CONSERVE THE CALL

Identifying and Managing Environmental Threats to the Common Loon

About BRI

The mission of Biodiversity Research Institute is to assess emerging threats to wildlife and ecosystems through collaborative research and to use scientific findings to advance environmental awareness and inform decision makers.

About the Ricketts Conservation Foundation

The mission of the Ricketts Conservation Foundation is to support the conservation of wildlife and wilderness areas, and to promote the importance of environmental stewardship as an enduring value.

Restore the Call Series Publications

As part of BRI's loon restoration project, *Restore the Call,* this booklet is the first in a series of publications that aim to highlight scientific findings in different areas of our loon research including environmental stressors, loon distribution and numbers, demographics and movement, and loon behavior.

Acknowledgements

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Design and Production: RavenMark
Illustrations: Adelaide Tyrol
Loon Raft Illustration: Shearon Murphy
Photos:

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Biodiversity Research Institute
276 Canco Road
Portland, Maine 04101
www.briloon.org

For more information, visit BRI's Center for Loon Conservation at www.briloon.org/looncenter or contact David Evers at david.evers@briloon.org.

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CONSERVE THE CALL

Identifying and Managing Environmental Threats to the Common Loon

A Series Publication by BRI's Center for Loon Conservation in Partnership with the Ricketts Conservation Foundation

Summer 2014

INTRODUCTION

The Common Loon is an important indicator of the health of its aquatic environment.

The Common Loon (*Gavia immer*) is one of five loon species that exist worldwide and is a highly visible resident in North American waters. Many individuals and organizations are dedicated to conserving this species, in part due to its great public appeal. Common Loons are widely recognized symbols of northern wilderness and indicators of aquatic health. Landscape-level alterations, habitat disturbance, fishing practices, and pollution threaten loon populations across their range, but at both individual and population levels, loons are resilient and able to acclimate to many of these threats, often within the same generation.

The sustainability of loon populations over time will ultimately depend on our own awareness and response to minimize the many threats known across North America.

The Common Loon is a long-lived bird with delayed maturity and low fecundity. In parts of its range, the loon's natural history, population dynamics, movements, and pollution exposure levels are well characterized by long-term, landscape-level capture and color-marking programs. Recent advances in high-resolution population models, habitat quality ranking models, and mercury wildlife criterion value models provide refined quantitative tools to support science-based management and policy decisions. These models and their associated databases have already contributed toward a better understanding of the major threats to loons. Further efforts in marking, sampling for contaminant and genetic profiles, and satellite telemetry will enhance long-term landscape-level conservation.

Overall, the Common Loon population in North America is relatively healthy and robust, with a total estimated breeding population of 258,000 territorial pairs. The nonbreeding cohort increases the total adult population to about 621,000 individuals. This number swells to an estimated 726,000 individuals during fall migration after including young of the year. Approximately 30 percent of the fall population migrates to the Pacific coast and 70 percent to the Gulf of Mexico and Atlantic coast. More than 94 percent of the breeding loon population resides in Canada.

The large breeding population of loons in Canada's vast lake-rich areas is relatively protected from shoreline development and recreational activities. However, concerns remain over other threats that could negatively impact Canada's robust populations. These threats include contamination of lakes by mercury and acid rain, by-catch from commercial fishing, marine oil spills, botulism outbreaks, and emaciation syndrome. Mercury and acid rain severely affect breeding loon populations across large areas of wilderness habitat. Acute, catastrophic events such as the annual loss of large numbers of fall migrant adults to botulism outbreaks on Lake Erie and Lake Ontario are problematic, especially when combined with air pollutants that, based on new findings from the Canadian Lakes Loon Survey, appear to be causing severe adverse impacts on Ontario's and Quebec's breeding population.

Conservation of isolated and peripheral populations at the southern range limits in the United States is important to loon restoration efforts. Localized threats, such as shoreline development, recreational activities, reservoir management, and lead poisoning are more intense in the southern part of the loon's breeding range than in roadless areas of Canada.

Based on the U.S. Fish and Wildlife Service Conservation and Management Plan (USFWS Plan) for the Common Loon, this publication, *Conserve the Call*, outlines loon monitoring, research, education, management, and policy requirements as well as provides proven strategies designed to reduce impacts to loon populations.

Threats to loons vary by geographic region and season (Table 1; Figure 1). The governing U.S. Fish and Wildlife Service and Canadian Wildlife Service offices will benefit by working together to prioritize conservation and management efforts. We recommend a Joint Steering Committee be established to implement the recommendations in the USFWS Plan, and therefore establish a network of regionally customized strategies that prioritize actions based on the goals set forth in the Plan.

BRI'S CENTER FOR LOON CONSERVATION

This Center is dedicated toward a greater awareness of loon species worldwide. Since 1986, our biologists have monitored breeding, migratory, and wintering loon populations across North America. A major basis for this work has been the discovery and widespread use of a replicable and safe capture method that permits regular banding and sampling of adult and juvenile loons. More than 5,000 Common Loons have been uniquely color-banded.

BRI continues to identify threats to loon populations and develop collaborative research projects to help at-risk populations achieve self-sustaining levels, not only for the Common Loon, but for other species of loons, including the Yellow-billed Loon, Red-throated Loon, and Pacific Loon.

For detailed information about BRI's loon research, visit our Center for Loon Conservation at:

www.briloon.org/looncenter

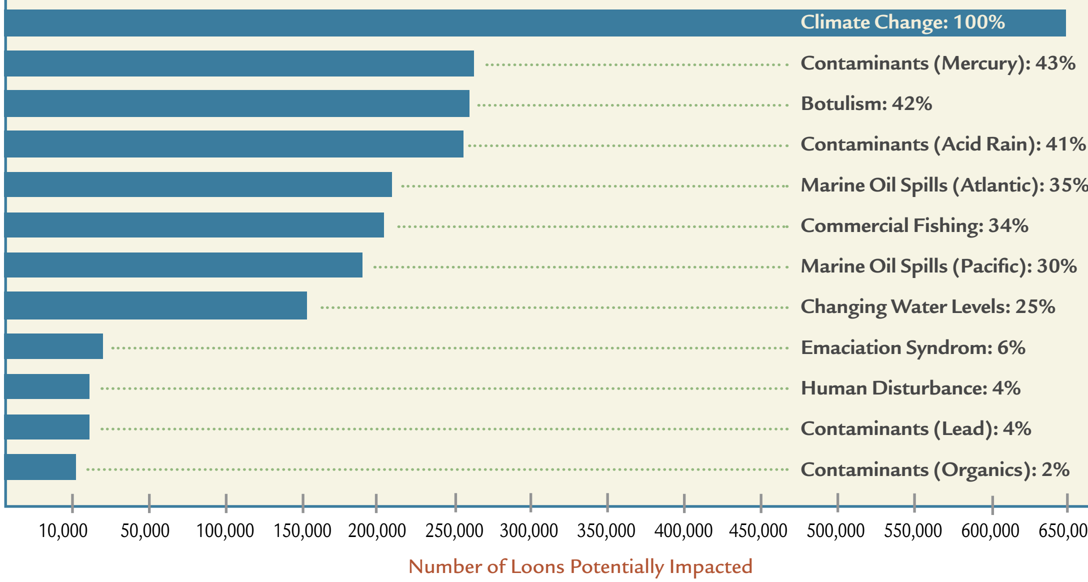
Table 1. **Threats to Common Loons by Geographical Region and Estimated Impact**

Threats to Common Loons	USFWS Region* Impacted	Canadian Province Impacted	Estimated Numbers Potentially Impacted	Relative Severity Index Ranking
Human Disturbance	1, 3, 5, 6, 7	NB, NS, ON	27,000	11
Commercial Fishing	1, 4, 5, 7	BC, NF, PQ	212,000	6
Marine Oil Spills (Atlantic)	4, 5,	NB, NF, NS, PQ	217,000	5
Marine Oil Spills (Pacific)	1, 7, 8	BC	186,000	7
Contaminants: Mercury	3, 5	NB, NF, NS, ON, PQ	267,000	2
Contaminants: Acid Rain	5	NB, NF, NS, ON, PQ	254,000	4
Contaminants: Lead	1, 3, 5, 6	NB, NS, ON	25,000	10
Contaminants: Organics	5		11,000	12
Changing Water Levels	1, 3, 5, 7	All of Canada	155,000	8
Emaciation Syndrome	4		35,000	9
Botulism	3, 5	ON, MB, SK	262,000	3
Climate Change	All Regions	All of Canada	621,000	1

*USFWS Regions can be found at www.fws.gov/where; Canadian Provinces can be found at www.nrcan.gc.ca

Figure 1. **Percentage of Total Common Loon Populations at Risk by Threat**

Loons are susceptible to multiple threats depending on the locations of their breeding lakes, migration corridors, and wintering grounds.



BRI LOON RESEARCH

BRI's loon research stretches across much of North America to include breeding areas, migratory corridors, and wintering regions. Many of our studies investigate significant environmental threats to loon populations. The project list below demonstrates how BRI contributes to a better understanding of the major threats to loon populations. The map at right depicts the locations of these studies.

HUMAN DISTURBANCE

The largest loon research and conservation project in North America, *Restore the Call*, funded by the Ricketts Conservation Foundation (see page 32), strives to develop conservation plans to reduce human disturbance and other threats and restore breeding loons to parts of their former range—with an emphasis in Massachusetts, Minnesota, and Wyoming.

In collaboration with other nonprofit groups, BRI works in protected areas—national parks, national forests, and other wildlife areas across North America—to better manage human disturbance through monitoring and outreach efforts.

COMMERCIAL FISHING

Nearshore commercial fishing nets can inadvertently capture and drown large numbers of loons in areas such as the mid-Atlantic coast and Puget Sound in Washington. BRI has worked to develop net mesh sizes that permit the escape of loons with minimal loss of target fish.

MARINE OIL SPILLS

BRI's research helps to understand the impact of oil spills, both large and small, to loons. BRI's projects include the *North Cape* oil spill in Rhode Island, the *Bouchard Barge 120* oil spill in Massachusetts, the *Deepwater Horizon* oil spill in Louisiana, Mississippi, Alabama, and Florida, and an oil spill on Sanborn Pond in Maine. BRI continues to investigate this threat with the U.S. Fish and Wildlife Service and its Natural Resource Damage Assessment and Restoration Program, which quantifies the number of *loon-years* (adults and future progeny) lost from oil.

CONTAMINANTS

Hg

Mercury is one of the greatest conservation concerns for breeding loons in North America. The 2013 Canadian Lakes Loon Survey identified mercury, in combination with acid rain, to be the primary cause of significant declines in breeding success of loons across Canada over the past two decades, especially in the eastern part of that country.

In the United States, the risk of mercury is especially high; biological mercury hotspots have been identified across many areas of the country. BRI has played an important role in working with state and federal collaborators to characterize the exposure and effects of mercury.

Lead sinkers and jigs are toxic when ingested by loons and other birds. BRI is investigating the blood lead levels in loons across North America and has identified background levels that can be compared to those that cause mortality.

CHANGING WATER LEVELS

Since 1993, BRI studies in the Rangeley Lakes region of Maine have emphasized the potential impacts of changing water levels on reproductive success and how artificial nesting platforms (rafts) can be used as effective management tools. Rafts have been shown to improve nesting success by more than 50 percent on some reservoirs.

EMACIATION SYNDROME

Loons overwintering on the coasts of North America must endure threats that are different from their breeding lakes. During times of physiological strain, such as active feather molt and storm events, loons may be more prone to cyanobacteria blooms or an inability to find high energy food. Mass mortality from emaciation syndrome can result. BRI is working across the Gulf of Mexico to better understand the physiology, behavior, and movements of loons and how environmental stressors could play a role in threatening overwintering populations.

BOTULISM AND OTHER DISEASES

Botulism type E is a disease that can cause large-scale mortality events and has been especially prevalent over the past decade in Lake Erie, Lake Ontario, and Lake Michigan. BRI is working in New York to quantify the overall impacts to migrating loons and connectivity to breeding populations.

CLIMATE CHANGE

Changing climate conditions have the potential for significant adverse impacts at a population level to loons across their breeding and wintering ranges. BRI has initiated a study to examine the interaction of climate change with environmental mercury loading.

OFFSHORE WIND TURBINES

In 2012, BRI began a three-year project, funded by the U.S. Department of Energy, to provide essential baseline information on animal distributions and habitat use on a regional scale, including loon species. This information will be used to assess potential risks to wildlife and to attempt to minimize the effects of planned offshore wind turbine development.

BRI Arctic Coastal Plain Biostation
Kenai, AK
North Central Saskatchewan
Western Alberta
Flin Flon, SK
South-Central British Columbia
Summer Breeding Range
La Mauricie NP, PQ
Rangeley Lakes Region, ME
Isle Royale NP, MI
Upper Peninsula, MI (Seney NWR; Hiawatha & Ottawa NF)
Lepreau Region, NB
Kejimkujik NP, NS
Washington
Montana
Acadia NP, ME
Greater Yellowstone Ecosystem: ID, MT, WY
Voyageurs NP, MN
Southeastern, NH
Buzzards Bay, MA
Block Island Sound, RI
Lake Erie & Lake Ontario, NY
Walker Lake, NV
Adirondack Park, NY
Quabbin Reservoir Area, MA
Mid-Atlantic Region: DE, MD, NC, VA
Morro Bay, CA
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Barataria Bay, LA
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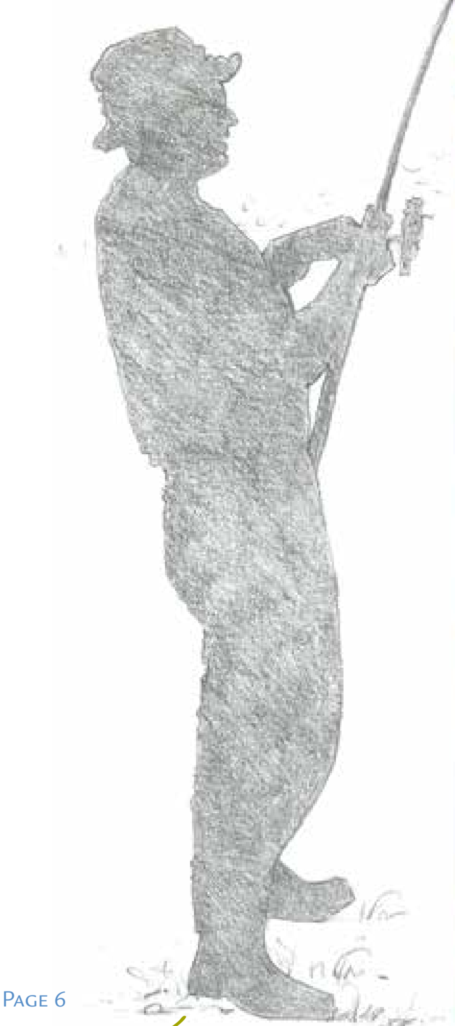
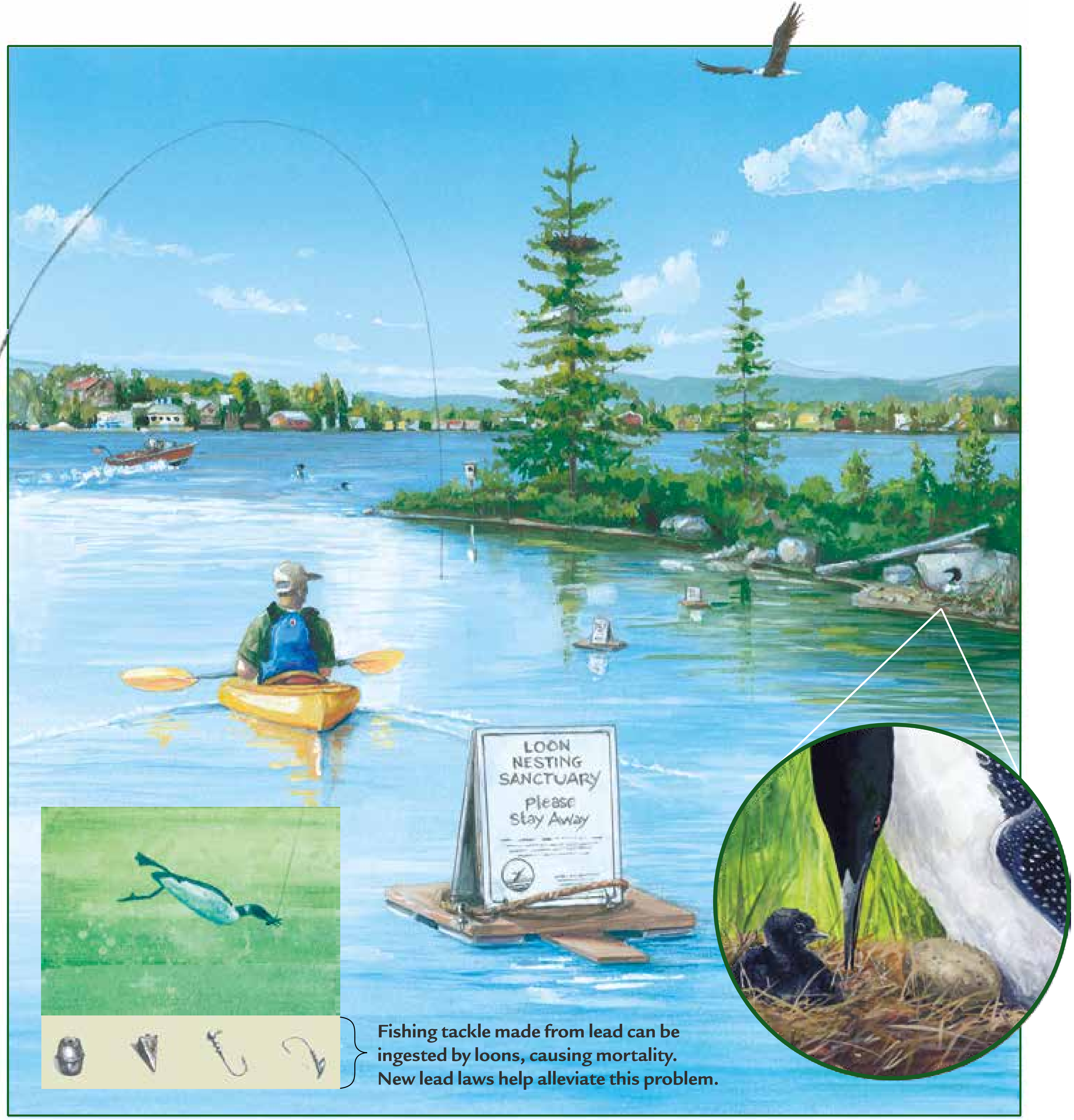
Global Climate Change
Offshore Wind Turbines
Restore the Call Sites
Yellow-billed, Red-throated, Pacific Loon Studies

Sharing the Lakes: How Recreation and Shoreline Development Affect Breeding Loons





Fishing tackle made from lead can be ingested by loons, causing mortality. New lead laws help alleviate this problem.

Human Disturbances

Loons respond to human disturbance in diverse and complex ways. Development and recreational pressures on northern lakes have been implicated in the decline of breeding loons. Despite these declines, however, some studies report that loons can successfully breed on water bodies with such disturbances; loons also develop adaptive behaviors in response to human activity. The processes and limits of habituation are unknown and are best addressed by evaluating site-specific conditions.

Evidence of the loon's ability to acclimate suggests that, with forethought and understanding, people and loons can adapt and live together.

SHORELINE DEVELOPMENT

Habitat degradation and loss from shoreline development are often viewed as major contributors to reduced reproductive success in loons. Shoreline development adversely affects habitat quality by: modifying and/or removing vegetation and substrate material; enhancing predator densities; increasing the overall presence of human activity; and introducing nonnative plants.

When vegetation is removed, shoreline erosion and water temperatures tend to increase. Ensuing sedimentation and phosphorus enrichment cause excessive algae and aquatic weed growth, change prey composition and patterns of vegetative growth, and reduce water clarity and quality. Urban, suburban, and municipal stormwater runoff can further contribute to water quality problems.

Shoreline development is generally accompanied by increases in loon predators. Raccoons are widely considered the most common predator of loon eggs; there is a correlation between raccoon densities and increasing shoreline development. Other wildlife associated with increasing human habitation include avian predators such as gulls and corvids.

Loons, particularly those breeding pairs that are unaccustomed to people, are likely to relocate nest and nursery sites away from areas with high human presence. Shoreline development in preferred loon breeding habitat, such as island habitats, can prevent or reduce the use of highly suitable areas by a territorial pair.

RECREATIONAL ACTIVITY

Recreational boating can be a threat to breeding loons. The extent of the threat, however, depends on boater awareness and loon acclimation. Motorboats generally represent a greater disturbance and risk to loons in open water than to those nesting and foraging in shallow water. Repeated exposure to boating activity can dull response times in loons, making them more susceptible to collisions. Thirty-nine percent of all loon mortality in New England is caused by trauma, 36 percent of which is due to boat collisions.

Along with motorboats, motorized personal watercraft, such as jet skis, also present a threat to loons. Not only do these watercraft cause blunt trauma mortality to loons in direct collisions, they can also have a major impact on nesting loons. Because jet skis have a shallow draft, drivers can closely approach shorelines at high speeds, which can cause nests to wash out. Also, jet skis are loud enough to drown out loon vocalizations; a driver unaware of a loon's alarm calls may not move away from the nesting area.

Evidence of the loon's ability to acclimate suggests that with forethought and understanding both people and loons can adapt and live together.

Adult loons will vigorously "dance" on the water or call loudly to distract predators and people away from chicks or a nest. Although a disturbed loon is interesting to watch as it performs this "penguin dance," calling familiar tremolos or yodels, intruders should recognize that they are too close, and should quickly withdraw so as to minimize interference with egg incubation or the raising of young.

Shoreline development can increase populations of predatory species, such as raccoons, crows, and gulls, that adapt easily to humans.

Radiograph depicting ingested lead tackle in a Common Loon. Individuals that swallow lead sinkers or lead-headed jigs die from lead poisoning within two weeks.

People in nonmotorized watercraft, such as canoes and kayaks, also pose a threat because they can access shallow water areas typical of loon nesting and brood sites. Disturbance by canoists and kayakers is most detrimental during the early stages of nesting when loons are more likely to abandon their nests (and their eggs). Although loons breeding on lakes where there is high human activity flush at shorter distances and less readily, any increase in activity near the nest may attract predators. One study showed that the average time spent off the nest was eight minutes for flushes related to natural causes versus 24 minutes for those caused by human disturbance.

Irresponsible angling practices can also have considerable adverse effects on loons. Excessive angler wading and boating in shallow vegetated areas can disturb nesting and foraging activity. Discarded fishing line (monofilament) poses mortality risks from entanglement. Lead fishing tackle is poisonous to loons and can cause fatalities.

Management and Policy Recommendations

▶ Management: Post Signs, Buoys, and Roping for Nest Sites

Preferred nest sites are found on small islands and in wetlands with an undeveloped buffer area of at least 500 feet. To enhance nesting success, the use of ropes and floating signs to cordon off high-risk loon territories can be effective, especially where enforcement is possible. On highly developed lakes in New Hampshire, territories with signs and float lines surpassed the hatching success of territories without such restrictions.

Use of voluntary enclosures should be based on site-specific nest failure history and an understanding of typical lake use patterns. We recommend floating three to six signs approximately 550 feet from the nest site for optimal buffering capacity. Enclosures should be removed immediately following hatch, or when the adults have moved young to another location. This will maximize public acceptance and compliance.

▶ Policy: Establish Working Partnerships

Partnerships between developers and conservation organizations can be helpful to incorporate low impact uses and practices in the deed restrictions of lake associations and shoreline subdivisions.

Beneficial practices could include:

- cluster development on shorelines, leaving areas of undeveloped tracts
- limit the number of motorized craft allowed on a waterfront property, including the exclusion of jet-propelled watercraft
- limit horsepower or enforce headway speed in sensitive areas
- include the cost of increased monitoring effort in subdivision fees, lake association fees, or other local fees
- restrict construction activities, particularly those involving barges, from occurring during the nesting season

▶ Policy: Require Nonlead Fishing Tackle

Lead fishing sinkers and jigs greater than one ounce regularly kill Common Loons across North America. Many states have enacted laws to restrict the use of lead tackle. Refer to pages 14-15 for more information.

Recreational pressures may affect breeding loons. Evidence of the loon's ability to acclimate suggests, however, that properly designed mitigation efforts and, more importantly, outreach initiatives can be successful in many instances.

Commercial Fishing

Commercial fishnet by-catch is well documented in freshwater areas such as the northern areas of Lake Michigan and Lake Huron and the southern shore of Lake Superior. In the 1960s and 1970s, studies documented fishnet mortality in several lakes in the Northwest Territories and Manitoba.

In the Great Lakes, trap nets with long, strung-out wings (or leads) are often used to capture schools of fish. Loons are attracted to the fish activity and readily enter the heart of the trap net. This part of the net is enclosed on top and is completely submerged in deep areas, often drowning the loon.

Shallow set nets, where the top of the net is at the water's surface, have an even greater impact on loon mortality. In shallow set nets, the loon is able to surface but remains trapped under the net and its struggling movements attract nearby loons that are also eventually caught and drown. One observed event identified at least 50 migrant loons captured this way in one net over a one-week period on Lake Superior.

Loons overwintering in marine waters are especially prone to getting caught in commercial fishnets. One late 1990s study documented by-catch in commercial gillnets from the mid-Atlantic shores—of the more than 2,500 birds trapped and killed in these nets, 21 percent were Common Loons. Although by-catch in this region is highest for the Red-throated Loon, the Common Loon is a close second for a species of concern. Since the mid-Atlantic coast supports the highest densities of wintering Common Loons, annual takes in this region constitute an important threat to this species. Although not as well documented, other commercial fishing areas that pose threats to loons include the Puget Sound and surrounding areas in Washington.

Common Loons are inadvertently captured in nets set by commercial and tribal fishing interests.

SPORT HUNTING

Sport and game hunting of loons was common prior to the federal Migratory Bird Treaty Act of 1918. Historically, loons were killed due to their perceived threat to game fish. Such sport shooting was linked to regional population declines across New England and the Pacific Northwest.

While illegal take through recreational hunting in the U.S. and Canada is now rare, it still occurs.

In the late 1800s, loons were regularly hunted for sport.

Balancing fishing interests and the safety of loons is possible through innovative net designs.

Marine Oil Spills

New field and analytical techniques provide ways to restore breeding populations connected to loss from oil spills.

Loons spend part of their life cycle in marine environments, making them susceptible to oil spills.

Winter is naturally a critical time for loons; additional stressors in the environment such as oil spills can have a disproportionate impact on their survival and, potentially, their breeding success.

Marine oil spills are a major threat to seabirds, including the Common Loon. Both the ingestion of oil and deposition of oil on feathers can have immediate (i.e., death) and long-term (i.e., reproductive impairment) ramifications on birds. Since the early 1900s, multiple oil spills across the United States have accounted for significant loon mortality events. Several recent oil spills illustrate these impacts in Alaska, Louisiana, and New England.

In March 1989, the *Exxon Valdez* spilled nearly 11 million gallons of oil across more than 1,100 miles of Alaskan shoreline killing an estimated 720 to 2,160 Common Loons. Based on monitoring efforts overseen by the Exxon Valdez Oil Spill Trustee Council the Common Loon is considered recovered in the spill area.

In January 1996, the tank barge *North Cape* spilled 828,000 gallons of home heating oil off the Rhode Island coast, killing an estimated 400 loons. Models based on the population dynamics of color-marked individuals indicate approximately 3,900 loon-years were lost in this event (including adult loons that died from the spill as well as their lost future progeny). On-site replacement of loons was deemed logistically impractical, so state and federal trustees made a precedent-setting decision that mitigation would entail the purchase of lake shoreline breeding habitat in New England (see Management Recommendations).

A similar approach may be used for assessing injury and compensating the loss of approximately another 4,000 loon-years lost during the April 2003 oil spill in Buzzard's Bay, Massachusetts (see box at right).

When the *Deepwater Horizon* oil rig exploded in 2010, 200 million gallons of crude oil spilled into the Gulf of Mexico, spreading 650 miles across four coastal states, with the majority of oil reaching the Louisiana coast. Local bird populations, including wintering loons, were affected.

Ingested oil can compromise immune and hormonal systems as well as blood cells. Polyaromatic hydrocarbons (PAHs) found in crude oil are mostly responsible for the toxic effects attributed to petroleum exposure.

BRI FINDINGS FROM THE FIELD

From 2010-2014, BRI's winter study in Louisiana* monitored the health of individual loons and investigated aspects of loon winter ecology and natural history. Findings include:

- The concentrations of PAHs in loons were relatively low in 2011 and 2012 (<5 parts per billion), but increased 20x to more than 100 ppb in 2013. Understanding the true impact of the spill requires more monitoring over time and across multiple seasons.
- Coastal Louisiana Common Loons migrate to Saskatchewan where they breed. And, resighted color-banded loons overwinter in the same bays throughout the winter and in successive winters (based on satellite transmitter data).
- Further research is being conducted to fully understand the winter ecology of loons and how added stressors like oil spills can affect the long-term health of these loons and potentially contribute to emaciation syndrome (see page 19).

This study was funded by Earthwatch Institute.

Management Recommendations

▶ Proven Restoration Strategies

In a precedent setting 10-year restoration effort for the North Cape oil spill in Rhode Island, BRI worked with the U.S. Fish and Wildlife Service (USFWS) to identify and purchase best lake shoreline properties for mitigation.

A multi-million dollar injury was paid by the responsible party (and administered by the USFWS) for the loon-years lost from this oil spill. Surveys were conducted and purchase priority was given to quality shoreline habitat in Maine, including the Rangeley Lakes region, the West Branch of the Penobscot River, the upper Allagash River, and the Downeast area.

At these sites, BRI biologists monitored the protected loon pairs on a weekly basis (for two to ten years—depending on the site). This long-term approach was instrumental to document the success of replacing the loon-years lost. This strategy is worth using as a basis for other oil spills.

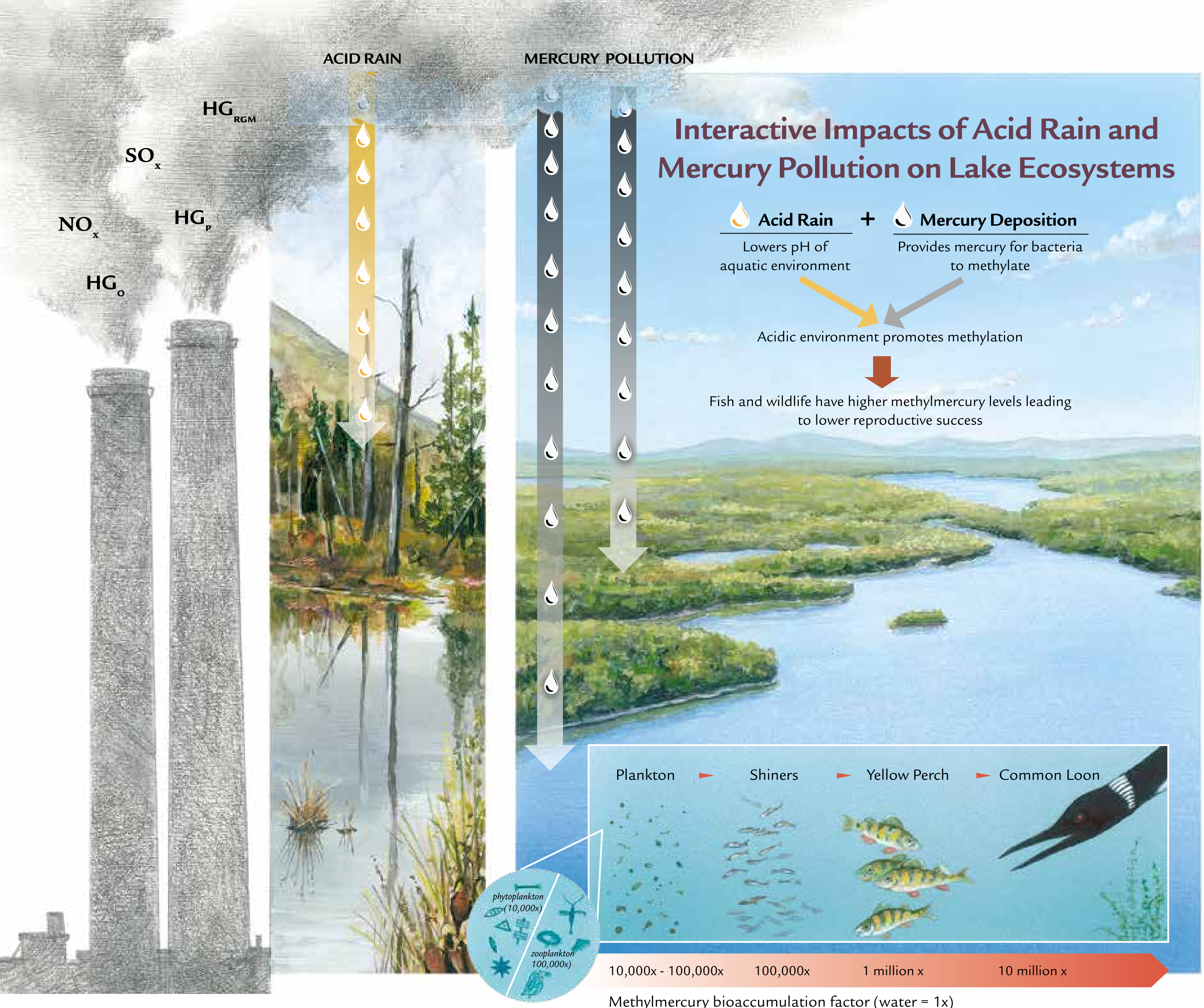
From top: Clean up measures provide some relief, however, monitoring loons over time will help determine how best to mitigate the long-term effects of oil spills on loons; awareness helps prevent oil spills; surveying and monitoring loons help inform conservation efforts.

MARINE OIL SPILLS:
APPLYING SUCCESSFUL APPROACHES

On April 27, 2003, the *Bouchard Barge 120* (B120) struck ground near Cape Cod Canal. Between 22,000 and 98,000 gallons of No. 6 fuel oil spilled into Buzzards Bay. This event occurred during the spring migration of several bird species including the Common Loon. Approximately 200 dead or moribund loons were collected and a rapid field assessment was coordinated by the USFWS through the Loon Preservation Committee (LPC) and BRI to document the range and fate of dispersing individuals.

OIL FINGERPRINTING

Dispersed loons with oiled plumage were identified in Maine, Massachusetts, and New Hampshire. Five loons were observed with oil in Maine and New Hampshire. One of these loons was identified by its color bands and found on its traditional breeding territory in central New Hampshire. Another loon captured in New Hampshire was tested and found to have been contaminated by the B120 oil spill. This finding and other observations documented that the “footprint” of impact was greater than the immediate Buzzards Bay area. Under ultraviolet light, researchers can easily identify oil on the bird’s feathers.



Species at Risk

River Otter

Bald Eagle

Northern Long-eared Bat

Rusty Blackbird

Yellow Perch

Contaminants

Piscivorous (fish-eating) birds are well established indicators of aquatic contaminants. The Common Loon serves that role for a variety of bioaccumulative pollutants, including mercury and organochlorines. Sulfur emissions, which result from the burning of coal, are deposited as acid rain. This raises further concern, especially because the methylation of mercury is exacerbated in acidic conditions.

Loon conservation and research efforts have primarily focused on the exposure to and impacts of mercury, acid rain, and lead on breeding populations and of polycyclic aromatic hydrocarbons (PAHs) for wintering populations (see page 10). A new study by the Canadian Lakes Loon Survey found a significant decline in breeding loon success across Canada over the past 20 years, particularly in the East, and identified the combined impacts of environmental mercury and acid rain to be responsible for the losses.

MERCURY

Mercury is used in many industrial processes, and is emitted into the atmosphere as waste. While some source types, such as waste incinerators, reduced their mercury emissions by 95 percent between 1990 and 2005, utility coal boilers continue to emit tons of mercury each year. Exposure to mercury is a serious threat to wildlife in many parts of North America. Mercury deposition and methylmercury (the organic and more toxic form of the heavy metal) is now sufficiently elevated in parts of North America to cause population-level impacts on wildlife, including the Common Loon.

Sampling efforts indicate a west-to-east increasing trend in methylmercury availability across North America. In the Northeast, at least five biological mercury hotspots significantly impact breeding loons. Others are found elsewhere across Canada and the Great Lakes. Many of these biological mercury hotspots exist because their hydrology (e.g., shallow flow paths) and biogeochemistry (e.g., unproductive and acidic waters) create conditions for elevated methylmercury production. In some areas, point sources of mercury emission persist as important drivers of mercury risk. Mercury exposure is not as severe in marine environments, where loons overwinter, compared to breeding lakes. For example, loons captured in mid-winter on the Pacific coast, Gulf of Mexico, and Atlantic coast generally have safe blood mercury concentrations of less than 1.0 parts per million (ppm) wet weight (ww).

Geographic patterns of mercury exposure in loons have been well documented, but investigations quantifying population-level effects across the continent are still needed. Research over the past decade has provided corollary evidence relating mercury exposure to changes in behavior, physiology, reproduction, and survivorship. These findings include increased lethargy in adults—as their bodies become more laden with mercury, loons spend less time incubating eggs.

ACID RAIN

Atmospheric emissions and deposition of sulfur dioxide (SO_2) and nitrogen oxides (NO_X) form acid rain. Both SO_2 and NO_X are deposited to watersheds as sulfuric and nitric acid. Acid rain has been documented for more than a century, yet it was not until the mid-1970s that research on levels and effects in North America began in earnest. Federal directives, including the U.S. National Acid Precipitation Assessment Program and the Canadian

Regulations controlling mercury emissions and the elimination of lead fishing tackle have proven to be helpful measures in reducing the impact of these threats.

Pollution from power plants is a global problem.

Loons ingest small stones to aid digestion. The contents of a loon's gizzard include a row (bottom) of lead sinkers and fishing tackle, which are indistinguishable to the bird, and cause fatal results.

Lead poisoning resulting from the ingestion of lead fishing tackle has been identified as a significant cause of Common Loon mortality throughout eastern Canada and the United States. Note monofilament line extending from fish's tail fin.

Lead poisoning in loons can lead to neurological dysfunction with a variety of associated physical and behavioral symptoms: from immunosuppression and decreased body fat and muscle mass to disorientation, lethargy, and paralysis.

Long Range Transport of Air Pollutants Program, were instituted in the 1980s and, by the mid-1980s, reductions of SO_2 and NO_X began. Although some improvements were shown in the 1990s, many lakes still appear to lack the required buffering capacity and show little or no improvement (i.e., the pH returning to former levels).

The impacts of acid rain overlap with the breeding range of loons in large areas of eastern Canada, including southern Ontario and Quebec and the Canadian Maritimes, and smaller areas of the United States, including north-central Wisconsin, the western Upper Peninsula of Michigan, and New York's Adirondack Park.

The reproductive success of piscivorous birds is affected by acid rain through associated changes in ecological processes. Increasing acidity negatively affects invertebrate species richness, and fish species diversity and abundance. The relationship of acid rain to wildlife is complex because lowering pH increases water transparency, which likely contributes to higher foraging efficiency for visual predators.

The yellow perch, one of the loon's favored prey items, is generally tolerant of pH levels greater than 5 and, therefore, provides prey on mildly acidified lakes. Studies have documented the relationship of loon reproductive success and lake acidity and found: fledging success is highly unlikely at a lake pH of 4.0 to 4.3; high chick mortality is consistent on some lakes with a pH of 4.4 to 5.8 (particularly small ones); and acidity-related chick mortality can occur on lakes with a pH lower than 6.3.

When breeding on lakes with no fish, adult loons will commonly forage in a neighboring lake, while chicks are fed invertebrates. Invertebrate diets are generally considered energetically insufficient for successful fledging. Current studies still predict continued impacts to biota in lake ecosystems of southeastern Canada unless further reductions in the deposition of SO_2 and NO_X are achieved.

LEAD

The toxic effects of lead are well documented and confirm a direct link between ingestion of lead fishing tackle and mortality. In a nationwide waterbird study (based on live bird sampling),

BRI FINDINGS FROM THE FIELD

Measurable effects of mercury on loon productivity have been documented in many regions of North America through capture and sampling efforts by BRI: Canadian Maritimes, New England, New York, Ontario, and Quebec.

Loons with blood mercury concentrations >3.0 ppm (ww) produced 37% fewer fledged young than loons with background mercury concentrations <1.0 ppm (ww). Characterization of potential mercury risks to Common Loon populations can be developed (known as biological mercury hotspots). Such areas have significant adverse impacts to breeding populations (or >20% of the population) and are found across eastern North America in association with certain reservoir types (i.e., those with water level fluctuations >3 feet and with shallow bathymetry, low pH lakes, and waterbodies with abundant wetland shorelines).

BRI has initiated a large-scale loon health assessment study *(see page 21).*

Common Loons had the highest incidence of lead ingestion (3.5 percent). In New England, a 14-year study diagnosed 44 percent of the 522 breeding adults as having died from lead toxicosis, and substantial rates of lead-related mortality are also known for Michigan and Minnesota. Mortality of adult loons from ingestion of lead sinkers or jigs can be locally significant. In New Hampshire, the ingestion of lead sinkers and jigs accounted for 40 to 71 percent of identified annual adult mortality from 1996 to 2002. Further analysis of the New Hampshire data indicates the highest rates of mortality occur during July through September, even though loons are present on their breeding territories in May and June. The timing of lead-related deaths and the presence of associated tackle in the gizzard suggest a close relationship of fishing and loon deaths.

ORGANIC POLLUTANTS

Organic pollutants are synthetic compounds and are relatively recent additions to the natural environment. The impacts of organochlorine insecticides including DDT and its derivatives, such as DDE, are well known for thinning eggshells and causing region-wide population declines in Bald Eagles, Brown Pelicans, Peregrine Falcons, and Osprey. Loon eggshell thickness during the 1960s and 1970s thinned but, apparently, not at a level to cause local reproductive impacts.

In the mid-1990s, organochlorine insecticide scans on eggs (including DDE, PCBs, and other pollutants) found low levels in the Rangeley Lakes region of Maine and were considered reflective of New England exposure. Other organic pollutants, such as flame retardants (PBDEs) and teflons (PFCs) in New England show loons have some of the highest levels compared with other breeding bird species, although the effects thresholds are poorly understood. Exposure to PAHs is primarily problematic in areas with oil spills, which may be relatively small but may have lasting impacts.

Policy Recommendations

Enact Emissions Controls

Recent policy decisions to control mercury emissions are significantly changing the potential exposure to mercury for both wildlife and humans. Three new policies will reduce mercury as one of the most important stressors to healthy loon populations.

In 2007, Canada announced the development and implementation of regulations to reduce emissions of mercury under the Clean Air Regulatory Agenda (CARA). CARA is based on scientific findings to support regulatory activities and accountability, which identify key indicators, including the Common Loon, to track the effects of mercury.

In 2011, the U.S. EPA finalized the Mercury and Air Toxics Standards (MATS) rule that requires all electric generating plants to upgrade pollution control equipment by 2016. Based on broad temporal and spatial mercury datasets, the monitoring of Common Loons will play a role to track the impact of the MATS rule.

In 2013, the United Nations finalized the Minamata Convention. Under treaty requirements and as an evaluation of the effectiveness of its stipulations, monitoring of mercury concentrations in fish, birds, and marine mammals is included. The Global Mercury Observation System of the United Nations Transport and Fate Partnership Group plans to use Common Loons as one indicator species for North America.

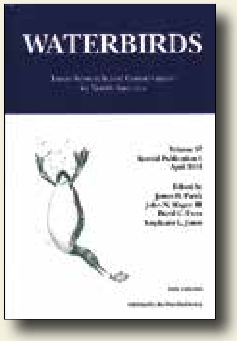
Set Wildlife Criterion Values

One approach for setting regular standards for mercury in aquatic systems is the use of a wildlife criterion value (WCV). A WCV identifies the amount of mercury in the water column that is deemed harmful to wildlife.

The model establishes links among water column mercury, fish mercury for various trophic levels, and mercury levels of a high trophic level species of wildlife that, ideally, can be related to population-level effects.

The model's formula uses a test dose with associated uncertainty factors as the numerator and ingestion of mercury as the denominator. Development and refinement of a spatially-explicit WCV for Maine and New York identified less than 1.4 and 1.7 ng/L of total mercury in unfiltered water, respectively, as protective of breeding loon populations.

The ability to track mercury concentrations in water versus wildlife is sometimes viewed as an easier endpoint by governmental agencies.



Recent scientific research helps direct policy and management decisions.

Enact Lead Legislation

Bans on the use of lead in fishing tackle began in 1987 in Great Britain. Since then, six states and various governmental agencies have enacted lead laws. Further steps that best coordinate these laws and policies into national standards will provide clearer and more defined approaches for companies that produce and distribute lead alternatives.

1987: Great Britain (lead sinkers 28.35 g or less)

1991: U.S. eliminates lead shot for hunting in all 50 states

1995: Three National Wildlife Refuges ban all lead sinkers

1997: Canadian National Parks (lead sinkers or jigs 50 g or less)

2000 (2005): New Hampshire (use and sale of lead sinkers 1 oz or less, lead jigs 1-inch or less)

2000: Massachusetts, Quabbin, and Wachusett Reservoirs only (use of lead sinkers)

2002: Maine (sale of lead sinkers 0.5 oz or less)

2002: Denmark (all lead hunting and fishing products)

2004: New York (use of lead sinkers 0.5 oz or less)

2006: Vermont (sale and use of lead sinkers less than 0.5 oz)

2012: Massachusetts (all fresh water gear less than one oz)

2012: Washington (use of lead fishing gear on loon breeding lakes)

2013: New Hampshire (sale and use of lead sinkers 1 oz or less and lead jigs less than 1-inch long)

2013: Maine (sale and use of lead sinkers weighing 1 oz or less or measuring 2½ inches or less)

Installing rafts and maintaining stable water levels on reservoirs are effective conservation measures.

Loons build their nests close to the water's edge, leaving them vulnerable to water fluctuations that can strand or flood a nest.

This nest, while still viable, is in danger of being flooded.

Loons are well adapted for swimming, but have difficulty walking. Because of this adaptation, they nest right on the water's edge, where changing water levels can pose a serious threat. A rise in water level can flood eggs on a nest; a fall in water level can leave a nest high and dry. Natural fluctuations on a lake are seasonal and occur occasionally (such as snow melt, or a storm), where as fluctuations on reservoirs or managed lakes occur on a more regular basis and may be sudden and severe (dropping or raising quickly).

Water level management is generally dictated by the reservoir's primary purpose, which may include: flood control; recreational use; fisheries management; or storage for municipal water supplies. In these types of reservoirs, water levels generally peak after spring runoff, slowly decline over the summer, peak again in autumn, and drop considerably over the winter. Other reservoirs, including some industrial and hydroelectric facilities, operate with daily or weekly water level fluctuations. The ability for Common Loons to nest successfully on reservoirs depends on the type of reservoir and the water management strategies in place.

FEDERAL ENERGY REGULATORY COMMISSION

The Federal Energy Regulatory Commission (FERC) oversees the licensing of dams in the United States and issues new licenses every 20 or more years. Canada does not have a corresponding legal entity. The renewal of FERC licenses in the past decade has taken place within the context of negotiated settlement agreements arrived at by the dam licensees, state and federal agencies, and nongovernmental organizations. The International Joint Commission (IJC) plays a similar role to FERC for reservoirs that cross the U.S./Canadian border.

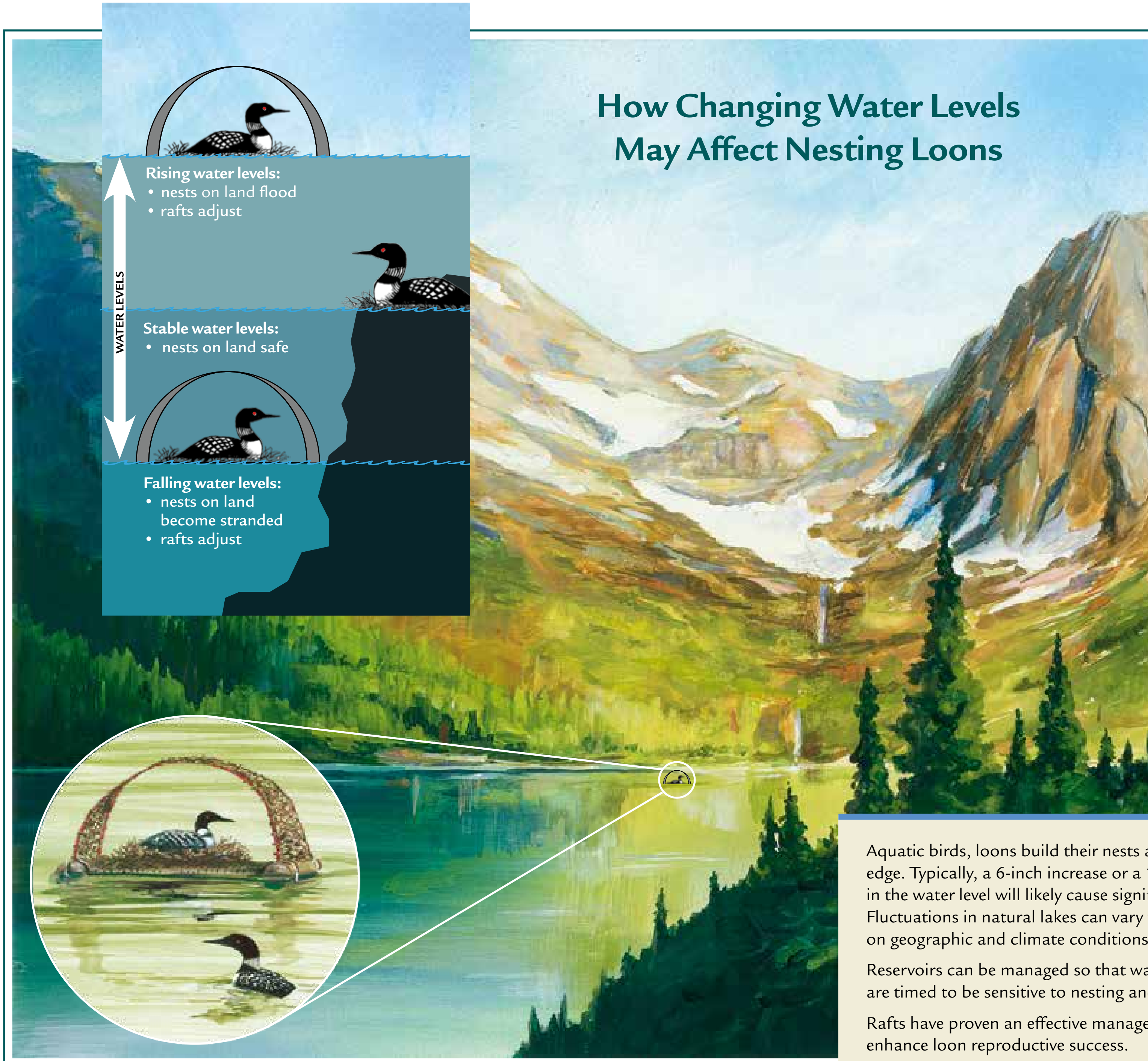
Increased interest in recreational and environmental resources associated with these reservoirs, including breeding loons, has generated new considerations for reservoir management. Fluctuating water levels during the nesting season can have deleterious effects on loon nesting success. Increasing water levels easily inundate nests while lowering water levels strand nests, increasing the difficulty of incubation exchanges and enhancing predation. In Voyageurs National Park's Rainy, Namakan, and Kabetogoma Lakes, a study from the 1980s found an average of 60 to 70 percent of loon nests failed due to water level fluctuations. Since 2000, the International Joint Commission has instituted new water level management guidelines for these water bodies in order to minimize the impact on loon nesting success.

For the past 20 years, the FERC relicensing process has also implemented reservoir management schemes that minimize impacts to nesting loons. The general guidelines recommend maintaining water levels within a 6-inch rise and 12-inch drop during the primary loon nesting period, or the implementation of artificial loon nesting rafts to enhance nesting success.

BRI FINDINGS FROM THE FIELD

In the Rangeley Lakes region in Maine, water level fluctuations were documented on Aziscohos, Richardson, and Mooselookmeguntic Lakes. The FERC relicensing process established changes in water level management and instituted the use of artificial loon nesting rafts on these reservoirs. The minimized water level fluctuations combined with the management and monitoring of nesting rafts (more than 80 to date) has doubled the loon nesting success on these reservoirs.

How Changing Water Levels May Affect Nesting Loons



Aquatic birds, loons build their nests at the water's edge. Typically, a 6-inch increase or a 12-inch decrease in the water level will likely cause significant nest loss. Fluctuations in natural lakes can vary widely depending on geographic and climate conditions.

Reservoirs can be managed so that water drawdowns are timed to be sensitive to nesting and egg hatching.

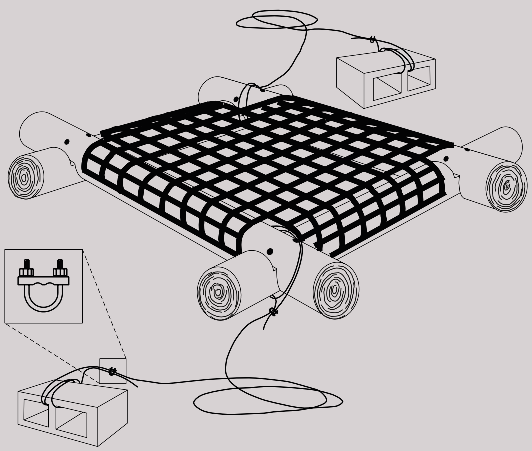
Rafts have proven an effective management tool to enhance loon reproductive success.

HOW TO MAKE A LOON RAFT

Proper construction is important to maximize use by loons and for longevity. Rafts are generally constructed from cedar logs, with galvanized bolts or nails and plastic mesh fencing which is attached using 1½ inch galvanized fencing staples. Rafts should be lined with material such as sphagnum moss, grasses, and other vegetation. Loons will typically add nesting material gathered from the immediate vicinity of the nesting site, but it is important to have a natural base.

Avian guards are made of metal fencing and camouflage mesh. Burlap camouflage mesh is a useful surrogate and is adequate for single-season use.

Rafts require regular monitoring to insure proper placement, buoyancy, and sufficient nesting materials throughout the nesting season. Remove rafts from the water soon after nesting has ceased to increase the longevity of the raft.



This diagram shows construction of the base of the raft. Adding a canopy, or avian guard, is recommended to protect the loon from predators.

Management and Policy Recommendations

▶ Management: Water Levels

Regional stakeholders have become more involved in FERC relicensing procedures for reservoirs over the past decade. Related settlements for reservoirs with breeding loons have included stringent management mandates to ensure loon sustainability.

For reservoirs that have the hydrological flexibility to maintain relatively steady water levels, loon nests are most successful when water levels do not increase more than six inches or decrease more than 12 inches during the peak nesting period (June 1 to July 15 in New England).

Where lake-level stability is not achievable, mitigation through the proper use of artificial nesting islands (loon rafts) may be effective. Precedent-setting loon management plans in Maine employ reservoir-wide raft programs. Rafts are placed and monitored weekly at every loon territory, except those where island configuration or floating bog mats make successful natural nesting likely.

▶ Management: Use of Artificial Nest Platforms

Proper employment of loon rafts is an effective management tool to effect mitigation for loss of productivity due to water level fluctuations.

Raft location is determined by:

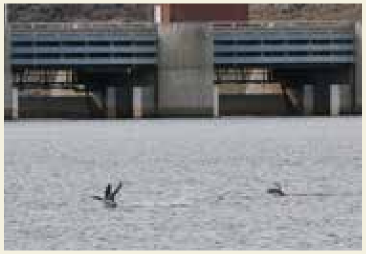
- wind and wave action patterns relative to each territory
- loon territorial boundaries and proximity to other territories
- previous traditional and nontraditional nest site locations
- boat traffic and human activity patterns relative to the specific territory; this is particularly important relative to the orientation of the avian guard

Avian guards are effective in reducing egg exposure to predators, lessening raft visibility by recreationists, and increasing the probability that incubating loons remain on the nest during close approaches by recreationists and potential predators.

▶ Policy: Developing a FERC Process

Guidelines are needed to compensate for the loss of loon reproductive success from enhanced environmental methylmercury loads and water level changes, especially on reservoirs with summer water level fluctuations over three feet. These steps should include:

1. Identify stakeholder participants (state and federal governmental agencies, environmental organizations, and lake associations).
2. Develop a comprehensive program to evaluate impacts on reproductive success; standardize field monitoring strategies to include identification of territorial pairs, nesting attempts, chicks hatched, and chicks fledged. Weekly surveys are required for high confidence.
3. Determine if rafts are needed to compensate for fluctuating water levels. To insure normal loon productivity, require rafts on those peaking facilities and storage reservoirs where water levels may drop over three feet.



From left: Loons can breed successfully on properly managed reservoirs; rafts are an effective management tool; a collaborative meeting of the New England Loon Study Working Group.

Emaciation Syndrome

Loons become emaciated for many reasons based on physical injuries and physiological limitations. One 1990s study in Florida surmised that emaciation syndrome is a regular mortality problem for wintering Common Loons and may be one of the greatest threats to the species. Researchers described an ecological string of events where inclement cold weather and storm-induced turbidity in feeding areas caused stress.

During and following such weather events, loons generally need to switch foraging emphasis from fish to crustaceans. Compared to fish, crabs and shrimp have higher salt and parasite loads, which may result in increased physiological stress in loons.

Loons are usually able to withstand such dietary changes, but imbalances may occur during times of energetically demanding physiological changes, such as molting. Greater than normal physiological stress would result in increased metabolism of fat reserves and catabolism of muscle tissue, remobilization of contaminants stored in both fat (organochlorines) and muscle (mercury), and behavioral changes that negatively impact foraging efficiency resulting in starvation and death.

Large die-offs of wintering loons in the early to mid-1980s in the Florida Panhandle are often attributed to emaciation syndrome. In late winter of 1983, an estimated 13,000 loons died during an epizootic event (an outbreak of disease spreading quickly among animals). Similar events for wintering loons along the mid-Atlantic coast have also been documented.

Emaciation syndrome can also strike loons on their breeding lakes. Lakes in Ontario and Minnesota are, respectively, considered responsible for 12 percent and 20 percent of the dead loons collected from multiple studies.

Emaciation syndrome results in loons not able to endure harsh conditions during winter months.

A CHALLENGING TIME FOR LOONS

Based on survivorship data, more loons die during the winter in their marine environments than on their breeding lakes.

Unlike waterfowl, which undergo a wing molt prior to migration, loons delay their molt until they reach their wintering area. Molting generally requires a great deal of energy; simple feather regeneration occurs concurrently with new tissue growth and a metabolic overhaul. Molting loons have higher than normal metabolic rates and nutritional needs and, consequently, an increased demand on energy reserves.

During winter, loons often succumb to a condition known as emaciation syndrome. Birds transitioning from fresh to marine water already experience physiological stress and must further contend with weather-related stressors such as severe storms, which stir up coastal feeding grounds. Because they are visual predators, loons have difficulty finding food in turbid water.

Ongoing studies of wintering loon populations aid in our understanding of the loon's winter ecology and how added stressors can affect their long-term health.

Loons molt their wing feathers when they arrive at their wintering territories. The extreme energy reserves needed for this process leave loons exhausted and especially vulnerable to additional environmental stressors such as storms and oil spills.

Botulism and Other Diseases

Long-lived and highly site faithful, loons help indicate changes in the environment over time and provide links between our health and that of the ecosystems we depend on.

In the field, BRI researchers take blood and feather samples, which are later analyzed for mercury concentrations.

Wildlife diseases can be important stressors for loon populations. Diseases of greatest concern are those that occur in concentrations higher than normally present, such as avian botulism. While botulism type C is a relatively common and widespread disease in waterfowl, sporadic epizootics of type E occur—primarily in the Great Lakes Basin—that affect fish-eating birds including Common Loons. Impact to individual loons is also highest when a bird is physiologically compromised and its lowered immune system is unable to ward off fungal diseases such as Aspergillosis.

Scientists are working to understand the mechanisms for these diseases, and a general concern is how human activities might disrupt ecosystems.

BOTULISM TYPE E

Avian botulism is a disease caused by the neurotoxin from the *Clostridium botulinum* bacteria, which birds ingest from contaminated food and water. These bacteria are categorized into different types, A through G, based on the characteristics of the toxins that they produce. These toxins cause progressive muscle paralysis leading to an inability to maintain an upright posture, most often resulting in death by drowning or eventual cardiac and respiratory failure. Botulism type E has been linked with multiple waterbird mortality events in the Great Lakes.

The first Common Loon die-off attributed to botulism type E occurred in 1963 on the southern shores of Lake Michigan. An estimated 3,300 loons were reported dead in mid-November through early December of that year, likely due to lake water level declines that facilitated the botulism outbreak. Smaller sporadic outbreaks occurred in the 1970s and 1980s on Lake Michigan and Lake Huron. Since 1999, however, large-scale outbreaks in fish-eating birds have increased in frequency and severity and also include Lake Erie and Lake Ontario. During the fall seasons of 2000 through 2006, aerial and shoreline transects by the New York State Department of Environmental Conservation estimated that more than 12,000 Common Loons died from botulism type E on both the U.S. and Canadian shores of Lake Erie. Outbreaks have also occurred more frequently on Lake Michigan where an estimated mortality of more than 10,000 waterbirds, mostly Common Loons, was attributed to botulism type E during the 2006 to 2007 autumn migration periods. Since then, thousands of dead adult Common Loons continue to be reported each fall across the Great Lakes due to botulism type E.

Spores of *Clostridium botulinum* are found in the soils, surface waters, and sediments of aquatic environments. These spores are widespread but unevenly distributed throughout the Great Lakes region. A wide variety of fish ingest these spores during feeding, often resulting in rapid illness and death. Loons appear to feed exclusively on live fish and, therefore, are likely exposed to the type E toxin found in the alimentary canal of moribund prey.

Invasive species may also play an important role in the transmission of botulism. Alewife and American smelt, both introduced species, are common forage fish that carry the *Clostridium botulinum* bacteria. An abundance of alewife was linked with the botulism-related loon mortality events that occurred in the 1960s in Lake Michigan.

Recently, another suite of invasive species have become established in the Great Lakes—zebra and quagga mussels are a link for annual, large-scale fall die-offs of loons. These voracious mollusks, supplanting native mussels, decimate zooplankton populations that form the basis of food chains. Bottom-dwelling round gobies, another nonnative species, eat the toxic mussels and, once contaminated, these fish swim erratically, which attracts the deep-diving loons.

The epidemiological factors that lead to botulism type E outbreaks are poorly understood. It is known that certain ecological conditions must occur simultaneously in order for outbreaks to occur, including low water levels, warmer water temperatures, and oxygen-deprived waters. Further study is necessary to determine how these outbreaks can be predicted and prevented.

BRI's biologists continue to monitor Common Loon populations that may be affected by botulism outbreaks on the Great Lakes. Monitoring efforts in New York have found that botulism-related mortalities on Lake Ontario declined between 2008 and 2012 after the initial outbreaks that occurred in 2006 and 2007. However, a recent spike in loon deaths in 2013 indicates that botulism type E is still a threat. BRI's collaboration with the New York State Department of Environmental Conservation will use genetic analysis techniques to identify those loon populations most at risk and estimate potential population impacts.

BRI IN ACTION: WILDLIFE HEALTH ASSESSMENT STUDY

In response to ongoing and emerging health threats to loons, BRI has initiated a continent-wide Common Loon health assessment study. This large-scale study will be the most comprehensive loon health survey ever conducted, focusing on loons from key regions across North America: New England, New York, Minnesota, Wyoming, Montana, Washington, Alaska, British Columbia, and Saskatchewan.

In collaboration with researchers across the country, this study will examine a wide range of health parameters, including baseline health data, toxicology, immune function, and infectious disease surveillance, to provide insight into the health status of individual loons that may be affected by various diseases or environmental conditions. BRI's veterinarians will also be working with the University of Miami Avian and Wildlife Laboratory to utilize cutting edge diagnostic techniques to quantify exposure and infection rates of *Aspergillus* in Common Loons.

By assessing exposure to toxic contaminants in the environment, including heavy metals, persistent organic pollutants, and cyanotoxins produced by algal blooms, loons serve as sentinels of environmental health. Studying health and disease in wild avian species such as loons is vital to public health because birds can carry a number of zoonotic diseases (transmitted between animals and humans). These include influenza A virus (Avian influenza), mosquito borne diseases such as Eastern and Western equine encephalitis virus and West Nile virus, and tick-borne diseases such as Lyme disease.

Climate change and increased human/wildlife interaction will continue to increase the occurrence of these pathogens in wildlife, and therefore increase the risk of transmission to humans. In collaboration with infectious disease experts in human and wildlife health, BRI's researchers will monitor loons' exposure to these important zoonotic diseases, and help evaluate emerging risks to public health.

BRI's veterinarians, in collaboration with Tufts Cummings School of Veterinary Medicine, perform post-mortem examinations, which provide vital data on causes of mortality in Common Loons. This information can be used to prioritize conservation efforts, and inform legislative measures to protect wildlife and environmental health.

ASPERGILLOSIS

Aspergillosis is a fungal disease caused by several *Aspergillus* species, especially *Aspergillus fumigatus*. These fungi are ubiquitous in the environment worldwide. Birds usually become infected with *Aspergillus* by inhaling spores or by ingesting spores while feeding on or near contaminated sources. Aspergillosis is primarily a respiratory infection, but can become more generalized in advanced cases. Growth of *Aspergillus* fungal plaques in the respiratory passages, lungs, air sacs, and body cavity leads to respiratory compromise, anorexia, emaciation, and death in severe cases.

Loons are very prone to aspergillosis, particularly if their immune systems are otherwise weakened. Aspergillosis is usually considered an opportunistic secondary infection that follows stress from other diseases, nutritional deficiencies, or other primary reasons that suppress the immune system. This fungal disease is the primary reason that loons do not survive long in captivity. Based on multiple studies, prevalence of aspergillosis in breeding populations was 2 percent in Ontario, 2 percent in New England, 7 percent in Minnesota, and 7 percent in wintering Florida loons. While prevalence is relatively low, loons are especially prone to aspergillosis compared to other avian species.

Global Climate Change

Rigorous research helps us understand how to mitigate the environmental impacts of global climate change.

Loon panting on nest to increase heat dissipation.

According to the Intergovernmental Panel on Climate Change, our planet will experience significant environmental effects in the coming decades. A global increase in the concentration of carbon dioxide and other greenhouse gases (e.g., methane, nitrous oxide, tropospheric ozone) in the atmosphere will bring about significant changes in the United States, including an increase in mean surface air temperature, a warming of mean sea surface temperature, and a rise in global mean sea level.

Predicted changes in the seasonality of precipitation may greatly impact the structure of existing ecosystems. In New England, precipitation is predicted to increase, drought periods are expected to become extended, and air temperature will likely increase. These changes will influence freshwater ecosystems and local hydrologic regimes. For example, a prolonged drought could alter the flow of water and solutes (water-borne nutrients and minerals) in a lake, in turn modifying the water chemistry, which could increase the methylation of mercury.

These anticipated changes may also affect the distribution and abundance of particular waterbird species because changes in air and water temperature can alter the production, abundance, and distributions of aquatic organisms. Studies have shown that climate change can alter bird distributions through range shifts, contractions, and expansions. Accurately predicting changes in the distributions of birds using abiotic drivers, however, is challenging.

Maine is already warmer and wetter than it was 30 years ago. Increases in both air and water temperatures will most likely affect the production, abundance, and distributions of plants in Maine lakes and streams. The potential for impacts—both positive and negative—on loon breeding success is unknown. There are indications that loon occupancy and, ultimately, breeding success could be adversely affected by changes to lake depths, surface water temperatures, water acidity (pH), the amount of dissolved organic carbon, conductivity, and water clarity.

Policy Recommendations

A Call to Action

The National Fish, Wildlife and Plants Climate Adaptation Strategy is a unified response to the call to action from the U.S. Congress and many others for a national coordinated fish, wildlife, and plant climate adaptation strategy.

The Strategy outlines key steps to help natural resource managers, private land owners, and other decision makers safeguard the natural world in a changing climate. It is also a call to inspire action.

Unless the nation begins serious adaptation efforts now, we risk losing priceless living systems—and the countless benefits and services they provide—as the climate changes.

The Strategy was developed by a partnership of the U.S. Fish and Wildlife Service, the National Oceanic and Atmospheric Administration, and the New York State Division of Fish, Wildlife, and Marine Resources.

The technical content of the Strategy was developed by more than 90 scientists and natural resource managers from federal, state, and tribal agencies across the country. For more information, visit:

www.wildlifeadaptationstrategy.gov/strategy.php

Emerging Threat—Offshore Wind Turbines

The environmentally responsible development of offshore wind energy along the Eastern Seaboard has become a priority in the United States. The U.S. Department of Energy has identified a national goal for 54 gigawatts of power generated by about 9,000 offshore turbines by the year 2030. However, marine wind turbines have yet to be installed off U.S. coasts. The siting of marine wind energy development hinges, in part, on a better understanding of the extent of direct and indirect environmental impacts.

Regulatory oversight of offshore wind power development is determined by many state and federal agencies. Federal laws (e.g., the National Environmental Policy Act and the Migratory Bird Treaty Act) require an understanding of the potential risks that offshore wind turbines pose to wildlife.

We are aware of a number of predicted and known effects to wildlife from offshore development. European researchers have suggested that these effects can be separated into three categories, or hazard factors: 1) direct mortality and sublethal effects (e.g., collision with turbines); 2) behavioral responses (e.g., attraction to or avoidance of development areas); and 3) changes to habitat structure or function, including changes in prey distributions.

In some cases, we can infer risk based on comparisons to land-based wind turbines, or from other types of marine development (such as oil and gas drilling). Unlike terrestrial environments, however, the dynamic nature and difficult sampling conditions of marine ecosystems make prediction of the effects of offshore wind power development on wildlife particularly challenging.

BRI FINDINGS FROM THE FIELD

BRI satellite tracking studies on Common Loons (ongoing in Maine, New York, and parts of the Midwest) provide relevant data to help understand impacts of offshore wind turbine development.

In other studies, BRI conducts boat and aerial surveys of a variety of species, including the Common Loon, to identify distribution patterns off the mid-Atlantic coasts of Delaware, Maryland, Virginia, and North Carolina, as well as across the Great Lakes.

Loon with satellite tag.

This knowledge helps inform the siting of offshore wind turbines.

For more information: www.briloon.org/mabs.

Policy Recommendations

▶ Understand Wildlife Movements Offshore

In Europe, where offshore wind farms are in operation, researchers have documented that Red-throated Loons avoid offshore wind farms at a macro scale, and this avoidance can lead to long-term displacement. This displacement may lead to habitat loss, which is the primary reason loons rank high in vulnerability assessments for offshore wind turbines.

We do not know how Common Loons will respond to offshore wind turbines. However, Common Loons, like Red-throated Loons, may be displaced from offshore wind farms. The best method for avoiding adverse effects of offshore wind on wildlife is to document critical migratory staging and wintering areas, and to site wind farms away from these areas.

Scientific research provides a clearer understanding of how wildlife use coastal environments, which will help inform decisions about offshore wind energy development.

In 2012, BRI began a three-year project to provide essential baseline information on the distribution and habitat use of birds off the mid-Atlantic coast. Preliminary results of this project (funded by the U.S. Department of Energy, Bureau of Ocean Energy Management, USFWS, and others). In 2013, BRI partnered with the Great Lakes Commission and others to establish baseline information for the Great Lakes.

Spotlight on National Landscapes: NATIONAL PARKS

"Preservation is about deciding what's important, figuring out how to protect it, and passing along an appreciation for what was saved to the next generation."

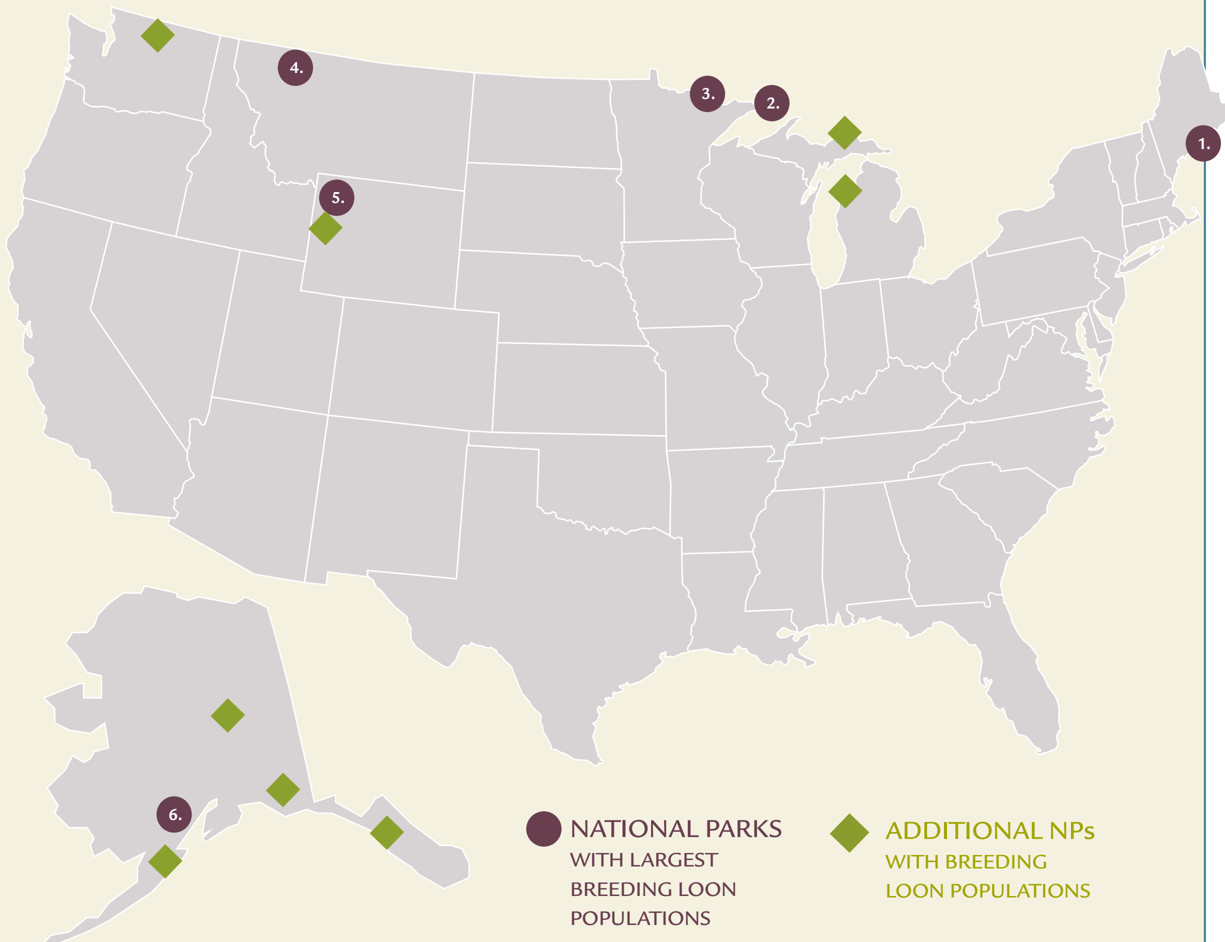
– National Park Service

Loon Breeding Populations in National Parks (NP)

The National Park Service (NPS) preserves the natural and cultural resources and values of the National Park system for the enjoyment, education, and inspiration of this and future generations.

The NPS manages 388 properties totalling 84 million acres that includes national parks, national seashores, national lakeshores, and national monuments.

Of the 59 national parks, only a few include suitable breeding habitat for the Common Loon. Six national parks with the largest breeding populations are identified on this map. Other parks where breeding loons are found are also identified.



Photos are courtesy of the National Park Service

1. Acadia NP

Location: Maine
Total acreage: 47,000+
Number of lakes: 22
Territorial loon pairs: 7
Threats:

The small and isolated population of breeding loons makes long-term sustainability vulnerable to the increased number of visitors attracted to a national park. BRI is conducting a long-term monitoring effort, which began in 1998, to help manage threats caused by human disturbance and contaminants.

2. Isle Royale NP

Location: Michigan
Total acreage: 571,796
Number of lakes: 200+
Territorial loon pairs: 121
Threats:

While there are many breeding loons on the interior lakes, the pairs nesting in the coves and bays of the Lake Superior shoreline are unique as loons are not known to nest elsewhere along the shores of the Great Lakes. BRI conducted studies to understand the exposure of mercury to loons and comparisons with more eastern sites indicate that human disturbance may be the most serious threat in this park.

3. Voyageurs NP

Location: Minnesota
Total acreage: 218,054
Number of lakes: 30
Territorial loon pairs: 130
Threats:

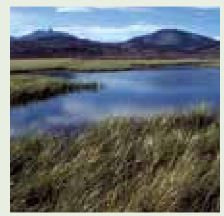
Most of the breeding loon populations nest along the shore of three reservoirs: Rainy, Kabetogoma, and Namakan. These reservoirs are regulated by the International Joint Committee. Long-term research efforts by BRI have helped inform management decisions about water levels and have tracked ongoing mercury issues.

4. Glacier NP

Location: Montana
Total acreage: 1 million+
Number of lakes: 131 (named)
Territorial loon pairs: 16
Threats:

While 16 of the 72 territorial pairs in Montana are found in this park, breeding loons mostly occupy remote lakes that are not often disturbed by park visitors. BRI is working with Glacier National Park to assist with surveys and to initiate a color-marking program that will coordinate with the state's efforts.

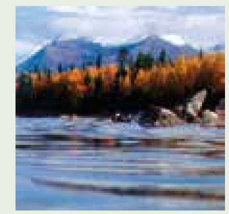
5. Yellowstone NP



Location: Wyoming
Total acreage: 2.2 million
Number of lakes: 231
Territorial loon pairs: 10
Threats:

This declining breeding population is at high risk of extirpation and because the nearest breeding population is more than 200 miles away (in Montana), natural recovery is problematic. In 2012, BRI began a long-term study to better understand current and future threats to loon populations in the Greater Yellowstone Ecosystem, including pairs in Grand Teton National Park.

6. Lake Clark NP



Location: Alaska
Total acreage: 4 million+
Number of lakes: 21
Territorial loon pairs: *Unknown*
Threats: *Unknown*

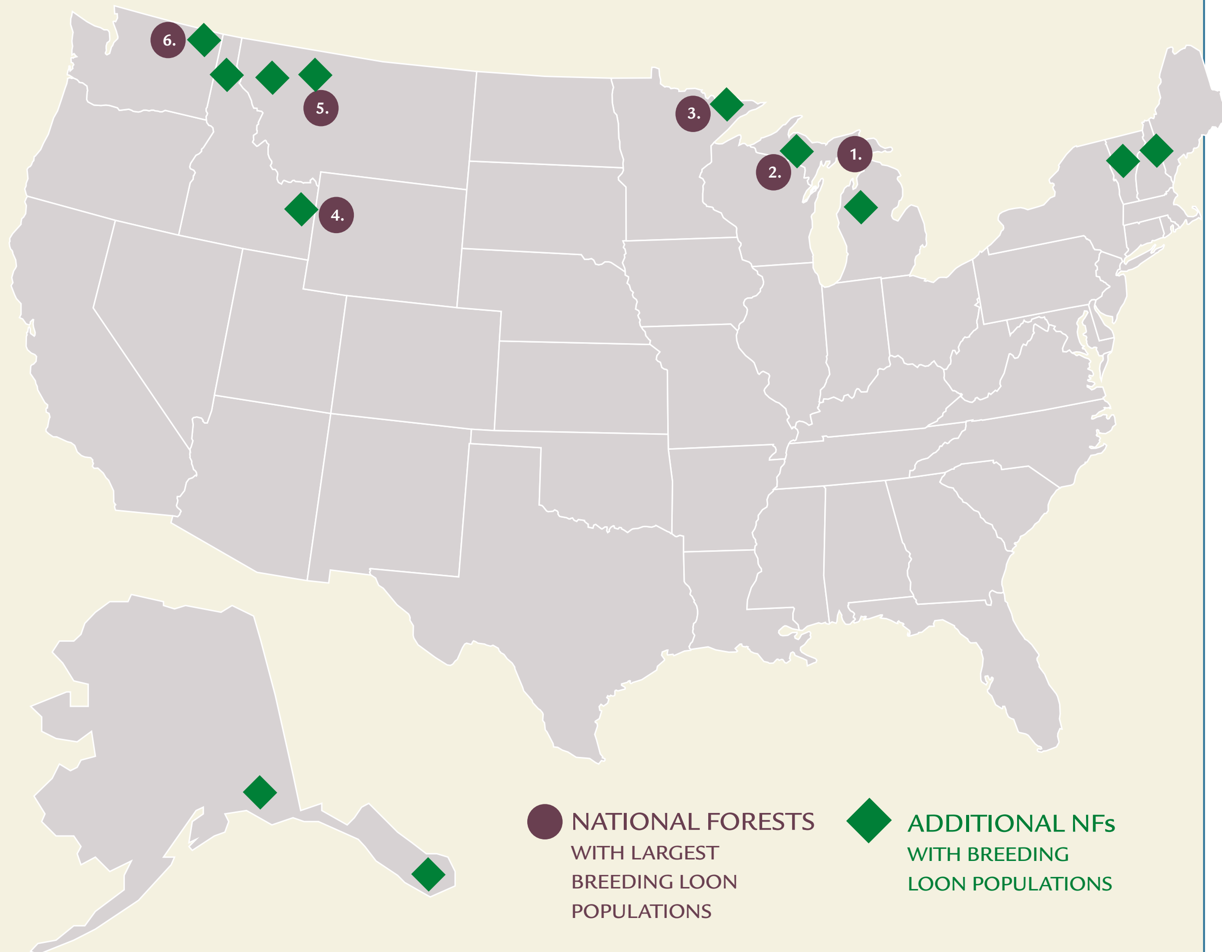
Generally, Alaskan breeding Common Loon populations are stable because threats on the breeding and wintering areas are minimal. While oil spills from transport tankers pose a possible threat and commercial fishing nets may potentially take migrant or wintering loons from this park, little is known.

Additional National Parks where loons breed:

Alaska: Denali NP; Glacier Bay NP; Katmai National Park and Preserve; Wrangell-St. Elias National Park and Preserve
Michigan: Pictured Rocks National Lakeshore; Sleeping Bear Dunes National Lakeshore
Washington: North Cascades NP
Wyoming: Grand Teton NP

"Working with partners, the U.S. Forest Service is focusing on restoring healthy, resilient forest and grassland ecosystems."

– U.S. Forest Service



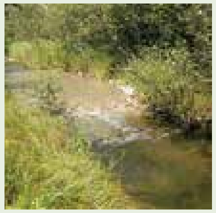
Loon Breeding Populations in National Forests (NF)

Entrusted with 193 million acres of national forests and grasslands, the U.S. Forest Service is dedicated to the improvement of water resources, development of climate change resiliency, creation of jobs that will sustain communities, and restoration and enhancement of landscapes.

Many national forests across the northern United States and Alaska provide large areas of suitable breeding habitat for Common Loons. While the Forest Service focuses on the management of forested landscapes, much emphasis is placed on how best to minimize negative impacts to the quality of lakes where loons breed, such as minimizing logging of lake shorelines and retaining riparian areas of lake watersheds.

Photos are courtesy of the National Forest Service

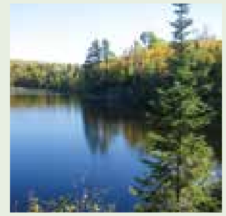
1. Hiawatha NF



Location: Michigan
Total acreage: 1 million
Number of lakes: 57
Territorial loon pairs: 18
Threats:

The two units of this national forest reach both Lake Superior and Lake Michigan shorelines. While Common Loons do not breed on the shores of the Great Lakes (except at Isle Royale NP), the local threat of commercial trap nets and botulism on summering loons is important to sustainable populations in the forest. BRI has worked to develop net mesh sizes at the top of trap nets to permit loons to escape.

2. Chequamegon-Nicolet NF



Location: Wisconsin
Total acreage: 1.5 million
Number of lakes: *Unknown*
Territorial loon pairs: *Unknown*
Threats: Hg

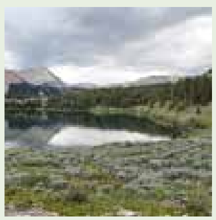
North-central Wisconsin holds some of the highest densities of breeding loons in the contiguous United States. Although many of the state's lakes have large numbers of shoreline cabins and associated recreational activities, outreach programs help reduce human disturbance. BRI works closely with state officials to better characterize the exposure and effects of mercury, found to be particularly high on lakes with a pH <6.3.

3. Chippewa NF

Location: Minnesota
Total acreage: 666,542
Number of lakes: >1,300
Territorial loon pairs: *Unknown*
Threats:

North-central Minnesota has robust breeding populations of loons that are often found on large lakes with multiple pairs. This area contributes to BRI's national restoration effort for breeding loons in Minnesota. As part of that effort, studies include outreach programs to increase awareness about the negative impacts of lead sinkers and jigs.

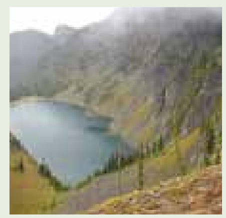
4. Bridger-Teton NF



Location: Wyoming
Total acreage: 3.4 million
Number of lakes: >1,500
Territorial loon pairs: 1
Threats:

While there is only one known territorial pair here, Bridger-Teton is an important contributor toward sustaining the small and isolated breeding loon population in Wyoming. Reasons for the decline of Wyoming's small breeding population are not fully understood, but BRI is working with governmental agencies to reverse the decline and restore loons to former population levels.

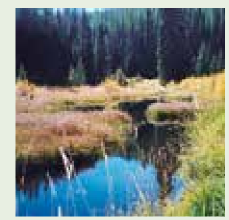
5. Lolo NF



Location: Montana
Total acreage: 2 million
Number of lakes: >100 (named)
Territorial loon pairs: 10
Threats:

The recovery of breeding loons in Montana is partly because of the research, monitoring, and outreach efforts of local working groups within areas such as national forests. Banded loons from Lolo National Forest have been found in central California, where marine oil spills could be problematic.

6. Okanogan-Wenatchee NF

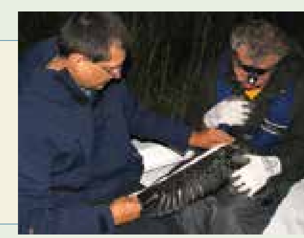


Location: Washington
Total acreage: 4 million
Number of lakes: 20
Territorial loon pairs: 5
Threats:

The slow recovery of the breeding loon population in north central Washington is a direct outcome of the outreach and monitoring efforts by local loon conservation groups and governmental agencies. BRI has worked with these groups since 1996 to help monitor individual loons through color-banding efforts.

Additional National Forests where loons breed:

Alaska: Chugach NF; Tongass NF
Idaho: Caribou-Targhee NF; Kaniksu NF
Michigan: Huron-Manistee NF; Ottawa NF
Minnesota: Superior NF
Montana: Flathead NF; Kootenai NF
New Hampshire/Maine: White Mountain NF
Vermont: Green Mountain NF
Washington: Colville NF



Spotlight on National Landscapes: NATIONAL WILDLIFE REFUGES

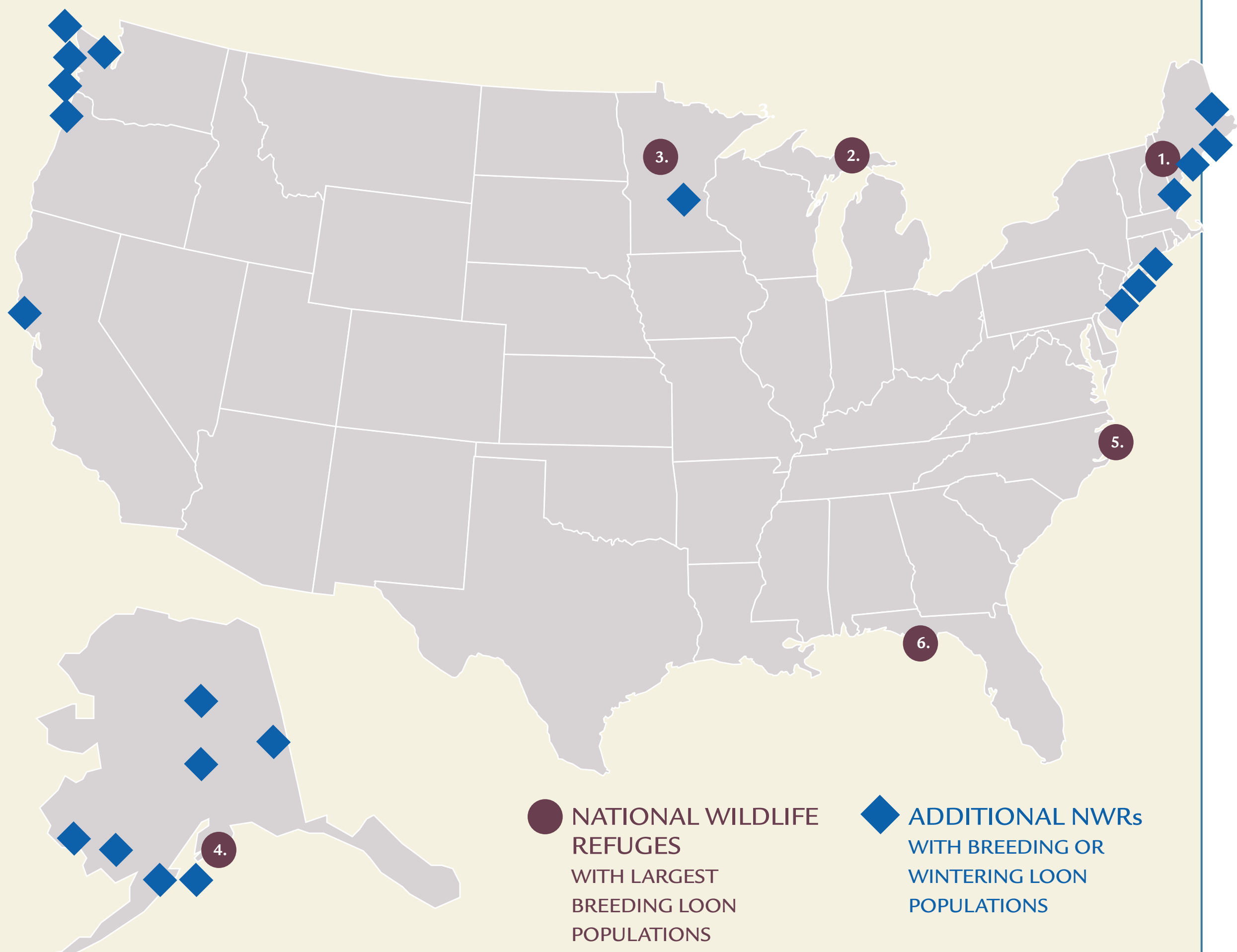
"Wild lands and the perpetuation of diverse and abundant wildlife are essential to the quality of the American life."

– National Wildlife Refuge System

Loons in Summer and Winter in National Wildlife Refuges (NWR)

Operating under the U.S. Fish and Wildlife Service, the National Wildlife Refuge System administers a network of more than 560 refuges that encompass 150 million acres of land and water with a mission of conservation, management, and restoration of our natural resources.

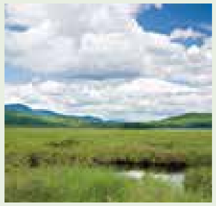
Accessible breeding loon populations are found primarily in three refuges in the contiguous United States and one refuge in Alaska. Wintering loon populations widely use the coastal refuges.






Photos are courtesy of the National Wildlife Refuge System

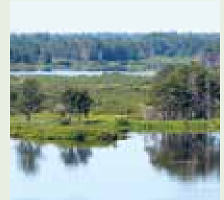
1. Lake Umbagog NWR



Location: New Hampshire and Maine
Total acreage: 30,841
Number of lakes: 9
Territorial loon pairs: 14
Threats:

As part of BRI's long-term study in the Rangeley Lakes region of Maine, ongoing since 1993, breeding Common Loon populations have experienced a dramatic decline in the number of territorial pairs, from a high of 32 to a low of 12 on Lake Umbagog alone. Today, the still-depressed breeding population has not recovered; the reasons behind the decline remain largely unknown.

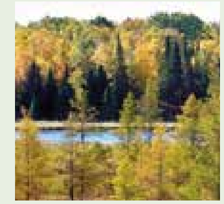
2. Seney NWR



Location: Michigan
Total acreage: 95,238
Number of managed pools: 27
Territorial loon pairs: 12
Threats:

BRI's continental banded loon and mercury monitoring program began in Seney in 1989. While the protected status provided by the refuge for the territorial loon pairs minimizes on-site threats, banded loons that migrate and stage on northern Lake Michigan are known to have died from botulism type E.

3. Tamarac NWR



Location: Minnesota
Total acreage: 42,744
Number of lakes: 32
Territorial loon pairs: 25
Threats: Hg

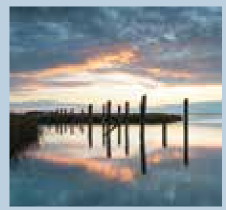
The territorial pairs that use this refuge are part of the largest breeding loon population in the contiguous United States—more than 4,600 pairs are known in the state of Minnesota, the land of 10,000 lakes.

4. Kenai NWR

Location: Alaska
Total acreage: 2 million
Number of lakes: 70+
Territorial loon pairs: *Unknown*
Threats:

A unique and expansive system of canoe trails in this refuge follow more than 70 lakes, many with breeding loon pairs, making Kenai a popular attraction for outdoor enthusiasts. A strong outreach program is likely all that is needed to minimize any concerns from issues related to human disturbance.

5. Pea Island NWR



Location: North Carolina
Total acreage:: 5,834 (land); 25,700 (Proclamation Boundary Waters)
Loon winter density:* High
Threats:

The largest densities of wintering Common Loons on the Atlantic coast are found along the shores of North Carolina. Within this area and across the mid-Atlantic, BRI is working to better understand the potential impacts of planned marine wind turbines on loons.

6. St. Vincent NWR

Location: Florida
Total acreage: 12,490;
Conservation easements: 1,625
Loon winter density:* High
Threats:

Every April, large numbers of migrating loons stage along the Florida Panhandle after spending the winter in the Gulf of Mexico. BRI research in this area focuses on the impacts from marine oil spills and emaciation syndrome.

**Based on standardized National Audubon Christmas Bird Counts*

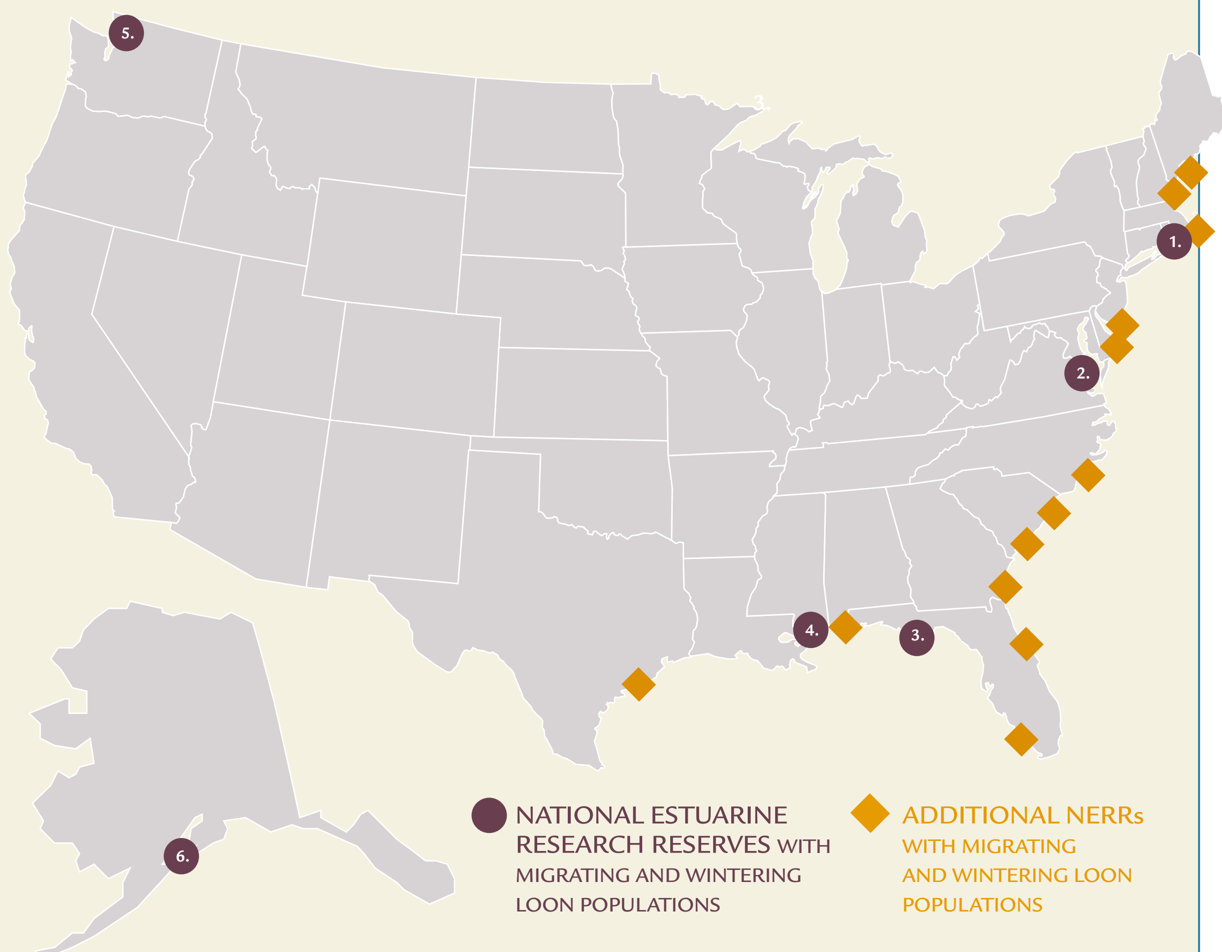
Additional National Wildlife Refuges where loons breed, stage, and overwinter:

Alaska: Alaska Peninsula NWR; Kanuti NWR; Kodiak NWR; Nowitna NWR; Tetlin NWR; Togiak NWR; Yukon-Delta NWR
California: Farallon NWR
Maine: Moosehorn NWR; Petit Manan NWR; Rachel Carson NWR
Minnesota: Crane Meadows NWR
New Hampshire: Great Bay NWR
New Jersey: Forsythe NWR
New York: Elizabeth Morton NWR; Seatuck NWR
Oregon: Cape Mears NWR
Washington: Copalis NWR; Dungeness NWR; Flattery Rocks NWR; Quillayute Needles NWR

Spotlight on National Landscapes: NATIONAL ESTUARINE RESEARCH RESERVES

"Stewardship strategies assess and respond to threats from coastal development, human use of reserve resources, climate change, and invasive species."

– National Estuarine Research Reserve System



Loon Migrating and Wintering Populations in National Estuarine Research Reserves (NERR)

The National Estuarine Research Reserves System, operated by the National Oceanic and Atmospheric Administration, protects more than 1.3 million coastal and estuarine acres in 28 reserves located in 22 states and Puerto Rico for purposes of long-term research, environmental monitoring, education, and stewardship. The Reserve System's stewardship approach uses the best available science to maintain and restore healthy, productive and resilient ecosystems, and disseminates information to regional and national stakeholders.

The coastal sites protected by this System are important habitats for overwintering and migratory loons. Some of the more important areas are highlighted here.

Photos are courtesy of the National Estuarine Research Reserves

1. Narragansett Bay NERR

Location: Rhode Island
Total acreage: 4,259
Loon winter density:* Medium
Threats:

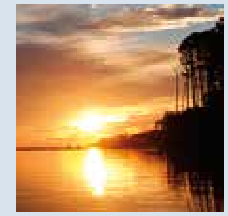
During April, migrating loons move through in large numbers and are at most at risk to marine oil spills. BRI worked with federal and state trustees to quantify the loss of loons from the *North Cape* oil spill. To offset this loss or injury, restoration of lost loon years was made across multiple lakes in Maine through the purchase of lake shorelines.

2. Chesapeake Bay NERR

Location: Maryland and Virginia
Total acreage: 9,321
Loon winter density:* High
Threats:

Wintering loons are found off the mid-Atlantic coast in some of the highest densities in North America, and they face some of the greatest threats. Working with federal and state governmental agencies, BRI researchers track loons via satellite transmitters to better understand their distribution and movement within and outside of this area.

3. Apalachicola NERR



Location: Florida
Total acreage: 246,000
Loon winter density:* High
Threats:

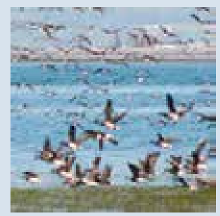
Migrating and wintering loons regularly use this reserve and nearby St. Vincent National Wildlife Refuge. One of the largest mortality events related to emaciation syndrome happened from January to March 1983 between Pensacola and Naples, Florida with an estimated loss of more than 13,000 individuals. BRI is establishing study sites in this area to better understand the synergy of stressors that may cause large loon die-offs.

4. Grand Bay NERR

Location: Mississippi
Total acreage: 18,049
Loon winter density:* Medium
Threats:

Wintering loons from Mississippi and nearby Louisiana are regularly prone to marine oil spills from tankers and platforms. The *Deepwater Horizon* oil spill has had a significant impact to wintering loons. USFWS selected BRI to investigate the full impact to loons of oil circulating in the Gulf of Mexico.

5. Padilla Bay NERR



Location: Washington
Total acreage: 11,460
Loon winter density:* High
Threats:

Some of the largest densities of wintering Common Loons on the Pacific coast are in the Puget Sound area. Commercial fishnets have been shown to take relatively large numbers of loons. BRI is working with local nonprofit organizations and governmental agencies to better track breeding loons in Washington and to identify the connectivity between breeding and wintering populations.

6. Kachemak Bay NERR

Location: Alaska
Total acreage: 366,100
Loon winter density:* Low
Threats:

Common Loons, along with Alaska's three other major breeding loon species (Yellow-billed, Pacific, and Red-throated Loons) are found here as they migrate through to northern breeding lakes. Breeding loons from the Kenai National Wildlife Refuge were tracked by BRI and found to stage in Kachemak Bay on their way to wintering areas along Kodiak Island.

**Based on standardized National Audubon Christmas Bird Counts*

Additional National Estuaries where loons stage or overwinter.

Alabama: Weeks Bay NERR
Delaware: Delaware Bay NERR
Florida: Guana Tolomato Matanzas NERR; Rookery Bay NERR
Georgia: Sapelo Island NERR
Maine: Wells NERR
Massachusetts: Waquoit Bay NERR
New Hampshire: Great Bay NERR
New Jersey: Jacques Cousteau NERR
North Carolina: North Carolina NERR
South Carolina: ACE Basin NERR; North Inlet-Winyah NERR
Texas: Mission-Aransas NERR

Recommendations

The Ricketts Conservation Foundation

The Ricketts Conservation Foundation was created to support the conservation of wildlife and wilderness areas, and to promote the importance of environmental stewardship as an enduring value. Underlying the Foundation's mission is the belief that conservation is everyone's responsibility.

As we move toward the future, government resources may not be sufficient to deal completely with environmental challenges, requiring private sector commitment to conserve our of wildlife and wilderness areas. By answering this need, and encouraging others to do the same, the Ricketts Conservation Foundation aims to make a difference in the quality of life enjoyed by future generations.

BRI received the Foundation's first grant—a five-year, $6.5 million study aimed at restoring the Common Loon to its former habitats in the Western, Midwestern, and Northeastern United States.

www.joericketts.com

The following recommendations provide approaches to best track, understand, and minimize threats to breeding, migratory, and wintering Common Loon populations across their North American range. It is the hope of this effort that a joint, interagency committee can be established to implement the elements needed to sustain Common Loon populations across their range.

MONITORING

- Increase standardized monitoring efforts for breeding populations in greatest need (e.g., mainly in the contiguous United States) and those populations undergoing largest declines in breeding success (e.g., eastern Canada)
- Develop migratory stations that can be used for long-term monitoring of migratory populations on both the Pacific (e.g., Point Reyes, CA) and Atlantic coasts (e.g., Cape May, NJ)
- Track changes in wintering populations using existing Christmas Bird Count data

RESEARCH

- Identify populations that are not self-sustaining or that are extirpated within the traditional breeding range and develop and implement restoration plans
- Determine connectivity among breeding, migratory, and wintering Common Loon populations
- Use the Common Loon as an indicator of environmental mercury loads; these data can be applied to other piscivorous wildlife populations across relevant parts of North America
- Develop a web-based information center to enhance networking among field biologists, lab scientists, and museum curators and to compile standardized geo-referenced databases

EDUCATION AND INFORMATION

- Develop a web-based information center to increase conservation awareness and enhance access to loon databases
- Promote responsible recreation fishing practices, commercial fishing techniques, and awareness of the needs of breeding and wintering loons

MANAGEMENT ACTIVITIES

- Enhance loon nesting habitat on FERC reservoirs through management of water levels or placement of artificial nesting islands
- Use best available logging practices to reduce adverse impacts on lake quality and ultimately loon reproductive success

PUBLIC POLICY

- Create a standard process for FERC and resource managers to best reduce impacts from reservoirs on breeding success from water level fluctuations and environmental mercury loads
- Develop a national standardized rule for changing the use of lead sinkers and jigs to other materials
- Monitor the impacts of national (e.g., CARA and MATS) and global (e.g., Minimata Convention) polices to reduce mercury emissions and effluents on the environment by using the Common Loon as a prime indicator species of ecological health over space and time
- Solidify a process for assessing injury and restoring loon years lost from oil spills and other contaminants with the USFWS' Natural Resource Damage Assessment and Restoration Program

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Resources For More Information

Biodiversity Research Institute's (BRI) Center for Loon Conservation is dedicated toward a greater awareness of loon species worldwide through monitoring, research, and conservation. The Center continues to identify threats to loon populations and develop collaborative research projects to help at-risk populations achieve self-sustaining levels. Supported by a generous grant from the Ricketts Conservation Foundation (RCF), BRI and RCF have initiated the largest and most comprehensive conservation study for the Common Loon, *Restore the Call*.

Other organizations conducting research and monitoring loons include:

Alaska

- Alaska Loon and Grebe Watch Monitoring Program » www.aknhp.uaa.alaska.edu

Maine

- Maine Audubon Society » www.maineaudubon.org
- Northeast Loon Study Working Group » www.briloon.org/NELSWG

Massachusetts

- Department of Conservation and Recreation » www.mass.gov/dcr
- The Massachusetts Division of Fisheries and Wildlife (MassWildlife) » www.mass.gov
- Tufts University Wildlife Clinic » www.tufts.edu

Michigan

- Common Coast Research and Conservation » www.commoncoast.org
- Michigan Loon Preservation Association » www.michiganloons.com
- Whitefish Point Bird Observatory » www.wpbo.org

Minnesota

- Minnesota Department of Natural Resources » www.dnr.state.mn.us

Montana

- Montana Loon Society » www.montanaloons.org
- Montana Loon Working Group » www.fwp.mt.gov/FishAndWildlife

New Hampshire

- Loon Preservation Committee » www.loon.org

New York

- BRI's Adirondack Center for Loon Conservation » www.briloon.org/adkloon
- Wildlife Conservation Society » www.wcs.org

Vermont

- Vermont Center for Ecostudies » www.vtecostudies.org

Washington

- Loon Lake Loon Association » www.loons.org

Wisconsin

- Sigurd Olsen Environmental Institute, LoonWatch » www.northland.edu
- The Loon Project » www.loonproject.org
- U.S. Geological Survey: Upper Midwest Environmental Sciences Center » www.umesc.usgs.gov
- Wisconsin Department of Natural Resources » www.dnr.wi.gov

Wyoming

- Wyoming Game and Fish Department » http://wgfd.wyo.gov

Canada

- Bird Studies Canada, Canadian Lakes Loon Survey » www.bsc-eoc.org