PETITION TO LIST THE
Northern Bog Lemming (*Synaptomys borealis*)
UNDER THE U.S. ENDANGERED SPECIES ACT

Northern bog lemming. Photo © Dean Pearson (used with permission).

Petition Submitted to the U.S. Secretary of Interior
Acting through the U.S. Fish and Wildlife Service

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WILDEARTH GUARDIANS
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25 YEARS

INTRODUCTION

WildEarth Guardians (Guardians) respectfully requests that the Secretary of the Interior, acting through the U.S. Fish and Wildlife Service (Service) list the northern bog lemming (*Synaptomys borealis*) as "threatened" or "endangered" under the U.S. Endangered Species Act (ESA) (16 U.S.C. §§ 1531-1544). WildEarth Guardians also requests that the Service designate critical habitat for this species.

The northern bog lemming is found only in the northern hemisphere in subarctic climates along the northern tree line south into Washington, Idaho, Montana, Minnesota, and New England. Though they typically inhabit sphagnum bogs, they can occasionally be found in other habitats including alpine tundra, wet subalpine meadows, and mossy forests. The glacial relict habitats of northern bog lemmings are isolated and patchy in nature, as are lemming populations, making the risk of extinction very high. No populations of northern bog lemmings are known to exist in captivity and the small mammals are difficult to trap and rarely seen in the wild. Population density surveys have not been successful due to the inability of surveyors to find and trap the lemmings for counting. Currently, their presence is only known through their sign (fresh droppings of a distinctive green).

Several states have listed the lemming as "imperiled" or "critically imperiled" at the state level. Northern bog lemmings are threatened by timber and peat harvest, climate change, biological vulnerability due to isolated, small populations with limited allelic exchange, and the cumulative effect of those threats. The preferred habitat of the lemming—sphagnum bog fields and peatlands—are already-rare glacial relicts sensitive to climate change. Listing under the Endangered Species Act would afford the northern bog lemming critical habitat designation, a recovery plan, and the stringent federal protection it needs to survive. Designating the northern bog lemming as "endangered" or "threatened" could also benefit national forests such as Kootenai and Beaverhead-Deer Lodge; areas that are home to other rare and endemic species. We request listing of the full species, listing of individual subspecies—in particular the disjunct population of *S. b. sphagnicola* south of the St. Lawrence River in Maine and New Hampshire—and/or listing of the U. S. distinct population segment (DPS) of *S. b. chapmani.*

ENDANGERED SPECIES ACT AND IMPLEMENTING REGULATIONS

The Endangered Species Act, 16 U.S.C. §§ 1531-1544, was enacted in 1973 "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species and threatened species." 16 U.S.C. § 1531(b). The protections of the ESA only apply to species listed as endangered or threatened according to the provisions of the statute. The ESA delegates authority to determine whether a species should be listed as endangered or threatened to the Secretary of Interior, who in turn delegated authority to the Director of the U.S. Fish & Wildlife Service. As defined in the ESA, an "endangered" species is one that is "in danger of extinction throughout all or a significant portion of its range." 16 U.S.C. § 1532(6); *see also* 16 U.S.C. § 533(a)(1). A "threatened species" is one that "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1532(20). The Service must evaluate whether a species is threatened or endangered as a result of any of the five listing factors set forth in 16 U.S.C. § 1533(a)(1):

A. The present or threatened destruction, modification, or curtailment of its habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms; or
E. Other natural or manmade factors affecting its continued existence.

A taxon need only meet one of the listing criteria outlined in the ESA to qualify for federal listing. 50 C.F.R. § 424.11.

The Service is required to make these listing determinations "solely on the basis of the best scientific and commercial data available to [it] after conducting a review of the status of the species and after taking into account" existing efforts to protect the species without reference to the possible economic or other impacts of such a determination. 16 U.S.C. § 1533(b)(1)(A); *see also* 50 C.F.R. § 424.11(b). "The obvious purpose of [this requirement] is to ensure that the ESA not be implemented haphazardly, on the basis of speculation or surmise." *Bennett v. Spear*, 520 U.S. 154, 175 (1997). "Reliance upon the best available scientific data, as opposed to requiring absolute scientific certainty, 'is in keeping with congressional intent' that an agency 'take preventive measures' *before* a species is 'conclusively' headed for extinction." *Ctr. for Biological Diversity v. Lohn*, 296 F. Supp. 2d 1223, 1236 (W.D. Wash. 2003) (emphasis in original).

In making a listing determination, the Secretary must give consideration to species which have been "identified as in danger of extinction, or likely to become so within the foreseeable future, by any State agency or by any agency of a foreign nation that is responsible for the conservation of fish or wildlife or plants." 16 U.S.C. § 1533(b)(1)(B)(ii); *see also* 50 C.F.R. § 424.11(e) (stating that the fact that a species has been identified by any State agency as being in danger of extinction may constitute evidence that the species is endangered or threatened). Listing may be done at the initiative of the Secretary or in response to a petition. 16 U.S.C. § 1533(b)(3)(A).

After receiving a petition to list a species, the Secretary is required to determine "whether the petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A). Such a finding is termed a "90-day finding." A "positive" 90-day finding leads to a status review and a determination whether the species will be listed, to be completed within twelve months. 16 U.S.C. §1533(b)(3)(B). A "negative" initial finding ends the listing process, and the ESA authorizes judicial review of such a finding. 16 U.S.C. § 1533(b)(3)(C)(ii). The applicable regulations define "substantial information," for purposes of consideration of petitions, as "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted." 50 C.F.R. § 424.14(b)(1).

The regulations further specify four factors to guide the Service's consideration on whether a particular listing petition provides "substantial" information:

i. Clearly indicates the administrative measure recommended and gives the scientific

and any common name of the species involved;
ii. Contains detailed narrative justification for the recommended measure; describing, based on available information, past and present numbers and distribution of the species involved and any threats faced by the species;
iii. Provides information regarding the status of the species over all or significant portion of its range; and
iv. Is accompanied by appropriate supporting documentation in the form of bibliographic references, reprints of pertinent publications, copies of reports or letters from authorities, and maps.

50 C.F.R. §§ 424.14(b)(2)(i)-(iv).

Both the language of the regulation itself (by setting the "reasonable person" standard for substantial information) and the relevant case law underscore the point that the ESA does not require "conclusive evidence of a high probability of species extinction" in order to support a positive 90-day finding. *Ctr. for Biological Diversity v. Morgenweck*, 351 F. Supp. 2d 1137, 1140 (D. Colo. 2004); *see also Moden v. U.S. Fish & Wildlife Serv.*, 281 F. Supp. 2d 1193, 1203 (D. Or. 2003) (holding that the substantial information standard is defined in "non-stringent terms"). Rather, courts have held the ESA contemplates a "lesser standard by which a petitioner must simply show that the substantial information in the Petition demonstrates that listing of the species may be warranted" (emphasis added). Morgenweck, 351 F. Supp. 2d at 1141 (quoting 16 U.S.C. § 1533(b)(3)(A)); *see also Ctr. for Biological Diversity v. Kempthorne*, No. C 06-04186 WHA, 2007 WL 163244, at *3 (N.D. Cal. Jan. 19, 2007) (holding that in issuing negative 90-day findings for two species of salamander, the Service "once again" erroneously applied "a more stringent standard" than that of the reasonable person).

The Service and the National Marine Fisheries Service have jointly published standards for defining a Distinct Population Segment (DPS) (61 Fed. Reg. 4722). A species must be a vertebrate that is both discrete from other populations of the species and significant to the species as a whole. These terms are defined as follows:

> **Discreteness:** A population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions:
>
> 1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
> 2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.
>
> **Significance:** If a population segment is considered discrete under one or more of the above conditions, its biological and ecological significance will then be considered in light of Congressional guidance...that the authority to list DPSs be used "...sparingly" while encouraging the conservation of genetic diversity. In carrying out this examination, the Services will consider available scientific evidence of the discrete population

segment's importance to the taxon to which it belongs. This consideration may include, but is not limited to, the following:

1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,
2. Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon,
3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or
4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics. (*Id*. at 4725)

Although these criteria are "non-regulatory" and serve only as policy guidance for the agencies, the Service is committed to using these criteria for evaluating DPSs described in this petition (*Id.* at 4723).

CLASSIFICATION AND NOMENCLATURE

Common Name. The common name for *Synaptomys borealis* (Richardson 1828) is the northern bog lemming. We refer to this species as the "northern bog lemming," "bog lemming," or "lemming" throughout this petition.

Taxonomy. The petitioned species is *Synaptomys borealis*. The full taxonomic classification is shown in Table 1. Nine poorly differentiated subspecies are currently recognized (Chadde et al. 1998 at 31; Hall 1981 at 833-835; *see also* Howell 1927, *entire*). We are petitioning *S. borealis* as a full species because many subspecies were described from very few individuals and *S. borealis* is "in need of taxonomic reevaluation at the subspecific level" (West 1999 at 655). However, if available information indicates that one of the subspecies included in Table 1 merits listing individually, we ask that the Service consider listing the subspecies in addition to the full species. For example, the subspecies *S. b. sphagnicola* likely qualifies for listing, as does the population of *S. b. chapmani* at the southernmost edge of its range in Idaho, Montana, and Washington (*see* "Subspecies and Distinct Population Segments," *infra*).

Species Description. Northern bog lemmings are small rodents with cylindrical bodies covered in long coarse grey or brown fur with pale grey undercover (Nicholas 2001 at 2). They are microtine rodents, in the same subfamily as voles and muskrats, characterized by short, stocky bodies, short legs and tails, inconspicuous ears, and blunt noses (West 1999 at 655). Their bicolored tails are brown above and white below (*Id*.). They have small patches of buffy orange fur at the base of the ears (Banfield 1974 at 190). The flank glands of adult males are often marked by patches of white hair (*Id*.). They are on average 120 millimeter (mm) in length and weigh 22 to 25 grams (MNHP and MFWP 2014 at 1). Bog lemmings do not have significant sexual dimorphism (Nicholas 2001 at 2). The northern bog lemming is distinguished from other small rodents and mice by its very short tail (21 to 23 mm), "broad shallow grooves on the outer surface of the upper incisors, and… deep reentrant angles on the outer side of the upper cheek teeth and the inner side of the lower cheek teeth" (*Id*.). They can be differentiated from their closest relative, *Synaptomys cooperi* (southern bog lemming), by the buff-colored patches at the

base of the ears, mandibular molars without triangles on the outer side, and a palate which ends in a sharply pointed, backward-projecting spine (West 1999 at 656). Northern bog lemming females have eight mammae of which two are pectoral pairs and two are inguinal pairs; southern bog lemmings have only six (Banfield 1974 at 190).

Table 1. Taxonomy of *Synaptomys borealis* (Nicholas 2001; Hall 1981).

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Rodentia
Family	Cricetidae
Genus	*Synaptomys*
Subgenus	*Mictomys*
Species	*borealis*
Subspecies	*artemisiae* *borealis* (synonym: *bullatus*) *chapmani* *dalli* (synonym: *andersoni*) *innuitus* *medioximus* *smithi* *sphagnicola* *truei* (synonym: *wrangeli*)

Behavior. Northern bog lemmings are social animals who live in colonies (MDIFW 2003 at 2). They nest underground during summer, when the risk of predation is higher, and in winter construct globular nests of mosses, grasses and sedges on the ground surface, under the snow. They are active all winter (Nicholas 2001 at 1, West 1999 at 656) and during most of the twenty-four-hour period (Banfield 1974 at 191). In summer they clip vegetation and create runway systems through the underbrush where they forage. They repeatedly leave droppings along these runways, creating a scent "signpost" (West 1999 at 655). Active runways are indicated by the presence of these droppings as well as freshly clipped vegetation, which can be found scattered along the runways, in burrow entrances, or sometimes in small piles resembling haystacks (*Id*.). Burrow systems may be up to 30 centimeters deep. Individuals likely maintain a home range of less than one acre, and population densities may be up to 36 per acre (Streubel 2000). Yearly population fluctuations reflect the spring-summer breeding season and winter die-off (Foresman 2001 at 126).

They are predated upon by a wide variety of predators (West 1999 at 655-656) including martens and gartersnakes (MNHP and MFWP 2014 at 3). Like the southern bog lemming, they are likely prey for "a number of carnivorous animals that inhabit bogs and swamps, including opossums, shirt-tailed shrews, raccoons, grey and red foxes, long-tailed weasels, striped skunks, red-tailed, broad-winged, and marsh hawks, great horned and barred owls, crows, and black, king, water, and pine snakes" (Banfield 1974 at 188-189).

Diet. Northern bog lemmings eat primarily grasses and sedges, but also eat raspberry seeds, fungus, mosses, snails, slugs, or other invertebrates; their droppings are bright green (Nicholas 2001 at 2; MDIFW 2003 at 2; USFS undated; MNHP and MFWP 2014 at 3).

Reproduction. The breeding season lasts from May through late August annually. Litter size ranges from 2 to 8 young per litter, and female lemmings are capable of breeding a day after giving birth and of having 2 to 3 litters in a breeding season (West 1999 at 655). Gestational length is likely similar to that of the southern bog lemming: 21 to 23 days (MDIFW 2003 at 2).

SUBSPECIES AND DISTINCT POPULATION SEGMENTS

S. b. sphagnicola. The subspecies *S. b. sphagnicola* is particularly distinct, as it is found in a disjunct portion of northern bog lemming range in Maine and New Hampshire, south of the St. Lawrence River where it runs through southeastern Canada. The geographical isolation of this subspecies qualifies it for individual listing.

Discreteness. *S. b. sphagnicola* is physically different from other subspecies of northern bog lemming, with a large skull and long rostrum, proportionally wide at the tip. It is distinguished from *S. b. borealis* by coat color (*S. b. sphagnicola* is grayer anteriorly) and by longer foot size. It is more difficult to distinguish it physically from *S. b. medioximus* (Howell 1927 at 30-31), however that subspecies is found much further north and is separated from *S. b. sphagnicola* by physical barriers.

Significance. *S. b. sphagnicola* occurs in an ecological setting unusual or unique for the taxon: it is the only subspecies of northern bog lemming in New England (*see* "New England," *infra*). It is physically separated from other northern bog lemming populations by the St. Lawrence River (*see* Figure 2). This subspecies inhabits the southeasternmost portion of the species' range. "[R]ear edge populations, defined as those populations residing at the current low-latitude margins of species' distribution ranges, are disproportionately important for the long-term conservation of genetic diversity, phylogenetic history and evolutionary potential of species and that their investigation and conservation deserve high priority… [M]arginal rather than central populations commonly harbour the bulk of species' genetic diversity" (Hampe and Petit 2005 at 461).

Moreover, "bog lemmings are probably the rarest mammal in New England and eastern Canada, making them vulnerable to local extirpation" (NHGFD 2005 at A-312). If this subspecies is lost, there is no evidence that other subspecies of northern bog lemming would be able to recolonize the area. This would leave a significant gap in the range of the taxon.

U. S. DPS of *S. b. chapmani.* The southernmost portion of the range of *S. b. chapmani* qualifies as a DPS and should be listed as such.

Discreteness. The southern portion of the range of *S. b. chapmani* is geographically separated from peatland habitats further north in Canada. "Peatlands are rare in the Panhandle region of Idaho and adjacent Washington. They are disjunct by nearly 1000 kilometers from the largely unbroken peatlands occurring at boreal latitudes of North America" (Bursik and Moseley 1995 at

3; *see also* Chadde et al. 1998 at Figure 1). Nothing is known about the dispersal capabilities of northern bog lemmings (Reichel and Corn 1997 at 19). Other species of lemming make relatively long-distance movements: male collared lemmings (*Dicrostonyx torquatus*) moved over 3 kilometers in 24-hour periods on several occasions (Engstrom 1999 at 664), and brown lemmings (*Lemmus sibiricus*) have been found 10 miles (~16 kilometers) from land when travelling across frozen seas during emigration events (Banfield 1974 at 186). However these movements are orders of magnitude less than what would be required to cross the 1,000 kilometers between the northern U.S. peatlands and the Canadian boreal peatlands, and it is unlikely that the closely related northern bog lemming would be able to make the journey.

S. b. chapmani is distinguished from two other subspecies with similar ranges. Its neighbor to the west, *S. b. artemisiae*, does not come in contact with *S. b. chapmani*:

> The specimens of northern bog lemmings [*S. b. artemesia*] recently caught… are more similar in total length (117–125) to previous specimens of *Synaptomys borealis artemisiae* (113–122) or to the Rocky Mountain subspecies *S. borealis chapmani* (114–132) than to the coastal subspecies *S. borealis* [*truei*] (129–140), or the northern British Columbia subspecies, *S. borealis dalli* (131 average). However, there is no known zone of contact between *S. borealis artemisiae* and *S. borealis chapmani* so that *S. borealis artemisiae* is probably a valid subspecies. (Gyug and Peatt 2000 at 420-421, *internal citations omitted*)

The range of *S. b. artemisiae* lies between *S. b. chapmani* and *S. b. truei*, the only other subspecies known to occur in the southwestern portion of bog lemming range. Any zone of contact between *S. b. chapmani* and *S. b. truei* could therefore only exist further north, if it exists at all. Southern *S. b. chapmani* are therefore separated both from northern *S. b. chapmani* and other southern subspecies of *S. borealis*.

Significance. The U. S. DPS of *S. b. chapmani* occurs in an ecological setting unusual or unique for the taxon. It inhabits the southernmost edge of the subspecies' range. "[R]ear edge populations, defined as those populations residing at the current low-latitude margins of species' distribution ranges, are disproportionately important for the long-term conservation of genetic diversity, phylogenetic history and evolutionary potential of species and that their investigation and conservation deserve high priority… [M]arginal rather than central populations commonly harbour the bulk of species' genetic diversity" (Hampe and Petit 2005 at 461). This DPS is likely genetically distinct. "[L]ow elevation valley peatlands [in Idaho] are separated from each other by vast stretches of upland... The isolated nature of peatland habitats in Idaho creates a laboratory for the evolution of ecotypes of more wide-ranging, disjunct species that are uniquely adapted to local conditions" (Bursik and Moseley 1995 at 1). If this DPS is lost, there is no evidence that other northern bog lemmings would be able to recolonize the area. This would leave a significant gap in the range of the taxon.

HABITAT REQUIREMENTS

The northern bog lemming is almost exclusively found in peatland habitats (Reichel and Corn 1992). "Habitat of the northern bog lemming consists primarily of fens and bogs or bog-like

environments that are… relict communities from the Pleistocene. However, this species has also been taken in wet meadows…; old-growth hemlock (*Tsuga heterophylla*) forest…; subalpine-fir *(Abis lasiocarpa)* forest…; and alpine habitat in Washington… [T]he presence of mat-forming *Sphagnum* spp. is a good, though not definitive, indicator for this rare lemming-mouse" (Pearson 1999 at 24, *internal citations omitted*). "One site [in Montana] had a thick moss layer of *Tomentypnum nitens* rather than sphagnum. Thick moss mats appear to be the most reliable indicator of a potential site" (Chadde et al. 1998 at 31). In Montana, they have not been found utilizing habitat patches smaller than 1 acre or approximately 4,046 m^2 (Reichel and Corn 1997 at 6; *see also* Reichel 1996 at 9). More generally, northern bog lemmings can be found where moisture levels are high and growth of sedges and grasses are sufficient to provide cover as well as act as their food supply (West 1999 at 656), hence their occasional occurrence in habitat types aside from peatlands. Other habitats "may either support lower densities of bog lemmings; be used primarily by dispersing individuals; be used during specific seasonal, climatic, or competitive situations; or be population sinks. Marginal habitats and areas may be important to maintain population viability" (Reichel 1997 at 44).

GEOGRAPHIC DISTRIBUTION

Fossil record. In the Pleistocene, northern bog lemmings were present further south, on isolated mountains in the Great Basin where they are no longer found today (Mead et al. 1992 at 235-236; *see* Figure 1). The northern bog lemming prefers boreal habitats, and has been retreating northward along with them (Nicholas 2001 at 1). "Populations of northern bog lemmings in the northwest U.S. have apparently been isolated since the last ice age ended over 10,000 years ago. It seems likely lemming populations were more wide-spread at that time, then were reduced in size and number during the Hypsithermal 6000-3000 years ago, when the climate was warmer than at the present time" (Reichel and Beckstrom 1993 at 16).

> The northern bog lemming may be a relic species whose present distribution, particularly in Montana, reflects the glacial history of this region. Forced to migrate southward as the Pinedale Glacier advance occurred (18,000-10,000 years before present), the northern bog lemming, through its habitat preferences, established itself in the boreal climate of the time. As the glacial mass receded northward over the past 10,000 years small northern bog lemming populations remained behind, ultimately becoming trapped in islands of boreal (bog) habitat as broader habitat changes occurred. (Foresman 2001 at 126)

Historic and Current Distribution. "The northern bog lemming is boreal in distribution, occurring in North America from near treeline in the North, south to Washington, Idaho, Montana, Minnesota, and New England" (Reichel 1997 at 2; *see* Figure 2). It occurs across northern North America from Labrador to Alaska but is uncommon in northwestern Canada and rare in eastern Canada (Banfield 1974 at 191). There is an isolated population south of the St. Lawrence River in the Northern Appalachian Mountains (*Id*.). The species has a large but patchy distribution (West 1999 at 655); the disjunct nature of its populations is most likely explained by "1) the localized nature of its primary habitat; and 2) the currently patchy distribution of a boreal species that was more widely distributed during the Pleistocene" (Reichel and Beckstrom 1993 at 2).

Alaska. The subspecies *S. b. dalli* is found in Alaska (Hall 1981 at 834), south of Brooks Range

throughout Alaska except the Aleutian Islands and most of insular Alaska (Walton et al. 2013 at 1; *see* Figure 3). There are 641 specimen records throughout the Alaskan range (*Id*. at 2). "Northern bog lemmings have been documented on the Kenai Peninsula west of the Kenai Mountains... This species is often uncommon to rare and generally restricted to open habitats with a preference for damp meadows, marshes, bogs, and fens. Continued inventory efforts, particularly in the vicinity of the Resurrection River, may eventually document the occurrence of this lemming up within [Kenai Fjords National Park]" (Cook and Macdonald 2003 at 15). "They seem to occupy cold bog or spring areas, but they are also found near rocky cliffs. They live primarily in burrows among sedges and grasses where moisture levels are high, providing cover as well as food" (Whitney 2007 at 1).

Canada. All nine subspecies are found in Canada (Hall 1981 at 834; *see* Figure 2 *and* Banfield 1974 at 190 (Map 78)). Northern bog lemmings are "uncommon in northwestern Canada and rare in eastern Canada" (Banfield 1974 at 191). "A few Ontario records exist from the James and Hudson Bay lowlands, and the Rainy River area" (Dobbyn 1966 at 66).

Washington. Washington is home to the subspecies *S. b. chapmani* in the northeast, *S. b. artemesiae* in the north, and *S. b. truei* in the northwest (Hall 1981 at 834; *see* Figure 2 *and* Figure 4; *see also* "Subspecies and Distinct population Segments," *supra*).

> The northern bog lemming is limited to the cold, wet bogs or grass/forb meadows within or on the edges of the boreal coniferous forest. The watersheds that contain known records of the northern bog lemming include the Lower Pend Oreille, Middle Pend Orielle, Upper Methow, Lost River, Upper Chewuch, and Sinlahekin Creek… Bog lemmings are found in sphagnum bogs, wet meadows, moist mixed and coniferous forests; alpine sedge meadows, krummholz spruce-fir forest with dense herbaceous and mossy understory, and mossy stream sides (Gaines et al. 2012 at 174, *internal citations omitted*)
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> [Northern bog lemmings] were inventoried in the Southern Interior of British Columbia (B.C.) from 1996 to 1998 in areas where conflicts were likely to develop with proposed timber harvesting. Sagebrush northern bog lemmings (*Synaptomys borealis artemisiae)* were found at 2 sites, and are only known from 8 localities (5 in British Columbia, 3 in Washington State). They are found mainly in fens, swamps, and marshes at 1,600 m or higher. (Gyug and Peatt 2000 at 417)

A note on *S. b. artemesia*. The subspecies *S. b. artemesia* has been considered particularly distinctive due to its apparent association with sagebrush slopes (West 1999 at 656). A recent study indicates it is more similar to other subspecies of bog lemming in terms of habitat preference:

> The specimens of northern bog lemmings [*S. b. artemesia*] recently caught… are more similar in total length (117–125) to previous specimens of *Synaptomys borealis artemisiae* (113–122) or to the Rocky Mountain subspecies *S. borealis chapmani* (114–132) than to the coastal subspecies *S. borealis* [*truei*] (129–140), or the northern British Columbia subspecies, *S. borealis dalli* (131 average). However, there is no known zone

> of contact between *S. borealis artemisiae* and *S. borealis chapmani* so that *S. borealis artemisiae* is probably a valid subspecies… Seven of [the eight known locations of sagebrush northern bog lemmings] were characterized as bog birch or willow wetlands, or as wet meadows, which is more typical of the species throughout its range. The type specimens collected in sagebrush habitat near Stevenson Lake in 1927 now are the anomaly in terms of habitat rather than the norm. The subspecific name "sage-brush" (artemisiae) is probably misleading and it appears that the subspecies habitat preferences are more similar to the other subspecies of northern bog lemmings rather than to any "semidesert" affinities. Perhaps the subspecies should be renamed "Cascade northern bog lemming" to more accurately describe its geographical distribution. (Gyug and Peatt 2000 at 420-421, *internal citations omitted*)

Though the distinctiveness of this subspecies is less clear-cut than once thought, the Service should consider whether available information indicates that *S. b. artemesia* should be listed as a subspecies alongside the U. S. DPS of *S. b. chapmani*.

Idaho. Idaho is home to the subspecies *S. b. chapmani* (Hall 1981 at 834). "In Idaho the species occurs in scattered localities in the extreme northwestern part of the state… this species has been found in sphagnum bogs near stands of Engelmann spruce, lodgepole pine, and subalpine fir, and occurs most frequently in second-growth stands and sometimes in old-growth forest" (IDFG 2005 at 1, *internal citations omitted*; *see* Figure 5).

Montana. Montana is home to the subspecies *S. b. chapmani* (Hall 1981 at 834). The northern bog lemming is ranked by the Montana Natural Heritage Program as species of special concern at the state level (Pearson 2000 at 45). The first northern bog lemming identified in Montana was found on the west side of Glacier Park in the early 1950s (Stephens 2008 at 7). "The total number of known bog lemming sites in Montana is 18, the most sites in any of the lower 48 states (Reichel and Corn 1997 abstract; *see* Figure 6).

> [P]rior to 1992, evidence of bog lemmings in Montana included: 1) 2-3 locations on the west side of Glacier National Park; 2) Shoofly Meadows in the Rattlesnake drainage north of Missoula; and 3) a single skull recovered from a Boreal Owl (*Aegolius funereus*) pellet west of Wisdom; where the owl captured the lemming was unknown. (Reichel and Beckstrom 1994 at 2, *internal citations omitted*)

"In 1992 and 1993, 51 sites were trapped which located 10 new populations of northern bog lemmings" (Reichel and Corn 1997 at 1). Elevation of the sites supporting northern bog lemming ranged from 1,360 to 1,800 meters (Chadde et al. 1998 at 31). Eight out of ten sites where northern bog lemmings were caught in 1992 and 1993 were characterized by thick mats of sphagnum moss, though one site had a thick moss layer of *Tomentypnum nitens* rather than sphagnum (*Id*.).

> Areas with extensive moss mats, particularly sphagnum, are the most likely sites in which to find new bog lemming populations in Montana. Other habitats in Montana may either support lower densities of bog lemmings; be used primarily by dispersing individuals; be used during specific seasonal, climatic, or competitive situations; or be population sinks. Marginal habitats and areas may be important to maintain population viability. (Reichel

1997 at 44)

The northern bog lemming has been documented in the Bitterroot, Beaverhead-Deerlodge, Flathead, Lolo, Lewis and Clark, and Kootenai national forests (Pearson 2000 at 45; Reichel and Corn 1997 at 2). It is confirmed in Beaverhead, Flathead, Lewis and Clark, Lincoln, Missoula, and Ravalli counties (MNHP 2014 at 7).

Minnesota. Minnesota is home to the subspecies *S. b. smithi* (Hall 1981 at 834). The species is rare in the state. The Minnesota patterned peatlands region is the southernmost extent of the northern bog lemming's range in central North America (Figure 7). It has a highly restricted distribution in open bog, shrub carr (wet, open conditions with a dense layer of ericaceous plants), spruce woods, tamarack-black spruce forest, and sedge-grass meadow (Nordquist 1992 at 102-103). However, it is rarely found outside of peatlands (Id. at 108). "[L]ess than 10 occurrences have been documented in Roseau, Koochiching, Itasca, and St. Louis counties" (MDNR 2014 at 1).

New England. There is a disjunct segment of northern bog lemming range from New Hampshire into Maine and north to the Gaspe Peninsula, Quebec (ASM undated at 3; *see* Figure 8). This area is home to the subspecies *S. b. sphagnicola* (*see* "Subspecies and Distinct Population Segments," *supra*). "The northern bog lemming is among Maine's rarest and most elusive mammals. Like the Canada lynx, it is more numerous in the North and reaches the southern edge of its range here. Unlike the lynx, it has not received federal listing attention, associated research, and surveys, and its status remains a mystery" (MDIFW 2003 at 1).

> In Maine, the northern bog lemming has been found at five locations, including two sites at Baxter State Park. The species has also been captured in three locations in New Hampshire: along the Wild River not far from the Maine/New Hampshire border, near the base of Mt. Washington, and on Mt. Mooselauke. Most occurrences are at elevations of 2000 feet or greater. In other parts of the species' range, it occurs at much lower elevations, where its habitat needs are provided by northern tundra-like habitat, rather than an alpine environment. (MDIFW 2003 at 1)

"Because the northern bog lemming is found in so few sites and in such low numbers in Maine, it is vulnerable to extirpation. Suitable habitat is not abundant in Maine" (*Id*. at 2).

POPULATION STATUS: HISTORIC AND CURRENT

There are no comprehensive population studies and no population trend information for this species; it is "rarely trapped and is one of the least known mice in North America" (Reichel 1997 at 2). It is more common in northern latitudes than in the U. S. portion of its range, but "even there its populations are localized, and its avoidance of traps has limited ecological information on this species to anecdotal accounts and speculation" (Pearson 1999 at 14).

Metapopulation dynamics. A preliminary attempt at a Population Viability Analysis (PVA) model, using data from a Montana metapopulation, determined that "the probability of quasi-extinction (<100 individuals) in the metapopulation is 0.257 at 50 years, and the median time to quasi-extinction is 26.2 years." However, the authors caution that without survival rate

information for the northern bog lemming (southern bog lemming data was used to fill knowledge gaps) the model is too speculative to be used as a management tool (Reichel and Corn 1997 at 15). The model does indicate that the ability to disperse between patches is crucial to the survival of bog lemming metapopulations (*Id.* at 16).

Each population of northern bog lemming is likely to be adapted to its own climatological conditions and may have different phenotypic variations made to order for the individual habitat of that area (Hampe and Petit 2005 at 461). Subspecies divisions may reflect adaptations to specific local environments. "It seems likely that 1) some patch complexes are isolated from others and have been for long periods of time; 2) some relatively long distance movements may increase gene flow, supplement small populations, and allow for recolonization of extirpated patches; and 3) while bog lemmings use a variety of habitats to a limited (and largely unknown) extent, bog and fen habitats hold the densest populations of lemmings" (Reichel 1997 at 47).

Alaska. In Alaska the species' status is unknown, and though the state of Alaska does not consider it biologically vulnerable, more information is needed (Walton et al. 2013, entire).

Canada. Northern bog lemmings are "uncommon in northwestern Canada and rare in eastern Canada" (Banfield 1974 at 191).

Washington. Gaines et al. (2012) are assessing the viability of terrestrial species in northeastern Washington's National Forests. "After species were clustered into groups based on habitat relationships and other environmental factors, a single or small set of focal species was identified within each group" (*Id*. at 20). Northern bog lemmings were selected as a "focal species" for the Boreal Forest Group (*Id*. at 174). There are several types of focal species: bog lemmings are in the group with "localized populations… confined to very specific habitats (*Id*. at 21). "It is assumed that a focal species has more demanding requirements for factors putting other group members at risk of extinction than the rest of species in the group" (*Id*. at 19).

Idaho. "The northern bog lemming… is considered rare in Idaho" (Bursik and Moseley 1995 at 13).

> Loss of sphagnum or other bog mats and corridors for inter-patch movement might affect population viability. Habitat disturbance may be caused by timber harvest, livestock grazing, road-construction, or snowmobiling… The northern bog lemming is poorly studied throughout its range. Basic information on the distribution and status of populations and habitat associations is needed. Protection of bogs and fens where this species occurs is also important for the conservation of this species. (IDFG 2005 at 2)

Montana. Sightings of the northern bog lemming in Montana are rare (*see* Figure 9). Typical northern bog lemming populations appear to consist of patches of suitable habitat strung out along a drainage. The Sunday Creek area presents a typical example of conditions for northern bog lemming populations in Montana:

> In the past, when one subpopulation was lost, the habitat patch could be recolonized from adjoining subpopulations. Beaver alternately created and destroyed habitat patches along

> the drainage via flooding with dams, but dispersal from adjacent areas on the drainage provided inhabitants for the new habitat patches. Fires swept through the area, drying out areas to some extent. However, this drying out was probably reduced somewhat by the timber in the stream bottom being more resistant to fire than that on the slopes above. This dynamic process has lasted thousands of years. However, the Sunday Creek population of lemmings may now be in danger of extirpation [due to habitat degradation]. (Reichel and Beckstrom 1993 at 20; *see* "Factor A: Montana," *infra*)

Minnesota. The species is rare in Minnesota; the patterned peatlands region is the southernmost extent of the northern bog lemming's range in central North America (Nordquist 1992 at 102-103). "[L]ess than 10 occurrences have been documented in Roseau, Koochiching, Itasca, and St. Louis counties. The small number of documented locations in areas of apparently suitable habitat supports the species' listing as special concern" (MDNR 2014 at 1).

New England. "Bog lemmings are probably the rarest mammal in New England and eastern Canada, making them vulnerable to local extirpation" (NHGFD 2005 at A-312; *see* "Subspecies and Distinct Population Segments," *supra*).

> The disjunct population of *S. borealis* south of the St. Lawrence River may prove to be the most sensitive of all Quebec rodents. Although spruce bogs are not a disappearing habitat, as relicts of the last glaciation they are extremely patchy and frequently very isolated. *Synaptomys b. sphagnicola* may thus be represented by a series of more or less isolated populations of extremely small size. If this is indeed the case, then many may be below a minimum viable population size and subject to a high risk of extinction. (Yensen and Kirkland 1998 at 119)

IDENTIFIED THREATS TO THE PETITIONED SPECIES: CRITERIA FOR LISTING

The Service must evaluate whether a species is threatened or endangered as a result of any of the five listing factors set forth in 16 U.S.C. § 1533(a)(1):

A. The present or threatened destruction, modification, or curtailment of its habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms; or
E. Other natural or manmade factors affecting its continued existence.

Factor A: The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The fate of the bog lemming is tied to the fate of its preferred habitat: peatlands. "Two types of peatlands are generally recognized, fens and bogs. Fens receive groundwater and/or surface water from surrounding uplands, whereas bogs receive hydrologic and nutrient inputs primarily from atmospheric deposition" (Jones 2003 at 1).

> Peatlands are generally nutrient-poor wetlands characterized by wet, organic substrates comprised of partially decomposed plant material. Due in part to saturated substrates, plant productivity exceeds decomposition in these systems, and peat may accumulate to depths in excess of 30-40 cm. Given the exceptional water-holding capacity of organic substrates, peatlands are very stable and may persist for centuries. Peatlands are distinctive in that they are one of the only ecosystems largely dominated by bryophytes. (*Id*., *internal citations omitted*)

> Peatlands are an important terrestrial habitat worldwide, occupying one percent of ice-free continental land masses, including nearly 15 percent of Canada. Peatlands exert an enormous influence on the world's climate. Anaerobic respiration within peat soils may account for nearly 40 percent of the methane released into the biosphere annually. They also act as immense sinks of carbon dioxide storing an estimated 15 to 20 percent of terrestrial carbon reserves, more than twice the amount in all living northern latitude forests. Others have estimated the amount of carbon tied up in peatlands is 3-3.5 times that present in moist tropical forests, despite covering half the land area. (Bursik and Moseley 1995 at 3, *internal citations omitted*)

Though stable under natural conditions, once destroyed peatlands are nearly impossible to restore. "[R]esiliency, or the ability to recover from disturbance, is low in peatlands. Recovery from major disruptions to water or nutrient flows or to the removal of vegetation may require centuries. Rates of peat accumulation have been estimated to be approximately 2 cm per century in boreal and temperate climates" (Chadde et al. 1998 at 31). Therefore, losses of peatlands over the last century are likely permanent. Peatlands are sensitive to human disturbance: "[l]and-use activities that directly impact peatlands (such as peat mining, draining) and indirect impacts such as upslope timber harvest or road construction can cause changes to peatland biodiversity because many species are sensitive to minor changes in water chemistry and hydrology." *Id*. "The abrupt, large-scale, and often irreversible nature of changes in hydrology and nutrient concentrations that result directly or indirectly from human activities… may be beyond the tolerance level of resident populations [of peatland flora and fauna] to relocate and persist" (Bursik and Moseley 1995 at 23).

> Any management of other activity that might alter bog or fen habitat could jeopardize the persistence of [the northern bog lemming]. Bogs and fens are defined by their hydrology and associated acidity and bog/fen plant communities and, therefore, possibly bog lemmings are dependent upon these hydrological conditions. Any activity likely to alter bog/fen hydrology (forestry, grazing, trampling, road or trail building, etc.) may destroy the unique flora and fauna associated with these rare communities. (Pearson 1999 at 15)

Below we describe threats to peatlands generally, and threats to specific lemming habitats state by state.

Altered hydrology and water chemistry. "The two most important parameters affecting peatland vegetation are water level and surface and subsurface water chemistry" (Bursik and Moseley 1992 at 17). The two are inter-related: "Numerous environmental variables, including

groundwater movement, fire, logging in adjacent areas, and acid precipitation, could directly or indirectly affect water chemistry in peatlands" (*Id.).*

"Water chemistry of surface and substrate waters are known to affect the relative abundance and distribution of plant species in peatlands" (Bursik and Moseley 1992 at 17*, internal citations omitted*). Increased nutrient concentrations increase common, competitively dominant species and reduce vascular plant diversity in peatlands. Beaked sedge (*Carex rostrata*) decreased and bog cranberry (*Vaccinium oxycoccos*) increased at Hager Lake Fen due to a decrease in the mineral content of the surface and subsurface waters (Bursik and Moseley 1992 at 17). "The abundance of *Carex utriculata* [Northwest Territory sedge] was positively associated with concentrations of NH_4, and negatively associated with vascular plant diversity" (Jones 2003 at 7). In situations of increased nutrient input, bog lemmings may benefit from an increase in sedge; however, increased nutrient concentrations may also facilitate the invasion of aggressive colonizers such as reed canary grass (*Phalaris arundinacea*) (*Id*. at 10) and negatively impact peat moss. "Studies concerned with the effects of increased atmospheric N deposition on bogs have found negative associations between increased N and the vigor, establishment, and persistence of a number of bog species, including… several species of *Sphagnum*" (Jones 2003 at 9). As bog lemmings appear to need both sphagnum moss mats and sedges, shifts in vegetation and the loss of vascular plant diversity resulting from increased nutrient concentrations and altered hydrology will likely impact lemming populations in ways that are complex and difficult to predict.

Changes in hydrology also cause changes in vegetation abundance and distribution. "Artificial regulation of water levels around lakes and water flows associated with streams is [a] potential threat. Peatlands around lakes with regulated water levels could be threatened with a loss of species dependent on naturally fluctuating water regimes" (Chadde et al 1998 at 32). "Drainage ditches in fens lower the water table in adjacent areas, allowing shrubs to colonize habitat previously dominated by more hydrophytic graminoids and forbs" (Bursik and Moseley 1992 at 18). The potential impact of shrub colonization on bog lemmings is unknown, but as they depend on sedges (graminoids) for food and shelter, it is likely that shrub replacement of graminoids due to lowered water tables makes the habitat less suitable for bog lemmings.

Peat harvest. Peat harvest is restricted in the United States and generally prohibited on National Forests. "Little peat mining has taken place in the Northern Rocky Mountains, although limited local peat operations are known to occur in Idaho and Montana. This type of habitat destruction may be increasing, however, as private landowners and mining companies become increasingly interested in exploiting peat" (Chadde et al. 1998 at 32).

Peat mining is a concern in Canada:

> [I]ncreasing habitat degradation in southeastern Canada, resulting from industrial, agricultural, or urban development, raises concern about the conservation of peatlands and, especially, of ombrotrophic peatlands or bogs. The peat-mining industry is currently expanding and generates up to 90 million Canadian dollars annually. Large bogs with deep deposits of organic matter are particularly valuable in southeastern Canada, as they offer a considerable volume of horticultural peat. These bogs are mined using the vacuum

> method, which creates flat surfaces of bare peat divided into 30 m wide fields separated by drainage ditches. (Mazerolle et al. 2001 at 296, *internal citations omitted*)

A small mammal trapping study comparing mined and undisturbed peat bogs was inconclusive in terms of peat mining's impact on northern bog lemmings. The most abundant species captured were habitat generalists who also used adjoining forest fragments. No northern bog lemmings were captured during the study (Mazerolle et al. 2001 at 300).

> [T]he general scarcity of the three species that prefer bogs [the northern bog lemming, southern bog lemming (*Synaptomys cooperi*), and the Arctic shrew (*Sorex arcticus*)] suggests that the usefulness of [undisturbed fragments near mined areas] could be limited to the Arctic shrew, the only species more abundant in bog fragments than in natural bogs. Further work is required to assess the habitat requirements of the two species of lemmings, *S. borealis* and *S. cooperi.* Particularly dry conditions in bogs due to climatic variation or drainage within bogs or in their vicinity may extend the range of certain species not typically associated with peatlands. These disturbances may threaten *Synaptomys* spp. via competitive exclusion from invading species such as the meadow vole. To demonstrate whether scarcity of *Synaptomys* spp. in our study area is the result of competitive exclusion, a long-term experiment involving the removal of generalist species would be required. However, if bog specialists have already been extirpated regionally, even a removal experiment might yield inconclusive results. Further work will be necessary to assess the conservation status of mammalian bog specialists, especially in regions where bogs and the surrounding habitat are under intense management. (Mazerolle et al. 2001 at 301, *internal citations omitted*)

Peat mining appears to reduce biodiversity in remaining fragments, as well as directly destroying habitat:

> [P]lant species assemblages of residual fragments from peat extracted sites differ from those found at the edge of natural bogs. The peat surface of residual fragments is dryer and *Sphagnum* mosses are less abundant than at the edge of natural bogs… In addition, species assemblages of birds, small mammals and amphibians in residual fragments of peatlands are not representative of natural peatlands. (Poulin et al. 2004 at 338, *internal citations omitted*)

This is all the more concerning as peat harvest appears to be on the rise in Canada as of 2012:

> North America's largest peat producer, Sun Gro Horticulture, is proposing a 531-hectare mine in Hecla/Grindstone Provincial Park, a two-hour drive north of Winnipeg. In Manitoba 184 peat quarry leases have been granted, which means more than 30,000 hectares of peat land could potentially be subject to peat mining—almost twice as much as the peat land currently in production across Canada, according to Manitoba Government sources. (Csath 2012 at 1: *see also* <manitobapeatlands.weebly.com/local-peatland-news.html>)

Timber harvest and associated activities. Timber harvest and associated activities, particularly road building, "can alter hydrologic fluxes, nutrient inputs, and sedimentation rates and can facilitate the spread of invasive exotic species" in peatlands (Jones 2003 at 1). "Human disturbances (timber harvesting and roading) were directly related to the decreased diversity of vascular plants in rich fens, perhaps mediated by increased soil nutrient levels associated with these land use activities" (*Id.* at 8).

Loss of beavers. Beaver activity plays an important role in maintaining peatlands and peatland species diversity.

> Artificial manipulation of dynamic hydrological regimes at… sites with significant beaver activity could significantly disrupt processes at play for millennia that have allowed the long-term persistence of a wide array of species adapted to various successional stages within the peatland. Long term stability (maintenance of water level and nutrient status) in peatlands leads toward poor fen formation and a gradual depauperization of the flora as sphagnum takes over and guides the course of succession autogenically. Episodic beaver activity creates and maintains a mosaic of successional stages within a site and contributes to the habitat and floristic diversity of Panhandle peatlands. (Bursik and Moseley 1995 at 22, *internal citations omitted*)

A recent study in Montana found "an 80% decrease in beaver pond numbers and acreage during the approximately 20 year study time frame."

> Only about 5 acres of beaver ponds remain in this 1.4 million acre area despite the large amount of suitable beaver habitat. Beavers are a keystone species with a disproportionate effect on ecological functions compared to their numbers. Beaver activity improves water quality through sediment retention, influences on nutrient cycling and decomposition, and hydrologic modifications. Beavers create wetlands that would otherwise be rare in mountainous terrain, thus providing important habitat for many other wetland–dependent species. (Kudray and Schemm 2008 at iv)

The beaver ponds in the study area were replaced by constructed wetlands, which reduced species diversity (*Id*. at 23) and facilitated the invasion of non-native species (many constructed wetlands are stocked with non-natives fishes for recreational fishing purposes) (*Id*. at 27). "If constructed wetlands do not function like natural wetlands, then landscape wetland functions may still be lost even with a gain in wetland acreage" (*Id*. at 26).

Wildfire. In Montana, the Mussigbrod and Middle Fork fires burned adjacent to one of the known occurrences of bog lemmings (*see* "Factor A: Montana, *infra*). The threat of more extreme and frequent wildfires will likely increase in the future (*see* "Climate change," *infra*).

Snowmobiles. "Snow compaction from snowmobiles or other activities creates barriers to the lemmings' travel between their feeding areas" (USFS undated). "Snow compaction has been cited to cause mortality and to present barriers to small mammals that move in subnivean spaces, such as bog lemmings do" (Gaines et al. 2012 at 174).

Invasive plants. "Invasion by exotic plant species is apparent in some peatlands. Reed canary grass (*Phalaris arundinacea)* is a commonly observed exotic species in peatlands, and is able to aggressively spread by rhizomes. Canada thistle (*Cirsium arvense)* may also invade peatlands following disturbances such as wheel ruts or fire" (Chadde et al. 1998 at 32).

Canada. Threats to Canadian peatlands may be accelerating. "[P]eatlands are coming under increasing pressure for logging... An estimated 69,723 ha of peatlands have been drained for forestry in the last 20 years (1983-2003) in the province of Québec alone" (Poulin et al. 2004 at 331-332).

> Loss of natural peatlands in Eastern Canada has been caused by several industries, such as construction of hydroelectric dams, reclamation for agriculture, drainage for forestry and peat extraction (for horticultural or therapeutic uses). Construction of hydroelectric dams is the main cause of peatland loss in the country and approximately 900,000 ha of peatlands have been flooded, mostly in Québec, Manitoba and Alberta. (*Id*. at 331)
>
> Beside dam construction for the production of hydroelectricity, which mainly takes place in the north above the 50° parallel, other pressures on peatlands, in the form of urban sprawl, agriculture, forestry and peat extraction, occur in the south. This is also where peatlands are least abundant. In some regions, such as the Bas-Saint-Laurent region of southeastern Québec, up to 62% of the total peatland area has been destroyed or disturbed by logging, farming or peat mining activities between 1929 and 2000. (*Id*. at 337)

Washington. The risk factors identified for the northern bog lemming in Washington include "the fragmentation or loss of habitat due to road construction and mortality associated with winter recreational activities causing snow compaction. Snow compaction has been cited to cause mortality and to present barriers to small mammals that move in subnivean spaces, such as bog lemmings do… [H]eavy grazing and loss of habitats due to impoundments [have been identified] as additional risk factors" (Gaines et al. 2012 at 174). Suggested management strategies for bog lemming habitat conservation include:

1. Protection of wetlands and alpine meadows from management activities, along with adjacent boreal forests. Management activities include timber harvest, road-construction, trail construction, and dam construction.
2. A riparian conservation strategy that includes wetlands protections would likely provide for adequate habitat for this species to maintain their viability.
3. Limit timber harvest to occur outside of 330 feet around areas of sphagnum or other fen/bog moss mats or associated riparian areas that could provide corridors for inter-patch movements.
4. Minimize domestic livestock grazing in drainages with un-surveyed moss mats present or known lemming populations. Range conditions in riparian areas with moss mats should be maintained in good to excellent categories.
5. Manage snowmobile use in areas with known or suspected populations to provide for habitats that are not subjected to snow compaction. (*Id*. at 174-175)

Idaho. In Idaho, valley peatlands are widely scattered and rare on the landscape. "Many species restricted to valley peatlands are rare in Idaho and, consequently, valley peatland conservation is

of paramount concern in the state" (Bursik and Moseley 1992 at 1, *internal citations omitted*). "Peatlands of northern Idaho are largely intact when compared to those in Europe. [The] challenge [of] maintaining the diversity of peatland communities and biota in the region, however, is no less daunting. The rarity and isolation of peatlands on the landscape is coupled with increasing, often incompatible use of adjacent uplands" (Bursik and Moseley 1995 at 4). For example, "[g]round disturbance associated with home building, road building, logging, and grazing is the most widespread threat to Panhandle peatlands. Only a handful of… sites… have adequate upland buffers to eliminate this threat" (Bursik and Moseley 1995 at 23).

"Several peatlands in Idaho and Montana have been significantly altered by major ditching, filling, and development. Although National Forest peatlands are not subject to development, some of these sites have been altered by ditching and drainage" (Chadde et al 1998 at 32, internal citations omitted). Hager Lake Fen is one of the most intensively studied peatlands in Idaho and demonstrates the impact of anthropogenic activities. As a result of drainage and ditching, livestock grazing, and agriculture, the species diversity of Hager Lake Fen in Idaho was significantly altered over 40 years; fourteen species disappeared between 1952 and 1992 (Bursik and Moseley 1992 at 10; *see also* Chadde et al 1998 at 32). Fluctuations of lake and groundwater water levels created by ditching episodes likely account for most of the changes in vegetation (*Id*. at 17). Any possible restoration of peatland habitat in Hager Lake Fen would need to begin with filling of drainage ditches, especially the ditch that exits the lake (*Id*. at 19). Similar impacts occurred at Huff Lake Fen in Idaho, where 13 plant species were lost in 20 years, most likely as a result of altered hydrology and increased nutrient inputs from adjacent road building (Bursik and Moseley 1995 at 23).

Cow Creek Meadows is a known location of bog lemmings in Idaho (Bursik and Moseley 1995 at 13). The area is aptly named:

> Grazing takes place within and around peatland communities at several of the privately owned sites and in two managed by the Forest Service (Cow Creek Meadows and Hoodoo Lake). We have implemented a vegetation monitoring study and made management suggestions to protect sensitive peatland communities at Cow Creek Meadows from direct grazing threats. It is too early to assess the impacts of cattle on the peatland communities of Cow Creek Fen, but 20- and 40-year changes in plant populations and vegetation at Huff Lake Fen and Hager Lake Fen indicate that subtle changes in hydrology and nutrient regimes that can result from cattle grazing could lead to changes in community composition and structure. (*Id*. at 24, *internal citations omitted*)

Livestock can impact moss mats in riparian areas, potentially destroying bog lemming habitat (Reichel and Corn 1997 at 18).

Montana. Montana peatlands support a large number of rare taxa and are consequently of great conservation value. In addition to the northern bog lemming, forty plant species of concern—9 percent of Montana's rare flora—are associated with peatlands (Jones 2003 at 1). But "peatland communities constitute a very small proportion of the landscape in Montana and have not been adequately classified" (Reichel 1997 at 44).

> Much of northwestern Montana, which has the greatest abundance of peatlands in the state, has been highly fragmented by timber harvesting and associated road building [*see* Figure 10]. These activities can alter hydrologic fluxes, nutrient inputs, and sedimentation rates and can facilitate the spread of invasive exotic species. Changes in these factors have been shown to affect plant species diversity in peatlands and other wetlands. (Jones 2003 at 1*, internal citations omitted*)

In the Kootenai National Forest, "[l]ogging and roading were associated with increased soil nutrient levels at distances of up to 100 m from peatland sites. Increased nutrient levels, in turn, were clearly associated with decreased diversity of vascular plants" (Jones 2003 at 8-9). Increased nutrient levels also contribute to eutrophication. "Eutrophication of peatlands [the process of adding excess nitrogen and phosphorus to a water ecosystem] may lead to irreversible changes in species composition, replacing diverse and species rich systems with ones increasingly dominated by common or possibly exotic species" (*Id.* at 11). "These findings support the importance of limiting timber harvest and road construction around peatlands as required by existing regulations" (*Id*. at 8). However, the maximum buffer distance required under the 1987 Kootenai National Forest Plan is insufficient:

> [U]pland land uses may be increasing nutrient loadings in peatlands at distances of up 100 m from peatland boundaries. Based on this, it appears that the existing set-asides of 8-30 m required under streamside management zone regulations are too narrow to fully buffer peatlands from the effects of upland land uses. [One hundred] m may be an adequate buffer distance; however… this study did not address possible modifications to peatland hydrology caused by upland land uses. Hydrological modifications are likely: forestry practices such as road building have been shown to alter wetland hydrology at distances greater than 100 m. (Jones 2003 at 10)

The Beaverhead-Deerlodge National Forest, a known location of bog lemmings, experienced extreme fires in 2000:

> In less than two months, two fires affected 77,073 acres... The Mussigbrod Fire on Wisdom Ranger District burned most of 59,073 acres. The Middle Fork Fire Complex on the Pintler Ranger District burned most of 18,000 acres. (Actual burn areas in the 77,073 acres calculated within fire perimeters are closer to 69,000 acres). This scale of wildfire is unprecedented in the history of the Forest. The 1998 Monitoring Report notes the Beaverhead-Deerlodge National Forest burned about 49,000 acres of vegetation for ecosystem health (for purposes other than timber production) from 1989 to 1999, a ten-year period. More acreage burned from wildfires in two months during the 2000 season than that monitoring period. (USFS 2000 at 4)

Fortunately, the small area of known bog lemming habitat in the Beaverhead-Deerlodge was not affected. However, lack of survey data means that other unsurveyed bog lemming habitats may have been destroyed: "The only known population south of the Continental Divide in Montana is at Maybee Meadows, about one mile south of the [Mussigbrod Fire Complex] perimeter. Preferred bog lemming habitat appears to consist of moderately wet sites which support sphagnum moss mats within spruce-fir and lodgepole pine forests. Such habitat occurred within

the burn area, but very little of it had been surveyed for northern bog lemmings" (Id. at 12, internal citations omitted). "The fire didn't reach the Maybee Meadows bog lemming occupied habitat; however, bog-fens that might have been occupied by bog lemmings were burned over. The concern is that the amount of impact to most of these bog-fens and surrounding forests needs to be determined, so that effects of the fire on bog lemming habitat, and hence on bog lemming population viability, can be evaluated" (*Id.* at 13-14). The threat of more extreme and frequent wildfires will likely increase in the future (*see* "Climate change," *infra*).

Human population growth and associated development is of particular concern in Montana: "[T]he West is the fastest growing region by population in the United States with Intermountain states leading the list of fastest growing states" (Kudray and Schemm 2008 at 2).

> Rapid development in the large river valleys of Montana has generated concern about changes to the wetlands and their associated functions. In Montana and the Intermountain West, wetlands are concentrated in broad river valleys and riparian areas, which also form some of the most attractive sites for residential development. (Kudray and Schemm 2008 at 2; *see* Figure 11)

Minnesota. Though timber harvest and mineral exploration are allowed in much of Minnesota's peatlands, the state has one of the stronger protection policies for these fragile ecosystems. Some damage has already been done, however. About 28 percent of Minnesota's peatlands are classified as commercial forest land, mainly in the north-central and northeastern part of the state. The most commonly harvested trees are black spruce (*Picea mariana*), tamarack (*Larix laricina*), and northern white cedar (*Thuja occidentalis*) (Keirstead 1992 at 289). Another 10 percent of the state's peatlands were used for agriculture as of 1992, and "thousands of acres of peatland in Beltrami, Roseau, Lake of the Woods, and Koochiching counties were ditched in an unsuccessful attempt to drain the land for agricultural use. These efforts resulted in widespread forfeiture of the land by owners and legislation that declared the land unsuitable for agriculture" (*Id*. at 290).

> All Minnesota records for northern bog lemmings are from peatland habitats in the Agassiz Lowlands, Littlefork Vermillion Uplands, and Border Lakes ecological subsections. While this region has not experienced the level of habitat destruction and alteration observed in other parts of the state, harvesting of pulpwood, peat, and Christmas trees affects the habitats used by northern bog lemmings. (MDNR 2014 at 3)

U. S. DPS of *S. b. chapmani.* Threats in Washington, Montana, and Idaho impact the U. S. DPS of *S. b. chapmani* (*supra*).

> Factor D: The Inadequacy of Existing Regulatory Mechanisms

Federal. There are no federal protections in place for the northern bog lemming. The subspecies *S. b. sphagnicola* was at one time considered a Category 2 candidate species for listing (USFWS 1985 at 37,967) but was removed from the list in 1996 when Category 2 was discontinued. Some federal laws may offer protection to bog lemming habitat: "The Clean Water Act and State water

quality standards help prevent the occurrence of activities or pollution that could result in altered water chemistry and nutrient regimes in peatlands" (Chadde et al 1998 at 32).

The U. S. Forest Service Northern Region lists the northern bog lemming as Sensitive (Chadde et al 1998 at 31). It has no status in the Forest Service Intermountain Region (IDFG 2005 at 1). It is listed as a Species of Special Concern by the Idaho, Minnesota, Montana, and New Hampshire Natural Heritage Programs, and is on the Special Animal Priority List of the Washington Natural Heritage Program (Reichel and Corn 1997 at 1).

States. Though most states within bog lemming range recognize it as a species in need of special attention and conservation, only one state (Maine) has listed it under the state Endangered Species Act. Other state designations, such as Species of Concern, are intended to result in special consideration for the species but are not enforceable regulatory mechanisms. Peatland habitats have some protections at the state level, but they are often patchy or inadequate.

Alaska. In Alaska, the northern bog lemming is considered a Species of Greatest Conservation Need (Walton et al. 2013 at 1).

Washington. In Washington, the taxon is on the state Monitor list (Yensen and Kirkland 1998 at 119).

Idaho. The state of Idaho considers the bog lemming Unprotected Wildlife, though it is ranked Critically Imperiled (IDFG 2005 at 1). Some peatland habitats in Idaho fall under regulatory protection:

> A majority of the peatland sites are entirely or partially on publicly-owned land. The U.S Forest Service, Idaho Panhandle National Forests, is the primary land manager, managing part or all of 25 sites. Other federal and state agencies, including the U.S. Bureau of Land Management, Idaho Department of Lands, and Idaho Department of Fish and Game, are also peatland managers. Ten of the sites are entirely private land, while portions of 14 others are privately-owned. Few of these private sites have any legal or voluntary protection. (Bursik and Moseley 1995 at 11)

Montana. There are no special management activities for the bog lemming in Montana, though it is designated a Species of Concern (MNHP and MFWP 2014 at 3). Some habitat areas have protective designations: "Peatlands with Research Natural Area designation typically disallow manipulative management, such as timber harvest and livestock grazing, and water quality of these peatlands are protected under the Clean Water Act and state water quality standards" (Id.).

The U.S. Forest Service and State of Montana require that buffers be left around wetland and riparian areas to minimize the potential adverse effects of timber harvest and associated road building, although some timber harvesting is still allowed within the buffers. The buffer requirement of 8 to 30 m is insufficient:

> [N]arrow buffers have been shown to be effective at reducing sediment and nutrient loadings; however, other studies have shown wetland plant and animal diversity to be

> negatively associated with land use and road density at much greater distances. Findlay and Houlahan reported significant negative relationships between road density and richness of birds, herpetofauna, and plants and positive relationships between proportion of forest cover and richness of herpetofauna and mammals. Both these associations were found at distances of up to 2,000 m from study wetlands. Mensing et al. reported a negative association between the diversity of shrub carr vegetation and land use at distances up to 1,000 m from wetland sites… It is likely that upland land use changes affect hydrological and biogeochemical processes in peatlands at distances greater than those of existing buffers. (Jones 2003 at 2, *internal citations omitted*; *see also* "Factor A: Montana," *supra*)

Minnesota. The bog lemming is a Species of Special Concern in Minnesota (MDNR 2014 at 1). Eight percent of the state's peatlands—about 500,000 acres—are legislatively protected as Scientific and Natural Areas (Keirstead 1992 at 297; *see* Figure 12) or Peatland Scientific Protection Areas (PSPA). PSPAs are open to mineral exploration and development with certain restrictions; mitigation standards for potential mineral development and a maximum of 1,500 acres for development (Aaseng and Djupstrom 1992 at 307).

New England. The lemming is listed as threatened in Maine (MDIFW 2003 at 2). "There are no management efforts for bog lemmings in New Hampshire" (NHGFD 2005 at A-313).

Canada. The subspecies *S. b. artemisiae* is listed as a Species of Special Concern by the British Columbia Conservation Data Centre (Reichel and Corn 1997 at 1), and the British Columbia Ministry of Environment placed the subspecies on its Red List as potentially endangered or threatened (Yensen and Kirkland 1998 at 119).

Peatlands on federal lands in Canada are protected by the Federal Policy on Wetland Conservation, adopted in 1991:

> The main objective of the policy is to sustain the ecological (water recharge, habitats, etc.) and socio-economic (hunting, trapping, agriculture, etc.) functions of wetlands, now and in the future. The policy ultimately aims at no net loss of wetland functions on all federal lands, *i.e.,* 29 % of all Canada's wetlands. Peatlands are… considered by the policy since they represent 88% of all wetlands in Canada. (Poulin et al. 2004 at 332, *internal citations omitted*)

The amount of peatland protected varies from province to province: New-Brunswick has 11 percent of its total peatland under protection whereas 3.6 percent is protected in Québec. Preliminary estimates for British Columbia, Prince Edward Island, Nova Scotia and Manitoba range from 3.3, 12.5, 15 to 25 percent, respectively (*Id.* at 339).

> Factor E: Other Natural or Man-made Factors Affecting its Continued Existence

Climate change. Climate change is impacting the boreal peatland habitat of the northern bog lemming. "Western Montana has thus far experienced a +1.33°C (1900– 2006) rise in annual average temperatures, which is 1.8 times greater than the +0.74°C (1900–2005) rise in Global temperatures… The rapid rise in temperature has had a substantial impact on regional resources

and ecosystems, in part due to the crossing of critical daily and seasonal temperature thresholds" (Pedersen et al. 2010 at 146). The impacts include a changing fire regime, and permafrost degradation. "Climate change is also related to reductions in snow water and changes in streamflow amount and timing" (Pedersen et al. 2010 at 147).

Wildfire. The western U. S. has already experienced changes in fire regimes as a result of climate change.

> The forests of western Montana and the northern Rockies have been found to have a fire regime strongly controlled by temperature and precipitation (i.e. water balance), thus making the forests of western Montana highly vulnerable to increased temperatures… The potential increased vulnerability to fire… is important since forest fires play an important role in species structure and composition, and changes in fire frequency are expected to play a role in driving biome shifts. The recent decades of increasingly large fires may signal Montana's forested ecosystems are currently in the process of change. (Pedersen et al. 2010 at 147, *internal citations omitted*; *see also* Calkin et al. 2005)

> [A]lthough land-use history is an important factor for wildfire risks in specific forest types (such as some ponder osa pine and mixed conifer forests), the broad-scale increase in wildfire frequency across the western United States has been driven primarily by sensitivity of fire regimes to recent changes in climate over a relatively large area… Regardless of past trends, virtually all climate-model projections indicate that warmer springs and summers will occur over the region in coming decades. These trends will reinforce the tendency toward early spring snowmelt and longer fire seasons. (Westerling *et al*. 2006 at at 943)

Permafrost degradation. "Many peatlands in the sub-arctic region and the northern part of the boreal region are wholly or partly underlain by thin and discontinuous permafrost, and climate warming will affect these wetlands through thawing and retreat of the permafrost" (EC 2004 at 102). These northern peatlands are dependent on permafrost for their existence, as permafrost impedes drainage and prevents the wetlands from drying out.

> In the boreal region of western Canada, permafrost degradation is changing the character of many peatlands. The southern boundary of discontinuous permafrost occurrence has moved northward by tens of kilometres during recent decades and will continue to migrate. Extensive peatland plateaus in the northern part of the boreal region, presently underlain by permafrost, will be increasingly affected... This retreat of permafrost can be considered the largest present-day impact of climatic change on Canadian wetlands. (*Id*. at 104, *internal citations omitted*)

> Climate warming scenarios suggest the southern boundary of the boreal region may move northwards by hundreds of kilometres over the next century. The reality of this possibility is attested to by the fact that 6000 years ago the southern boundary of the boreal forest and peatlands was located 200 to 400 km north of the present boundary. At that time, the climate of northern Canada was warmer than at present because the area received more solar energy due to slow changes in the tilt of the earth's axis. If a large northward

> movement of the southern limit of the boreal forest does indeed occur, the peatlands may degrade as well and perhaps disappear. The water resources of the area would change drastically and of course there would be very large releases of carbon to the atmosphere. (*Id*. at 102, *internal citations omitted*)

Climate change pressure on the bog lemming and its habitat will likely concentrate at the lowest latitudes of the species' range. "[R]ear edge populations, defined as those populations residing at the current low-latitude margins of species' distribution ranges, are disproportionately important for the long-term conservation of genetic diversity, phylogenetic history and evolutionary potential of species and that their investigation and conservation deserve high priority" (Hampe and Petit 2005 at 461). "[M]arginal rather than central populations commonly harbour the bulk of species' genetic diversity… [T]he utility of the deterministic centre-periphery-model is limited in the context of range modifications driven by climatic changes" (*Id*., *internal citations omitted*).

> Appropriate conservation strategies need to be designed that consider the peculiarities of rear edge populations. For instance, the particular genetic structure of rear edge populations requires conservation strategies directed towards the detection and maintenance of the greatest possible number of local populations, regardless of their size or performance, instead of focusing on the most viable core populations. Likewise, improvement of landscape connectivity is commonly considered essential to allow species to match climate changes by shifting their range, but it would be of little use at stable rear edges and might even be counterproductive, if it enhances competition with surrounding communities or promotes invasion by aliens. Hence, specific conservation measures will have to be identified to effectively preserve these relict populations. (*Id*. at 466, internal citations omitted)

Life history factors. "The most significant threat to the bog lemming is its rarity. The natural distribution may be that of isolated metapopulations with few individuals in each location. This pattern might inhibit dispersal and habitats may not repopulate easily if there are local extirpations" (NHGFD 2005 at A-314).

The Service has previously recognized that small population size and small, isolated populations increases the likelihood of extinction.[1] For example, in reference to the Sisi snail (*Ostodes strigatus*), the Service noted that "[e]ven if the threats responsible for the decline of this species were controlled, the persistence of existing populations is hampered by the small number of extant populations and the small geographic range of the known populations." Heightened risk of extinction is "inherent in low numbers," a basic tenet long a cornerstone of conservation biology (Caughley 1994 at 216). Small, isolated populations such as those of the northern bog lemming are particularly vulnerable to: 1) demographic fluctuations, 2) environmental fluctuation in resource or habitat availability, predation, competitive interactions and catastrophes, 3) reduction in cooperative interactions and subsequent decline in fertility and survival, 4) inbreeding depression reducing reproductive fitness, and 5) loss of genetic diversity reducing the ability to

[1] For examples, see candidate assessment forms for *Ostodes strigatus* (Sisi snail, June 2013), *Porzana tabuensis* (spotless crake, June 2013), *Vagrans egistina* (Mariana wandering butterfly, June 2013), *Gallicolumba stairi* (friendly ground-dove, June 2013), and *Hyla wrightorum* (Arizona treefrog, April 2013) (Available at http://ecos.fws.gov/tess_public/pub/SpeciesReport.do?listingType=C&mapstatus=1).

evolve and cope with environmental change (Traill et al. 2010 at 29).

The Service, in their final rule listing the streaked horned lark and Taylor's checkerspot butterfly, considered both species at risk due to small population size or small, isolated populations (USFWS 2013a at 61,489).

> Populations that are small, fragmented, or isolated by habitat loss or modification of naturally patchy habitat, and other human-related factors, are more vulnerable to extirpation by natural, randomly occurring events, to cumulative effects, and to genetic effects that plague small populations, collectively known as small population effects. These effects can include genetic drift (loss of recessive alleles), founder effects (over time, an increasing percentage of the population inheriting a narrow range of traits), and genetic bottlenecks leading to increasingly lower genetic diversity, with consequent negative effects on evolutionary potential. (*Id*. at 61,488)

The Service found similar threats when listing the Florida bonneted bat:

> In general, isolation, whether caused by geographic distance, ecological factors, or reproductive strategy, will likely prevent the influx of new genetic material and can result in low diversity, which may impact viability and fecundity. Distance between subpopulations or colonies, the small sizes of colonies, and the general low number of bats may make recolonization unlikely if any site is extirpated. Isolation of habitat can prevent recolonization from other sites and potentially result in extinction. The probability of extinction increases with decreasing habitat availability. Although changes in the environment may cause populations to fluctuate naturally, small and low-density populations are more likely to fluctuate below a minimum viable population (i.e., the minimum or threshold number of individuals needed in a population to persist in a viable state for a given interval). If populations become fragmented, genetic diversity will be lost as smaller populations become more isolated. (USFWS 2013b at 61037, *internal citations omitted*)

The bog lemming has small, isolated populations and fragmented habitat, and thus is facing a similar risk of extinction.

Competition. Bog lemmings "are typically found in graminoid-dominated habitats, where they coexist with, and are often numerically dominated by, the meadow vole (*Microtis pennsylvanicus*). Southern bog lemmings (*S. cooperi*) are displaced from preferred habitat in Virginia by meadow voles during periods of high vole densities. Similar observations in Minnesota suggest that bog lemmings retreat to suboptimal peatland habitats rather than adjacent upland sites when meadow voles are numerous. The relatively rare occurrence of southern bog lemmings in some habitats, such as shrub fens and cedar swamps, may be the result of displacement by competing species rather than an indication of preference" (Nordquist 1992 at 108). Displacement by competition is likely also a threat to the northern bog lemming, which has a similar life history and is also found with meadow voles, as well as vagrant shrews, masked shrews, deer mice, water voles, southern red-backed voles, northern red-backed voles, tundra voles, and brown lemmings (West 1999 at 656). This threat may intensify as climate change

reduces or shifts both preferred and marginal habitats for this suite of species.

Cumulative threats. The Service should consider whether the array of aforementioned threats intersect and act synergistically, therefore increasing the likelihood of extinction or endangerment of the northern bog lemming in the foreseeable future.

For example, habitat loss and degradation due to logging, livestock grazing, and fire suppression is exacerbated by the threats of increased temperatures and more extreme weather caused by climate change, which may restrict or shift the lemming's peatland and boreal habitat. Climate warming may also increase competition and hasten the spread of invasive species. "[C]ompetition with surrounding communities (or invasive aliens) appears to accelerate the breakdown of 'islands' of relict vegetation which might otherwise be more resistant to direct climate effects" (Hampe and Petit 2005 at 465-466). "The timing, duration, and severity of a specific temperature anomaly may cause undesirable biological organisms (i.e. invasive) to thrive, and strain physical resources such as water and its sources (e.g. snow and glaciers)" (Pedersen *et al.* 2010 at 136). These are just examples of intersecting threats facing the lemming.

> Traits such as ecological specialization and low population density act synergistically to elevate extinction risk above that expected from their additive contributions, because rarity itself imparts higher risk and specialization reduces the capacity of a species to adapt to habitat loss by shifting range or changing diet. Similarly, interactions between environmental factors and intrinsic characteristics make large-bodied, long-generation and low-fecundity species particularly predisposed to anthropogenic threats given their lower replacement rates. (Brook *et al.* 2008 at 455*, internal citations omitted*)

> [O]nly by treating extinction as a synergistic process will predictions of risk for most species approximate reality, and conservation efforts therefore be effective. However challenging it is, policy to mitigate biodiversity loss must accept the need to manage multiple threatening processes simultaneously over longer terms. Habitat preservation, restoring degraded landscapes, maintaining or creating connectivity, avoiding overharvest, reducing fire risk and cutting carbon emissions have to be planned in unison. Otherwise, conservation actions which only tackle individual threats risk becoming half-measures which end in failure, due to uncontrolled cascading effects. (*Id.* at 459, *internal citations omitted*)

CONCLUSION AND REQUESTED DESIGNATION

WildEarth Guardians hereby petitions the U.S. Fish and Wildlife Service under the Department of Interior to list the northern bog lemming (*Synaptomys borealis)* as an "endangered" or "threatened" species under the Endangered Species Act. We request listing of the full species, listing of individual subspecies—in particular *S. b. sphagnicola*—and/or listing of the U. S. DPS of *S. b. chapmani.* Listing is warranted, given the rarity of this species and ongoing and future threats to its already-rare preferred habitat. The northern bog lemming is threatened by at least three of the five listing factors under the ESA: present and threatened destruction, modification and curtailment of habitat and range; inadequacy of regulatory mechanisms; and other natural or manmade factors affecting its continued existence.

WildEarth Guardians also requests that critical habitat be designated for the northern bog lemming in occupied and unoccupied suitable habitat within its U. S. range as appropriate concurrent with final ESA listing. Designating critical habitat for this species will support its recovery and protect areas crucial to long-term survival of bog lemming metapopulations.

FIGURES

Figure 1. Western North American distribution of northern bog lemming *Synaptomys borealis* and Pleistocene age deposits containing Micromys. The triangle indicates Cathedral and Smith Creek caves, Snake Range. Dots indicate other fossil localities (Mead et al. 1992 at 230).

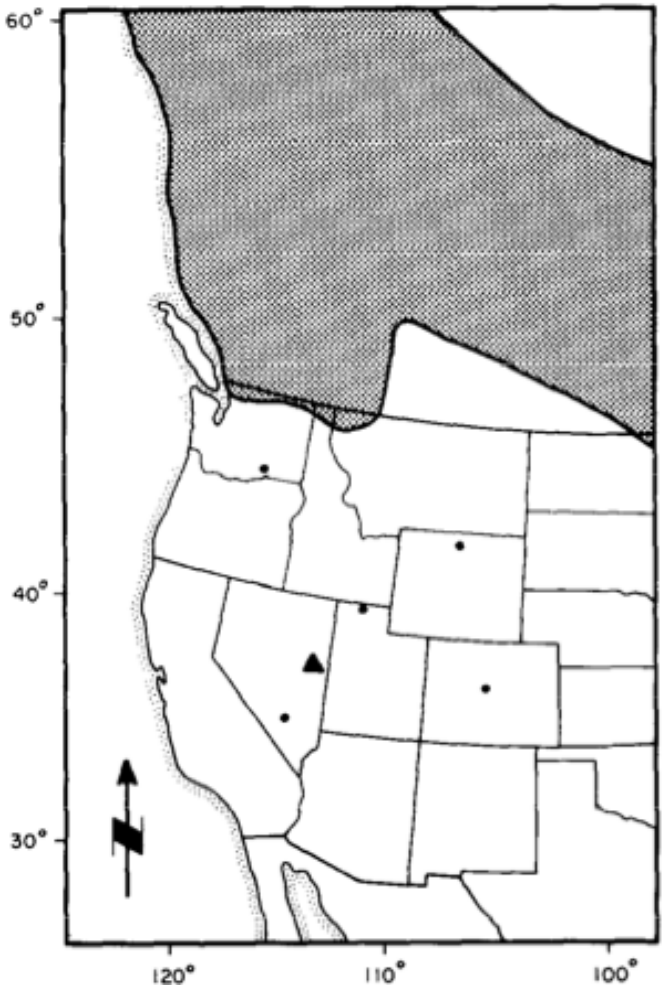


Figure 2. Distribution of *Synaptomys borealis*. 1. *S. b. artemisiae;* 2. *S. b. borealis;* 3. *S. b. chapmani;* 4. *S. b. dalli;* 5. *S. b. innuitus;* 6. *S. b. medioximus;* 7. *S. b. smithi;* 8. *S. b. sphagnicola;* 9. *S. b. truei* (Hall 1981 at 834).

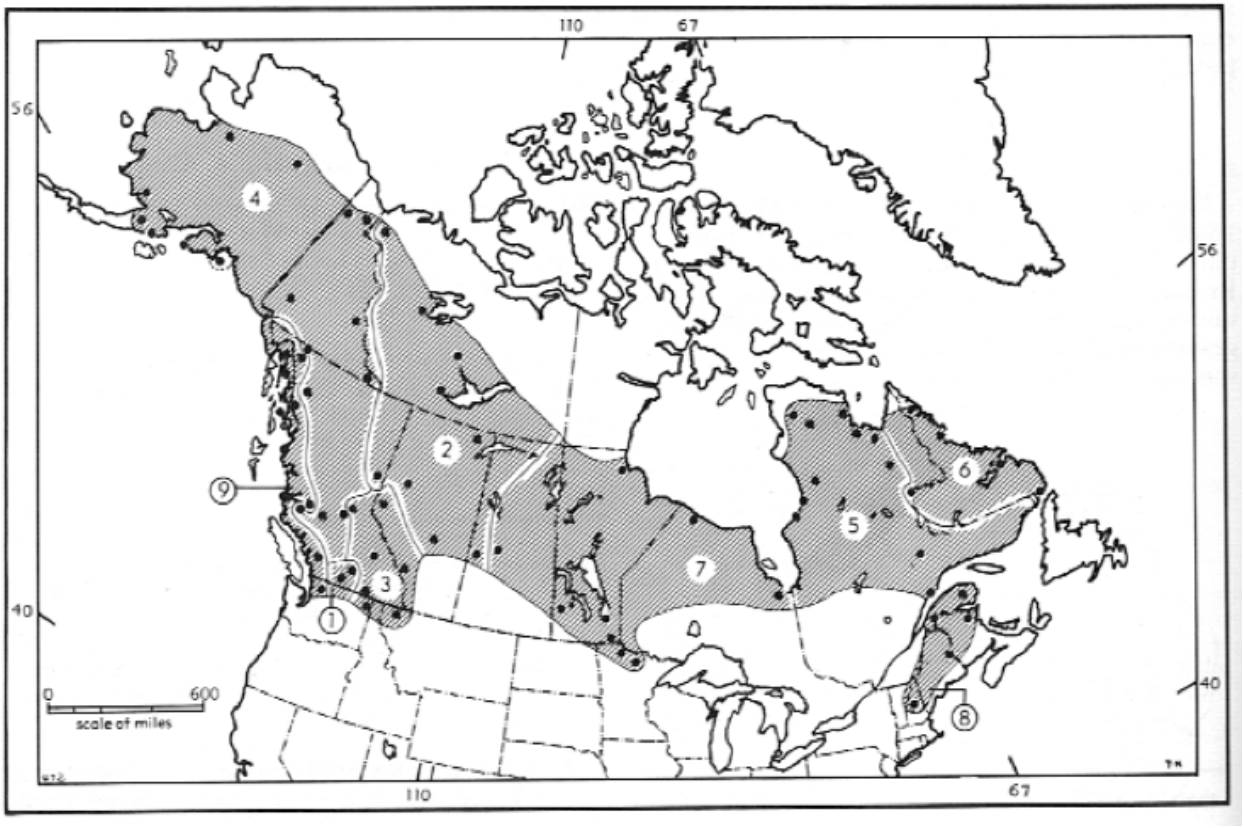


Figure 3. Northern bog lemming range in Alaska (Walton *et al.* 2013 at 3)

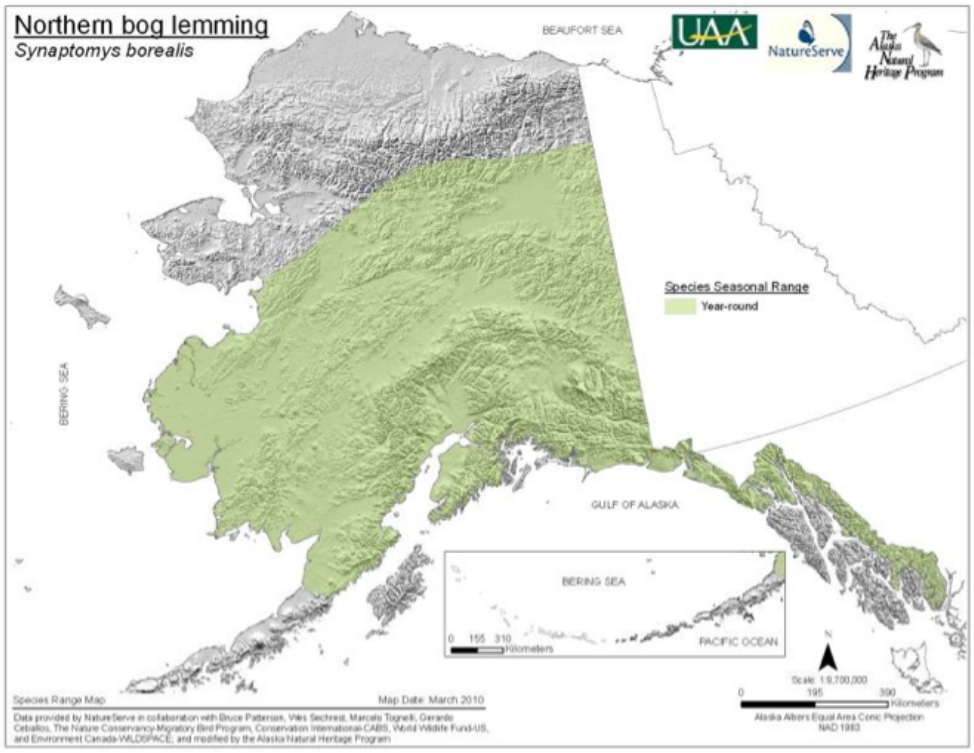


Figure 4. Range of the northern bog lemming in Washington (Marcot *et al.* 2003 at 248).

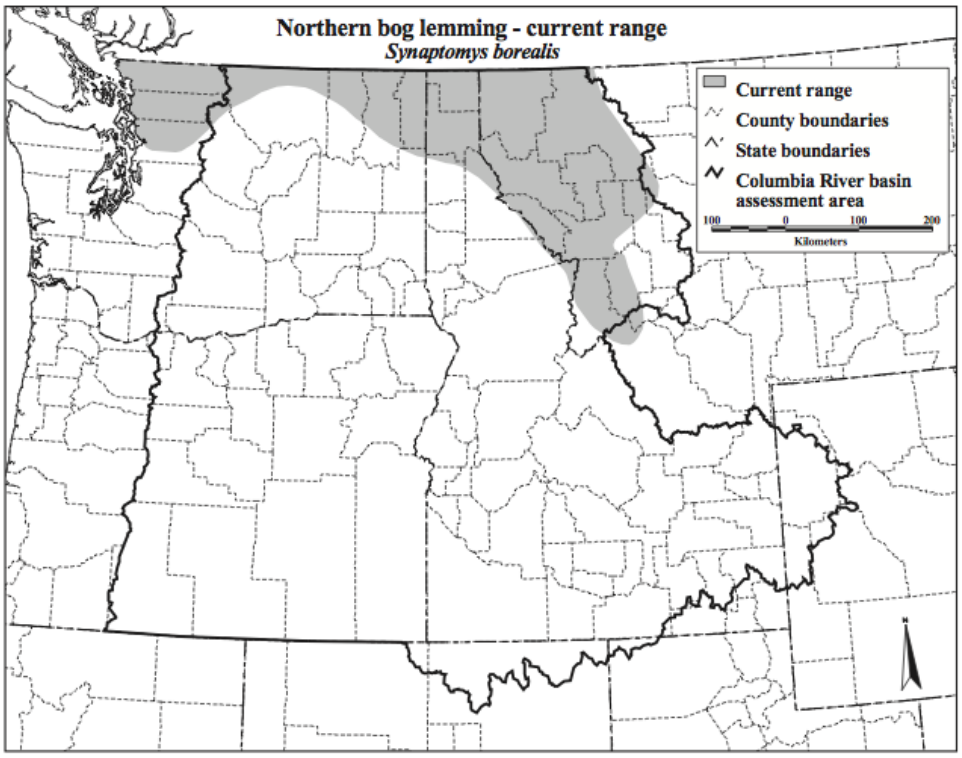


Figure 5. Northern bog lemming locations and predicted distribution in Idaho (IDFG 2005 at 3).

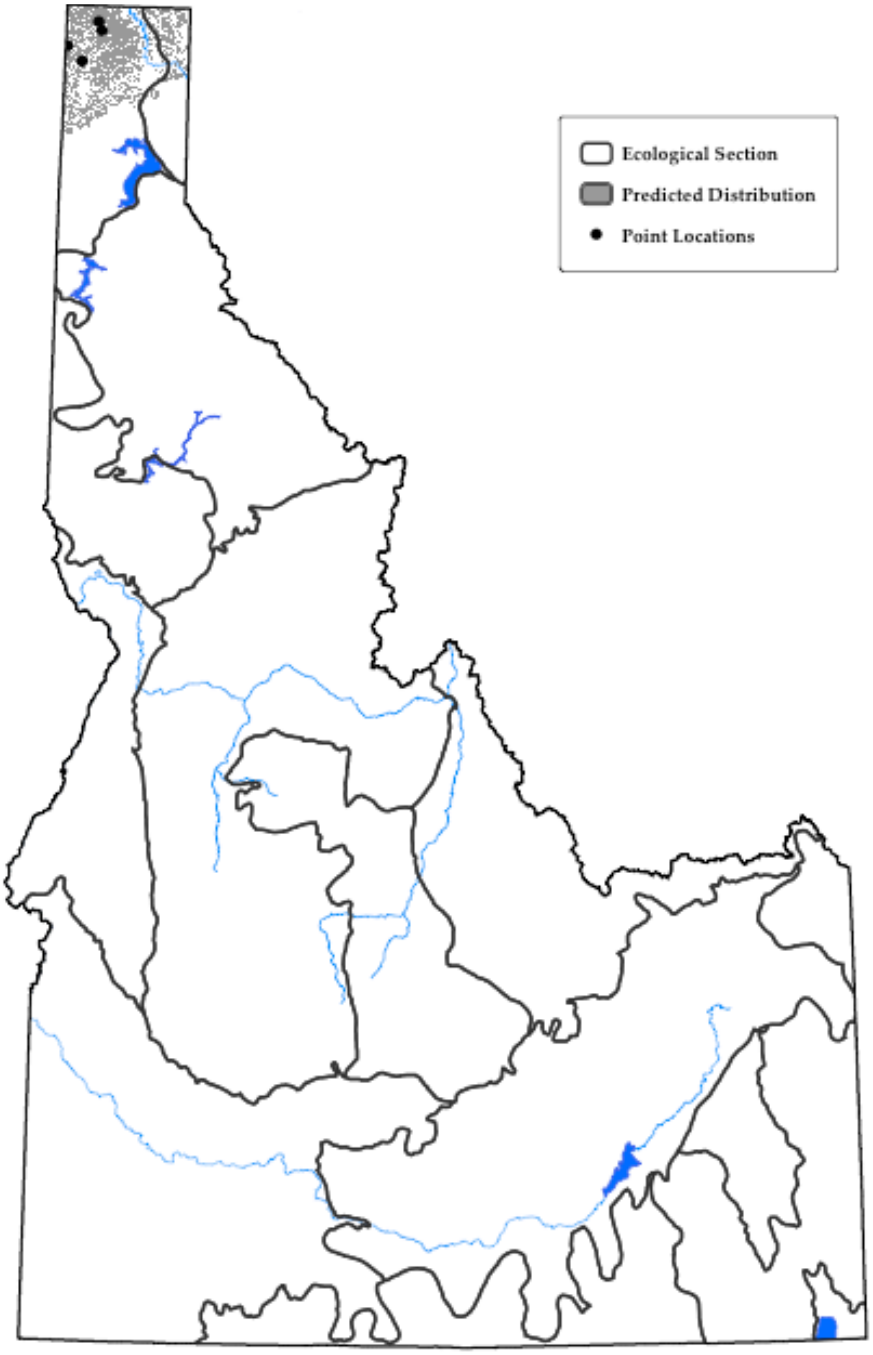


Figure 6. Northern bog lemming occurrences in Montana (Reichel and Corn 1997 at 2).

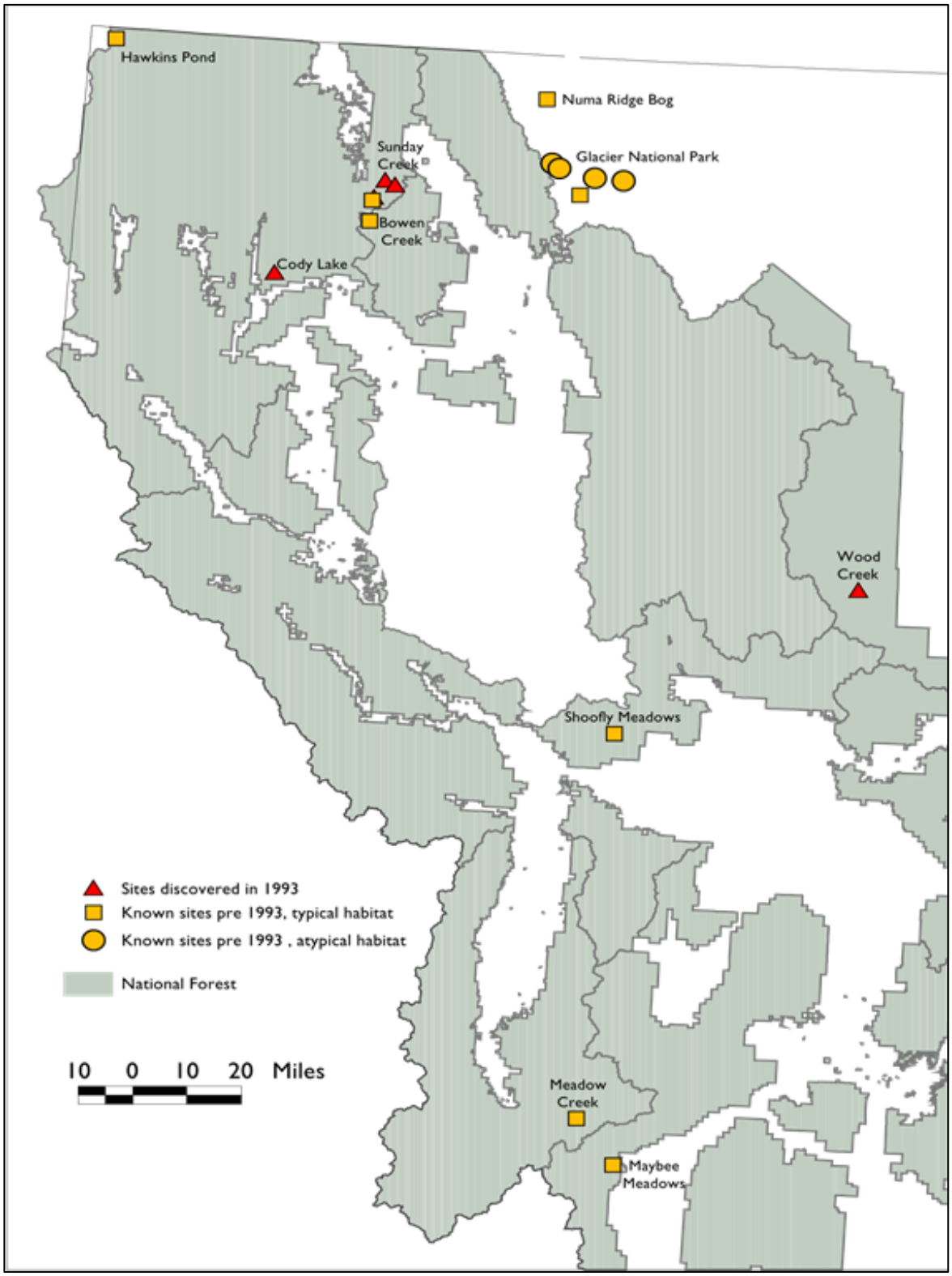


Figure 7. Northern bog lemming range in Minnesota. Top: approximate distribution of the northern bog lemming in Minnesota (Nordquist 1992 at 102). Bottom: historical or extant presence of northern bog lemmings by county (MDNR 2014 at 1).

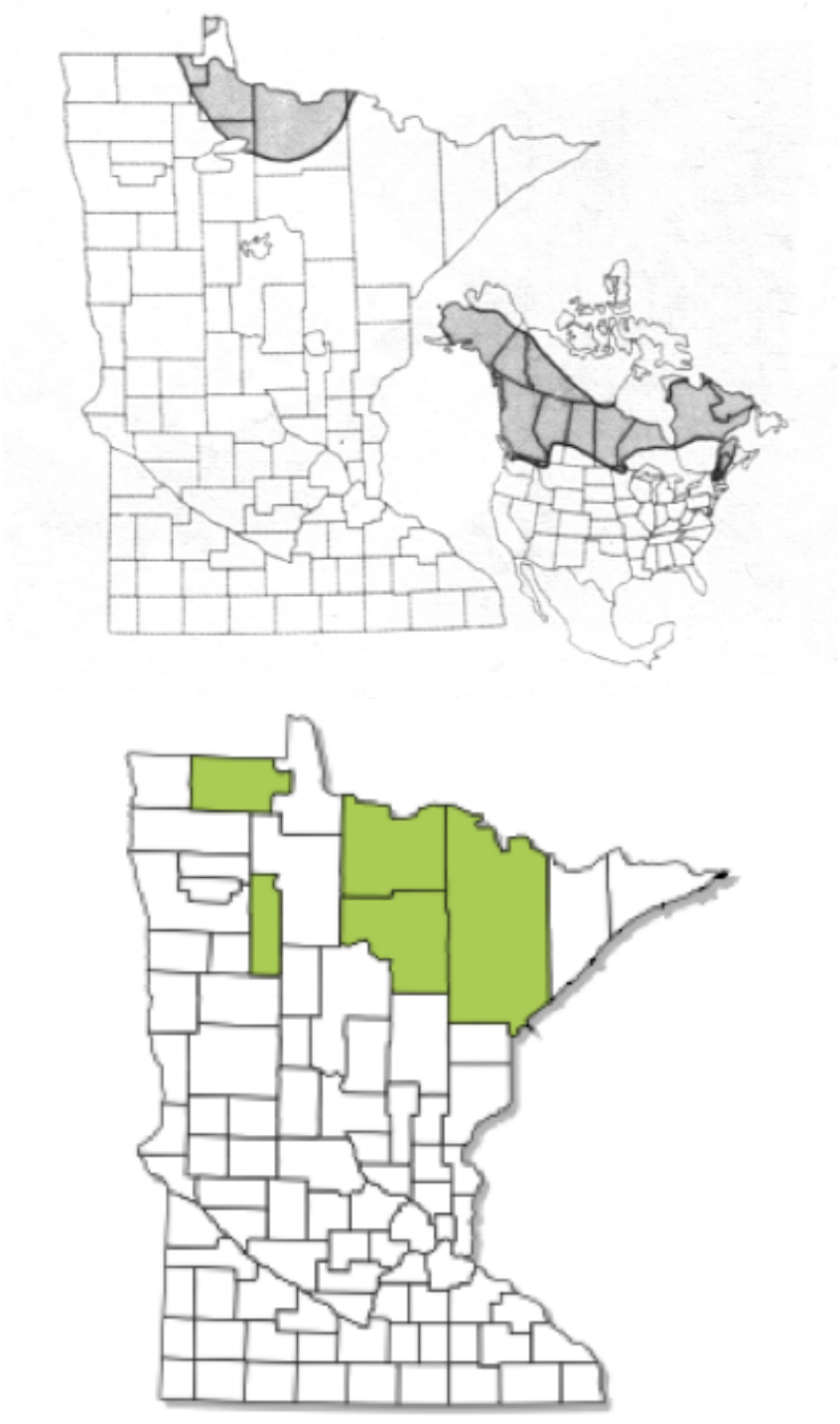
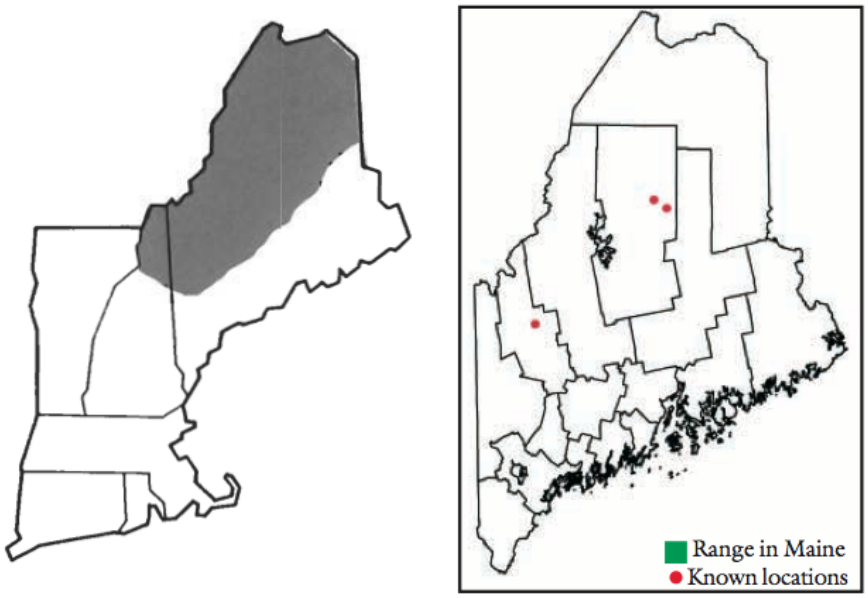


Figure 8. Northern bog lemming range in New England. Top left: approximate range of the northern bog lemming in New England (DeGraaf and Rudis 1986 at 439); Top right: northern bog lemming locations in Maine (MDIFW 2003 at 1); Bottom: northern bog lemming distribution in New Hampshire (NHFGD 2005 at A-317).



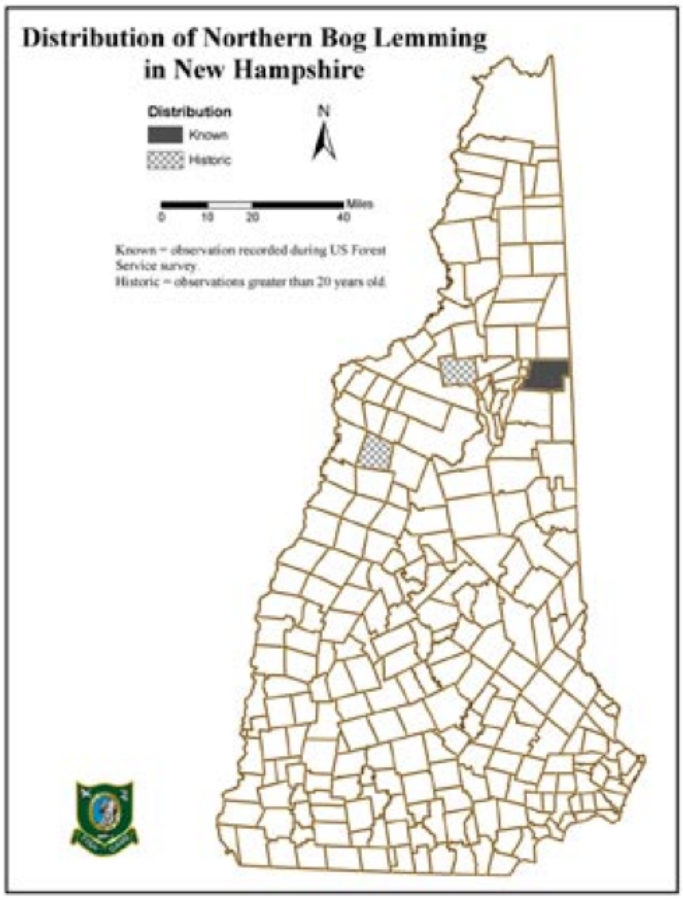


Figure 9. Observations of the northern bog lemming in Montana (MNHP and MFWP 2014 at 2).

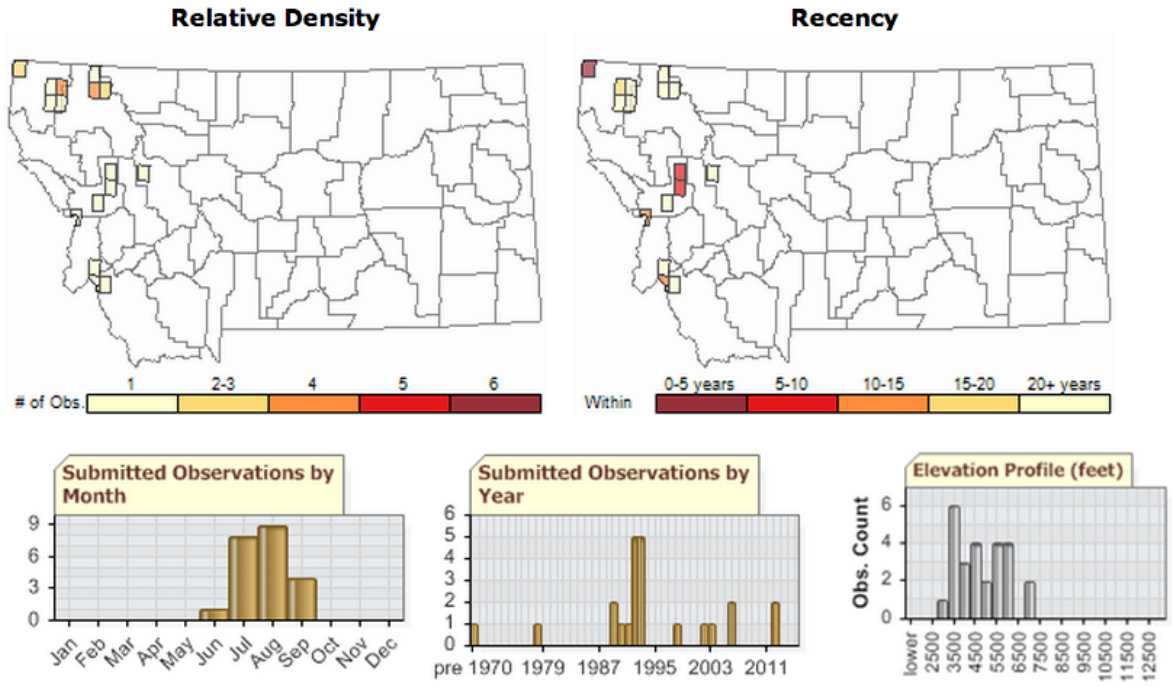


Figure 10. A representative portion of a peatland study area in Montana showing pervasive forest fragmentation. (Jones 2003 at 3).

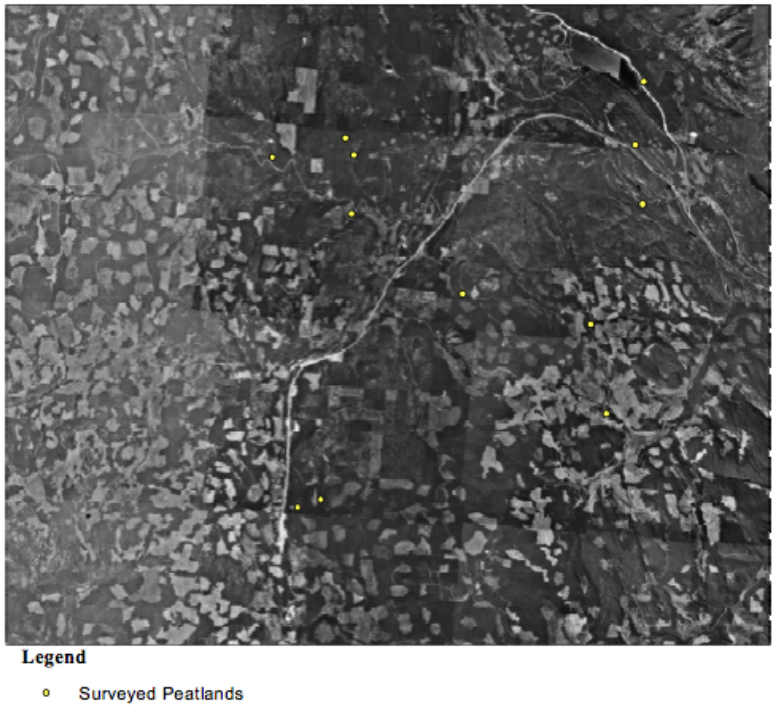


Figure 11. Annual estimates of the population for Missoula and Ravalli Counties of Montana (Kudray and Schemm 2008 at 5).

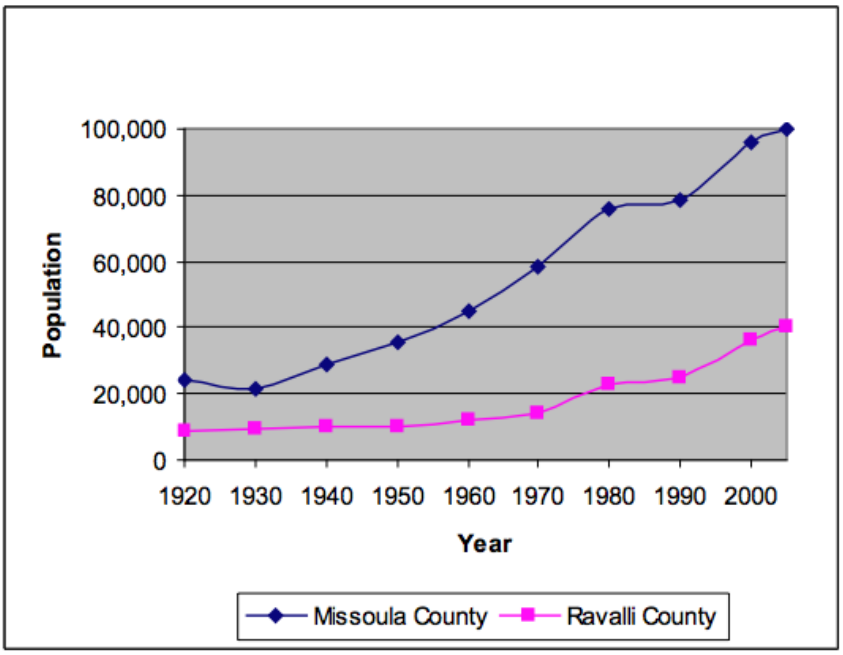
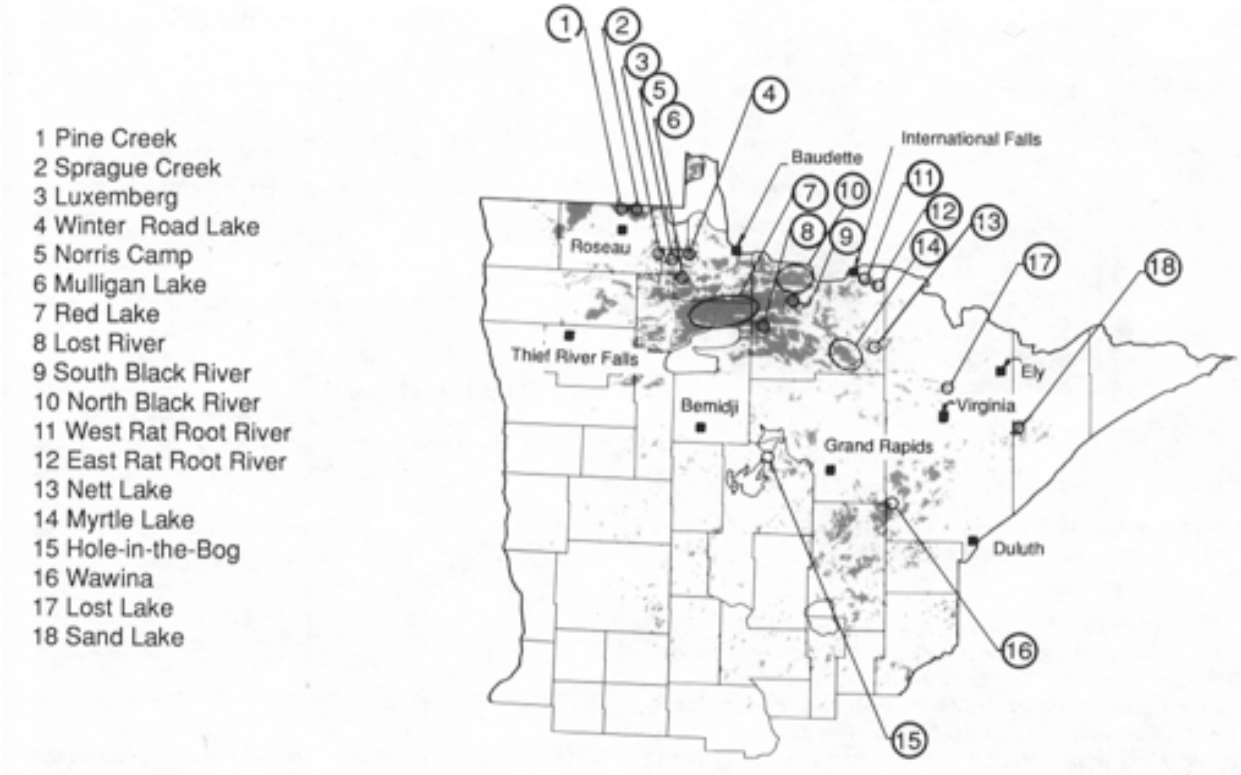


Figure 12. Peatland protection areas in northern Minnesota (Aaseng and Djupstrom 1992 at 305).



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