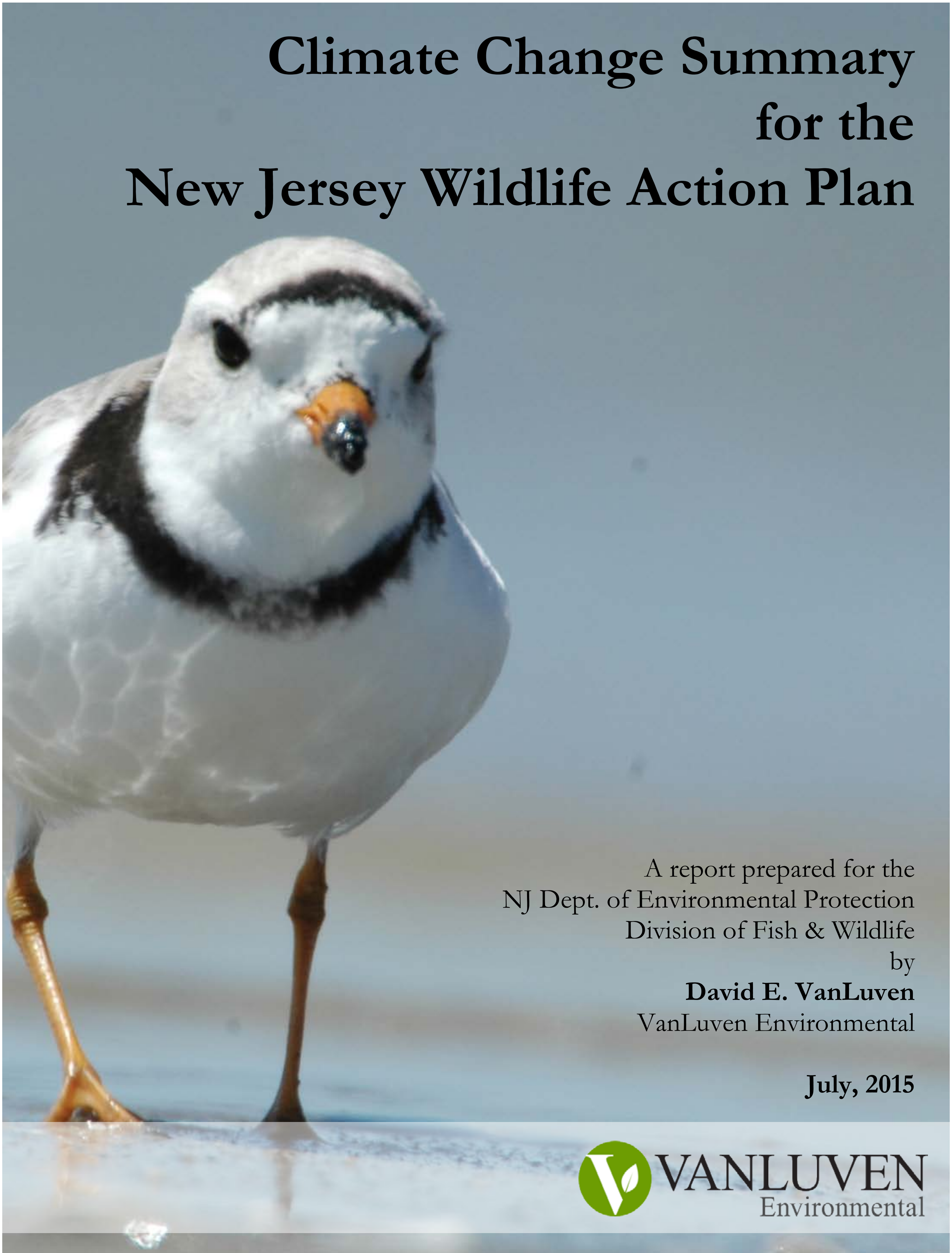
# Climate Change Summary for the New Jersey Wildlife Action Plan



A report prepared for the
NJ Dept. of Environmental Protection
Division of Fish & Wildlife
by
**David E. VanLuven**
VanLuven Environmental

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VANLUVEN Environmental

## EXECUTIVE SUMMARY

Climate change is already underway in New Jersey, and the State Climatologist at Rutgers University has clearly documented increases in average temperatures, fluctuating extremes in precipitation, and sea level rise. These and other climate change impacts are projected to affect New Jersey's wildlife and ecological communities well into the future – exacerbating many long term challenges while presenting new challenges as well.

- Rising sea levels will **inundate intertidal wetlands and beaches**. Extreme storms and storm surge will prompt coastal communities to **further armor coastlines** which can lead to both short- and long-term impacts on coastal habitats and wildlife. **Post-storm replenishment of ocean and estuarine beaches** can deleteriously affect shoreline nesting birds if poorly planned or timed. Higher sea levels will also **push the saltwater toe landward**, making low elevation freshwater wetlands brackish. Excessive groundwater withdrawal could exacerbate this problem.
- Shifting temperatures and altered precipitation patterns will **shuffle species compositions** of ecological communities at the southern edges of their ranges, altering habitat for dependent wildlife species.
- Higher temperatures and altered precipitation patterns could **warm rivers, streams, wetlands, and other aquatic systems**, with deleterious consequences for freshwater mussels, turtles, amphibians, and invertebrates.
- More intense precipitation could cause **more flooding and erosion in streams and rivers**, with a variety of deleterious consequences for fish, mussels, and aquatic invertebrates. In turn, the flooding could motivate landowners within riparian areas to **harden river and stream banks** to protect property and infrastructure, further altering important wildlife habitats.
- Lower water levels in rivers and streams could **impede fish access** to spawning and overwintering areas, and less consistent rainfall into vernal pools could result in drying that eliminates and further isolates these important wildlife habitats. Heavier surface and groundwater withdrawal by humans during droughts could exacerbate these problems.
- Warmer winter temperatures will allow less cold-tolerant species, including problematic **invasives and pathogens**, to expand their ranges into New Jersey, impacting native wildlife and their habitats.

Adapting to climate change doesn't require new strategies, it requires widespread implementation of strategies that have been well known for decades, like maintaining and recreating connectivity between key wildlife habitats.

There is consensus across the scientific community that climate change is happening and recognition that strategies to address its projected impacts on wildlife and their habitats need to be undertaken now. And we know what to do, as the majority of these strategies have been recognized as being necessary for many years regardless of climate change. Further, climate change, with its broad impacts across all sectors of New Jersey interests, could be a catalyst that brings diverse stakeholders with many different motivations together to advance common strategies.

## CLIMATE CHANGE & IMPLICATIONS

Climate change is underway in New Jersey, with well documented increases in average temperatures, fluctuating extremes in precipitation, and sea level rise (ONJSC, 2013). A suite of climate change impacts are projected to affect New Jersey's wildlife and ecological communities, exacerbating many long term challenges and presenting new ones. In this chapter, we will briefly consider the relevant elements of climate change on New Jersey's wildlife and ecological communities, identify likely implications, and present potential adaptation strategies.

### Temperature

If emissions remain high, average winter temperatures could increase by 8$^o$ to 12$^o$ F, and summer averages by 6$^o$ to 14$^o$ F by the end of the century (NCIA, 2006). If emissions are dramatically lowered, winter average temperatures could still warm by 5$^o$ to 7.5$^o$ F and summer averages by 3$^o$ to 7$^o$ F (NCIA, 2006).

*Implications*: Warmer winter temperatures will allow less cold-tolerant invasive species and pathogens to expand their ranges into New Jersey (NCIA, 2006) with deleterious consequences for ecological communities and wildlife. Shifting temperatures across seasons could alter the phenologies of species so they are no longer synchronized – a particular issue for migratory species who may suffer lower reproductive rates as a result (Carey 2009). These temperature changes, combined with altered precipitation patterns, will likely also shift the plant compositions of ecological communities at the edges of their ranges, with comparable shifts in wildlife species (Staudinger *et al.*, 2013).

Higher temperatures, combined with altered precipitation patterns, could further warm rivers and streams, wetlands, and other aquatic systems, making them less suitable for cold water fish, mussels, turtles, amphibians, and invertebrates (Trumbo *et al.*, 2014; Manomet and NWF, 2013a; Brooks, 2009; Hastie *et al.*, 2003; Gibbons *et al.*, 2000). This is especially a concern in waters with marginal temperatures or with isolated populations where cold water fish could be gone by 2030 (Jones *et al.*, 2013). These changes in water temperature, however, are likely to be highly site specific, as key determinants appear to be shading from riparian vegetation, cold water input from springs, surrounding land use, and elevation (Trumbo *et al*., 2014; Manomet and NWF, 2013a).

### Precipitation & Flooding

Winter precipitation totals are projected to increase, while models predict summer totals will remain about the same as we see today (ONJSC, 2013; NCIA, 2006). Precipitation, however, is projected to increasingly come in less frequent but more intense storms (Broccoli *et al.*, 2013; NCIA, 2006).

*Implications*: More intense precipitation could cause more flooding and erosion in streams and rivers, with a variety of deleterious consequences for fish, mussels, and aquatic invertebrates, from smothering siltation to transport downstream to unsuitable habitats (Manomet and NWF, 2013a; Hastie *et al.*, 2003). In turn, this flooding could motivate landowners within riparian areas to harden shorelines to protect properties and infrastructure, further altering important wildlife habitats.

### Drought & Low Stream Flows

Summers in New Jersey are projected to be hotter, with both higher average temperatures and 30 to 60 more days above 90$^o$F by the end of the century (NCIA, 2006). Higher summer temperatures – combined with steady summer precipitation averages, more rapid evaporation, and more rapid evapotranspiration – will likely lead to more frequent short-term summer droughts and lower stream and river flows in summer (Manomet and NWF, 2013a; ONJSC, 2013; NCIA, 2006).

*Implications*: Droughts and earlier peak flows could impede migratory fish from reaching spawning areas (Faass *et al.*, 2012). Heavier water withdrawal by humans during droughts could further lower water levels in rivers, streams, and wetlands. Vernal pools are particularly vulnerable to drought and altered precipitation patterns, and the wildlife habitat they provide will change with alterations to their hydroperiods (Brooks 2009). Drying trends will cause some vernal pools to disappear, leaving remaining pools increasingly isolated and less able to support dependent amphibian metapopulations (Brooks 2009).

<u>Sea Level Rise</u>

Records show steady rises in sea level along New Jersey's shores, with an average increase of 1.5 inches per decade at Atlantic City since 1912 (Broccoli, *et al.*, 2013). Climate change will speed this rate – potentially dramatically. Broccoli *et al.* (2013) project increases of 7 to16 inches by 2030 (best estimate = 10 inches), 13 to 28 inches by 2050 (best estimate = 18 inches), and 30 to 71 inches by the end of the century (best estimate = 42 inches). Analyses by Miller *et al*. (2013) project sea levels in 2100 to be 3 to 3.5 feet higher if emissions are lowered, or 5.5 to 6 feet if emissions remain high.

*Implications*: Higher sea levels will inundate intertidal habitats (notably salt and brackish marshes), estuarine and ocean beaches, and low-lying freshwater wetlands and streams. If these ecological communities are able to migrate landward, they and the important wildlife habitat they provide can persist – especially if the rates of sea level rise are lower and there is sufficient sediment for intertidal wetlands to accrete on pace with the rising waters (NWF and Manomet, 2014; Hartig *et al.*, 2002). However, more intense storms and storm surge will trigger additional shoreline armoring, as was observed after Hurricane Sandy, thus making inland migration nearly impossible. NWF and Manomet (2014) project that ocean and estuary beaches will be reduced between 20% and 75% through the century, and salt marshes by 45% to 65%, depending on rates of sea level rise. Inundated and eroded salt marshes would likely be replaced by intertidal flats, providing a benefit for migratory shorebirds and waterfowl that depend on these habitats (NWF and Manomet, 2014) but a sharp decline in nesting habitat for wading birds, terns, gulls and other species that breed in salt marshes. Other researchers give more dire predictions, with one predicting that 89% of New Jersey's salt marshes will disappear with a 1-foot rise in sea level, and 95% being inundated with a 3-foot rise (Faass *et al.*, 2015).

Sea level rise will also increase saltwater intrusion into inland freshwater systems. Low-lying river and stream reaches will become tidal and brackish, and the ecological communities and wildlife they support will transition accordingly (Najjar *et al.*, 2000). The underground saltwater toe will also shift landward, making low elevation freshwater wetlands brackish, especially if accompanied by excessive groundwater withdrawal (Werner and Simmons, 2009). This will be particularly damaging to isolated systems, like vernal pools, and the amphibians and bird species that depend on them.

<u>Extreme Storms</u>

The confidence levels for models of tropical cyclone activity are low, leaving it unclear whether New Jersey will experience more frequent extreme storms or if past patterns will continue (Broccoli *et al.*, 2013). One researcher (Miller *et al.*, 2013), however, noted the possibility that by 2050 storms with 10-year recurrence intervals could be more intense than all historic storms that have hit Atlantic City.

*Implications*: Storm surge will inundate higher elevations due to sea level rise. If the frequency of damaging storm surge increases, then coastal communities will likely undertake more aggressive shoreline armoring to protect imperiled or damaged properties and infrastructure (Berry *et al.*, 2013). This armoring, in turn, could create a sense of safety in shoreline communities and stimulate further coastal development (Franck, 2009). This additional shoreline hardening and development would exacerbate the impacts of sea level rise on intertidal habitats and beaches by further impeding their ability to migrate landward – a process that is already a severe challenge with development along 67% of New Jersey's sandy oceanfront and 59% of these beaches armored with hard stabilization structures (Rice, 2015).

Severe storms can benefit wildlife, with new overwashes and inlets creating ideal foraging and breeding habitat for species like piping plover. These benefits can be rapidly undone, however, by post-storm management that closes new inlets and seals dune breaches. Further, post-storm replenishment of ocean and estuarine beaches can also deleteriously affect shoreline nesting birds if not carefully planned and timed.

<u>Human Responses to Climate Change</u>

As noted above, human responses to climate change can present serious challenges for wildlife and ecological communities in New Jersey (Manomet and NWF, 2013b; Faass *et al.*, 2012). For example, more variable precipitation patterns are projected to deliver more protracted periods of drought. During these times, municipalities may draw more heavily on surface and groundwater to supply clean water for drinking, watering lawns, and other purposes. These withdrawals could have a variety of implications for New Jersey wildlife, from lower stream flows that impede the movement of migratory fish to less seepage that alters wetlands vital for wildlife species of greatest conservation need. In another example, the typical response to flooding along the coast is to harden shorelines (Berry *et al.*, 2013), which can increase erosion and impede the ability of coastal habitats, and subsequently, coastal-dependent wildlife, to migrate landward with sea level rise. As such, adapting to climate change requires strategies not only that address climate challenges, but that also account for human responses to climate change.

## TAKING ACTION DESPITE UNCERTAINTY

One of the biggest difficulties climate change presents to wildlife managers is uncertainty (Trumbo *et al.*, 2014). We can see climate change happening around us and know that it will continue. Across North America, researchers are recording rising sea levels, earlier or later fish and bird migrations, earlier peak flows in rivers and streams, and a northward expansion of pests (Manomet and NWF, 2013b; ONJSC, 2013). However, the magnitude of climate change over the next 80 to 100 years is unclear, and in turn the consequences of it are uncertain as well. For example, sea level in New Jersey is projected to rise by about 3 feet if emissions are lowered dramatically and by about 6 feet if emissions remain high (Miller *et al.*, 2013). Salt marshes may be able to accrete on pace with the low-emission rate of sea level rise with adequate deposition of sediments and reductions in non-climate change threats like pollution and shoreline hardening (NWF and Manomet, 2014). They are, however, unlikely to accrete on pace with the high-emission rate, which means their persistence will largely rely on the availability of adjacent uplands to convert to salt marsh habitat. So for which scenario should wildlife managers plan?

The answer is both, or rather, decision-makers should pursue climate change adaptation strategies that will yield benefits across a range of climate change scenarios (Staudinger *et al.*, 2015; The Nature Conservancy, 2009). Since we don't know exactly what the future will hold, we should advance strategies that are most likely to yield benefits regardless of what happens.

This raises the additional challenge of moving forward on actions – some of which would be financially or politically costly – without a clear guarantee that they will be successful. Wildlife management has long worked in a world of incomplete information, as the data ideal for decision making (e.g., population sizes, habitat requirements, and in some cases even life histories) are not always available. But climate change exacerbates this difficulty by introducing variability in parameters that have historically been considered relatively stable (e.g., average seasonal temperatures, precipitation patterns, etc.).

Not only is there consensus across the scientific community that climate change is happening, there is recognition that strategies to address its projected impacts on wildlife and their habitats need to be undertaken now (Staudinger *et al.*, 2015). And we know what to do, as the majority of these strategies have been recognized as being necessary for many years regardless of climate change. Further, climate change, with its broad impacts across all sectors of New Jersey interests, could be a catalyst that brings diverse stakeholders with many different motivations together to advance common strategies (The Nature Conservancy, 2009).

## OLD THREATS REMAIN

Climate change is affecting wildlife habitats and ecological communities in New Jersey with more rapidly rising sea levels, more variable precipitation patterns, higher temperatures, and more. In addition to direct impacts, climate change is interacting with other stressors like habitat destruction, pollution, invasive species, off-road vehicle use, and an overabundance of white-tailed deer to deleteriously affect New Jersey's wildlife and ecological communities (Johnson and Strakosch Walz, 2013; Manomet and NWF, 2013b; Staudinger *et al.*, 2013; Faass *et al.*, 2012). As adaptation strategies are developed, wildlife managers need to continue addressing these serious threats as well, incorporating approaches that address multiple issues whenever possible.

## MULTIPLE APPROACHES TO ADAPTATION

Wildlife conservation planning has typically focused on maintaining existing conditions that will allow local populations to persist in healthy sites that are able to rebound after local disturbances (Stein *et al.*, 2013; Staudinger *et al.*, 2015). Unfortunately, the challenges created and exacerbated by climate change may make the goals of this approach infeasible as altered precipitation patterns, higher temperatures, and other factors lead to fundamental changes in the landscape and at local sites. As a result, managers need to consider conservation goals that manage change in addition to maintaining existing conditions (Staudinger *et al.*, 2013; Stein *et al.*, 2013).

This shift in perspective is further developed in the two approaches to adaptation that are briefly outlined below. Both approaches have similar intents of protecting healthy ecological communities and wildlife populations that can rebound from perturbations while supporting a diversity of native species. But while one approach focuses on the persistence of *current* ecological communities and species in particular places, the other focuses on the geophysical conditions that underlie *future* species richness.

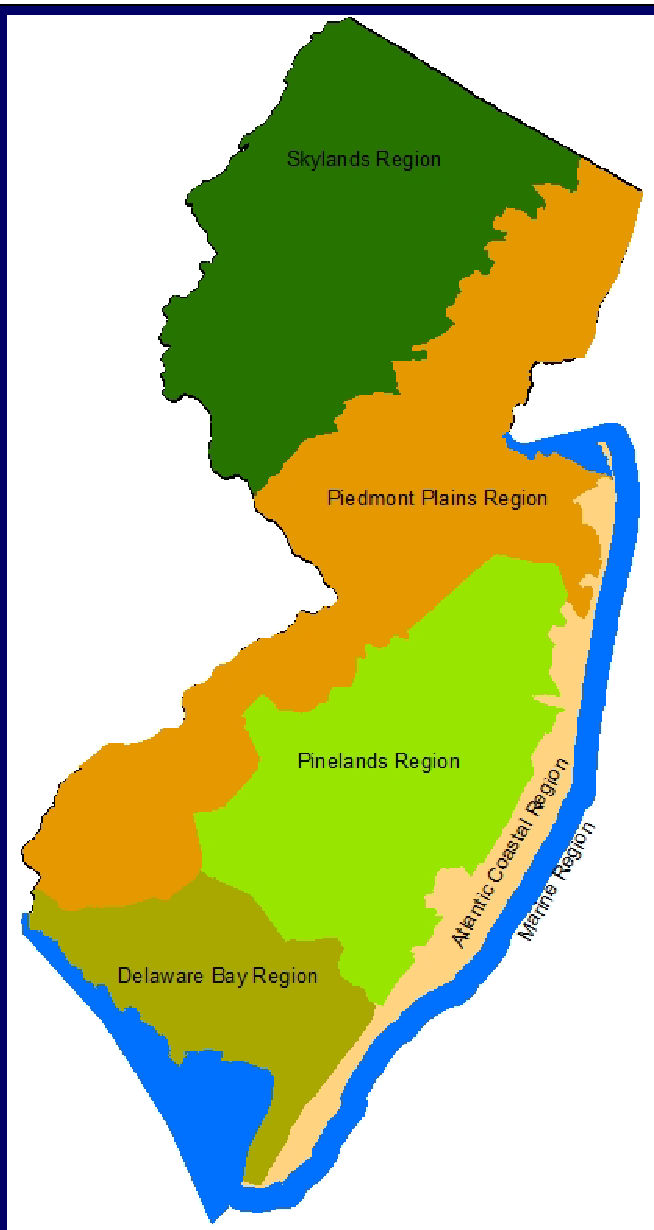
<u>Current Species and Ecological Communities</u>

This approach is the most common one seen across the United States. It focuses on the factors that affect a species' or habitat's vulnerability to climate change and strives to implement strategies that will overcome these challenges to ensure the species' or habitat's persistence. This includes approaches referred to as "resistance" and "resilience." Key elements include increasing connectivity between protected areas and other refugia, and sustaining ecological processes and functions (Staudinger *et al.*, 2015). While this approach recognizes that there will be major changes across the state, the emphasis is on protecting the species and the habitats that are in New Jersey now.

Geophysical Foundations of Future Species and Ecological Communities
This approach was developed by Anderson and Ferree (2010) and focuses on protecting places with the geophysical features (including geology, topography, elevation, and moisture gradients) that are most likely to support species richness regardless of climate change (Anderson *et al.*, 2011). Because the focus is on the abiotic features that support biodiversity, this approach may not prevent immediate local extinctions (Anderson and Ferree, 2010), a particular risk for species living at the extremes of their climactic tolerances or within habitats that are expected to experience major changes (Staudinger *et al.*, 2013).

## LANDSCAPE REGIONS

New Jersey has six landscape regions which contain similar ecological communities and processes (NJ Division of Fish and Wildlife, 2012). Brief descriptions of these regions, concise notes on primary climate change threats, and potential adaptation strategies are provided below.




Map of New Jersey's six Landscape Regions

## DELAWARE BAY LANDSCAPE REGION

Description

This landscape encompasses all or parts of Cape May, Atlantic, and Cumberland counties. It features significant populations of bald eagle, barred owl, eastern tiger salamander, and Cope's gray treefrog, and. It also provides habitat for 30 other endangered and threatened species. The vast woodland tracts of this region are among the largest in the state and support a large portion of New Jersey's neotropical birds and interior-forest bird populations. The extensive saltwater marshes and sandy overwash beaches support a significant horseshoe crab breeding area and migrating shorebirds including the red knot, a species of worldwide ecological significance. The expansive habitat mosaic of rivers and streams flowing into the tidal Delaware Bay supports concentrations of wildlife species of greatest conservation need and wintering waterfowl. Despite the heavy loss of habitat, the Cape May Peninsula remains one of the country's most important migratory "stopovers" for hundreds of bird, bat, and insect species. The peninsula's habitats, however, have been degraded by continuing development and invasions of exotic vegetation that crowd out native plants. The loss of peninsula habitat is a significant threat to migratory birds and to other species that reside permanently in this limited area. The region has many interior forests in conservation ownership, but forest management approaches do not necessarily secure the future for many wildlife species of conservation greatest conservation need. The largest threat to the region's habitats is the continuing conversion of habitat to development that fragments the remaining natural landscape.

Primary Climate Change Threats & Adaptation Strategies

- Rising sea levels will **inundate intertidal wetlands and beaches**. Extreme storms and storm surge will prompt coastal communities to **further armor coastlines** which can lead to both short- and long-term impacts on coastal habitats and wildlife. **Post-storm replenishment of estuarine beaches** can deleteriously affect shoreline nesting birds if poorly planned or timed. Higher sea levels will also **push the saltwater toe landward**, making low elevation freshwater wetlands brackish. **Excessive groundwater withdrawal** could exacerbate this problem.

  Strategies:
  - limit coastline hardening and development to allow beaches and intertidal wetlands to migrate landward
  - implement dune protection policies that protect dunes and ensure space for landward migration
  - integrate wildlife conservation into beach replenishment programs to minimize deleterious effects on nesting shorebirds
  - implement groundwater withdrawal policies that account for saltwater intrusion

- Shifting temperatures and altered precipitation patterns will **shuffle species compositions** of ecological communities at the southern edges of their ranges, altering habitat for dependent wildlife species.

  Strategy:
  - undertake site-specific and landscape-level programs to maintain and recreate connectivity between key habitats and areas of high geophysical diversity

- Higher temperatures and altered precipitation patterns could **warm rivers, streams, wetlands, and other aquatic systems**, with deleterious consequences for freshwater mussels, turtles, amphibians, and invertebrates.

  Strategies:
  - maintain and restore riparian vegetation to increase shading
  - limit and remove impervious surfaces near waterways to reduce their warming effect on runoff

- during droughts, limit water withdrawal that could reduce input of cold groundwater

- More intense precipitation could cause **more flooding and erosion in streams and rivers**, with a variety of deleterious consequences for fish, mussels, and aquatic invertebrates. In turn, the flooding could motivate landowners within riparian areas to **harden river and stream banks** to protect property and infrastructure, further altering important wildlife habitats.
  Strategies:
  - maintain and restore floodplains and wetlands to slow runoff
  - guide development away from flood-prone areas
  - limit river and stream bank hardening
  - integrate more intense precipitation and flooding considerations into soil erosion and sediment control best management practices

- Lower water levels in rivers and streams could **impede fish access** to spawning and overwintering areas, and less consistent rainfall into vernal pools could result in drying that eliminates and further isolates these important wildlife habitats. Heavier surface and groundwater withdrawal by humans during droughts could exacerbate these problems.
  Strategies:
  - implement water conservation strategies during droughts to maintain flows
  - remove barriers that could impede movement during low flows
  - maintain vegetated buffers around vernal pools to increase their resiliency

- Warmer winter temperatures will allow less cold-tolerant species, including problematic **invasives and pathogens**, to expand their ranges into New Jersey, impacting native wildlife and their habitats.
  Strategy:
  - manage sites to limit establishment of invasives and to control their spread

## ATLANTIC COASTAL LANDSCAPE REGION

Description

This landscape encompasses parts of Monmouth, Ocean, Cape May, and Atlantic counties. New Jersey's Atlantic Coast beaches and marshes are among the most productive coastal habitats in the country. Despite heavy development, they still support important portions of Atlantic Coast populations of colonial nesting birds, such as common tern, little blue heron, and great egret, and endangered beach-nesting birds such as least tern and piping plover. The coastal habitats also support most of the state's ospreys, peregrine falcons, and northern diamondback terrapins, as well as northern harriers and large concentrations of wintering waterfowl. However, human development has played a large role in degrading the quality of the habitat and there are very few natural areas remaining to support wildlife. By and large, this region has been shaped by the heavy hand of man. Upland portions of the barrier islands are almost entirely developed with residential and commercial properties. Due to this propensity for building permanent structures in a dynamic system, the need to stabilize the islands through extensive use of groins, seawalls, jetties, and intense beach replenishment programs has translated into a reduced ability of the coastal system to function normally. This tug of war is intensified by erosion, which has noticeably affected both the marsh and barrier islands in this landscape, and has diminished the suitability of the landscape for wildlife.

Primary Climate Change Threats & Adaptation Strategies

- Rising sea levels will **inundate intertidal wetlands and beaches**. Extreme storms and storm surge will prompt coastal communities to **further armor coastlines** which can lead to both short- and long-term impacts on coastal habitats and wildlife. **Post-storm replenishment of estuarine beaches** can deleteriously affect shoreline nesting birds if poorly planned or timed. Higher sea levels will also **push the saltwater toe landward**, making low elevation freshwater wetlands brackish. **Excessive groundwater withdrawal** could exacerbate this problem.

  Strategies:
  - limit coastline hardening and development to allow beaches and intertidal wetlands to migrate landward and undergo other coastal processes (including the development of new inlets and overwash areas)
  - educate communities on the benefits of naturally functioning coastal systems that better protect people and important wildlife habitats
  - implement dune protection policies that protect dunes and ensure space for landward migration
  - integrate wildlife conservation into beach replenishment programs to minimize deleterious effects on nesting shorebirds and rare plants
  - implement groundwater withdrawal policies that account for saltwater intrusion

- Shifting temperatures and altered precipitation patterns will **shuffle species compositions** of ecological communities at the southern edges of their ranges, altering habitat for dependent wildlife species.

  Strategy:
  - undertake site-specific and landscape-level programs to maintain and recreate connectivity between key habitats and areas of high geophysical diversity

- Warmer winter temperatures will allow less cold-tolerant species, including problematic **invasives and pathogens**, to expand their ranges into New Jersey, impacting native wildlife and their habitats.

  Strategy:
  - manage sites to limit establishment of invasives and to control their spread

## PIEDMONT PLAINS LANDSCAPE REGION

Description

This landscape region combines two of New Jersey's physiographic regions, the Piedmont and the Inner Coastal Plains. It encompasses all or parts of Burlington, Gloucester, Salem, Mercer, Middlesex, Monmouth, Hunterdon, Somerset, Union, Essex, Hudson, Passaic, and Bergen counties. It is dominated by the Delaware and Raritan rivers and is characterized by farmed areas, extensive grasslands, fragmented woodlands, and tidal freshwater marshes that are among the world's most productive. Imperiled species within this landscape include grassland birds such as the endangered upland sandpiper, and it is the only landscape in NJ where the endangered Allegheny woodrat resides. The Piedmont Plains Landscape has been, and continues to be, greatly influenced by human settlement. Most of this region has been logged, farmed, and developed, resulting in contaminated wetlands, fragments of even-aged forest, large fields planted in corn, soybean, or cool-season hay, a plethora of exotic invasive plants, a collection of roads and residential areas, and ideal sanctuaries for white-tailed deer.

Primary Climate Change Threats & Adaptation Strategies

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  - maintain and restore riparian vegetation to increase shading
  - limit and remove impervious surfaces near waterways to reduce their warming effect on runoff
  - during droughts, limit water withdrawal that could reduce input of cold groundwater
- More intense precipitation could cause **more flooding and erosion in streams and rivers**, with a variety of deleterious consequences for fish, mussels, and aquatic invertebrates. In turn, the flooding could motivate landowners within riparian areas to **harden river and stream banks** to protect property and infrastructure, further altering important wildlife habitats.
  Strategies:
  - maintain and restore floodplains and wetlands to slow runoff
  - guide development away from flood-prone areas
  - limit river and stream bank hardening
  - integrate more intense precipitation and flooding considerations into soil erosion and sediment control best management practices
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  Strategy:
  - manage sites to limit establishment of invasives and to control their spread

## PINELANDS LANDSCAPE REGION

Description

This landscape encompasses all or parts of Atlantic, Ocean, Burlington, Camden, and Gloucester counties. New Jersey's pinelands are an internationally recognized ecosystem consisting predominantly of pine and pine-oak mesic upland forests, pitch pine lowlands, and cedar swamps supporting extremely diverse reptile, amphibian, and invertebrate populations including interior-forest and area-sensitive species. Extensive cedar swamps and wetland systems contain numerous insect species, as well as sustainable populations of many neo-tropical birds. Its waterways support aquatic communities unique among the mid-Atlantic states.

Primary Climate Change Threats & Adaptation Strategies

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  Strategy: - manage sites to limit establishment of invasives and to control their spread

## SKYLANDS LANDSCAPE REGION

Description

This landscape region combines two of New Jersey's physiographic regions, the Ridge and Valley and the Highlands. It encompasses all or parts of Sussex, Warren, Hunterdon, Somerset, Passaic, Essex, Bergen, and Morris counties. The region contains extensive tracts of contiguous upland and wetland forests that support diverse animal populations including interior-forest and area-sensitive species. Forests on conserved lands suffer from a long-term lack of management and consist more typically of even-aged stands of similar structure. The forest tracts' understories range from a semi-barren landscape of mostly leaf litter and humus due to extensive deer browse and/or a lack of sunlight to an invasive species-dominant (or at least present at significant percentages) ground and shrub cover. Scrub-shrub habitat is minimal and geographically scattered, but is vital to various rare, common, and game wildlife species in this region. The lack of scrub-shrub habitat is also a result of long periods of unmanaged forests, habitat loss to development and infrastructure, and lack of regeneration due to over-browsing by deer.

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## MARINE REGION

Description

This region is exclusively aquatic and includes the New Jersey portion of the Delaware and Raritan bays and the Atlantic Ocean within three-nautical miles of the New Jersey shoreline. It supports shellfish of commercial value as well as a variety of fish species of commercial and recreational importance. Over half of New Jersey's federal listed species are found exclusively within this region, including several species of whales and sea turtles. Federally endangered sturgeons (shortnose and Atlantic) can be found in Delaware Bay (with Atlantic sturgeon migrating into ocean areas). Waters of the Delaware Bay are also critical habitat to one of the largest populations of horseshoe crabs in the world. During the summer, near-shore Atlantic Ocean waters are calving and nursery grounds for bottlenose dolphins while many additional species utilize these waters as a migratory corridor.

Threats

The likely responses of ocean ecological systems and marine species to climate change are not well known (Staudinger *et al.*, 2015), and articles tend to consider the issue on a global scale (for example, Kaschner *et al.* (2011) and Herr and Galland, 2009). That said, projected effects include decreased growth and reproduction in some marine fish species, range shifts for species at the northern or southern edges of their ranges, increases in diseases and pathogens, and a "reshuffling" of marine plants and animals (Staudinger *et al.*, 2013).

Adaptation Strategies

While researchers have speculated on potential challenges that climate change poses to marine systems, they have not identified many options that states might take to directly address them. But in a summary report on tools and guidelines for action (Herr and Galland, 2009), the International Union for Conservation of Nature (IUCN) did recommend a variety of strategies, including the following.

- Implementing various mitigation activities to reduce the effects of climate change on marine systems by decreasing its magnitude.
- Addressing unsustainable human activities, such as overfishing, pollution, and habitat destruction to help keep ocean systems and species more resilient.
- Creating networks of Marine Protected Areas to buffer ocean ecosystems from non-climate change challenges and to increase their resiliency.
- Restoring degraded ecosystems to make them more resilient. For New Jersey, this would likely be most important in coastal ecological systems that serve, for example, as nurseries for a variety of fish species.

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