Pollution

Pollution is a very broad category within the IUCN classification (IUCN 9), and includes any threat involving the addition of materials or energy into a natural system where they would not normally occur. For the purposes of the New Hampshire Wildlife Action Plan, pollution has been sub-divided into more specific "**Exposure Pathways**" as listed below:

Domestic and urban wastewater addresses issues related to water-borne sewage and non-point runoff from housing and urban areas that include nutrients, toxic chemicals and sediments. This includes chemicals and next generation pollutants (caffeine or pharmaceuticals) in household waste streams. Technically, sewage from a pipe is "point-source" whereas a leaking septic system is "nonpoint-source."

Threats to wildlife and habitats under the heading of **Agricultural & Forestry Effluents** include the following exposure pathways:

> **Nutrient loads** from agricultural practices focuses on water-borne pollutants from agricultural, silvicultural and aquaculture systems. This includes nutrients and toxic chemicals, and the effects of these pollutants on the site where they are applied.
>
> **Herbicides and Insecticides** can enter an ecosystem through agricultural run-off and can have impacts to both species and habitats.
>
> **Sedimentation** inputs may come from agricultural practices, or may come from domestic and urban wastewater run-off.

Persistent organic contaminants include a range of toxic or potentially toxic chemicals unrelated to pesticides. Many of these are byproducts of industrial processes or may come from agricultural sources, chemicals from disease control or from manufacturing. Examples of emerging chemicals of concern include flame retardants and components of plastics that mimic or disrupt hormones. Various contaminants can be transported by air, water or soil, making this group of pollutants widespread and often hard to track.

Oil spills, under the category of **Industrial and military effluents** (IUCN category 9.2), can directly cause injury or death to species, and can have lasting impacts on effected habitats. Examples include leakage from fuel tanks, oil spills from pipelines and ships, or polychlorinated biphenyls (PCBs) in river sediments.

Mercury and **Acid Deposition** are forms of airborne pollutants, which include all atmospheric pollutants from point and non-point sources. It is often difficult to determine the sources of many atmospheric pollutants – and thus hard to take action to counter them.

Excess energy includes all inputs of heat, sound or light that disturb wildlife or ecosystems. The most common examples of this are light pollution (such as lamps that attract insects) and thermal pollution (such as heated water from power plants).

Risk Assessment Summary

Pollution affects all 24 habitats and 112 SGCN. This is the greatest number of species affected by any single threat category. The majority of threat assessment scores were ranked as low (n=221, 63%), followed by moderate (n = 105, 30%) and high (n = 25, 7%). Only the moderate and high ranking threats are summarized for each category in Table 4-19.

Because pollution operates in many ways, and often on broad spatial scales, it was the most common threat evaluated during species and habitat threat assessment. All terrestrial, wetland, aquatic, and marine habitats experience at least one pollution-related threat (Table 4-19). Aquatic systems (rivers and lakes) had the most threats as a group, with wetland and coastal habitats occupying an intermediate position. Most terrestrial habitats had only a few threats identified, and some had none. Along the same lines, more threats were identified for coastal and aquatic species, and relatively few for wetland and terrestrial ones. A significant exception to the latter was a large number of birds and insects for which pesticides were identified as a threat.

When specific threat pathways were identified, pesticides were the most common threat with 92 instances across species and habitats (Table 4-19). This threat pathway operated across a wide range of species and habitats, and was even listed for migratory species on their winter grounds. However, pesticide-related threats were often ranked low, usually because of limited information on their impacts. Atmospheric pollutants were a close second, including 42 instances of mercury and 40 of acid deposition. Mercury and acid deposition were also noted across a wide range of habitat types. General pollution from runoff was listed in 48 cases, with specific runoff pollutants of sediment and nutrients listed 11 and 38 times, respectively. Almost all instances of these three runoff related threats apply to non-terrestrial species and habitats. Oil spills were listed 26 times, almost entirely for coastal species and habitats.

Threats can also be compared based on the proportion of targets for which a threat was ranked relatively highly. Under this approach, oil spills would be considered the most important threat, since 30% of all targets assessed received a medium or high rank. Again, the greatest risk from this threat is in coastal habitats. Pesticides rank second with 12% of targets receiving a medium or high threat score. Most affected were insects and insectivorous birds, with additional impacts on some aquatic organisms. Threats associated with runoff accounted for 7.8%, and 5.3% associated with nutrients received a medium or high score, with mussels, fish, and aquatic habitats being the primary targets. The only other threat to receive medium or high scores was acid deposition at 2.5%, where the main targets were species and habitats associated with cold water, high elevation, or forest.

Known Wildlife Exposure Pathways

Domestic and urban wastewater

Pollutants from developed areas affect many species and habitats of concern in New Hampshire, primarily in wetlands and aquatic systems. Although the severity of wastewater pollution varies by habitat, experts reported that most habitats are already being impacted. Severity decreases as one moves north and away from densely populated areas. Coldwater rivers and streams, especially at higher elevations, are the least impacted by wastewater pollution, but possibly the most vulnerable. Associated pollutants can alter water chemistry, trophic state, and organisms' physiology. Direct impacts to specific aquatic species warrant further investigation, but it is predicted that the degree of ecological change caused by runoff pollution is substantial. Pollutants vary in the extent to which their impacts have been documented, with more research on nutrients and road salt and less on emerging threats such as pharmaceuticals.

Water-borne sewage and non-point runoff from housing and urban areas introduces a wide variety of pollutants into wetland and aquatic systems, including nutrients, toxic chemicals, road salt, and pharmaceuticals. Also included in such runoff are sediments and pesticides, but because of more specific interest in these pollutants, they are being treated separately (see *Pesticides* paragraph). Note that nutrient runoff from agriculture is a separate exposure pathway.

In New Hampshire, over 90% of water pollution issues are attributed to stormwater runoff (NHDES 2015). Runoff from faulty septic systems, industry, landscaping activities, roads, golf courses, landfills, junkyards, and wastewater treatment facilities can affect aquatic systems by contributing excessive nutrients (e.g., phosphorus and nitrogen) and other pollutants (e.g., heavy metals, organic compounds, and sediment) (Richter et al. 1997, NHDES 1999, Francis and Mulligan 1997). Introduced nutrients from fertilizers entering aquatic systems can change plant composition in wetland communities and cause algal blooms, reducing dissolved oxygen concentrations enough to kill or displace fish and invertebrates (Carpenter et al. 1998).

Stormwater runoff from impervious surfaces (e.g., roofs, roads, and parking lots) often flows directly into aquatic systems. These surfaces accumulate a variety of contaminants including petroleum products, lead, PCBs, road salt, sand, pesticides, and fertilizers (United States Environmental Protection Agency 2005). The decline in aquatic species diversity as watersheds become more urbanized is well documented (Weaver and Garman 1994, Richter et al. 1997). In a Massachusetts fen community, species richness, evenness, and the abundance of individual species were adversely impacted by high sodium and chloride concentrations along a turnpike (Richburg et al. 2001). Roadside vernal pools in New Hampshire had higher levels of both sodium and chloride and lower embryonic survival of spotted salamander larvae when compared to woodland vernal pools (Turtle 2000).

Combined Sewer Overflows (CSOs), which allow wastewater treatment plants to release untreated wastewater into water bodies during heavy rain, increase nutrient and turbidity levels and prolong the presence of persistent toxins in riverine habitats. New Hampshire currently has 33 identified CSOs in six communities (NHDES 2012). These communities are working with NHDES and the USEPA to reduce their CSO discharges.

Nutrient loads from agriculture

Excessive nutrient inputs into wetland and aquatic systems have long been recognized as a significant threat. Impacts are generally greater in the major river valleys where agriculture predominates, and hence on large river habitats, floodplains, and their embedded wetlands.

Fertilizers applied to farmlands that are not taken up by crops eventually wash into water bodies or wetlands. Such runoff can affect aquatic systems by contributing excessive nutrients (e.g., phosphorus and nitrogen) (Richter et al. 1997, NHDES 1999, Francis and Mulligan 1997). Introduced nutrients from fertilizers entering aquatic systems can change plant composition in wetland communities and cause algal blooms, reducing dissolved oxygen concentrations enough to kill or displace fish and invertebrates (Carpenter et al. 1998).

Sedimentation

According to expert opinion, problematic land uses near waterbodies can result in excessive erosion, sediment deposition, increased turbidity, and the introduction of contaminants. Marsh and shrub wetlands, temperate swamps, large warmwater rivers, and aquatic habitats appear to be the most impacted. Some aquatic species are directly impacted, particularly freshwater mussels and aquatic insects, while others are indirectly impacted by habitat changes caused by excessive sedimentation.

Excess sediment can enter wetlands and aquatic systems in a variety of ways, most typically in runoff from agriculture or impervious surfaces. This category also includes altered sedimentation patterns in aquatic systems that result from altered hydrology in lotic waters (e.g., dams, bank stabilization).

Sedimentation can alter natural community composition and reduce population sizes of fish, amphibians, and benthic invertebrates by increasing turbidity and burying cobble, gravel, and boulder substrates (Hedrick et al. 2005). Soil particles entering wetlands can affect hydrology and vegetation (Mahaney et al. 2004). In estuarine and nearshore marine systems, sedimentation can limit aquatic plant growth and cause direct physical impact to sessile species such as oyster beds. Conversely, an adequate sediment supply is vital to build salt marsh habitat, particularly in regions of rising sea level.

Bank erosion and sediment deposition are natural processes that can be accelerated by human activity. Dense impervious surfaces, road upgrades, poor forestry practices, residential development, wetland filling, dredging and filling, mining, water level fluctuations, recreational vehicles, riparian zone alterations, channelization, and boat wakes increase bank erosion (Alexander and Hansen 1983, Connecticut River Joint Commission (CRJC) 2002, Francis and Mulligan 1997, Zankel 2004). Shoreline stabilization projects may reduce erosion at a specific location, but negatively affect downstream locations (CRJC 2002). A survey of 1,300 landowners along the Connecticut River indicated bank erosion as their primary concern (NHDES 1999).

Pesticides

Pesticides have long been known to negatively affect wildlife beyond their intended targets, and many of the more dangerous and broad-spectrum insecticides are no longer in widespread use as a result. However, new classes of pesticides, which often have a much narrower mode of action, have been documented to have both direct (e.g., mortality) or indirect (e.g., on food supply) effects on non-target organisms. Experts identified 31 Species of Greatest Conservation Need and nine critical habitats that are impacted by pesticide use in New Hampshire. Overall, pesticide exposure was evaluated as a low threat to most species and habitats, but experts agree that this threat is poorly understood because data is often insufficient, and the response of many species to pesticide exposure needs further study.

The pesticide category includes insecticides and herbicides intentionally or unintentionally released into the environment. Sources include agricultural uses, domestic and urban waste water that carries excess pesticides, and those pesticides used to control problematic species outbreaks or unwanted plant species.

Pesticides generally act in one of two ways: through direct toxicity or by altering food supplies and/or habitat, and more specific pathways within both these modes of action are discussed below. Toxic effects of pesticides involve the bioaccumulation of toxins within fat tissue. At high doses, exposure can result in acute toxicity and death.

Historically pesticides were usually broad-spectrum chemicals such as chlorinated hydrocarbons (e.g., DDT) that affect a variety of plant or insect species. In the case of insecticides, many non-target species were presumably killed through use of broad-spectrum pesticides, and these have been implicated in local extirpations of some insects (e.g., tiger beetles, Leonard and Bell 1998). Toxic effects of such pesticides on vertebrates include eggshell thinning in raptors (from DDT) and direct mortality (e.g., monocrotophos, Goldstein et al. 1999). Although DDT has been banned in the U.S., it is still used in parts of Latin America where some New Hampshire species migrate. Because of these extensive non-target effects, DDT and many other chemicals have been banned in many areas, and – at least in the case of DDT – the species affected by them have largely recovered. In their stead, more target-specific insecticides were developed, particularly related to control of disease-bearing Diptera. There is at present limited evidence of toxic effects of these chemicals on other species, although they are implicated in altered food availability (e.g., Evans et al. 2007, Nocera et al. 2012).

Neonicitinoids are a new class of systemic broad-spectrum insecticide that are directly applied to seeds to prevent insect damage to the growing plant. Introduced in 1994, they are now the most widely used class of insecticide in the US (Cresswell 2014). Neonicitinoiods have been implicated in declines in bee and butterfly populations (e.g. Jepsen et al 2015, Hatfield et al 2012), and toxic effects are increasingly being documented in vertebrates as well (Gibbons et al. 2015). A recent study in Europe also linked them to declines in several widespread bird declines (Hallman et al. 2014). These chemicals may act both directly (e.g., on pollinators) or indirectly through suppression of food supplies (e.g., for birds, Ghilain and Bélisle 2008, Paquette et al. 2013).

Broad-spectrum chemical herbicides and insecticides applied to forests to control hardwood regeneration and outbreaks of forest pests can enter stream systems soon after application, affecting wildlife, aquatic habitats, and human health (Miller 1982, Rashin and Graber 1993). Developed resistance from insecticides by individual species (such as spruce budworms) makes chemical applications less effective (Natural Resources Canada 1997). Even at low concentrations, the combined effect of multiple pesticides and herbicides can impact the resilience of aquatic organisms (Hua and Relyea 2014).

Persistent organic contaminants

This broad category includes a range of toxic or potential toxic chemicals other than pesticides, many of which have been detected in habitats or species of greatest conservation need. Examples of persistent organic contaminants include dioxins, PCBs, plastics and their derivative products, and flame retardants, although new types are continually being identified. In addition, there are unmonitored and unregulated inputs such as antibacterial products and pharmaceuticals that may have effects on wildlife that have yet to be determined.

Some of these contaminants can result in toxic effects, involving the bioaccumulation of toxins within fat tissue. At high doses, exposure can result in acute toxicity and death. At lower doses, toxins may be released during periods of negative energy balance such as hibernation or lactation in species such as bats (Kunz et al. 1977). Organic compounds may accumulate and persist in the sediment and in the tissue of fish and benthic invertebrates (NHDES 1999).

Oil Spills

The effect of oil spills may be very localized or very extensive depending on the source and timing of the contamination and the affected species or habitat. Impacts could be serious for sand dunes, salt marshes, estuarine habitats, coastal islands and associated species (i.e., Roseate and Common Terns, Piping Plovers, American oysters) either immediately or in the long term. The effects of oil spills on dunes and coastal islands are well documented.

Most significant oil spills originate from pipelines, power plants, trains, or tankers, and it is this class of spill that is considered here. Small amounts of oil that enter waterways in developed areas (e.g., from roads) are considered under "domestic and urban waste water."

Wildlife exposed to oil can be directly poisoned if they ingest it, or physiologically compromised if it coats their fur or feathers. Birds and mammals so coated lose their ability to thermoregulate and are at high risk of dying from exposure. Oil is of particular concern in this regard when a spill occurs in an area where sensitive species congregate (e.g., nesting or rafting seabirds, fish spawning beds, or seal haulout areas). Aquatic fish and invertebrates are impacted by oil through direct exposure, ingestion or absorption. Oil can cause significant mortality especially to eggs and larvae of many species and to sessile organisms such as oysters and other shellfish beds. Physiological impacts such as fin erosion, enlarged livers and increased heart rates have been documented in fish after exposure to oil. Because oil can persist for long periods of time in the environment, habitats may remain impaired long after an initial oil spill response, and clean-up efforts themselves can lead to unintended ecosystem damage.

Mercury

The primary source of mercury as a pollutant is fossil fuel combustion (particularly coal-fired power plants), with smaller amounts also coming from incineration of municipal and hospital waste. Airborne mercury precipitates into the environment, and becomes methylated in environments with anoxic conditions and high concentrations of organic carbon. Methylmercury is readily taken up by organisms, and is then biomagnified at higher trophic levels. The effects of mercury on wildlife are varied, but generally involve neurological impairment that can lead to behavioral, reproductive, and/or physiological impacts. Such effects are generally more pronounced in longer-lived species at the top of food chains, which have a greater likelihood of accumulating mercury to toxic concentrations.

While the presence of mercury is well documented, the actual effects on most wildlife species have been fairly minor. Long-lived predator species are one exception to this. Because of a process called biomagnification, species such as loons that feed at high trophic levels have higher levels of mercury in their blood than those that species that feed at lower trophic levels (Evers et al 2012).

Methylmercury availability greatly affects species and habitats of conservation concern in New Hampshire, though habitat and species sensitivity varies. Impacts will likely be serious in salt marshes, marsh and shrub wetlands, and floodplain forests. Mercury will likely have a serious effect on aquatic and high-elevation habitats in the short-term. Methylmercury is well documented in aquatic habitats, somewhat documented in salt marsh, marsh and shrub wetlands, and high-elevation habitats, and weakly or undocumented in alpine and peatlands.

Because mercury is more likely to be biologically available in wetland and aquatic systems, most work to date has been done with wildlife that occupy these habitats, particularly those that feed primarily on fish (Evers and Clairs 2005a). For example, 14% of Common Loons in southeastern New Hampshire have blood mercury levels high enough to cause impairment (Evers et al. 1998), and lower Bald Eagle productivity in Maine is significantly correlated to chick blood mercury levels (DeSorbo and Evers 2005). Insectivorous species can also accumulate relatively high mercury levels (e.g., salt marsh sparrows, Lane and Evers 2005; Bicknell's Thrush, Rimmer et al. 2005), although to date impacts have not been documented in these species. It is possible that these smaller songbirds – in contrast to longer lived loons and eagles – do not live long enough for the toxic effects of mercury to manifest, and even studies in highly contaminated sites have obtained variable results (e.g., Brasso and Cristol 2008, Hallinger et al. 2010). In addition, mercury availability may increase in systems impacted by acid deposition, particularly high elevation habitats (e.g,. Bicknell's Thrush, above) and peatlands (Evers et al. 2005).

Acid Deposition

Acid deposition may have critical effects on species and habitats of conservation concern in New Hampshire. Impacts are expected to be critical for alpine habitats, high elevation spruce-fir forests, and northern hardwood-conifer forests. Effects are expected to be serious for montane watersheds, vernal pools, talus slopes and rocky ridges, lowland spruce-fir forests, and hemlock-hardwood-pine forests. For most habitats, these effects are possible in the near term, although such effects could be immediate in the case of vernal pools. With the exception of vernal pools, the impacts of acid deposition on these habitats are well documented.

Combustion in vehicle engines, power plants, and other industrial processes generates nitrogen oxides and sulfur oxides, which enter the atmosphere and are transformed into acids. These chemicals can travel for hundreds of miles in the upper atmosphere before falling as acid precipitation or dry deposition, at which point they can lower the pH of water bodies, damage plant tissues, or alter mineral availability in the soil. The estimated acidity (pH) of rainfall in 2010 for the Northeast ranged from 4.9 to 5.1 (USEPA 2014); normal pH for rainfall is approximately 5.5. Although surface waters in New Hampshire are naturally acidic due to low acid-neutralizing capacity of its bedrock, anthropogenic acidification has stressed most natural communities. Acidic precipitation can alter terrestrial and aquatic ecosystems in the Northeast (Driscoll et al. 2001), and may have additive or synergistic effects with other ecosystem stressors.

In aquatic systems, low pH can affect embryonic development, growth, metabolism, respiration, reproduction, and survival. Many species of aquatic organisms are sensitive to changes in pH, and aquatic insect diversity and abundance often declines in acidified lakes and streams (Haines 1981, Okland and Okland 1986). Crustaceans and mollusks are sensitive to acid deposition because it interferes with calcium uptake, and the state-endangered Dwarf Wedgemussel and Brook Floater may be affected by chronic acidity. Amphibians experience high mortality or reduced productivity in acidic environments via reduced abundance of egg masses, decreased hatching success, increased larval mortality, and inhibited development (Pough 1976, Rowe et al. 1992, Horne and Dunson 1994, Kiesecker 1996). Impacts to fish include reduced growth, reproductive failure, skeletal deformities, and mortality (Haines 1981, Schindler 1988, Baker et al. 1996). Brook trout have been shown to seek refuge downstream during pulses of acid deposition (Baker et al. 1996), and aluminum concentrations may reach toxic levels in streams where calcium has been leached away by acid rain (Baker and Schofield 1982). Wildlife at higher trophic levels may be compromised if their preys (e.g. fish) are less available (Longcore et al. 1987).

In terrestrial systems, plant productivity and health can be severely affected by acid deposition. This is particularly true in high-elevation habitats (e.g. high-elevation spruce-fir forest, alpine), where plants may suffer direct foliar damage from contact with acid fog and mist, which often has a much higher acidity than rain. Acidophilic plants will replace calciphilic plants due to chronic acidification, and some of New Hampshire's rarest alpine and cliff communities may be at risk (Rusek 1993). Acidity also leaches nutrients from foliage and mobilizes aluminum, which damages roots and contributes to soil infertility. Acid deposition works in concert with cold temperatures to cause winter injury, a proximate cause of widespread red spruce decline in the Northeast. At the same time, acidic precipitation is known to leach metals such as calcium from upper soil layers, making it less available to terrestrial invertebrates (snails, arthropods) which require it for exoskeleton development. Declines in these invertebrates may have bottom-up effects on their predators, particularly ground-foraging birds (e.g., Wood Thrush, Hames et al. 2002).

Excess Energy

The overall impacts of light pollution on New Hampshire wildlife are quite small in comparison to other threats. This threat is likely only important in large urban areas, and even there its magnitude is poorly known.

Human activity is increasingly responsible for inputs of excess energy into the environment. These inputs can take the form of light, heat, or sound, all of which have documented effects on wildlife and their habitats.

Outdoor lighting by streetlights, parking lot lights, and illumination associated with buildings has sharply increased over the last half century (Frank 1988, Cinzano et al. 2000). Light pollution has adverse effects on many species of insects, particularly nocturnal taxa such as moths. Lepidopterists have long attributed moth population declines, especially those of northeastern saturniids, to increasing artificial light pollution (Frank 1988). Artificial lighting disturbs flight, navigation, vision, migration, dispersal, oviposition, mating, feeding, and crypsis in some moths (Frank 1988). It also increases their susceptibility to predation by birds, bats, and spiders (Frank 1988). Heavily lit urban areas can attract nocturnally migrating birds (e.g., many songbirds, cuckoos, owls, rails), which become disoriented and may suffer mortality from collisions with buildings or other structures (Klem 1989). Disoriented birds, in turn, may be more susceptible to predation, or may find themselves in inhospitable environments with limited foraging opportunities. Recent analysis suggests that between 365 and 988 million birds (median of 599 million) are killed as a result of window collisions each year (Loss et al. 2014), although not all of these are related to light pollution.

Thermal pollution is generally associated with outflows of heated water from power plants, and can have strongly negative, albeit local, effects on aquatic fauna (Stewart et al. 2013). In addition to altering habitat for resident species, heated discharge may influence the spawning success of migratory fish species, including American shad. One of the largest contributors of heated discharge to the Connecticut River, the Vermont Yankee Nuclear Power Plant, was decommissioned in 2014. There are still active power plants with heated discharge in coastal New Hampshire and in the Merrimack River.

There is increasing evidence that noise pollution can alter the behavior of birds, and presumably other animals that communicate with vocalizations. Such effects may be most significant along busy roadways, but have also been proposed in far less noisy situations such as along recreational trails. Noise pollution was not identified as a specific threat in the 2015 NH WAP, but it could be considered under IUCN 6 as a sub-category of human disturbance.

Research Needs

Run-off

- Expand water quality monitoring to include a greater variety of aquatic habitats
- Compare areas known to be receiving polluted runoff with areas that are relatively pristine
- Conduct research on prevalence and impacts of emerging pollutants on wildlife (e.g., pharmaceuticals, hormone disruptors, plastics).

Nutrients

- Monitor sensitive freshwater indicator species (such as bridle shiners and freshwater mussels) for signs of nutrient impacts.

Sediment

- Gather more complete information on how sedimentation acts on species and habitats, and determine ecological responses to high nutrient inputs.
- Determine the severity of sedimentation in key habitats and investigate the severity posed to SGCN.

Pesticides

- Determine neonicitinoid levels in New Hampshire habitats and assess their potential effects on local insect populations.
- Monitor the long-term effects of pesticides on the reproductive fitness of avian predators.
- Monitor sublethal effects of aquatic herbicide applications on wildlife and aquatic plants.

Oil Spills

- Assess potential impacts of an oil spill near threatened and endangered species breeding grounds (i.e., Seavey Island, Hampton Beach State Park and Seabrook Town Beach).
- Conduct long-term assessments and biodiversity surveys of coastal islands, dunes, and salt marshes before and after oil spills to determine effects.
- Identify appropriate mitigation for loss of wildlife due to oil spills.

Mercury

- Initiate a steering committee of state agencies (NHFG and NHDES) to work with federal agencies (USEPA, USFWS, USDA, and USGS), industry, universities, and non-profit organizations that will facilitate operations of the National Mercury Monitoring Network. Process should follow the successful mercury network by BRI with the Northeastern Ecosystem Research Cooperative.
- Conduct a risk assessment for habitats and their species assemblages.
- Continue to monitor mercury levels in species of concern across a variety of habitats.
- Determine the effects of varying mercury loads on species of concern, particularly those known to have relatively high concentrations (e.g., Bicknell’s Thrush, Saltmarsh Sparrow).

Acid Deposition

- Are there potential effects of acid deposition on alpine communities, and how do these interact with the effects of climate change?
- How has acidification affected prey availability for non-forest species like the Rusty Blackbird?
- Additional research may be relevant to determine the efficacy of any proposed mitigation measures based on research conducted at Hubbard Brook Experimental Forest.

Table 4-19. Habitats and species at highest risk from the effects of pollution (threats ranked as *Low* not included here). IUCN Level 3 provided if evaluated to that level (if not evaluated to level 2 or level 3, text reads *not specified*). Some habitats and species were evaluated for multiple specific threats separately and therefore listed multiple times below. See Appendix E for additional information on specific threats and rankings

Habitat	IUCN Level 2	IUCN Level 3	Overall Threat Score
Alpine	Air-borne pollutants	Acid rain	M
Alpine	Air-borne pollutants	Mercury	M
Alpine	Air-borne pollutants	Ozone	M
Coastal Islands	Industrial & military effluents	Oil spills	H
Coldwater rivers and streams	Agricultural & forestry effluents	Not Specified	M
Coldwater rivers and streams	Air-borne pollutants	Acid rain	M
Coldwater rivers and streams	Domestic & urban waste water	Run-off	M
Coldwater rivers and streams	Not Specified	Not Specified	M
Dunes	Industrial & military effluents	Not Specified	M
Dunes	Industrial & military effluents	Oil spills	H
Estuarine	Domestic & urban waste water	Run-off	M
Estuarine	Industrial & military effluents	Oil spills	H
Estuarine	Not Specified	Nutrient loads	M
Floodplain Forests	Not Specified	Not Specified	M
Grassland (Cropland)	Agricultural & forestry effluents	Herbicides & pesticides	M
Lakes and ponds with coldwater habitat	Agricultural & forestry effluents	Not Specified	M
Lakes and ponds with coldwater habitat	Air-borne pollutants	Acid rain	M
Lakes and ponds with coldwater habitat	Not Specified	Not Specified	M
Large warmwater rivers	Agricultural & forestry effluents	Herbicides & pesticides	M
Large warmwater rivers	Domestic & urban waste water	Run-off	M
Large warmwater rivers	Excess energy	Thermal pollution	M
Large warmwater rivers	Not Specified	Not Specified	M
Marine	Air-borne pollutants	Mercury	M
Marine	Industrial & military effluents	Oil spills	M
Marsh and Shrub Wetlands	Not Specified	Not Specified	M
Peatlands	Domestic & urban waste water	Run-off	M
Peatlands	Not Specified	Not Specified	M
Salt Marsh	Domestic & urban waste water	Run-off	M

Salt Marsh	Industrial & military effluents	Oil spills	H
Salt Marsh	Not Specified	Not Specified	M
Temperate Swamp	Not Specified	Not Specified	M
Vernal Pools	Not Specified	Not Specified	H
Warmwater lakes and ponds	Agricultural & forestry effluents	Not Specified	M
Warmwater lakes and ponds	Domestic & urban waste water	Run-off	M
Warmwater lakes and ponds	Domestic & urban waste water	Sewage	M
Warmwater lakes and ponds	Not Specified	Not Specified	M
Warmwater rivers and streams	Agricultural & forestry effluents	Not Specified	M
Warmwater rivers and streams	Domestic & urban waste water	Run-off	H
Warmwater rivers and streams	Domestic & urban waste water	Run-off	M
Warmwater rivers and streams	Not Specified	Not Specified	M

Common Name	**IUCN Level 2**	**IUCN Level 3**	**Overall Threat Score**
American Brook Lamprey	Domestic & urban waste water	Run-off	M
American Bumble Bee	Agricultural & forestry effluents	Herbicides & pesticides	H
American Kestrel	Not Specified	Not Specified	M
American Oysters	Agricultural & forestry effluents	Nutrient loads	M
American Oysters	Domestic & urban waste water	Not Specified	M
American Oysters	Industrial & military effluents	Oil spills	H
Atlantic Sea Scallop	Air-borne pollutants	Mercury	M
Atlantic Sea Scallop	Industrial & military effluents	Oil spills	M
Bald Eagle	Not Specified	Not Specified	M
Banded Sunfish	Domestic & urban waste water	Run-off	M
Banded Sunfish	Not Specified	Not Specified	H
Bank Swallow	Agricultural & forestry effluents	Herbicides & pesticides	M
Bicknell's Thrush	Air-borne pollutants	Acid rain	M
Bobolink	Agricultural & forestry effluents	Herbicides & pesticides	M
Bridle Shiner	Domestic & urban waste water	Run-off	M
Bridle Shiner	Not Specified	Not Specified	H
Brook Floater	Not Specified	Not Specified	H
Brook Trout	Air-borne pollutants	Acid rain	H

Brook Trout	Domestic & urban waste water	Run-off	M
Chimney Swift	Agricultural & forestry effluents	Herbicides & pesticides	M
Cliff Swallow	Agricultural & forestry effluents	Herbicides & pesticides	M
Common Loon	Air-borne pollutants	Mercury	M
Common Tern	Industrial & military effluents	Oil spills	H
Dwarf Wedgemussel	Not Specified	Not Specified	H
Eastern Pondmussel	Domestic & urban waste water	Not Specified	M
Eastern Whip-poor Will	Not Specified	Not Specified	M
Golden Eagle	Not Specified	Not Specified	M
Horseshoe Crab	Agricultural & forestry effluents	Nutrient loads	M
Horseshoe Crab	Air-borne pollutants	Mercury	M
Horseshoe Crab	Domestic & urban waste water	Not Specified	M
Horseshoe Crab	Domestic & urban waste water	Run-off	M
Horseshoe Crab	Industrial & military effluents	Oil spills	M
Jefferson/Blue-Spotted Salamander Complex	Air-borne pollutants	Acid rain	M
Margined Tiger Beetle	Not Specified	Not Specified	H
Monarch	Agricultural & forestry effluents	Herbicides & pesticides	H
Monarch	Agricultural & forestry effluents	Not Specified	M
Nelson's Sparrow	Air-borne pollutants	Mercury	M
Nelson's Sparrow	Not Specified	Not Specified	M
Northern Leopard Frog	Agricultural & forestry effluents	Herbicides & pesticides	M
Northern Shrimp	Air-borne pollutants	Mercury	M
Northern Shrimp	Industrial & military effluents	Oil spills	M
Peregrine Falcon	Not Specified	Not Specified	M
Piping Plover	Industrial & military effluents	Not Specified	M
Piping Plover	Industrial & military effluents	Oil spills	H
Purple Martin	Agricultural & forestry effluents	Herbicides & pesticides	M
Rainbow Smelt (diadromous)	Not Specified	Not Specified	M
Rainbow Smelt (landlocked)	Domestic & urban waste water	Run-off	M
Roseate Tern	Industrial & military effluents	Oil spills	H
Round Whitefish	Agricultural & forestry effluents	Not Specified	M
Rusty-patched Bumble Bee	Agricultural & forestry effluents	Herbicides & pesticides	H

Saltmarsh Sparrow	Air-borne pollutants	Mercury	M
Saltmarsh Sparrow	Not Specified	Not Specified	M
Scarlet Tanager	Air-borne pollutants	Acid rain	M
Seaside Sparrow	Air-borne pollutants	Mercury	M
Seaside Sparrow	Not Specified	Not Specified	M
Softshell Clam	Agricultural & forestry effluents	Nutrient loads	M
Softshell Clam	Air-borne pollutants	Mercury	M
Softshell Clam	Domestic & urban waste water	Run-off	M
Softshell Clam	Industrial & military effluents	Oil spills	M
Swamp Darter	Domestic & urban waste water	Run-off	M
Swamp Darter	Not Specified	Not Specified	M
Veery	Air-borne pollutants	Acid rain	M
Willet	Air-borne pollutants	Mercury	M
Wood Thrush	Air-borne pollutants	Acid rain	M
Yellow Bumble Bee	Agricultural & forestry effluents	Herbicides & pesticides	H
Yellowbanded Bumble Bee	Agricultural & forestry effluents	Herbicides & pesticides	H

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