulnerable (VU), Endangered (EN) or Critically Endangered (CR), or;
6. Northeast Odonate Conservation Assessment Primary Responsibility, R₃ and Higher Concern, or;
7. High SLR or Climate Change Concern AND High Delaware Responsibility, or;
8. Delaware or Delmarva Population Endemic or Disjunct.

TIER 2

Tier 2 species are of moderate conservation concern in Delaware. These include species that have rare to uncommon breeding populations in the state, species with broad distributions that are threatened by climate change, and species for which Delaware has high responsibility within the Northeast region.

A species not already assigned to Tier 1 was assigned to Tier 2 if it met one or more of the following criteria:

1. State Rank of S₂ (rounded S rank) or S₂B;
2. IUCN Status of Near Threatened (NT or LR/nt) or Data Deficient (DD), or;
3. RSGCN High Northeast Responsibility AND High or Very High Concern, or;
4. Northeast Odonate Conservation Assessment Significant Responsibility, R₃ and Higher Concern, or;
5. High SLR or Climate Change Concern, or;
6. High Delaware Responsibility.

TIER 3

These species are for the most part still relatively common in Delaware, but are listed as SGCN for various reasons, including documented population declines, high responsibility of the Northeast region for the global population, or continued need for monitoring and/or management. This tier also includes non-breeding species that are uncommon in Delaware.

All remaining Species of Greatest Conservation Need that did not meet one or more of the criteria for Tier 1 or Tier 2 were assigned to Tier 3.

DATA NEEDS

These are species in need of monitoring efforts to determine their conservation status in Delaware. Any species with the following ranks that was not already categorized as a Tier 1 species was labeled as follows:

1. State Rank SU: Data Needs

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2. IUCN Status DD (Data Deficient): Data Needs

3. State Rank SH: Data Needs – Historical

EXTIRPATED

These species once occurred in Delaware, but have been determined through extensive survey effort to no longer occur in the state. The extirpated species included as SGCN have some possibility of reintroduction (i.e., suitable habitat may occur in the state and potential source populations may exist). Any SGCN with a State Rank of SX.

Table 1. 48 Delaware’s SGCN (by major Taxonomic Groups) meeting the 2015 SGCN criteria.

Taxonomic Group	Tier 1	Tier 2	Tier 3	Data Needs	Extirpated	Total Count
Mammals	10	3	6	3	1	23
Birds	49	69	62	3	1	184
Amphibians	5	8	6	0	0	19
Snakes and Lizards	3	9	1	1	0	14
Turtles	8	2	0	0	0	10
Lampreys	0	2	0	0	0	2
Sharks and Rays	18	11	5	2	0	36
Bony Fishes	12	18	37	0	0	67
Freshwater Mussels	6	4	0	0	1	11
Marine/Estuarine Invertebrates	1	3	3	0	0	7
Freshwater and Terrestrial Snails	4	20	2	0	0	26
Beetles	9	12	2	8	2	33
Bees and Wasps	6	5	0	2	0	13
Butterflies and Skippers	16	10	0	14	1	41
Moths	23	28	4	50	1	106
Dragonflies and Damselflies	18	38	21	6	0	83
Caddisflies and Stoneflies	10	3	0	0	0	13
TOTALS	198	245	149	89	7	688

Species Conservation Approaches

This revision of the DEWAP presents a practical approach to the conservation of species and habitats. Species prioritization, as discussed above, is based on rarity, threats, and regional and state responsibility. An efficient approach to conservation is to consider surrogate, umbrella, or indicator species that can provide a target for conservation actions that will benefit many species, but provide a focused way to assess project impact. The degree to which one species is representative of the needs for conservation action or the impact of actions is contextual. While Delaware recognizes the effectiveness of these approaches, it was not feasible to develop examples of surrogate, umbrella, or indicator species in the comprehensive WAP. However, these approaches are described here as a reference and a similar approach was taken in assigning issues and actions at higher grouping levels, such as Ecological Group, versus simply at the species level.

Surrogate Species

In 2012, the USFWS committed to using a Strategic Habitat Conservation (SHC) approach that emphasizes the use of surrogate species in biological and conservation planning. In 2014, a draft Technical Guidance on Selecting Species for Design of Landscape Scale Conservation was circulated (USFWS 2014). Peer review indicated significant concern about the scientific support for the use of surrogate species approaches (USFWS Region 6 Office 2014). The North Atlantic Landscape Conservation Cooperative (NALCC) and USFWS Region 5, along with partners at University of Massachusetts Amherst and the U.S. Forest Service had already (in 2011) initiated the process of identifying "representative species" for clusters of ecological system-level habitats in the Northeast based on an analysis of expert-assigned species-habitat matrices for SGCN in the region. This process resulted in the identification of a total of 87 "representative species," 66 of them birds, for 30 different habitat clusters in the region (USFWS 2012), plus 13 aquatic "representative species," one for each habitat type included (USFWS n.d.). These species are included for each habitat in Chapter 2. These regional "representative species" adequately reflect species that are closely associated with particular broad suites of habitats. However, most of the selected species will require more detailed validation in order to be used confidently as indicator or umbrella species.

The use of surrogate species to achieve the goals of particular projects within Delaware should be encouraged as a matter of practicality, but the challenges of such an approach should be clearly understood and surrogate species should be validated for their correlation with responses of target species and taxonomic groups. The suitability of any particular surrogate species approach (e.g., umbrella, indicator, flagship) depends on the specific conservation goals and objectives of the application. For this reason, these concepts are not directly addressed in SGCN selection or ranking for the DEWAP.

Umbrella Species

Sattler et al (2014) found that although most umbrella species do well in predicting high taxonomical diversity within their respective taxa, they are not necessarily good predictors of diversity within other taxa (supported by Fattorini et al 2011). Two exceptions to these findings in the urban habitats in this study were bees and spiders, both of which performed much better as indicators of high diversity in other groups, dramatically outperforming birds in this respect.

Functional diversity and taxonomical diversity are often not well-represented by a single umbrella species, so the approach of selecting multiple, complementary umbrella species is necessary. Due to the complexity of applying the umbrella species concept across numerous taxa, habitats, and functional groups, the DEWAP does not include a species's status as an umbrella species as an inclusion criterion for GCN listing.

Indicator Species

The status of a species as an indicator of environmental condition or habitat quality is likewise not explicitly included in the selection or prioritization criteria of SGCN in the DEWAP. While many species may serve as indicators depending on the goal of the assessment, indicator species should be validated empirically relative to the variable of interest, and a broad screening of all taxa for their relative suitability as indicators of various environmental conditions is beyond the scope of the DEWAP.

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