Species Conservation Assessment for the Common Loon (*Gavia immer*) in the Upper Great Lakes

USDA Forest Service, Eastern Region

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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service Threatened and Endangered Species Program at 626 E. Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

Photo credit: Adult common loon feeding a young chick at Seney National Wildlife Refuge, Michigan: The D Pool female was color-banded in 1989 and is the oldest known loon (at least 25 years old in 2011). Photo copyright by Rod Planck, 2006.

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1. EXECUTIVE SUMMARY

The purpose of this Conservation Assessment is to summarize current knowledge concerning the status, distribution, ecology and population biology of the common loon, as well as threats to upper Great Lakes loon populations. This document is intended to inform the development of a Conservation Strategy for continued loon viability in the region. Emphasis has been placed upon information and issues directly relevant to loon populations in Michigan, Minnesota and Wisconsin. In the upper Great Lakes region, the common loon *(Gavia immer)* is a designated Regional Forester Sensitive Species on the Ottawa, Hiawatha and Huron-Manistee National Forests in Michigan. Species occurrence is documented but not designated as Sensitive on the Chequamegon-Nicolet National Forest in northern Wisconsin and the Superior and Chippewa National Forests in northern Minnesota.

The common loon is a top predator that breeds on freshwater lakes and reservoirs across northern North America. High-quality nest habitat includes small islands and hummocks. As a K-selected species, the life history of a loon is characterized by delayed maturation, low fecundity and longevity (est. 30 years).

Despite its ecological prominence and cultural iconic status, the past century has seen a marked retreat in the breeding range of loons, owing largely to habitat loss and recreational disturbance. Current threats include continued habitat degradation, botulism, lead poisoning, oil spills and mercury exposure: those that impair adult survival are especially dangerous to the species' long-term regional viability.

Michigan, Minnesota and Wisconsin support half of the current U.S. loon population and the region is considered a priority for species conservation. The loon is currently considered stable at national and sub-national levels and is increasing in Wisconsin, though it remains Threatened in Michigan. Breeding occurs in all six National Forest units within the upper Great Lakes. Forest Plan guidance focuses upon protection of nesting habitat and reduction of disturbance. Forest surveys for loons are mostly sporadic and opportunistic except in the Ottawa National Forest, where surveys are annual.

Research priorities in the region include long-term monitoring of population vital rates, risk assessment of factors known to cause adult mortality and the identification and mapping of high quality breeding habitat and site-specific habitat requirements.

2. ACKNOWLEDGEMENTS

The Status Assessment and Conservation Plan for the Common Loon in North America (Evers 2007) and the Birds of North America Common Loon Species Account (Evers et al. 2010) were valuable resources for preparing this assessment. Numerous individuals contributed site-specific information used to compile this document (see Section 17.1). Damon McCormick and Joseph Kaplan of Common Coast Research & Conservation (CCRC) provided numerous comments and suggestions on earlier versions of this document. Michael Meyer of the Wisconsin Department of Natural Resources and Joanne Thurber of the Ottawa National Forest reviewed the final draft.

NOMENCLATURE AND TAXONOMY

Order:	Gaviiformes
Family:	Gaviidae
Scientific name:	*Gavia immer* (Brunnich, 1764)
Subspecies:	none currently recognized (American Ornithologists' Union 1998)
Common name:	Common Loon, Great Northern Diver (UK)
Synonyms:	*Gavia imber*
Previous names:	*Colymbus immer* *Urinator imber*

4. DESCRIPTION OF SPECIES

The Common Loon is a large waterbird ranging in mass from 2.2-7.6 kg and in length from 66-91 cm (see Evers et al. 2010). The large size range is attributable to both geographic variability and sexual dimorphism: Size is inversely related to migration distance, with interior breeding populations of the upper Great Lakes and central Canada smaller than breeding populations near the Atlantic and Pacific Coasts (see Evers et al. 2010); male loons are on average 27% heavier than female loons within the same region (Evers 2001). Due to their large size and adaptations suited for diving (e.g., solid bones and posterior leg location), loons cannot walk on land, and owing to heavy wing-loading, must run across the water to take flight.

Loons show no sexual dimorphism in plumage. Attained in the third or, more frequently, fourth calendar year (CCRC unpubl. data, Evers 2007), breeding (alternate) plumage is conspicuously characterized by black head, bill, neck, back, wings and feet, contrasting white breast and belly, and red eyes. The black neck, which may display green iridescence, is adorned with white dots forming a chinstrap and vertical white lines forming a collar. Black scapular and wing covert feathers are marked with two subterminal white rectangles, while sides, flanks and rump are also black with smaller white subterminal spots; together these feathers form an intricate and arresting piebald dorsal pattern (Figure 1).

Figure 1. Adult common loon in breeding (alternate) plumage.

Though there are five species of loons within the genus *Gavia*, only the common loon breeds in the lower 48 states. Common loons are occasionally confused with male common mergansers (*Mergus merganser*), but the latter is easily distinguished by its much smaller size (length: 64 cm, mass: 1.5 kg), unpatterned black back and bright orange bill (Sibley 2000).

Loon chicks are semi-precocial at hatching, and covered in down that is dark gray to black with a white breast and belly. A second set of longer grayish brown downy feathers replaces the natal down at three weeks of age. Downy tips gradually wear from these feathers until week nine, when no down remains and juveniles display an overall grayish aspect (Pyle 1997, CCRC unpubl. data).

Adult loons begin a post-breeding molt prior to fall migration, and finish this molt on their wintering grounds. Adult non-breeding (basic) plumage resembles juvenile plumage, but can most easily be distinguished by the retention of some spotted alternate feathers (especially visible in the scapulars) and some black pigment on an otherwise gray bill.

Adult loons have several high amplitude vocalizations, and engage in nocturnal chorusing between closely-spaced territories during the breeding season; the most common and recognizable vocalizations are described here. Popularly described as a haunting call, the *wail (oo-oo-oo)* is typically a contact mechanism between pair members; the number of notes delivered (one to three) is thought to positively correspond with anxiety level (Barklow 1988, Lindsey 2002). The *tremolo* call, frequently described as laughter, is characterized by rapid modulations (Lindsey 2002) and is often elicited in response to stressful events (Barklow 1979, McIntyre 1988). Loon pairs occasionally tremolo duet, and the tremolo is the only call used in flight. The *yodel*, a male-only vocalization that is primarily used during territory defense against conspecifics, consists of three introductory notes followed by repeated phrases of variable length (McIntyre 1988, Lindsey 2002).

5. LIFE HISTORY

5.1. Reproduction

Common loons are serially monogamous (Piper et al. 1997a) and form pair bonds on lake territories that are vigorously defended against conspecific intrusions during the breeding season (Piper et al. 2000, see section 6.2). During the pre-nesting period occupancy of established territories is high, and loon pairs are closely associated (i.e., typically within 20m, Piper et al. 1997a).

Courtship behavior is relatively inconspicuous, including bouts of tight circling, bill dipping, peering and shallow diving. These rituals are similar to those observed during interactions with intruding loons (see section 5.2 *Ecology*). During courtship, however, low 'mew' calls can often be heard when the pair nears shoreline areas where copulation and/or ritualized nest building may occur.

In the upper Great Lakes, the nesting season begins in May, peaks in June and extends into July (Evers et al. 2010). Nests are constructed by both pair members, preferably on small islands or offshore hummocks due to the protection provided from terrestrial nest predators. Nests are placed within two meters of the shoreline and, depending upon the availability of nest material, range in appearance from ill-defined scrapes in the substrate to well-developed mounds (Figure 2; Bent 1919, McIntyre 1988, Belant and Anderson 1991). Site selection appears to be driven by male loons, and nest reuse is negatively correlated with male turnover and positively correlated with nest success in the previous year (Piper et al. 2008a).

Clutch size is one or two (rarely three) large olive-colored eggs, variably marked with black splotches, which are laid one to three days apart in partially or wholly constructed nests and incubated by both sexes for 26-31 days (Yonge 1981, Evers et al. 2010). Re-nesting may occur up to two times following nest failure, but no more than a single clutch is raised annually. Semi-precocial chicks leave the nest within one day of hatching, but depend upon adults for food and protection. Parental care of young is shared (Evers 1994, Mager 2000), and chicks may back-ride and occasionally brood under the wing of an adult for the first two weeks. Parental dependence of young wanes throughout development, but juveniles continue to beg for food until fully developed at approximately 11 weeks of age (CCRC unpubl. data).

Figure 2. (a) Adult loon turning eggs on scrape nest. (b) Mound nest built in emergent wetland.

5.2. Ecology

Loons exhibit high inter-annual fidelity to breeding territories (up to 90% annually in the upper Great Lakes; Piper et al. 1997b, Evers et al. 2000, CCRC unpubl. data), and consequently to mates with whom a high level of reproductive success is achieved (77% of pairs will remain mated from one year to the next (see Evers 2000; Piper et al. 2000). Territory tenure averages 5.7+/- 4.4 years (n=33) for males and 4.6+/- 3.8 years (n=19) for females in Wisconsin (Piper et al. 2008a). Partnerships last an average of 5 years (Evers 2001), and up to 15 years (Seney NWR, MI; CCRC unpubl. data).

Intraspecific competition among loons is manifested in the form of frequent territorial intrusions during the breeding season. Territory defense can involve the male-only yodel call, chasing by either sex and potentially lethal fighting (more common in male-male competition; Piper et al. 2008b). Juvenile loons quickly retreat to nearshore areas and effectively hide during territorial intrusions. Territory takeover, whereby an intruding loon displaces the territory holder of the same sex, accounts for nearly half of all territory acquisitions in northern Wisconsin (Piper et al. 2000) and may be an important mechanism by which young adult loons acquire breeding territories (see Piper et al. 2000, 2006; CCRC unpubl. data). Territory takeover during nesting or chick-rearing typically results in nest abandonment, may result in chick death (Piper et al. 2000, D. McCormick pers. comm.) and has reproductive costs for usurped individuals in the year following dispersal to a new territory (Evers 2007, Evers et al. 2010). Less commonly, territories are acquired through passive occupation of a vacancy or through the founding of new territories on unoccupied sites (Piper et al. 2000). Competition among loon chicks is common and may result in siblicide by the dominant (typically first-born) chick (Strong and Hunsicker 1987, Dulin 1988, Evers et al. 2010).

Breeding loons are also territorial toward waterfowl and occasionally toward aquatic mammals (e.g., beaver, otter) that are within close physical distance; they “stalk” waterfowl by approaching with head and neck stretched out atop the water, then diving and surfacing under the targeted bird. Loons may share nest islands with trumpeter swans (*Cygnus buccinator*), but antagonism has been documented between male swans and nesting loon pairs at Seney National Wildlife Refuge in Michigan (D. McCormick pers. comm.).

Following the nesting season, loons interact in larger groups or “social gatherings” of up to 20 individuals whose behavior is distinctly less aggressive than territory intrusions earlier in the season. Though the function of social gatherings are not fully understood, they appear to be a less threatening means for loons to assess territory quality and the strength of existing pair bonds as they often involve experienced loons from neighboring territories (Piper et al. 1997b, Paruk 2006, CCRC unpubl. data). During migration and winter, loons show increased tolerance for both conspecifics and heterospecifics (Daub 1989, Evers and Jodice 1995) and may forage in groups (Ford and Gieg 1995, Vlietstra 2000).

For predators and parasites, see section *11.3. Disease or Predation*.

5.3. Dispersal/Migration

Loons are diurnal migrants (Williams 1973, Ewert 1982, Powers and Cherry 1983) that fly singly or in small groups, but not in pairs or family groups. Migrants fly between altitudes of 100 meters or less over water (Evers et al. 2010) and 1,500 to 2,700 meters overland (Kerlinger 1982) and at speeds averaging 70 km/hr (along Lake Superior; Binford and Youngman 2010). Neither the orientation mechanism nor migratory cues are well understood, but photoperiod (Evers et al. 2010) and weather events such as low pressure systems (Kenow et al. 2002) may be important factors in the initiation of migration.

Fall migration of upper Great Lakes loon populations begins as early as August (for failed breeders; Evers et al. 2010, D. McCormick pers. comm.), peaks in mid-October (in MN; Janssen 1987, Hertzel et al. 2000) and continues through November (Svingen 2000). Adult loons usually leave breeding lakes before juveniles, females typically depart before their male partners (D. McCormick pers. comm.) and failed breeders depart before those with young (Evers et al. 2010). Migration routes are overland and often include staging on large waterbodies such as the southern Great Lakes en route to coastal wintering sites from the Gulf of Mexico east to the mid-Atlantic coast (McIntyre and Barr 1983, Eberhardt 1984, Evers et al. 2000, Kenow et al. 2002) or large freshwater reservoirs (McIntyre 1988, Belant et al. 1991, Kenow et al. 2002) and south to the Florida Keys (Evers and Jodice 1995). Loons wintering in coastal areas may occupy large areas and have been observed up to 100 km offshore (Lee 1987; Haney 1990; Jodice 1993).

Spring migrants congregate in staging areas such as the northern end of the Gulf of Mexico, and stopover on large waterbodies such as the Great Lakes and the Mississippi River along their northward route (Perkins 1965, Ewert 1982, Evers et al. 2010). Spring migration peaks from mid-April through early May (Ewert 1982, Janssen 1987), and arrival to breeding territories coincides with the ice-out on lakes, with males arriving up to a week prior to females (Evers et al. 2010, CCRC unpubl. data).

Adult loons that are displaced from their breeding territories typically disperse short distances to neighboring lakes (mean = 4 km, maximum = 21 km; Evers 2001a, see also Evers 2007). Subadult loons remain on wintering sites until recruitment into a breeding population at three or more years of age (see Evers et al. 2010; CCRC unpubl. data). Dispersal distance between natal lake and first breeding territory varies by sex, as with other species with a similar life history strategy (Gaston 2004), where colonization of non-natal populations may be a mechanism of avoiding inbreeding (Pusey 1987). Young male loons return to their natal population, typically dispersing within 15 km (Evers 2000, Meyer 2006, CCRC unpubl. data, W. Piper pers. comm.). Fewer females than males are reobserved within their natal population as adults, and those that are have typically dispersed greater distances than males (on average 22 km in WI, Meyer 2006, W. Piper pers. comm.; 74km in MI, CCRC unpubl. data). Young adult loons typically do not return to their natal lake, though a few instances of brief mother-son pairings are known (Piper et al. 2001, D. McCormick pers. comm.).

5.4. Obligate Associations

As an obligate piscivore and top predator, loons have an important regulatory function in freshwater aquatic systems. Estimated prey removal on freshwater breeding lakes is upwards of 400 kg/year for a loon pair with two loon chicks (Barr 1996).

Loons find prey by peering below the surface of the water and use their feet to swim underwater to catch prey. Most prey items are small enough to be consumed underwater, but large fish may be brought to the surface (Evers et al. 2010). Small stones are swallowed to aid in the grinding of food in the gizzard (Pokras et al. 2009). Preferred freshwater prey species vary by lake and region, but include 10-15cm yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis Macrochirus*) and cyprinids (Olson and Marshall 1952, Barr 1996, Merrill et al. 2005, Burgess and Hobson 2006). Where abundant, other species are also readily consumed, including salmonids *(Oncorhynchus* spp.), bullheads (*Ictalurus* spp.) and crustaceans (Decapoda; (See Evers et al. 2010). Except in rare instances where prey abundance is inadequate (Parker 1985, Alvo et al. 1988, K. Tischler pers. obs.), young are fed whole fish and macroinvertebrates exclusively from their natal lake (Gingras and Paszkowski 2006). In winter and during migration, loons feed both singly and in groups on a variety of fish and crustaceans (Vliestra 2000, see Evers et al. 2010).

Sexual dimorphism in size (see Section *4. Description of Species*) may allow for niche partitioning of food resources among adult pairs. This dimorphism is extreme among adult pairs foraging on Lake Superior at Isle Royale National Park, where male loons are on average 41% heavier than females (CCRC unpubl. data), compared with the range-wide average of 27% (Evers 2001).

6. HABITAT

6.1. Range-wide

Breeding season loon habitat includes a wide range of freshwater lakes and reservoirs. Breeding territories can encompass entire lakes (whole lake territories), portions of lakes (partial lake territories) or multiple lakes (multi-lake territories) (Kaplan et al. 2002, Evers 2007), depending upon lake size and shoreline irregularity, prey abundance (see Section 6.4 Obligate Associations), water clarity and nesting habitat availability (McIntyre 1994, Meyer 2006).

The lower limit of usable lake size (2 ha at Isle Royale National Park and Ottawa National Forest, MI; Kaplan et al. 2002, Tischler 2010) is dictated by physical requirements for taking flight and achieving altitude to clear the surrounding treeline (Evers et al. 2010). Territory size is highly variable, but averages 60 ha among Great Lakes populations for which data are available (Table 1). The smallest lake known to support two loon territories is 50 ha at Isle Royale National Park (MI, Table 2) where loon density is likely near carrying capacity (Kaplan et al. 2002). It is additionally hypothesized that in this population, the proximity of several small lakes to Lake Superior makes possible the occupancy of all the island's inland lakes > 2 ha (Kaplan et al. 2002). Loons exhibit higher fidelity to whole lake territories than partial or multi-lake territories, an indication that whole lake territories may be of higher quality (Evers 2001).

Table 1. Territory size among common loon populations in the upper Great Lakes region.

Region	Territory size (ha) by type			All Territories	Source
	Whole Lake	Multi-lake	Partial lake		
Isle Royale NP, MI	26 (6-186), n=24	nd	66 (22-112), n=43[§]	51 (6-186), n=67	Kaplan et al. 2002[2]
Seney NWR, MI[1]	72 (32-167), n=13	nd	57 (26-11), n=7	66 (32-167), n=20	CCRC unpubl. data
Ontario, CA	n/a	n/a	n/a	70, n=222	Barr 1996
Ottawa NF, MI	52 (2-240), n=118	62 (6-210), n=22	98 (21-173), n=33	62 (2-240), n=173	CCRC unpubl. data
Oneida Co., WI	49 (3-134), n=72	43 (16-85), n=8	nd	46 (3-134), n=80	W. Piper, unpubl. data

nd - Insufficient data to report an average; at Isle Royale, multi-lake territories that include Lake Superior were excluded as the portion included in the territory was unknown.

§ Excludes territories on Lake Superior for which size has not been calculated.

1 Seney territory size represents usable lake size rather than whole lake size. Large territory size may be a result of the shallow bathymetry of pools (substantial portions of many pools are <0.5m deep) and the absence of very small pools.

2 Incorporates updated territory delineation from Egan (2010).

High quality breeding habitat is found on lakes with small islands and floating hummocks. Nests may be placed in a variety of habitat, including sphagnum bogs, sedge meadows, cattail marshes and beaches. Nests located on islands and offshore hummocks are strongly favored, as these sites provide protection from terrestrial nest predators (Olson and Marshall 1952, Vermeer 1973a, Sutcliffe 1980, Alvo 1981, Titus and VanDruff 1981, McIntyre 1988). Mainland sites may be used in lower quality territories or where island habitat is in close proximity to human activity (Valley 1987, Alvo 1981, Christenson 1981, McIntyre 1988). Artificial nest platforms can compensate for loss of natural nesting habitat. In areas where nesting habitat has been degraded or is inconsistently available (e.g., on reservoirs managed as hydroelectric projects) and where other factors necessary for successful breeding and rearing of young are met (i.e., prey fish abundance, water quality), loons readily accept floating nest platforms (Mathisen 1969, McIntyre 1977, Fair and Poirier 1993, Piper et al. 2002, Desorbo et al. 2007).

Loons frequently forage in the shallow littoral zone where forage fish densities are high (Strong and Bissonette 1989, Ruggles 1994), with notable exceptions occurring on the Great Lakes (KBT pers. obs.) Because loons are visual predators, water clarity is directly related to loon foraging efficiency (McIntyre 1975, Barr 1986, Gostomski and Evers 1998) and highly turbid water may preclude loon occupancy (Meyer 2006). Turbid conditions may be caused by the erosion of clay-based soils on some impoundments (McIntyre 1994). At the other end of the spectrum, high water clarity may be indicative of lakes with low productivity whose prey base may be insufficient to support loons (Ruggles 1994), although Meyer (2006) did not find this to be the case.

The Great Lakes are used extensively for migratory staging and stopovers (see Section 6.3 Dispersal/Migration) and for foraging by nonbreeding loons. The protected islands and bays within Isle Royale National Park on Lake Superior are the site of the only known current breeding population on the Great Lakes (Kaplan et al. 2002, Egan 2010). In coastal wintering areas loons may occupy large areas and have been observed up to 100 km offshore (Lee 1987; Haney 1990; Jodice 1993).

See *Section 11. Potential Threats* for factors effecting habitat quality.

Table 2. Size limitations for two-territory lakes among studied common loon populations.

Region	Lake size (ha)§	Source
Wisconsin	102	Zimmer 1979
Maine	119	Evers 2001
New Hampshire	125	K. Taylor, unpubl. data *in* Evers 2007
Michigan (Isle Royale National Park)	50	Kaplan et al. 2002
Michigan (Ottawa National Forest)	130	Tischler 2010

§ Smallest lake known to support >1 loon territory.

6.2. National Forests

Each of the six National Forest units in the upper Great Lakes region contains an abundance of glacially-formed lakes (Table 3), and all of them except the Huron-Manistee National Forest are considered to harbor important loon habitat (Evers 2007). The Superior National Forest alone contains more than 2,000 lakes > 4 ha in size, totaling 178,000 ha of water (USFS 2011a), over half of which are in the Boundary Waters Canoe Area (BWCA), a federally-designated Wilderness Area that stretches along the Minnesota-Canada border and joins the Quetico Provincial Park in Ontario. Combined, this area contains 20% of the freshwater in the National Forest System (USFS 2011a) and the largest amount of loon habitat in the lower 48 states. The lakes within the Ottawa National Forest (Table 3) and the surrounding Winnegar Moriane support the largest remaining breeding population of loons in Michigan, a status reflected in the region's recent designation as an Important Bird Area (IBA) for the conservation of loons in Michigan (NAS 2011). The Huron-Manistee National Forest sits at the southern edge of the breeding range for loons in Michigan.

Protection of shoreline habitat within the National Forests depends largely upon the abundance and size of private inholdings along lakeshore (see Section *10.1 Present or Threatened Risks to Habitat*). The Superior, Ottawa, Hiawatha and Chequamegon-Nicolet National Forests each contain federally designated wilderness areas where loon habitat is wholly intact (see Section 11: *Summary of Land Ownership and Existing Habitat Protection*). However, recreational activity in these areas may reduce the effectiveness of habitat protection where loons are sensitive to nest disturbance (see Section *10.2 Over Utilization*).

Table 3. Inland lake habitat on National Forests in the upper Great Lakes region.

National Forest unit	Lakes (n > 4 ha)§	Lake surface area (ha)§
Superior National Forest	2,000	178,000
Chequamegon-Nicolet National Forest	588	90,228
Chippewa National Forest	418	28,784
Ottawa National Forest	403	21,820
Huron-Manistee National Forest	1500*	17,000*
Hiawatha National Forest	260	13,633

§ The Great Lakes are excluded.
* Represents all lakes, not just those > 4ha.

6.3. Site Specific

The Important Bird Areas (IBA) Program recognizes vital habitat for bird species of conservation concern or whose populations are otherwise vulnerable at state, continental and global scales (NAS 2011). The common loon regularly occurs in several IBAs throughout the upper Great Lakes (Appendix A) and at least three IBAs (Winegar Moraine, Isle Royale National Park and Seney National Wildlife Refuge) were recognized specifically for their importance for loon breeding.

Additional habitat is found within the protected areas of Voyageurs National Park, Tamarac National Wildlife Refuge and Itaska State Park in Minnesota and Isle Royale National Park, Pictured Rocks National Lakeshore, Sleeping Bear Dunes National Lakeshore (mostly during migration) and Seney National Wildlife Refuge in Michigan. Voyageurs National Park protects 88,628 ha along the border in northern Minnesota: control of water level on large lakes, which cover approximately 40% of the park, has compromised loon habitat protection in Voyageurs (Paruk et al. 2008, see Section 10.5 *Other Natural or Human Factors*).

7. DISTRIBUTION AND ABUNDANCE

7.1. Range-wide

Common loons currently breed throughout northern North America (including coastal portions of Greenland) and Iceland, and winter along the Atlantic and Pacific coasts (Figure 3). In North America, the breeding range extends from the taiga shield of Alaska and Canada and portions of Greenland south to northern Washington, northern Idaho, northwest Montana, central Manitoba, central Alberta, southern Saskatchewan, north-central North Dakota, central Minnesota, northern Wisconsin, central Michigan, southern Ontario, northern New York, southern Quebec, portions of Vermont, New Hampshire and Massechusetts, southern Maine; there is also a small disjunct population in northwest

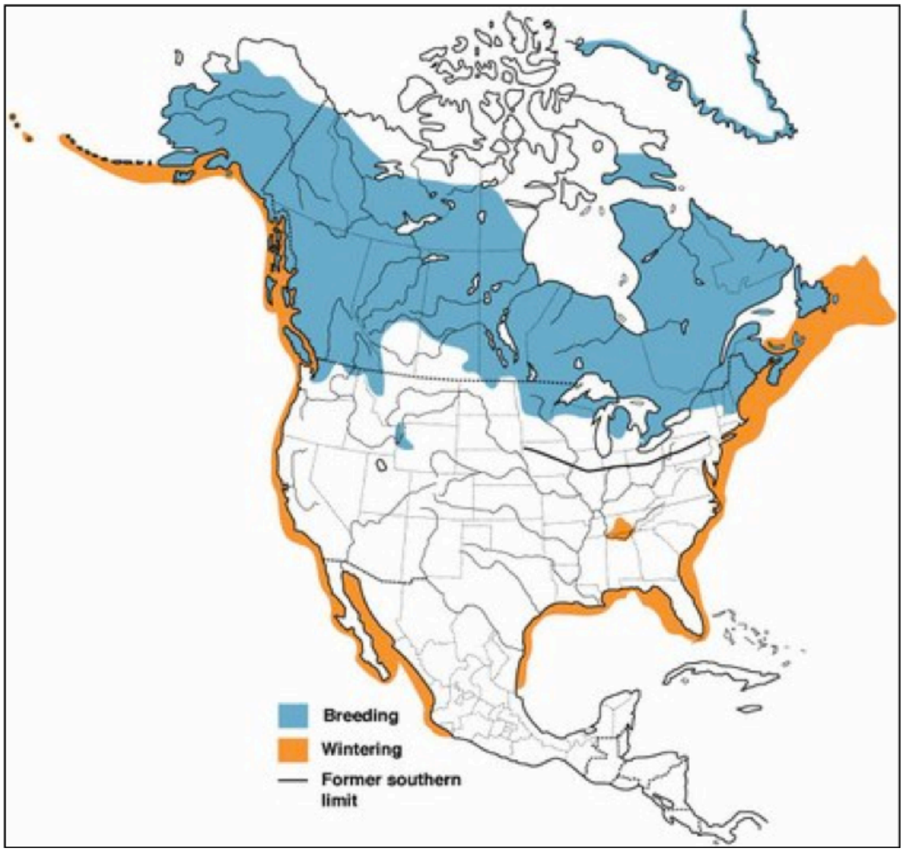

Figure 3. Current breeding and wintering range of the common loon and former southern limit in North America; range map reproduced with permission from Evers et al. 2010.

Wyoming (in Yellowstone National Park and Shoshone National Forest, see Evers et al. 2010).

The global population of loons is estimated at 607,000 to 635,000 individuals, the vast majority of which (>94%) breed in Canada, where populations are especially concentrated within Ontario and Quebec (Evers et al. 2010). Among United States populations (29,000 to 37,000 individuals; Evers 2007), approximately two-thirds breed in Alaska (8890-13,200 individuals; Tankersley and Ruggles 1993, Groves et al. 1996) and Minnesota (10,355 to 12, 897 individuals; Strong and Baker 2000) alone.

Owing largely to the loss of nesting habitat to shoreline development and the increased human use of lakes, the past century has seen a marked retreat in the southern extent of the breeding range across North America, with significant declines in the Great Lakes and New England (Sauer et al. 2011). Historically, the southern periphery of the breeding range extended into portions of Oregon and northern California, northern Indiana, Illinois, Ohio, Pennsylvania and Connecticut (McIntyre 1988). Ontario's loon population has also experienced a northward retreat, having once included a breeding population on Lake Erie (Cadman et al. 1987).

Though censuses are not standardized throughout the range, available survey data suggests that most breeding populations are currently stable and, as a whole, loon numbers may be increasing (Evers 2007, NatureServe 2011). New England populations have been recovering since the mid to late 1900s (Sauer et al. 2011), including the re-colonization of a small population in Massachusetts (Blodget and Lyons 1988) and a more than doubling of the populations in Vermont and New Hampshire (Taylor and Vogel 2003).

7.2. Region-wide

Breeding populations in the upper Great Lakes states of Minnesota, Wisconsin and Michigan (5,900 to 7,200 territorial pairs) account for half of the current U.S. loon population. Having suffered the largest atrophy during the last century (Figure 3), this region is a conservation priority for species recovery (Evers 2007, Evers et al. 2010).

In ***Michigan***, loons were abundant and widespread throughout the state until the early 1900s (Cook 1893, Hubel 1903). In 1912, Barrows reported a decline in abundance in the "more thickly settled parts of the state", and the trend continued for much of the century. The first statewide survey in the 1980s revealed the near loss of breeding loons from the southern half of the Lower Peninsula (Robinson et al. 1988, Robinson 1991). The current statewide population is estimated at 500-750 territorial pairs restricted to the northern two-thirds of the state, leaving thousands of suitably-sized lakes uninhabited (Zimmerman and Selzer 2002, Kaplan et al. 2010). Breeding along the southern periphery of the current range has expanded somewhat in the past two decades, except for a small disjunct population in the southwest part of the state, which has contracted and may be extirpated (Kaplan et al. 2010). Concentrations occur in the western and eastern-central Upper Peninsula and on Lake Superior at Isle Royale National Park (Kaplan et al. 2010).

Many naturalists at the turn of the last century recorded anecdotal accounts of the widespread distribution and abundance of loons throughout Michigan.

"There are records of sets [of loons] from almost every lake of considerable size in this county…who can imagine our beautiful lakes of Oakland County, amid all of their beauty and splendor, without the king of the freshwater swimmers?"

– Frederick Hubel (1903)

The last successful breeding of loons in Oakland County occurred on Lonesome Lake in 1952 (Kelly 1978).

The largest population of loons in the state is found within a high density of lakes on the Winegar Moraine in the western Upper Peninsula. Within this region, 174 territorial pairs are known to breed on approximately two-thirds of the lakes within the Ottawa National Forest (occupancy information for the remaining third is unknown, Tischler 2010). Isle Royale National Park additionally supports 118 loon pairs, 38% of which breed on Lake Superior (Egan 2010). The estimated population size in the eastern half of the Upper Peninsula, an area including the Hiawatha National Forest and the Seney National Wildlife Refuge, is 171 territorial pairs (McCormick, *in prep*). In the Huron-Manistee National Forest, there are 36 observations of loon nesting or presence on two forest districts (D. Newhouse pers. comm.).

In ***Minnesota***, where the historic breeding range included the entire state east of the Red River Valley (Janssen 1987), breeding is currently restricted to the northern two-thirds with concentrations in the north-central and northeastern regions (Hanson 1996, Strong and Baker 2000). In 1989, the statewide population was estimated at 11,626 +/- 1,272 adult loons (Strong and Baker 2000). Statewide monitoring in six index regions between 1994 and 2009 indicates that the population is stable, with 54-80% of lakes occupied in all index regions in 2009, except along the southern periphery of the current breeding range, where loons occupy only one third of lakes (Larson 2009, R. Baker pers. comm.). The loon population size within Chippewa and Superior National Forest boundaries has not been estimated.

Wisconsin's loon population also historically stretched throughout the state (Kumlien and Hollister 1951). The current breeding range has contracted to the northern third of the state, with a concentration in the north-central lake region, where occupancy of lakes > 4 ha was 46% between 2002-2004 (Meyer 2006). The first statewide loon survey estimated the population at 1300 adults in the mid 1970s (Zimmer 1982). Subsequent surveying between 1985-2005 suggests a 1.2% annual population increase, culminating in a most recent estimate of 3375 ± 495 adults, though recreational use of lakes, shoreline development pressure and mercury exposure continue to cause concern with regard to loon reproductive rates and long-term population viability (Gostomski and Rasmussen 2001, Meyer 2006).

8. RANGE-WIDE STATUS

The NatureServe (Nature Conservancy) status for the common loon is G5 (Globally Secure) (NatureServe 2011, see Appendix B for national and sub-national rankings in the upper Great Lakes Region). Formerly on the national list of Birds of Conservation Concern (USFWS 2002) and the U.S. Fish & Wildlife Service Species of Special Management Concern (Regions 1, 3-7; USFWS 1995, Evers et al. 2010), the common loon is currently considered a USFWS Region 3 Conservation Priority (USFWS 2002a). The North American Waterbird Conservation Plan (NAWCP) lists the loon as a species of Moderate Conservation Concern and the Boreal Hardwood Transition Bird Conservation Region (BCR 12) as a stewardship priority and a very important core breeding area (Wires et al. 2010). At the state level, the loon is Threatened in Michigan and New Hampshire and a Species of Special Concern in Connecticut, Idaho, Massachusetts, Montana, New York, Washington and Wisconsin. The loon is still considered “injured” in Alaska as a result of the 1989 Exxon Valdez oil spill (Evers et al. 2010). The USDA National Forest Service designates the common loon a species of Special Status and in the upper Great Lakes region as a Regional Forester Sensitive Species on the Ottawa, Hiawatha and Huron-Manistee National Forests in Michigan.

9. POPULATION BIOLOGY AND VIABILITY

The life history strategy of the common loon follows the model for K-selected species, characterized by delayed maturation, low fecundity, high parental investment and longevity (Pianka 1970). Loons attain definitive breeding plumage and recruit into a breeding population at three or more years of age and the average age at first-breeding is 6 years (ranging 4-11 years; Evers et al. 2000, see Meyer 2006, CCRC unpubl. data, W. Piper pers. comm.).

The breeding cohort represents approximately one-half to two-thirds of well-studied populations, while the non-breeding cohort is comprised of paired (3-27%) and unpaired individuals (15-33%; Table 4), the latter of which serve as population buffers against mortality events (Evers 2007, Grear et al. 2009). Though two-thirds to three-quarters of territorial pairs may attempt to breed annually (in New Hampshire, Taylor and Vogel 2003; in Saskatchewan, Yonge 1981), a small portion of the breeding cohort (19-22%) typically produces half of a population’s productivity (Appendix C; Croskery 1990, Meyer 2006, Evers et al. 2010, CCRC unpubl. data).

Reproductive success is highly variable at both spatial and temporal scales (see Evers 2007 for comparisons among populations across the range and Table 5 for upper Great Lakes populations). For example, within-population inter-annual variability may be as much as 20% (Evers 2007). The average annual productivity considered necessary to sustain breeding populations with an annual adult survival rate of 0.92 is 0.48 fledged young/territory (Evers 2001, Meyer 2006, Mitro et a. 2008). Though not measured by the

Table 4. Adult Common loon population structure.

Population	Years	breeding cohort (%)	non-breeding cohort (%)		Source
			paired	unpaired	
New Hampshire	1976-2002	54	27	19	Taylor and Vogel 2003 *in* Evers 2007
Northern Wisconsin	2002-2004	65	15	20	Meyer 2006
Seney National Wildlife Refuge, MI	2010	67	3	30§	CCRC unpubl.
Isle Royale National Park, MI	1999-2010	85*		15	Egan 2010

§ Estimated due to high proportion of unbanded unpaired individuals. Only 2010 reported, as the number of unpaired individuals has not been recorded annually.
* Represents both breeding and non-breeding paired loons.

Table 5. Common loon reproductive success in the upper Great Lakes.

Population/Region[1]	Years	Productivity[§]	Source
Itaska State Park, MN	1957-1976	0.29	McIntyre 1987a *in* Evers 2007
Voyageurs National Park, MN	1979-2006*	0.29	Fox 2007, VNP unpubl. data
Boundary Waters Canoe Area, MN	1950-1989	0.37	Mooty 1993 *in* Evers 2007
Northern Wisconsin	2004-2004	0.41	Meyer 2006
Isle Royale National Park, MI	1999-2010	Lake Superior: 0.21 Inland: 0.43	Egan 2010
Ottawa National Forest, MI	1985-2010	0.38	Tischler 2010; ONF unpubl. data
Seney National Wildlife Refuge, MI	1987-2010	0.66	CCRC unpubl. data
Northwestern Ontario	1983-1986	0.32	Croskery 1990

[1] See Evers 2007 for reproductive success of populations outside the upper Great Lakes region.

[§] Productivity is measured as the number of fledging-aged juveniles/loon territory. Surveys that do not report productivity using this metric and those less than three years in duration are not reported here.

* Data excludes years with limited survey effort (1987-1995).

standard metric allowing for comparison between populations (fledged young/territorial pair), it is likely that the average productivity of many populations in Minnesota surpasses this modeled sustaining reproductive rate (Larson 2009; MNDNR unpubl. data). Explanations for poor productivity include predation of eggs and chicks, human-caused population stressors (see Section 10 *Potential Threats*) and the use of marginal habitat for breeding in dense populations. A recent model of lifetime reproductive performance (based upon New England and Great Lakes data and assuming an average annual productivity of 0.48 chicks fledged/year, an age at first breeding of 6 years and a lifespan of 30 years) suggests an average lifetime reproductive performance of 12 fledged young, of which 3-4 will survive to adulthood (Evers et al. 2010).

Adult survival plays an important role in the viability of long-lived species (Russell 1999, Heppell et al. 1999). A decline in adult survival rate as small as 3% can significantly impair loon population growth in ways that cannot be compensated for through bolstered productivity (Vucetich et al. 2004, Mitro et al. 2008). Annual loon survival averaged over the first three years of life is 41% (W. Piper unpubl. data *in* Evers 2007), and annual survival of unknown-aged breeding adults is 92% (based on a model of New England and Wisconsin populations; Mitro et al. 2008, Meyer 2006, see Evers et al. 2010). Annual returns of banded individuals at Isle Royale National Park and Seney National Wildlife Refuge in Michigan indicated that annual survival is 95% in these populations, but this estimate includes a large amount of uncertainty (95% CI: 0.73-0.99), likely due to limited sample size (Vucetich et al. 2004). On the basis of these population survival rates, longevity is projected to exceed 30 years (J. Vucetich pers. comm., see also Evers et al. 2010), an estimate which is supported by several Michigan and Wisconsin color-marked adults that have reached at least 20 years of age as of 2011 (McCormick et al. 2007, CCRC unpubl. data, M. Meyer pers. comm., W. Piper pers. comm.) and by numerous longevity records over 30 years for other K-selected bird species (USGS 2011, Gaston 2004).

10. POTENTIAL THREATS

10.1. Present or Threatened Risks to Habitat

Habitat loss and human disturbance (see *Section 11.2 Over utilization*) over the last century are widely implicated in range-wide declines in the abundance and distribution of breeding populations of most waterbirds (Wires et al. 2010), including loons (Vermeer 1973b, Ream 1976, Titus and Van Druff 1981, Heimberger et al. 1983, Peck and James 1983, Dahmer 1986, Jung 1991, McIntyre 1988, Robinson et al. 1998, Strong and Bissonette 1989, Semenchuk 1992, Kelly 1992, Caron and Robinson 1994, Kaplan 2003, Kaplan et al. 2010). Lakeshore development can be associated with a series of ecosystem-level changes within lakes (Carpenter et al. 2007), and with the general degradation of riparian and aquatic habitats [e.g., reduced green frog (*Rana clamitans*) abundance and altered passerine bird composition in n. WI; Lindsay et al. 2002, Woodford and Meyer 2002]. Loss of shoreline vegetation results in increased water temperature as well as erosion and runoff (Liddle and Scorgie 1980); this erosion reduces water clarity, which impacts loon foraging efficiency (Gostomski and Evers 1998). Nutrient-enriched runoff can trigger algal and vegetative growth, which may in turn consume dissolved oxygen. Increased water temperature affects both plant and fish/amphibian communities in the littoral zone of lakes where loons forage and rear young (Carpenter and Kitchell 1993).

As part of an effort to evaluate the relative effects of multiple stressors on loon populations, the Wisconsin DNR developed a loon habitat model to assess population-level impacts of the record rate of housing development in the Northern Highland Lake District of northern Wisconsin, including some lakes within the Chequamegon-Nicolet National Forest boundary (Meyer 2006). This model found both water clarity and the presence of loon nesting habitat – two factors negatively impacted by shoreline development – to be strong predictors of loon presence and success in the region (Meyer 2006). Loons were absent from lakes on which building density exceeded 25 buildings/km. Two-thirds of lakes within the region are at risk for exceeding this building density considering current Wisconsin zoning regulations (WIDNR NR 115) which permit 33 buildings/km shoreline (1 building/100' of shoreline; Meyer 2006) and the low proportion of publicly-owned shoreline. At minimum, this study suggests that 10% of the shoreline in this region warrants protection from development in order to remain below the observed risk threshold for loon occupancy (Meyer 2006).

Private inholdings on lakes within the National Forests can contribute to the issues described above, and introduce challenges for effective habitat protection (Evers 2007). In the East Unit of the Hiawatha National Forest, approximately 60% of inland lakeshore is publicly owned (D. Huebner, pers. comm.). It is currently unknown to what degree lakes within the remaining National Forest units in the upper Great Lakes are at risk from development that threatens loon occupancy and productivity, as the proportion of federally-owned (or otherwise publicly-owned) lakeshore has not been quantified. At the other end of the spectrum, large areas within forests with no shoreline development (e.g., wilderness areas) may provide refuge for loon populations, though these regions are not immune to impairment by other means (e.g., recreational disturbance).

Public ownership of shoreline, conservation easements and/or more restrictive zoning requirements on privately-owned shoreline will be important for changing the current trajectory of lakeshore development, and thus preventing the loss of additional loon habitat and a future decline in loon populations.

Natural changes to habitat quality include lake eutrophication and succession, drought and flooding. In recent years, drought has affected the accessibility of nest sites on some small lakes in the Chequamegon-Nicolet, Hiawatha and Ottawa National Forests (M. Peczynski, pers. comm., D. McCormick pers. comm., K. Tischler pers. obs.).

10.2. <u>Over utilization</u>

Recreational use of northern inland lakes has increased markedly over the last century. Nesting – the life history stage during which loons are most vulnerable to disturbance caused by recreation – can be disrupted when recreational encroachment causes an incubating bird to "flush" from its nest (Titus and VanDruff 1981, Vucetich et al. 2004). Disturbance events can impair reproductive success by causing nest abandonment. Several studies have investigated this relationship (Olson and Marshall 1952, Ream 1976, Titus and VanDruff 1981, Valley 1987, McIntyre 1988, Caron and Robinson 1994, Kaplan 2003, Meyer 2006), but few have statistically demonstrated a negative effect of recreational activity on nest success (Titus and VanDruff 1981, Valley 1987, Kaplan 2003, see also Vucetich et al. 2004). One explanation for this phenomenon is the varied sensitivity of individual loons to disturbance: While loons nesting on lakes that receive little recreational use may flush at surprisingly large distances (up to 275m at wilderness lakes at Isle Royale National Park, MI; CCRC unpubl. data), others evidently become habituated to high levels of recreational use and can be approached closely without disrupting incubation (Sutcliffe 1980, Titus and VanDruff 1981, Heimberger et al. 1983, Belant and Anderson 1991, Ruggles 1994). Thus, lakes most at risk from human disturbance cannot necessarily be predicted by the level or type of human use they receive (Kaplan 2003, Heimberger et al. 1983).

In a northern Wisconsin study including lakes within the Chequamegon-Nicolet National Forest, human-caused nest disturbance was frequent (occurring every 3.7h) and accounted for 44% of all disturbance events, but the indicator of disturbance that was measured (number of boats observed) was not found to be a significant predictor of loon productivity (Meyer 2006). In the Boundary Waters Canoe Area of the Superior National Forest, two studies of human disturbance have been undertaken (Olson and Marshall

1952, Titus and VanDruff 1981); the latter reported frequent use of nest islands by recreationists but found only a modest impact of motor boat use on loon productivity. Among other Forest Service units in the upper Great Lakes, there is ample anecdotal evidence of human disturbance, but the degree to which such disturbance causes population-level impacts is unknown. It is noteworthy that highest long-term productivity across all regional sites listed in Table 5 (0.66 chicks/territory averaged over 24 years; CCRC unpubl. data) occurs at Seney National Wildlife Refuge, where all water recreation is prohibited (Kaplan et al. 2010).

Development and day-use of nest islands (Figure 4) pose significant threats to waterbirds (Wires et al. 2010) and can displace loons to lower quality nest habitat or impact nest success (Smith 1981, Titus & VanDruff 1981, K. Tischler pers. obs.).

Figure 4. Recreational day-use of a loon nest island by campers on Imp Lake, Ottawa National Forest.

Management approaches most likely to succeed in reducing human disturbance are geared toward understanding and addressing the impacts of disturbance on small spatio-temporal scales, with priority given to areas where loon productivity is below the threshold for maintaining a viable population. Modifying the behavior of recreationists through education may be a good strategy for bolstering loon nest success (Kaplan 2003) and reducing the small amount of chick mortality likely attributable to collisions with boats (see Meyer 2006, K. Tischler pers. obs.).

10.3. Disease or Predation

Predation. Consistent with their high trophic position, adult loons have few predators. Raccoons account for 80% or more of depredated nests in studied populations in Minnesota and Wisconsin (McIntyre 1988, McCann et al. 2005). Many other species of mammals and birds opportunistically depredate eggs, especially if left unattended (see Evers et al. 2010). Loon population declines attributed to shoreline development likely include impacts of nest predation by raccoons, whose population densities typically increase with lakeshore development (Sutcliffe 1978, 1980).

The presence of bald eagles (*Haliaeetus leucocephalus*), whose populations have recovered in recent decades (USFWS 2007), consistently elicits a high frequency wail response from adult loons. Bald eagles infrequently depredate adult loons from their nests (see Evers et al. 2010, M. Meyer pers. comm., CCRC unpubl. data) and occasionally prey upon loon chicks. Young chicks may also be preyed upon by snapping turtles (*Chelydra serpentina*), large fish (see Kenow et al. 2003a), gulls (*Larus* spp.) and fisher (*Mustela pennanti*) (see Evers et al. 2010).

Disease. Outbreaks of the Type E strain of **botulism** cause large episodic mortality events of migrating loons on the Great Lakes (with the exception of Lake Superior) that, based upon recent monitoring, disproportionately impact adults (CCRC unpubl. data). Botulism toxin is produced by the vegetative state of the anaerobic bacterium *Clostridium botulinum* (Brand et al. 1988), and results in muscle paralysis and death when ingested (NWHC 2007). Between 1963 and 1981 over 7,000 loon deaths were attributed to botulism poisoning on Lake Michigan (Kaufmann and Fay 1964, Fay 1966, and Brand et al. 1983, Brand et al. 1988). Since 1999, an increase in the frequency and extent of type E botulism outbreaks has resulted in an estimated 20,000 additional loon deaths (Domske and Obert 2001, CCWHC 2002, 2003; CCWHC 2003, Domske 2003, Kaplan and Tischler 2008).

Though *C. botulinum* is naturally-occurring and widespread, the resurgence of botulism-related mortality appears to be linked to shifts in the ecology of the Great Lakes (see Bailes et al. 2005), including the invasion and proliferation of at least three exotic species during the last 20 years: zebra mussels (*Dreissena polymorpha),* quagga mussels (*Dreissena bugensis*) and the round-goby (*Neogobius melanostomus),* a primary mussel predator (Domske 2003; Ruffing 2004; Ricciardi 2001, 2005; Getchell and Bowser 2006; Wires et al. 2010).

Breeding populations at risk from botulism-induced reductions in adult survival have not been determined. Among studied populations in upper Michigan (CCRC unpubl. data) differences in loon territory occupancy rates have yet to be detected, however reduced adult survival may not be immediately detectable in this manner due to compensatory replacement of breeders by unpaired buffer loons (Vucetich et al. 2004, Grear et al. 2009). The disproportionate influence of even a small decline in adult survival on the population growth rate in loons (Grear et al. 2009) suggests that botulism may pose a significant threat to loon population viability. From 2007 to 2010, three banded adults from the small (20 territories as of 2011) but productive Seney National Wildlife Refuge population were recovered on northern Lake Michigan, suggesting that the east-central Upper Peninsula may be at risk from botulism poisoning (CCRC unpubl. data).

Parasites. The common loon is the singular host to a species of black fly, *Simulium annulus*, that is active for a two to three week period during the early portion of the loon nesting season (Lowther and Wood 1964, Bennett and Fallis 1971, Weinandt 2006). Black flies are attracted to loons by physical and chemical cues and may transmit blood parasites, whose prevalence are positively correlated with adult loon mercury exposure levels (Weinerdt 2006). High densities of black flies around nests are occasionally responsible for nest abandonment, after which loon pairs often renest (McIntyre 1988, M. Meyer pers. comm., CCRC unpubl. data).

10.4. Inadequacy of Existing Regulatory Mechanisms

The U.S. Clean Air Mercury Rule of 2005 is the first regulatory action by the USEPA concerning mercury emissions from coal-fired power plants. There is concern, however, that this cap-and-trade approach will not alleviate biological mercury threats in certain hotspots if locally-derived emissions are not specifically reduced (Driscoll et al. 2007). Minnesota, Wisconsin, Michigan and Illinois have since also promulgated state-level mercury rules.

Six U.S. states have passed laws banning the use of lead tackle of the size that can be ingested by loons (see *Section 13. Past and Current Conservation Activities*); additional regulations on the sale and use of lead fishing gear are needed at state and national levels (see Evers 2007). Chemical and biological recovery of lakes from acidification requires more restrictive sulphur dioxide reduction standards than are currently in place in the US and Canada (Jeffries et al. 2003).

To protect loon nesting habitat and prevent further range contractions, more stringent zoning regulations pertaining to lakeshore lot size and housing density are needed at state and local levels (see Meyer 2006). Regulation and enforcement of island closures and prohibition of disturbance are additionally needed in some portions of the region.

10.5. Other Natural or Human Factors

Mercury in the environment is primarily cycled through atmospheric deposition of emissions resulting from coal burning and municipal waste incineration (Fitzgerald et al. 1998, Pacnya and Pacnya 2002, Driscoll et al. 2007). The methylation of mercury, which readily occurs in aquatic systems, renders it a potent neurotoxin that biomagnifies in the food chain and bioaccumulates over time (Mason et al. 1995, Macdonald et al. 2002), and thus places top-level piscivores such as loons at risk from mercury exposure (Schuehammer and Blancher 1994, Driscoll et al. 2007). Because the rate of mercury methylation is inversely related to lake pH (Eilers et al. 1986, Schnoor et al. 1986, Rapp et al. 1987, Grieb et al. 1990), loons breeding on acidic lakes (pH ≤ 6.3) may be at risk for mercury exposure (Meyer et al. 1995, Meyer et al. 1998, Counard 2001, Burgess et al. 2005, CCRC unpubl. data; see also *lake acidification* below).

Adverse effects to loons with elevated mercury levels have been measured in both field and dose-response laboratory settings, and include behavioral abnormalities (Barr 1986, Nocera and Taylor 1998, Counard 2001, Kenow et al. 2010), physiological abnormalities [i.e., suppressed immune function (Kenow et al. 2007a) and altered blood biochemistry (Kenow et al. 2008)], reduced chick fitness (Kenow et al. 2003b, Merrill et al. 2005, Kenow et al. 2007b) and impaired reproductive success (Barr 1986, Meyer et al. 1995,

Table 6. Lowest Observable Adverse Effect Level (LOAEL) from mercury exposure at various common loon life stages.

Life stage	LOAEL (ug/g Hg, wet wt.)	Exposure type	Source
Egg	1.3	in situ	Evers et al. 2003
Chick	0.4 (diet)	laboratory dose-response	Kenow et al. 2010
Adult	3.0 (blood), 40 (feathers)	in situ	Evers et al. 2008

1998, Burgess and Meyer 2007, Evers et al. 2008). Mercury thresholds associated with adverse effects (Lowest Observable Adverse Effect Levels, or LOAEL) have been developed for the loon life stages of egg, chick and adult (Table 6). Mercury exposure exceeding these LOAELs have been measured in loons breeding in the upper Great Lakes region (Meyer et al. 1995, Evers et al. 1998, Meyer et al. 1998, Counard 2001, Fevold et al. 2003, Evers et al. 2006, McCormick et al. 2006, Burgess and Meyer 2008, CCRC unpubl. data). Furthermore, 10% of female loons sampled in Wisconsin are predicted to lay eggs with Hg levels associated with a 50% reduction in hatching success (Meyer 2006).

Populations most at-risk to mercury exposure are in close proximity to emission sources, in regions characterized by poorly buffered soils (e.g., morainal systems), on lakes lacking drainages (i.e., seepage lakes) or on lake systems that experience fluctuating water levels (McCormick et al. 2006, Driscoll et al. 2007). Modeling tools are currently being developed to quantify the benefits of mercury reduction on loon productivity; these tools can be applied to populations for which site-specific demographic data and mercury profiles are available (Meyer 2006, Driscoll et al. 2007).

Lead poisoning has been attributed to 10-50% of adult loon mortality range-wide (Locke et al. 1982, McIntyre 1988; McNicholl and Strong 1988; Ensor et al. 1993; Pokras and Chafel 1992; Franson et al. 1993; Pokras et al. 1993; Poppenga et al. 1993; Scheuhammer and Norris 1996; Miconi et al. 2000, Stone et al. 2001, Franson et al. 2003, Sidor et al. 2003). The primary vector for lead poisoning in loons is the ingestion of lead sinkers, jig heads and split shot mistaken for similarly-sized stones that are swallowed to assist with mastication of prey (Franson et al. 2003, Pokras et al. 2009). Items ingested are typically <1g, <25mm long and < 10 mm wide (Pokras et al. 2009). Symptoms of lead poisoning include lethargy, reduced foraging ability and green feces, which lead to muscle paralysis and eventual death (see Evers 2007). Among waterbirds, loons are the species most impacted from this source of lead poisoning (Franson et al. 2003). Though population-level impacts have not been measured, adult mortality is considered significant throughout the upper Great Lakes (24% in WI, Strom et al. 2009, S. Strom pers. comm.; 8-17% in MN, Ensor et al. 1992, P. Perry pers. comm.) due to the disproportionate influence adult mortality has on loon viability.

Lake acidification caused by acid deposition from sulfur dioxide emissions is associated with loon reproductive failure (Parker 1985, Alvo et al. 1988, Ashenden 1988, Alvo

1996, McNicol et al. 1987, 1995; DesGranges 1989; Kerekes et al. 1994) and reduced juvenile survival (Alvo 1996, Meyer 1995). Low pH lakes are associated with elevated loon mercury levels (see *mercury* above) and reduced prey abundance (Parker 1988). Small lakes with no permanent drainage (i.e., seepage lakes) are disproportionately affected by acidic precipitation (Eilers et al. 1986, Schnoor et al. 1986, Rapp et al. 1987, Grieb et al. 1990), but lake chemistry does respond to reductions sulfur dioxide emissions (Keller et al. 1992a, 1992b, 2002; McIntyre and McNicol 2002, Jeffries et al. 2003; Keller et al. 2007).

The Great Lakes ecosystem is considered highly vulnerable to the effects of **climate change** – by the end of this century the upper Great Lakes is expected to see a 2-4°C average rise in air temperature, with up to 25% more precipitation and a 0.5-2.4 meter fall in lake levels (Wires et al. 2010). Risks of climate change to loon viability have not been assessed, but predicted ecosystem-level changes that are likely to affect loon populations include increased bioavailability of the contaminant mercury (Moore et al. 1998), altered aquatic ecosystem assemblages and prey base (Klyashtorin 1998, Wires et al. 2010), increased algal blooms, degraded water quality (IPCC 2007), increased rate and intensity of associated epizootic mortality events (as a result of warmer average lake and ocean temperatures) and altered or inconsistent nest habitat availability and hatching success (due to the increased rate and severity of lake level changes; Wires et al. 2010).

Reservoirs typically offer an expansiveness and island-inflected topography that is attractive to breeding loons, however **fluctuating water levels** cause frequent nest failure by flooding or stranding nests, decreasing nest accessibility and increasing vulnerability to predation (Fair 1979, Vermeer 1973a). As a result, reservoirs may serve as an ecological trap in which loon pairs, lured by the apparent suitability of nesting habitat, experience chronically poor productivity resulting from conditions that are not evident when a breeding site is selected in the spring (DeSorbo et al. 2007). In Voyageurs National Park, water level fluctuation is considered the primary limitation on loon productivity (0.29 chicks fledged/territory; 1979-2006; VNP unpubl. data, see Fox 2007).

The long-term introduction of more than160 **invasive aquatic species** into the Great Lakes (Ricciardi 2001, Wires et al. 2010) and the recent introductions of purple loosestrife (*Lythrum salicaria*), Eurasian water milfoil (*Myriophyllum spicatum*), curly leaf pondweed (*Potamogeton crispus*) and zebra mussels (among others) into loon breeding lakes in the region have produced yet unknown effects on loon populations, though interactions among invasive species on the Great Lakes have been linked with recent avian botulism outbreaks (see *Section 11.3 Disease or Predation*).

Episodic **oil spills** threaten coastal wintering habitat and have caused significant loon mortality in coastal Florida, New England and Alaska (Ford et al. 1996, Forrester et al. 1997, NOAA et al. 1999). Seventy five loons were recovered in the wake of the Deep Water Horizon spill in the Gulf of Mexico (as of 12 May 2011; USFWS 2011b), which is within the wintering range of breeding populations in the upper Great Lakes. In recent years, post-injury mitigation funds from oil spills have been directed toward protection of high quality breeding habitat in an amount deemed comparable to loon years lost to impacted populations (see Evers 2007, Evers et al. 2010).

Entanglement in monofilament fishing line on breeding lakes (Vermeer 1973a) and **entrapment in commercial fishing nets** on Great Lakes and coastal waters (McIntyre 1988, Wires et al. 2010) are additional causes of adult loon mortality (see Evers 2007).

11. SUMMARY OF LAND OWNERSHIP AND EXISTING HABITAT PROTECTION

Breeding loon populations occur in each of the six National Forest units in the upper Great Lakes region. The Chippewa and Superior National Forests contain a significant portion of all breeding loon pairs in the lower 48 states, the Ottawa National Forest contains the largest loon population in Michigan and the Huron-Manistee National Forest is situated along the southern edge of the current breeding range (Evers 2007).

Within the National Forests, congressionally-designated wilderness areas harboring loon habitat include the Boundary Waters Canoe Area (Superior National Forest), the Big Island Lake and Rock River Canyon Wilderness Areas (Hiawatha National Forest), the Sylvania and McCormick Wilderness Areas (Ottawa National Forest) and the Rainbow Lake Wilderness Area (Chequamegon-Nicolet National Forest). Additional publicly-owned habitat occurs in Voyageurs National Park, Tamarac National Wildlife Refuge and Itaska State Park in Minnesota, Apostle Islands National Lakeshore (mostly summer habitat for non-breeding loons) in Wisconsin and Isle Royale National Park, Pictured Rocks National Lakeshore, Sleeping Bear Dunes National Lakeshore (mostly during migration) and Seney National Wildlife Refuge in Michigan.

Protection of loon habitat within these areas is predicated upon the level of protection from 1) development along privately-owned lakeshore (see Section *10.1 Present or Threatened Risks to Habitat*), 2) recreational disturbance in wilderness and non-wilderness recreation areas (see Section *10.2 Over utilization*), and 3) water level fluctuations (e.g., Voyageurs National Park; see Section 10.5 *Other natural or human factors*).

12. SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

Artificial nest islands are an effective management tool for mitigating loon reproductive impairment caused by habitat degradation or fluctuating water levels (Piper et al. 2002, DeSorbo et al. 2007). Strategic placement of protective buoys (Figure 5) around nesting and chick-rearing (i.e., nursery) habitat and careful observation of human activity patterns can reduce disturbance by restricting human activity in the vicinity of a nest, particularly when these actions are combined with a measure of enforcement. As of 2010, twenty loon territories in the Ottawa National Forest contained floating nest platforms, and protective buoys were deployed around five such platforms and an additional three natural nest islands (Tischler 2010, J. Thurber pers. comm.). Collectively, loon territories with platforms and/or buoys fledged an average of 0.94 chicks/territory in 2010, a high level of productivity in comparison with the average long-term productivity for this site (0.38 chicks/territory). The Sylvania Wilderness Area in the Ottawa National Forest implements seasonal island closures for the benefit of loons from ice-off until 15 July. The Chequamegon-Nicolet and the Huron-Manistee National Forests maintain eight nest platforms and one nest closure area, respectively (S. Anderson, D. Newhouse, M. Peczynski pers. comm.).

Between 1990 and 1995, the Ottawa National Forest posted educational signs at public access sites and campgrounds with lake access to increase awareness about loon biology and to suggest recreational behaviors that minimize nest disturbance. These signs were recently updated and replaced in partnership with Common Coast Research & Conservation (Appendix D).

Many settlement agreements for the relicensing of hydroelectric reservoirs by the Federal Energy Regulatory Commission now include management requirements for loon habitat. In some agreements water level fluctuations are limited to a 15 cm (6 in) increase or a 30 cm (12 in) decrease during any 28-day period within the breeding season (Fair 1979), and in others floating nest platforms are utilized in combination with regular monitoring (DeSorbo et al. 2007, Evers 2007). In 2000, the International Joint Commission, which controls the international waters in Voyageurs National Park, ruled to change the timing and magnitude of water level fluctuations for hydroelectric generation, in part to reduce impairment to loon nests. Beneficial effects of those changes included reduced nest flooding and increased productivity on one of the reservoirs studied (Paruk et al. 2008).

Figure 5. Example of buoys used to protect both natural and artificial loon nests that are susceptible to disturbance in the Ottawa National Forest.

13. PAST AND CURRENT CONSERVATION ACTIVITIES

Several organizations protect loons and loon habitat at state and national levels. Many of these organizations coordinate programs whereby citizen volunteers (e.g., "loon rangers") educate neighbors and lake users about loon protection needs, monitor nest success and assess threats to specific lakes. Some loon rangers additionally deploy and maintain nest platforms and buoys. These efforts may be instrumental in maintaining and, in some cases, bolstering loon productivity on lakes with high levels of human activity.

The use of lead tackle has been prohibited throughout Great Britain (for the protection of Mute Swans, *Cygnus olor*) and in all Canadian national parks and wildlife preserves since 1987 and 1997, respectively. More recent restrictions have been implemented in Denmark (2002) and the United States, where Vermont, New York, and Maine prohibit the use of lead sinkers weighing less than 0.5 ounces, New Hampshire prohibits lead sinkers weighing less than one ounce, Massachusetts prohibits the use of lead sinkers in primary loon habitat, and in 2010, the state of Washington prohibits the use of lead tackle on loon lakes (D. Poleschook Jr. pers. comm., see also Michael 2006). Lead tackle is additionally prohibited on lakes in Yellowstone National Park and within thirteen national wildlife refuges, including the Seney National Wildlife Refuge in Michigan (Michael 2006). Bills prohibiting the sale and use of lead fishing tackle were introduced to the Minnesota and Michigan legislatures in 2003 and 2006, respectively. The Minnesota DNR, LoonWatch in Wisconsin and the Vermont Fish and Wildlife Commission all coordinate voluntary lead tackle exchange programs.

Protection of privately-owned lakeshore habitat through conservation easement has occurred on a few lakes in the Ottawa National Forest through partnership between the Keweenaw Land Trust and Common Coast Research & Conservation. In New England, oil spill mitigation funds were used to protect high quality loon habitat in an amount equivalent to loon years lost (see Evers 2007, Evers et al. 2010); this novel approach could be applied to loon populations in the upper Great Lakes.

Forest Plans for USDA National Forests must provide for sufficient fish and wildlife habitat to maintain viable populations of existing native vertebrate species that are well-distributed throughout the planning area over time (National Forest Management Act - 36CFR 219.27(a)(6), 1982). Common loons breed in all National Forest units in the upper Great Lakes, and are additionally designated a Regional Forester Sensitive Species (RFSS) on the Ottawa, Hiawatha and Huron-Manistee National Forests in Michigan. RFSS are defined as "plant and animal species identified by a Regional Forester for which population viability is a concern as evidenced by significant current or predicted downward trend in numbers and density" and "habitat capability that would reduce a species existing distribution" (FSM 2670.15). The following is a list of Forest Plan guidance pertaining to loons for the National Forests in the upper Great Lakes.

<u>Ottawa National Forest:</u>

- Protect loon nest sites and rearing habitat.
- Protect loon nesting islands from disturbance from ice-off through 15 July.
- Retain natural shoreline buffers along lakes to protect habitat.
- Support efforts to reduce the use of lead fishing tackle.

<u>Hiawatha National Forest:</u>

- Restrict use seasonally to protect active loon nests.

<u>Huron-Manistee National Forest:</u>

- Manage lakes with known loon populations to provide high quality nest areas and forage base with consistent water levels during the nesting season. Use artificial nesting rafts where appropriate.
- Protect nesting loons, use closure orders during the breeding period where human disturbance is a concern. Prohibit motorized watercraft or create no-wake-areas where appropriate.
- New developments will consider impacts on loons and should be placed one-fourth mile or more from nest sites on lakes with known loon populations.

- On lakes with known loon populations, manage or remove species that compete with loons, such as mute swans, within existing authority and with cooperating agencies, where needed.
- Fisheries management activities on lakes with known loon populations should ensure that loons are not harmed, caught or captured.

Chippewa National Forest and Superior National Forest:

- Maintain high quality, secure nesting habitat. This may include construction of artificial nests.
- Minimize management activities and new developments or other uses near nest sites between May 15 and July 1. Minimize management activities or new developments near nest areas frequently used by people.

14. RESEARCH AND MONITORING

14.1. Existing Surveys, Monitoring and Research

This section focuses primarily upon monitoring and research in the upper Great Lakes region; for a description of activities in other breeding regions as well as along migratory routes and in the wintering range see Evers (2007). Much of the existing knowledge of population dynamics and demographic parameters for the species has been obtained through 25 years of color-marking and reobservation by BioDiversity Research Institute, the Wisconsin Department of Natural Resources (WIDNR), Chapman University and Common Coast Research & Conservation.

Federal agencies. The Ottawa National Forest has monitored fledging-aged loon productivity on a non-random sample of approximately 150 lakes since 1982. Since 2000, this survey has been conducted in partnership with Common Coast Research & Conservation and with assistance from volunteer loon rangers from the Michigan Loon Preservation Association (see USFS 2008, Tischler 2010). The Hiawatha National Forest has sporadically surveyed a small number of lakes (approx. 15) one to two times annually since 1980; the Forest additionally records casual loon observations reported by the public (D. Huebner pers. comm.). Opportunistic surveys for loon productivity occur on a small proportion of lakes in the Chequamegon-Nicolet National Forest; at least four lakes have been monitored annually via ground surveys for the past 20 years in the Eagle River/Florence District (M. Peczynski pers. comm.) and nine lakes have been monitored sporadically in the Lakewood-Laona District since 2001 (S. Anderson pers. comm.). Additional lake information is conveyed to the Chequamegon-Nicolet National Forest from WIDNR staff (in the course of conducting research), LoonWatch loon rangers and forest visitors.

Voyageurs National Park has conducted extensive loon population surveys since 1979, with an emphasis on territory occupancy and productivity on large lakes (see Fox 2007). From 2004-2006 a study was conducted to investigate changes in loon nesting and productivity related to changes in the water level management regime (see Paruk et al. 2008). The National Park Service has monitored fledging-aged loon productivity at Isle Royale since 1985. Due to difficulty assessing reproductive rate in relation to the island's population as a whole, the

NPS and Common Coast Research & Conservation conducted a complete atlas of all loon habitat on the island between 1999 and 2002, using a hierarchical set of evidence codes to establish territory and breeding confirmation (Kaplan et al. 2002). This loon breeding atlas has been used in subsequent years by the NPS as a template for identifying and subsequently surveying territories.

The US Geological Survey's Upper Midwest Environmental Sciences Center in LaCrosse, Wisconsin, has studied mercury response thresholds for the behavior and physiology of captive-reared juvenile loons (in collaboration with the WIDNR). Current research is focused on identifying populations impacted by botulism events and oil spills using satellite telemetry and geolocation tags.

State agencies. The Minnesota Department of Natural Resources' (MNDNR) Department of Nongame Wildlife Program coordinates loon monitoring throughout the state. In 1989, the MNDNR conducted the first and only statewide loon population estimate through a random survey of 723 potential lakes via ground or air (Strong and Baker 2000). Since 1994, the Minnesota Loon Monitoring Program has conducted annual loon surveys of six 100-lake index areas throughout the state which were chosen to represent a range of factors that may impact loon populations (Larson 2009). The MNDNR also coordinates the Minnesota Loon Watcher Survey, which opportunistically collects monitoring data from approximately 400 volunteer citizen Loon Watchers annually (P. Perry, pers. comm.). In addition, the MNDNR's Sensitive Lakeshore Assessment Project has found loon nest sites to be one of three most important factors in the identification of sensitive shoreline; this information will be incorporated into a developing Rapid Assessment model (P. Perry, pers. comm.).

Between 1984 and 2002, The Michigan Department of Natural Resources (MIDNR), in conjunction with either Northern Michigan University or Lake Superior State University (depending upon the year), sporadically surveyed 200-300 lakes throughout the state using both stratified random and random sampling methods. The MIDNR does not currently conduct a loon survey.

WIDNR has conducted research and maintained a banded population of loons in northern Wisconsin since 1991. Studies have investigated mercury exposure and effects (in field and laboratory settings), habitat alteration associated with lakeshore development, human disturbance and population demographics. The WIDNR has constructed predictive models for understanding the relative risk of these environmental stressors to loon populations and population-level benefits of stressor reduction.

Common loons recovered dead in Michigan, Minnesota and Wisconsin are frequently necropsied to determine cause of death. Dead loons are analyzed by the WIDNR Wildlife Health Team if recovered in Wisconsin or Minnesota, and by the MIDNR Wildlife Disease Lab if recovered in Michigan.

Non-governmental organizations and universities. LoonWatch, a program of the Sigurd Olson Environmental Institute, is a non-profit organization involved with education, monitoring and conservation of loons, with a primary focus in Wisconsin. LoonWatch coordinates the Wisconsin Loon Population Survey, a one-day volunteer monitoring effort conducted every five years since 1985 on a stratified random sample of approximately 250 lakes as an estimate of the statewide loon population size and distribution. Conducted in July, the survey documents the presence of young, but does not provide an estimate of fledging-aged loon productivity. LoonWatch additionally coordinates annual Wisconsin lake monitoring by citizen volunteers, organizes lead fishing tackle exchanges and collaborates with the WIDNR and other organizations.

The Michigan Loon Preservation Association (MLPA) is a non-profit organization whose mission includes public education, research and protection of loons and their habitat. The MLPA administers Michigan Loonwatch, a program which facilitates the monitoring of loons by citizen loon rangers.

BioDiversity Research Institute (BRI), a Maine-based non-profit organization, collaborates with agencies and organizations to conduct loon-oriented research and monitoring across North America. BRI has conducted loon research in many locations throughout the upper Great Lakes, including Voyageurs and Isle Royale National Parks, the Ottawa, Hiawatha and Superior National Forests, Seney National Wildlife Refuge and northern Wisconsin.

Common Coast Research & Conservation (CCRC), a Michigan-based nonprofit organization, conducts research and long-term monitoring of loon populations in the Upper and northern Lower Peninsulas of Michigan, including Ottawa and Hiawatha National Forests and Isle Royale National Park. Research has focused upon population dynamics and demographics of banded individuals, exposure to mercury contamination, human disturbance, avian botulism and migration. In the eastern Upper Peninsula, the small and relatively isolated population of color-marked loons at Seney National Wildlife Refuge has been intensively studied since 1987, an effort that was initiated by BRI and continues through CCRC. Monitoring efforts focus upon the population dynamics of banded Refuge loons. In the eastern Upper Peninsula, surveys have been opportunistic and largely driven by searches for dispersed color-marked birds, whereas a complete population census has been done annually at Seney and Isle Royale (in collaboration with the NPS) since 1987 and 1991, respectively.

Chapman University conducts long-term research on a banded population of loons in northern Wisconsin. Research interests include behavior, population dynamics, genetic parentage of loon chicks, the influence of nest platforms on reproductive rates, and vocal tagging (in collaboration with Cornell University).

14.2. Survey Protocol

Objectives and endpoints. Existing loon surveys in the Upper Great Lakes region do not follow a single protocol, but often share the objectives of estimating two population parameters: size and productivity. While still valuable, surveys that do not include these two estimates have limited application for reproductive comparisons among populations (typically reported as fledged young per loon territory). The development of a standardized monitoring protocol for loons would aid both in the detection of temporal changes in population benchmarks indicative of status changes (i.e., decline or recovery) and the ability to make regional comparisons. The following are suggested guidelines for developing a standardized protocol to measure the endpoints of *population size* and *population productivity*. Additional endpoints such as adult survival and population stressors are also recommended and can be measured in color-marked populations. Inclusion of these endpoints into a monitoring program as well the choice of a sampling framework should take into consideration regionally-specific threats and resource availability; these factors are not included here.

Measurement metrics. Estimates of *population size* are based upon the number of paired <u>and</u> unpaired loons observed within a population. Paired loons occupy a territory, which is defined by the observation of a closely associated adult pair (i.e., two loons within 20m, not engaged in agonistic behavior) observed on more than one occasion during the breeding season.

The standard metric for estimating *population productivity* is total fledged young per territorial pair. Because fledging can be difficult to observe and chick mortality after six weeks of age is very low, productivity estimates may include all chicks $\geq$ six weeks of age. Though the rate of development among chicks is somewhat variable, typical physical characteristics at six weeks of age are a body size approximately two-thirds the length of an adult, with gray feathers replacing brown down on parts of the head, neck and mantle: remaining down often forms a "V" or "Y" shape on the nape (Figure 6).

Figure 6. Six week-old loon chick demonstrating typical plumage characteristics.

Survey season and methods. *Population size:* survey lakes annually from 15-31 May (or within four weeks of ice-out, depending on regional phenology), between sunrise and 10:00. This time period corresponds with peak occupation and defense of territories and close association of loons forming pair bonds. Surveys conducted during or after the breeding season result in underestimation of population size or artificial inflation of productivity because nesting loons are often missed during surveys and failed breeders often disperse from territories. Small lakes (< 16 ha) whose entirety is visible from a single location can be surveyed from the shoreline. Survey lakes larger than 16 ha or those with an irregular shoreline from multiple shoreline locations, or preferably, from a canoe, kayak or small motorboat. In each location, repeatedly scan all visible open water and shoreline areas for loons using binoculars or a spotting scope, from a sufficient distance to insure proper identification of all waterbirds encountered. Observe each loon or loon pair for $\geq$ 20 minutes, or until their status (paired, unpaired) can be confidently determined, noting the number of paired and unpaired adults observed, their location on the lake, the approximate distance between loons and all conspicuous behavior. Observers should be trained to correctly identify loon behavior. Behaviors indicative of a territorial pair include pair bonding (individuals within 20m of one another in the absence of additional intruders for the majority of the observation) and courtship (i.e., shallow diving, circling, bill dipping and clucking calls near shore). Territory and breeding status can additionally be assigned using the hierarchical list of criteria developed by Kaplan et al. (2002) on the basis of evidence observed (Kaplan et al. 2002, Appendix E).

To estimate *population productivity*, loon territories should be surveyed in late July through August (depending somewhat upon regional and seasonal phenology), when loon chicks are typically ≥ 6 weeks old. Utilize the same methods as described above, noting the number of adult and juvenile loons observed. If intruding loons are present during the observation, continue watching until the intruders have left the territory or return to the lake on another date, as loon chicks that are hiding during intrusions are easily missed.

Sampling considerations:
Include all lakes > 4 ha where possible, and > 8 ha where resources are limited.

- Sample design:
    - Complete population census: Appropriate in small or regionally-significant populations.
    - Stratified random sample: In large or remote areas with high densities of lakes where a complete survey of all suitably-sized waterbodies is time-prohibitive, survey a random sample of lakes, stratified by lake size as well as other important factors of reproductive success.

14.3. Research Priorities

In the Status Assessment and Conservation Plan for the U.S. Fish and Wildlife Service, Evers (2007) provides a thorough outline of range-wide research objectives for the common loon. The following includes research objectives outlined in this document and other sources that are regionally relevant and prioritized here for application to National Forest lands in the upper Great Lakes.

1. Implement long-term monitoring of population vital rates.

    "Certain features of the ecosystem appear to be particularly responsive to the seven sources of stress (including climate change) identified [for the Great Lakes]. Emblematic species such as certain fish-eating birds… should clearly be part of any monitoring program" (Bales et al. 2005).

    - Monitor abundance, productivity and adult and juvenile survivorship (Vucetich et al. 2004, Mitro et al. 2008, Grear et al. 2009).
        - Measure population parameters using standardized protocols that incorporate statistically-based sampling frameworks to allow for comparisons on larger spatial and temporal scales (Wires et al. 2010).

- Store and share data in a central repository (Evers 2007, Wires et al. 2010).
  - Facilitate data sharing through creation of an upper Great Lakes Loon Working Group
- Identify non-sustaining (sink) populations (Evers 2007).
- Identify and monitor population stressors (Evers 2007).

2. Assess population-level risk factors known to cause adult mortality (Meyer 2006, Mitro et al. 2008, Grear et al. 2009).

   "Given the strong influence of adult survival on estimated population growth rate, it is likely that minimal impairments or improvements of adult survival would be sufficient to cause long-term changes in loon population fitness. Thus, ***our research indicates a need for increased focus on adult mortality factors by managers and researchers****" (Grear et al. 2009).*

   - Include botulism (Wires et al. 2010), lead poisoning, oil spills and entanglement in commercial fishing nets and recreational fishing gear.
   - Develop linkages between breeding populations, migratory stop-over and wintering sites to identify populations most impacted by mortality events associated with botulism and oil spills (Evers 2007).
   - Prioritize at-risk populations (Evers 2007)
   - Prioritize state-listed populations (e.g. Michigan; Evers 2007)

3. Identify high quality habitat and site-specific habitat requirements.

   "A bird's-eye view of the present-day Northern Highlands Lake District [in N. Wisconsin] reveals a landscape made up of relatively intact second-growth forest…A closer look at lakeshore riparian areas, however, reveals rapid lakeshore residential development" (Carpenter et al. 2007).

   - Map and prioritize important island and shoreline habitat (Wires et al. 2010).
   - Evaluate the effects of aquatic invasive species on habitat quality.

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16. APPENDICES

Appendix A. Important Bird Areas (IBAs) in the upper Great Lakes region regularly used by common loons[§].

IBA Site	State	IBA Status[1]
Isle Royale National Park	MI	ABC; Identified
Seney National Wildlife Refuge	MI	ABC, Identified
Winegar Moraine	MI	Identified
Chippewa National Forest	MN	ABC
Mille Lacs Lake	MN	Recognized
Central Northern Highlands	WI	Recognized
Crex Meadows State Wildlife Area	WI	Recognized
Flambeau Headwaters	WI	Recognized
Kakagon/Bad River Wetlands and Forest Corridor	WI	Recognized
Lower Chequamegon Bay	WI	Identified
Manitowish Peatlands	WI	Identified
Owen-Teal Forest	WI	Recognized
South Shore Wetlands	WI	Identified

[§] Adapted from Upper Mississippi River Valley/Great Lakes Waterbird Conservation Plan (Wires et al. 2010).

[1] ABC = Designated a globally significant IBA by the American Bird Conservancy (ABC). Identified and Recognized refer to status of IBA consideration by the National Audubon Society's IBA Program.

Appendix B. Common loon conservation status at global, continental, national and sub-national scales.[§]

Ranking system (by geographic scale)	Status/rank	Description
Global		
NatureServe	G5	Globally secure
IUCN Red List	LC	Least concern
Continental/National		
NAWCP (North America)[1]	PS2, PT3, BD2, ND2, TB4, TN4	Population size 69,200-832,000 individuals; Population trend apparently stable; Breeding distribution widespread; Non-breeding distribution widespread; **Significant potential threats to breeding and Non-breeding range exist, Concentration results in high potential risk**
NatureServe (Canada)	N5B, N5N	Secure in breeding range Secure in non-breeding range
COSEWIC (Canada)[2]	Not at risk	
NatureServe (United States)	N4B, N5N	Apparently secure in breeding range Secure in non-breeding range
Sub-national		
BCR12[2]	Moderate (S), AI=3	**Moderate concern; Stewardship priority; Very important core breeding area**
Wisconsin		
State designation	SC	**Special Concern**
NatureServe	S3S4	Vulnerable – Apparently Secure
Michigan		
State designation	T	**Threatened**
NatureServe	S3S4	Vulnerable – Apparently Secure

[§] Sub-national status designations included here are for only the upper Great Lakes states of Michigan, Minnesota and Wisconsin.

[1] North American Waterbird Conservation Plan (Kushlan et al. 2002).

[2] Committee on the Status of Endangered Wildlife in Canada (01 April 1997, NatureServe 2011).

[3] NAWCP Bird Conservation Region 12: Boreal Hardwood Transition (see Wires et al. 2010).

Sources: NatureServe 2011, Wires et al. 2010

Appendix C. Common loon population cohort producing 50% of fledged young.

Population	Years	Productive cohort (%)[§]	Source
Northwestern Ontario		19	Croskery 1990
Rangeley Lakes, Maine	1995-2002	19	BRI, unpubl. data *in* Evers et al. 2010
Seney National Wildlife Refuge, Michigan	1987-2010	20	CCRC unpubl. data
northern Wisconsin	2002-2004	22[a]	from Meyer 2006

[§] Percent of breeding population that produces 50% of fledged young.
[a] Calculated from total pairs successful at hatch (could be inflated due to loss of clutches pre-fledging).

Appendix D. Common loon education/alert sign posted at public access sites in the Ottawa National Forest.

Loons need your help

Did you know loons are a Threatened Species in Michigan?

Once common on thousands of lakes throughout all of Michigan, fewer than 800 breeding loon pairs remain.

The good news is: loons nest on this lake

Loons are sensitive to disturbance – they nest along the shore and cannot walk on land nor take flight if startled, a factor which contributed to their decline. When disturbed, a loon pair may abandon its nest.

Adapt your behavior to ensure loons' continued occupancy of this and other lakes:

- Learn the signs of disturbance:

tremolo calling · hunkered on nest · penguin dancing

- Remember: when a loon tremolos, it is not laughing – it is distressed.
- Observe loons from a distance with binoculars.
- Give a wide berth to islands and areas marked by buoys during nesting season (May 1 – July 21).
- Kindly inform others if they are disturbing loons.
- Use lead-free fishing gear and pull fishing lines near loons.

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Appendix E. Loon-specific breeding classification developed by Kaplan et al. (2002)

Category	Code	Criteria
Confirmed	YO	Young with attendant adult(s)
	IN	Nest incubation by adult
	NE	Current-year nesting evidence: organic material formed into a nest cup, whole egg(s), and/or fresh, unfaded eggshells
Probable	CO	Pair copulation
	NB	Nest building by adult(s)
	NP	Recent nesting evidence (nest containing only faded eggshell fragments, and occupation by a pair)
Possible	PR	Pair occupation in absence of other nesting evidence
Observed	RN	Old or suspected nest site without a territorial pair present
	OB	Observation of single adult

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