The Status of
Arctic Hare
(Lepus arcticus bangsii)

in Insular Newfoundland

THE SPECIES STATUS ADVISORY COMMITTEE
REPORT NO. 26

February 20, 2012

RECOMMENDED STATUS

Recommended status: DATA DEFICIENT	**Current designation:** None
Criteria met: Data Deficient	
Reasons for designation: Uncertain taxonomic distinction Unknown area of occupancy Uncertain number of extant locations Unknown trend in number of locations Unknown habitat trend Uncertain population size Unknown population size trend Unknown if extreme population size fluctuations (>1 order of magnitude)	

This report was originally prepared by Brian Hearn and subsequently edited by the Species Status Advisory Committee.

STATUS REPORT

Lepus arcticus bangsii (Rhoads, 1896)
Arctic hare (Newfoundland population) lièvre arctique, Ukaliq

Family: Leporidae (Hares and Rabbits)
Life Form: Mammal

Systematic/Taxonomic Clarifications

This report examines the arctic hare population on the island of Newfoundland, a population within the subspecies *Lepus arcticus bangsii*, as a discrete and evolutionarily significant designatable unit because of its geographic and presumed reproductive isolation and its distinction as the southernmost population of arctic hare in North America.

The taxonomy of the arctic or northern hare group(s) is disputed. Presently, three species of arctic (northern) hare are recognized: the Arctic hare (*Lepus arcticus*) occupying the tundra regions of Canada and along the coastal regions of Greenland; the Alaskan hare (*Lepus othus*) which is restricted to the western and northwestern regions of Alaska; and the Mountain hare (*Lepus timidus*) which is found throughout most of the Palaearctic region from Great Britain and Fennoscandia to eastern Siberia (Figure 1). Not surprisingly, the taxonomic status of these three species has been a long-standing controversy (Hall 1951, Best and Henry 1994). Baker et al. 1983 suggested that a single Holarctic population exists that should be recognized as *Lepus timidus*. Early phylogenetic analyses supported the hypothesis that arctic hares represent a single species (arctic hare clade) with circumpolar distribution (Halanych et al. 1999). Subsequently, Waltari et al. (2004) and Waltari and Cook (2005) conducted more extensive genetic analyses of the arctic hare group (n = 95) and concluded that the northern hare group represented three closely related sub-species; Waltari and Cook (2005) also identified two *L. arcticus* clades, including a distinct Baffin Island-Quebec clade. Most recently, Alves et al. (2008) disputed the taxonomic classification of the arctic hare group by Walteri et al. (2004) and Walteri and Cook (2005) as a possible erroneous taxonomic classification because it was based solely on mitochondrial DNA.

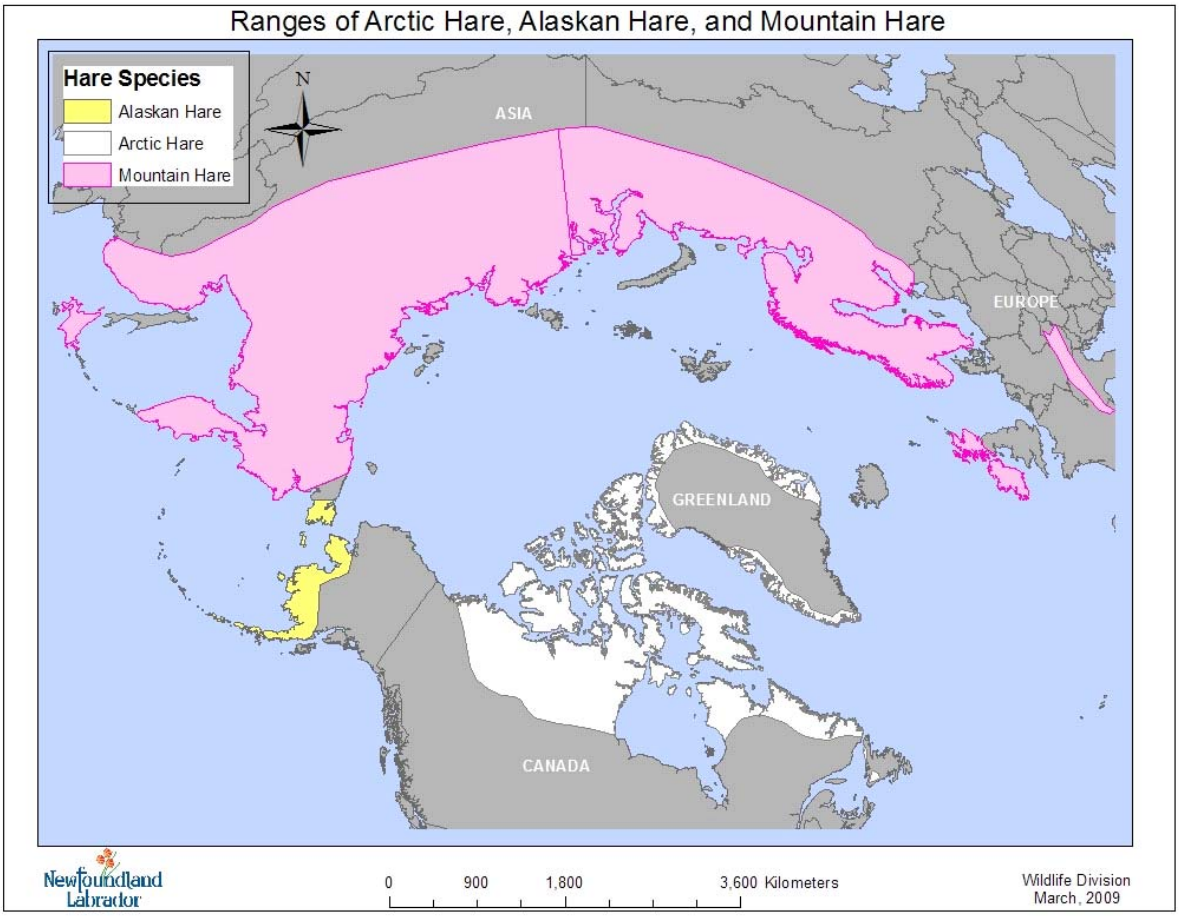

Figure 1. Worldwide distribution of arctic hare types; arctic hare (*Lepus arcticus*); Alaskan hare (*Lepus othus*); and Mountain hare (*Lepus timidus*). These species probably represent a single species of northern hare with circumpolar distribution (Alves et al. 2008).

Nationally, Banfield (1974) recognized 7 subspecies of *Lepus arcticus* in Canada (Figure 2), including two separate subspecies occurring in Newfoundland and Labrador; *L. a. bangsii* occurs in Newfoundland and southern to mid Labrador and *L. a. labradorius* occurs in northern Labrador and north to the Canadian Arctic Archipelago. As there are no molecular data for arctic hare from Newfoundland or Labrador (Halanych 1999, Waltari et al. 2004, Waltari and Cook 2005, Alves et al. 2008), the taxonomic division and geographical distributions of both *L.a. labradorius* and *L.a. bangsii* in Newfoundland and Labrador remains uncertain. Nonetheless, given their geographic and presumed reproductive isolation, this report considers arctic hare in Newfoundland as a reproductively isolated and potentially genetically distinct population.

Distribution

Global:

Arctic hares (*Lepus timidus*, *Lepus othus*, and *Lepus arcticus*) occur throughout the northern regions of the Palaearctic and Nearctic (Figure 1). *L. a. bangsii* occurs only on the island of Newfoundland and in southern Labrador. The Newfoundland population of *L.a. bangsii* assessed in this report occurs only on the island of Newfoundland.

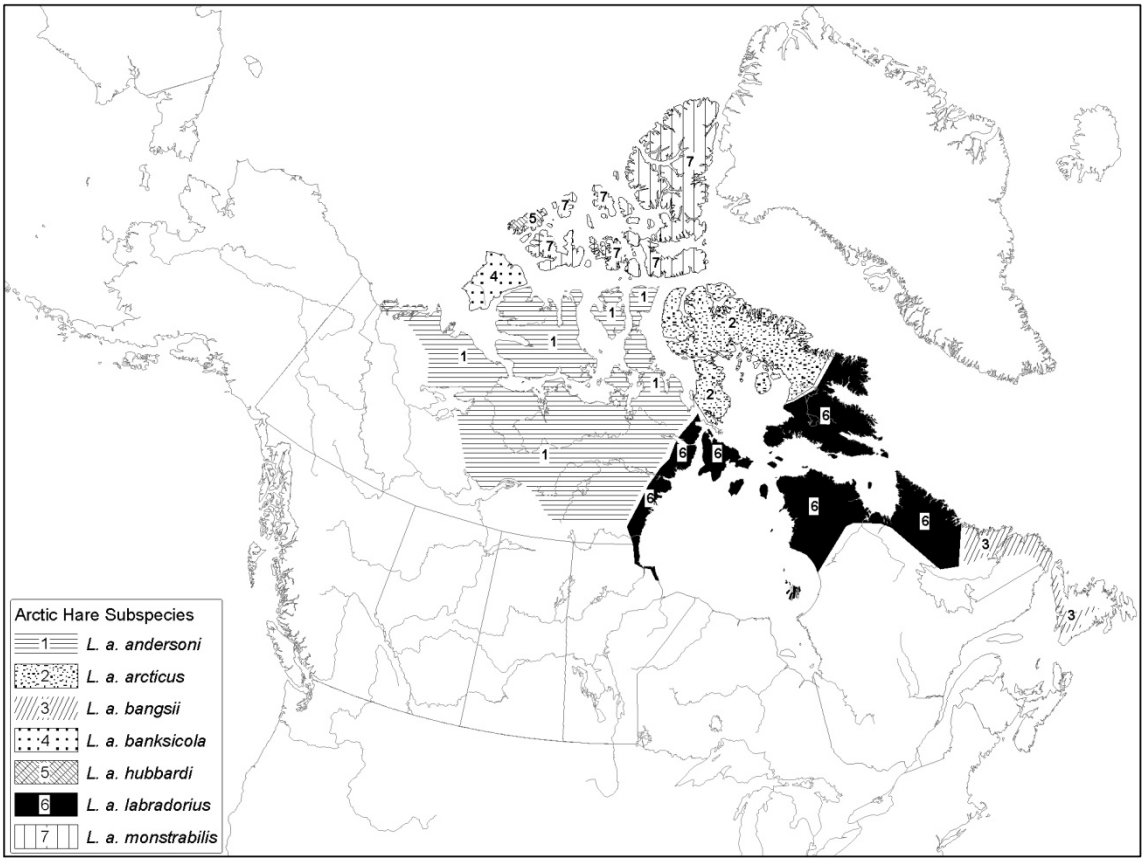

Figure 2. Distribution of the 7 recognized subspecies of arctic hare (*Lepus arcticus*): 1 = *L. a. andersoni*; 2 = *L. a. arcticus*; 3 = *L. a. bangsii*; 4 = *L. a. banksicola*; 5 = *L. a. hubbardi*; 6 = *L. a. labradorius*; 7 = *L. a. monstrabilis.* Map created by Adam Durocher, Atlantic Canada Conservation Data Centre (adapted from Banfield 1974).

National:

Arctic hares are widely distributed throughout the tundra habitat of northern Canada (i.e., Northwest Territories, Nunavut, a small area in northern Manitoba, Northern Quebec), and the islands of the Canadian Arctic Archipelago, south to the plateaus and mountains of Labrador and southwestern Newfoundland. Most populations of arctic

hare occur above treeline; however, local populations may move to forested habitat during winter (Bittner and Rongstad 1982) where available. Arctic hares have been observed on sea ice up to 5 km from land (Armstrong 1857 cited in Best and Henry 1994). *L. a. bangsii* occurs only on the island of Newfoundland and in southern Labrador and the Newfoundland population only on the island of Newfoundland.

Provincial:
Arctic hare are distributed throughout much of Newfoundland and Labrador. *L.a. labradorius* is located in northern Labrador while *L.a. bangsii* is found in southern Labrador and the island of Newfoundland. The two subspecies are separated at approximately 55-56° North, in the vicinity of Hopedale and Makkovik (Howell 1936). The island population of *L.a. bangsii* examined in this report is located only on the island of Newfoundland.

The arctic hare reaches the southernmost limit of its North American distribution on the island of Newfoundland where the population is restricted to arctic-alpine areas of the Long Range Mountains, interior west-central plateaus (i.e., Buchans - Topsails plateau complex) or exposed coastal barrens - an area of approximately 20,000 km^2 (Mercer et al. 1981); see Bergerud (1967) and Mercer et al. (1981; Figure 3) for island-wide distribution maps. Mercer et al. (1981) reported that arctic hares were not resident on the Blow-Me-Down Mountains, the Anguille Mountains or the Annieopsquotch Mountains; however, Keith (cited in Small and Keith 1992) found evidence of arctic hares on barrens outside the distribution described by Mercer et al. (1981) including the Annieopsquotch Mountains. More recent surveys (1997-2007) conducted by Parks Canada staff (S. Gerrow, Ecologist, Gros Morne National Park, personal communication) found no evidence that arctic hare currently occupy the Tablelands, the Gregory's, and Lookout Hills. No island-wide distribution systemic surveys have been conducted for arctic hare since Mercer et al. (1981), thus the current periphery of the core distribution of the arctic hare outside the Long Range Mountains and Buchans - Topsail plateau complex is unknown.

In April 1969, 4 hares (2M, 2F) were translocated from the southern Long Range Mountains to Brunette Island, Fortune Bay; Brunette Island was historically not known to support arctic hare. The hare population on this 20-km^2 predator-free island subsequently irrupted and by 1979 an estimated 800-1500 animals were resident (40-75 animals per km^2; Mercer et al. 1981). Subsequently (1974-1979), arctic hare (n = 373) were translocated to 10 other off-shore islands around Newfoundland (see Table 3 in Mercer et al. 1981). Of these islands, only Brunette Island is currently known to be occupied by arctic hare, and while the population appears to be healthy, current densities are unknown (M. McGrath, Senior Furbearer and Small Game Research Biologist, Newfoundland and Labrador Wildlife Division).

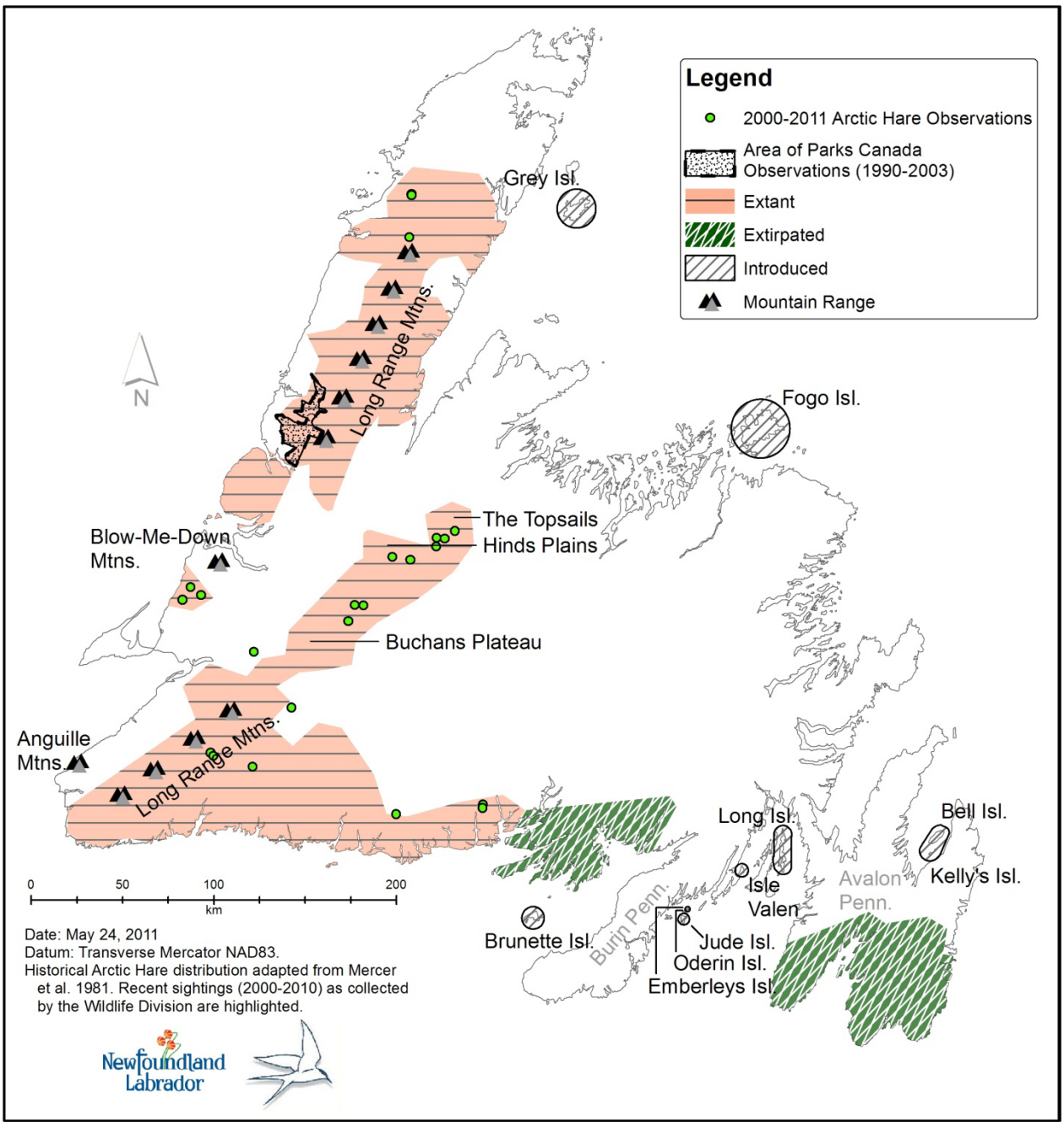

Figure 3. Arctic hare distribution in Newfoundland as reported by Mercer et al. (1981). Map created by Adam Durocher, Atlantic Canada Conservation Data Centre (adapted from Mercer et al. (1981)).

Description and Habitat

The arctic hare is the largest of the North American hares. It is a heavy-bodied hare weighting between 3.5 - 6.0 kilograms when fully grown. The winter coat is pure white with moderately long, black-tipped ears. The summer coat varies with latitude to blend with the local environment, i.e., northern populations of arctic hares remain white year-round while the summer coat of more southern populations, including those in Newfoundland (and Labrador) is typically bluish gray with white underparts. This variation in seasonal change in pelage likely is a result of natural selection for cryptic colouration with the local environment. Arctic hare are active year round and are highly adapted both physiologically and behaviourally to cold and barren habitat, with thick fur, relatively shortened ears, and a reduced surface area to volume ratio (Wang et al. 1973). The claws on the feet of the Arctic hare are long and broad adapted for digging in hard-packed snow. Arctic hares will dig snow shelters to conserve heat and, in arctic regions, will huddle together to share warmth.

Bergerud (1967) described arctic hare habitat in Newfoundland as: "[barren] areas primarily in the vicinity of boulder fields used as escape cover. Boulder fields within the presently occupied range that lack numerous interrock cavities are not inhabited. Also the boulder fields must be windswept at ground level to be suitable. Boulders surrounded by prostrate conifers that accumulate drifting snow are not utilized." However, Bergerud's observations more likely reflect the increased sightability of arctic hare in open areas. Hearn et al. (1987) routinely recorded radio-collared hares using areas of prostrate conifer (tuckamoor); their presence, however, would not have been noted had these animals not been radio marked. In winter, arctic hares in Newfoundland will utilize forested habitat closely adjacent to upland barren regions where available (Gerrow and Taylor, 2007) where they are easily trapped using deciduous (e.g., white birch (*Betula papyrifera*)) brush piles (B. J. Hearn, unpublished data). Throughout their range, the main summer foods are forbs and graminoids (i.e., grasses, sedges and rushes), and woody plant material from locally-available arctic alpine species. Winter diet is broad and hares reportedly will eat mosses, lichens, buds, berries, leaves, seaweed, bark, twigs, and roots of locally-available arctic alpine plant species.

Overview of Biology

The ecology and life history of the arctic hare is poorly documented with only a few field studies of arctic hare having been conducted to date throughout North America. At present, the most intensive (multi-year, year-round) field studies of arctic hare have been conducted in Newfoundland where the ecological setting for this species is unique and in contrast to those encountered by populations inhabiting mainland Canada and the Canadian Arctic Archipelago.

Breeding activity for the arctic hare begins in spring with the onset of changes in environmental and ecological factors (e.g., loss of snowcover, increasing daylength, improved nutritional status of hares). Hearn et al. (1987) reported a mean date of

conception for arctic hare in the southern Long Range Mountains of 19 April (range 8-26 April) for 23 litters collected between 1980 and 1984. Mean date of parturition for these 23 litters was 8 June (gestation period of 50 days). Mean litter size is variable across the range of the arctic hare, ranging from 3.0 young per adult female per year in Newfoundland (Hearn et al. 1987) to 6.3-6.5 young per female for high arctic populations in Canada and Alaska (Parker 1977, Anderson and Lent 1977). Because annual reproduction in hares is largely controlled by daylength (Lyman 1943), which in turn affects levels of reproductive hormones (gonadotrophins), early onset of breeding in Newfoundland hares produces a relative small mean litter size (Hearn 1985). While 2 or more litters per year have been suggested for arctic hare, no records of a second litter in a single year have been documented in the few field studies conducted to date for North American populations. Arctic hare young (leverets) are precocial, remaining in or near the nest for the first several weeks of life. They are fully weaned at 8-9 weeks.

Population size

The global population of arctic hares in Canada, including Labrador, appears secure. Population size of the Newfoundland population of *L.a. bangsii* is uncertain. Hearn et al. (1987), calculated a density of ca. 1 hare / km^2 on their study area in southwestern Newfoundland; similar to densities of mountain hares (*Lepus timidus*) on moors in Scotland and Ireland (Watson and Hewson 1973). More recently, Gerrow and Anderson (2007) reported densities fluctuating between 0.24-1.05 hares / km^2 for their 825-km^2 study area in Gros Morne National Park (Figure 4). Although, the status of arctic hare in some of the areas estimated by Mercer et al. (1981) to be occupied (i.e., Tablelands, Gregory Plateau) and unoccupied (i.e., portions of the Annieopsquotch Mountains) is uncertain, if Mercer et al.'s estimate of 20,000 km^2 of occupied habitat island-wide is roughly correct, then these density estimates suggest a population fluctuating between 5,000-20,000 hares on the island of Newfoundland.

Traditional and local ecological knowledge

Traditionally, the arctic hare has been used by aboriginal people in northern mainland Canada as a food resource and for their fur. On the island of Newfoundland, arctic hare are not legally harvested whereas snowshoe hares are readily available; up to 2M snowshoe hares are harvested per year during cyclic highs (M. McGrath, Small Game and Furbearer Research Biologist, NL Wildlife Division, personal communication). No particular reference to traditional or local knowledge for arctic hare on the island was identified during this review.

Trends

No island-wide surveys or distribution studies of arctic hare have been conducted over the last 25+ years (C. Callahan, Small Game Management Biologist, NL Wildlife

Division, personal communication). Consequently, there is no information on recent changes in the distribution or densities of arctic hare on the island of Newfoundland.

The historical distribution and abundance of the arctic hare on the island of Newfoundland is unclear, however, a number of historical documents and scientific publications (Appendix B; Nelson 1909, Howley 1913, Howell 1936, Cameron 1958, Dodds 1960, Bergerud 1967) suggest that arctic hare once were more abundant and widely distributed. Nelson (1909), Howley (1913), Howell (1936) and later Cameron (1958), Dodds (1960), and Bergerud (1967) attributed the decline in arctic hare populations to the introduction in 1864-1876 of the snowshoe hare (*Lepus americanus)*. Hypotheses for the decline (Appendix B) include the snowshoe hare's agonistic behavior toward arctic hare (interference competition; Howley 1913), its more efficient exploitation of the common winter food resource (exploitation competition; Cameron 1958, Dodds 1960), and increased predation of arctic hare by lynx (*Lynx canadensis*) populations at greater abundance following irruption of snowshoe hare (Bergerud 1967).

Gerrow and Anderson's (2007) survey results for their study area in Gros Morne National Park are the only recent trend data available. These authors documented a 4-fold fluctuation in numbers on their study area and suggested that arctic hare populations in Newfoundland may be cyclic with a periodicity of 6-7 years. Additional monitoring over several cycles would be required to clarify the extent to which arctic hare populations fluctuate (or cycle). No trend data for the arctic hare populations on the entire island are available at this time. Systematic surveys of occupied arctic hare habitat on the island of Newfoundland, as originally identified by Bergerud (1967) and Mercer et al. (1981), are now being initiated by the NL Wildlife Division (C. Callahan, Small Game Management Biologist, NL Wildlife Division, personal communication) to document current distribution; a presence/absence survey and the establishment of a hare pellet plot transect was initiated for the Lewis Hills in September 2010 (*ibid*).

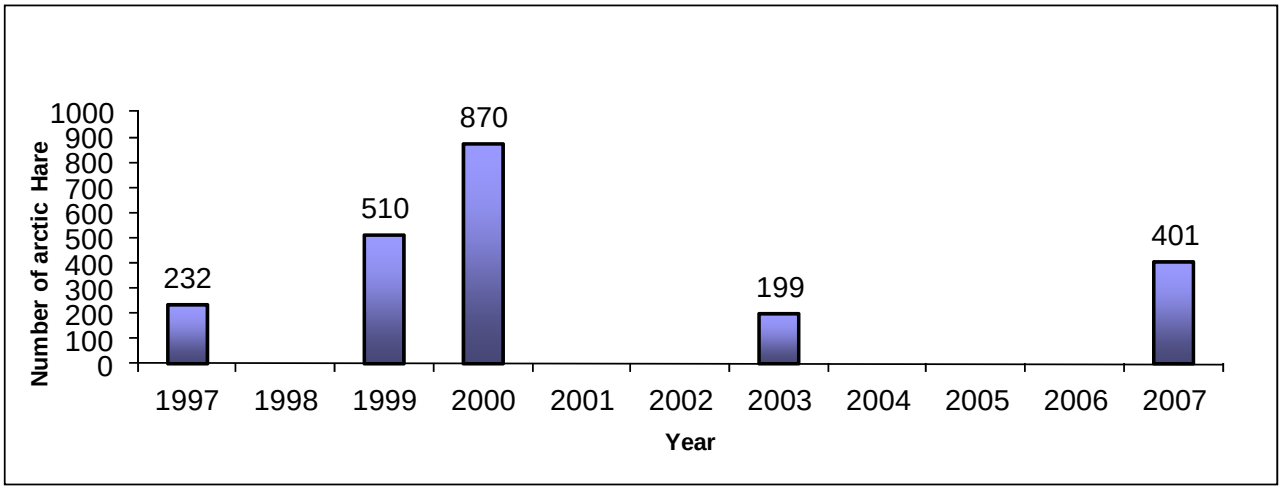

Figure 4. Estimated number of arctic hare for an 825-km^2 study area in Gros Morne National Park, 1997-2007 (Gerrow and Anderson 2007, unpublished data).

Threats and limiting factors

Specific potential threats to arctic hare populations in Newfoundland include the following:

1. **Predation**
   a. Fox predation: Arctic hare populations throughout their worldwide range appear limited by predation, particularly red fox (Lindlöf and Lemmell 1981, Mercer et al. 1981, Danell and Hörnfeldt 1987, Lindström 1987, Angerbjorn 1989, Barta et al. 1989, Fitzgerald and Keith 1990, Small et al. 1992a, 1992b). Red fox was the most important natural predator of radiocollared arctic hares reported by Hearn et al. (1987) and in studies conducted in Gros Morne National Park (S. Gerrow, Ecologist, Gros Morne National Park, NL, personal communication).

   b. Coyote predation: Expanding coyote (*Canis latrans*) populations may pose a risk to arctic hare populations, however, the extent to which they prey on arctic hare is unknown. Analysis of > 300 coyote gastrointestinal tracts have not indicated predation on arctic hare (M. McGrath, NL Wildlife Division, personal communication) but coyote populations are still expanding and increased predation on arctic hare, particularly during years of low alternate prey abundance, is possible.

   c. Mortality by other potential predators such as marten (*Martes americana atrata*), lynx (*Lynx canadensis*; e.g., Mercer et al. 1981), and raptors doubtlessly occurs but is likely opportunistic and felt to be of secondary importance to canid predation.

2. **Extraction Industries**: Forestry and mining operations likely pose limited risk to arctic hare populations in Newfoundland. Forests adjacent to alpine barrens are typically unmerchantable and of little interest to the forest industry. The recent decline in the forest industry in the province has seen the closure of two paper mills and forest harvesting levels (m^3 harvested annually) in the province are significantly reduced. No threats or concerns from mining operations are known. Further, mining operations typically have a spatially limited industrial footprint.

3. **Snowmobile Activity, Trails & Predator Movement:** Increased snowmobile activity, and increased availability of compacted snowmobile trails, has been suggested as a potential threat to arctic hare populations, particularly in high traffic areas (e.g., Gros Morne National Park and Lewis Hills). Hypothetically, compacted snowmobile trails allow predators (in particular canids) to move more easily up to high-elevation barrens to prey on hares. Similarly, increasing levels of snowmobiling activity might displace hares from traditional wintering areas thereby increasing energetic demands in winter. No studies have examined these issues on the island or elsewhere; however, given the limited availability of compacted snowmobile trails across the island-wide range of arctic hare, this potential threat appears slight, and if occurring, confined to

smaller portions of the arctic hare range on the island where snowmobile activity is highly concentrated (Gros Morne National Park and Lewis Hills). Kolbe et al. (2007) concluded that the overall influence of snowmobile trails on coyote movements and foraging success on snowshoe hare was limited in western Montana.

4. **Poaching and Accidental Snaring:** Accidental harvest of arctic hare in snowshoe hare snares reported to the NL Wildlife Division is very low (<5 per year, J. Sharpe, NL Wildlife Division, personal communication). Illegal harvest of arctic hare is believed to be extremely limited (W. Greene, NL Conservation Officer, personal communication), likely influenced by the remoteness and isolation of arctic hare habitat, and the general availability of snowshoe hare populations.

5. **Changing Predator - Prey Interactions**: Two significant ecological events have occurred in Newfoundland in recent years: the introduction of a new predator (i.e., coyote; Blake 2006) and the introduction of an alternate prey species - the red-backed vole (*Myodes gapperi;* Hearn et al. 2006). If the introduction of snowshoe hares caused a range contraction of arctic hare in Newfoundland via the indirect effects of higher predation rates following the addition of an alternate prey, then the indirect, community-level consequences of coyotes and red-backed voles are potential threats. If the introduction of red-backed voles improves the demographic performance of fox, coyotes, or other predators (raptors) generating a "*high-density of randomly foraging predators that spill over into other habitats*" (Small and Keith 1992) then further range contraction away from smaller barren areas currently occupied by arctic hare likely will occur. Such areas, once abandoned, might never be reoccupied due to the low reproductive rate (hence potential rate of increase) of these Newfoundland arctic hare populations.

6. **Climate Change**: Climate change is potentially a long-term threat to arctic hare persistence on the island. This threat could be realized in long-term changes to vegetation succession patterns thereby affecting habitat availability and connectivity for both hares and their associated predators. Additionally, climate change could affect the patterns (i.e., frequency and duration) of icing events thereby affecting food availability and/or foraging energetics.

Existing protection

Arctic hare are protected on the island of Newfoundland (i.e., snaring or shooting of arctic hare is prohibited). Gros Morne National Park provides a large continuous block of arctic hare habitat in permanent protection (*ca*. 825 km^2 of habitat with an estimated 200-900 hares; Gerrow and Anderson 2007). The Little Grand Lake Provisional Ecological Reserve, although established primarily as a forest reserve for Newfoundland marten, has patches of upland barren habitat and arctic hare are resident (B. Hearn, unpublished data); however, no population estimates or habitat mapping potential has been conducted to date. Gerrow and Taylor (2007) used field data from arctic hare surveys, winter telemetry and trapping to develop a habitat model

to predict winter hare distribution for Gros Morne National Park. This model should be applied over the island-wide range of the species to test its application over the broader landscape.

Special significance

The arctic hare is one of only 14 native terrestrial mammals currently resident on the island of Newfoundland and the only native lagomorph. The arctic hare on the island of Newfoundland and in southern Labrador is a taxonomically recognized subspecies (*L. a. bangsii*). It is likely that arctic hare on the island of Newfoundland represent a geographically and reproductively isolated population.

Ranks or Status

The following ranks for locations other than "Newfoundland" apply to the species *Lepus arcticus*, and are not specific to the Newfoundland population assessed in this report.

	Rank or Status
G-rank/IUCN	**Secure (G3)**
N-rank/National General Status/COSEWIC	**Secure (N5)**
General Status – provincial	**Secure**
Newfoundland • S-rank • General Status	 Vulnerable (S3) Sensitive
Labrador • S-rank • General Status	 Secure Secure

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Collections examined

N/A

TECHNICAL SUMMARY

Distribution and Population Information	**Criteria Assessment**
Extent of occurrence (EO)(km²)	20,000 km^2 (estimated)
Area of occupancy (AO) (km²)	Unknown
Number of extant locations	Uncertain
Specify trend in # locations, EO, AO (decline, stable, increasing, unknown)	Unknown
Habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat (known increases in snowmobiling in Gaff Topsails and GMNP)	Declining quality
Generation time (average age of parents in the population) (indicate years, months, days, etc.)	Unknown
Number of mature individuals (capable of reproduction) in the Provincial population (or, specify a range of plausible values)	5000-20000 (estimated)
Total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals or number of populations	Unknown
Are there extreme fluctuations (>1 order of magnitude) in number of mature individuals, number of locations, AO and/or EO?	Unknown
Is the total population severely fragmented (most individuals found within small and isolated populations between which there is little exchange, i.e., $\leq$ 1 successful migrant / year)? Populations may be large enough to be viable but exchange among populations is likely limited. Human influence on the landscape and introductions of competitors and predators is likely impacting exchange among populations. As an alpine species, climate change is predicted to have negative consequences in terms of extent and quality of habitat.	Unknown
Rescue Effect (immigration from an outside source)	
Does species (Newfoundland population) exist elsewhere?	No *
Status of the outside population(s)?	N/A
Is immigration known or possible?	N/A
Would immigrants be adapted to survive here?	N/A
Is there sufficient habitat for immigrants here?	Yes

* *Lepus arcticus* exists across the Canadian north and is considered secure at the species level.

Appendix A. Population Information

Appendix A Table 1: Recently verified occurrences of arctic hare on the island of Newfoundland outside Gros Morne National Park, as contained within the Atlantic Canada Conservation Data Centre (ACCDC) database. Data are plotted in Figure 3. Locations (provided as UTMs) have been generalized to the centre point of 10x10 km grids. Data queried by Adam Durocher of the ACCDC.

DD	MM	YYYY	Locality	Observer	UTME	UTMN	UTMZ
				Alex Murley	405000	5325000	21
				Alex Murley	405000	5325000	21
12	9	2009		Chris Callahan	535000	5445000	21
0	3	2008		Tom Foss (atlantic canada's snowmobile mag (2009))	535000	5445000	21
0	9	2008		John Neville	525000	5435000	21
0	9	2008		John Neville	475000	5395000	21
0	9	2008		John Neville	425000	5375000	21
23	5	2009		Chris Callahan	525000	5445000	21
23	5	2009		Chris Callahan	485000	5405000	21
23	5	2009		Chris Callahan	485000	5405000	21
15	3	2008		Mac Lavers	515000	5605000	21
16	3	2010	Arctic Hare Scat - Lewis Hills	Chris Callahan and Shannon Crowley	395000	5405000	21
16	3	2010	Arctic Hare Tracks - Lewis Hills	Chris Callahan and Shannon Crowley	395000	5415000	21
16	3	2010	Arctic Hare Tracks - Lewis Hills	Chris Callahan and Shannon Crowley	385000	5405000	21
26	3	2010	Anneopsquotch Mtns	Isabelle Schmelzer	445000	5345000	21
15	2	2010	South of Dolland Pond	Chris Callahan	555000	5295000	21
15	3	2008		John Neville	505000	5295000	21
25	3	2010		Mike McGrath and John Neville	555000	5295000	21
1	10	2010	Hare Hill	Stu Welden	425000	5315000	21
26	10	2010	Doctors Hills - 2 hares	Chris Callahan	515000	5625000	21
26	10	2010	Doctors Hills	Chris Callahan	515000	5625000	21
22	3	2011	Hinds Plains	Mark Breon	505000	5435000	21
22	3	2011	Hinds Plains	Mark Breon	515000	5435000	21

Appendix A Table 2: Recently verified occurrences of arctic hare on the island of Newfoundland in or near Gros Morne National Park, as contained within the Atlantic Canada Conservation Data Centre (ACCDC) database. Data are plotted in Figure 3. Note that many hundreds more occurrences are contained in databases at Gros Morne National Park (S. Gerrow). These additional data demonstrate the same spatial pattern, that arctic hare are located throughout the Long Range Mountains in the park, north and east of Highway 430, at elevations greater than 350m. Locations (provided as UTMs) have been generalized to the centre point of 10x10 km grids. Data queried by Adam Durocher of the ACCDC.

DD	MM	YYYY	Locality	Observer	UTME	UTMN	UTMZ
				Rooney G	455000	5505000	21
			Crown Hill	Moreland Adam	445000	5485000	21
			Black Pine Woods	Taylor Scott	445000	5495000	21
			Beaver Pond	Reid Clem	465000	5505000	21
23	4	1991	Long Pond	Rooney G	455000	5515000	21
23	4	1991	Heather Pond	Rooney G	465000	5515000	21
15	6	1992	Gros Morne	Moreland Adam	445000	5495000	21
22	6	1992	Gros Morne	Warden	445000	5495000	21
22	6	1992	Gros Morne	Warden	445000	5495000	21
22	6	1992	Gros Morne	Warden	445000	5495000	21
22	6	1992	Gros Morne	Warden	445000	5495000	21
24	6	1992	Gros Morne	Moreland Adam	445000	5495000	21
15	7	2002	Little Island Pond	Moreland Adam	455000	5505000	21
15	7	1992	Gros Morne	Moreland Adam	445000	5495000	21
15	7	1992	Little Island Pond	Moreland Adam	455000	5505000	21
15	12	1992	Killdevil	Warden	445000	5485000	21
1	2	1993	Big Island Pond	Moreland Adam	455000	5505000	21
7	2	1993	Grassy Brook		445000	5505000	21
10	2	1993	Bullet Pond	Moreland Adam	445000	5505000	21
10	2	1993	Bullet Pond	Moreland Adam	445000	5505000	21
22	2	1993	Big Island Pond	Moreland Adam	455000	5505000	21
22	2	1993	Big Island Pond	Moreland Adam	455000	5505000	21
22	2	1993	Arm Pond South	Moreland Adam	465000	5515000	21
22	2	1993	Steady Pond	Moreland Adam	465000	5515000	21
22	2	1993	Flat Gulch	Moreland Adam	465000	5515000	21
1	3	1993	Turnback Gulch	Anderson Steve	455000	5535000	21
9	3	1993	Marks Pond	Moreland Adam	455000	5505000	21

9	3	1993	Bullet Pond	Warden	445000	5505000	21
9	3	1993	Long Pond	Moreland Adam	455000	5515000	21
9	3	1993	Heather Pond	Moreland Adam	465000	5515000	21
10	3	1993	Bakers Brook Inner Pond	Warden	455000	5495000	21
10	3	1993	Western Brook Pond	Moreland Adam	455000	5505000	21
10	3	1993	Little Island Pond	Moreland Adam	455000	5505000	21
11	3	1993	Turnback Gulch	Moreland Adam	455000	5525000	21
28	3	1993	Old Crow	Warden	445000	5495000	21
28	3	1993	Puncheon Rock	Staff	445000	5505000	21
29	3	1993	Long Range	Moreland Adam	445000	5495000	21
21	4	1993	Marks Pond	Moreland Adam	455000	5505000	21
21	4	1993	Oliver's Hill	Moreland Adam	445000	5505000	21
9	6	1993	Rocky Harbour Hills	Moreland Adam	445000	5495000	21
9	6	1993	Rocky Harbour Hills	Moreland Adam	445000	5495000	21
9	6	1993	Grassy Brook	Moreland Adam	445000	5505000	21
9	6	1993	Gros Morne	Moreland Adam	445000	5495000	21
9	6	1993	Big Level	Moreland Adam	455000	5505000	21
9	6	1993	Big Level	Warden	445000	5505000	21
23	6	1993	Hardings Pond	Warden	455000	5495000	21
23	6	1993	Old Crow	Moreland Adam	445000	5495000	21
23	6	1993	Old Crow	Moreland Adam	445000	5495000	21
24	6	1993	Ferry Gulch	Moreland Adam	445000	5495000	21
24	6	1993	Gros Morne	Moreland Adam	445000	5495000	21
7	7	1993	Gros Morne	Moreland Adam	445000	5495000	21
10	7	1993	Old Crow	VISITOR	445000	5495000	21
10	7	1993	Old Crow	VISITOR	445000	5495000	21
17	7	1993	Marks / Hardings Pond Area	Moreland Adam	455000	5505000	21
27	7	1993	Marks Pond	Moreland Adam	455000	5505000	21
27	7	1993	Near Marks Pond	Moreland Adam	455000	5505000	21
27	7	1993	Marks / Hardings Pond Area	Moreland Adam	455000	5505000	21
27	7	1993	Marks / Hardings Pond Area	Moreland Adam	455000	5495000	21
27	7	1993	Marks / Hardings Pond Area	Moreland Adam	455000	5495000	21
27	7	1993	Marks / Hardings Pond Area	Moreland Adam	455000	5495000	21
27	7	1993	Marks Pond	Moreland Adam	455000	5505000	21
27	7	1993	Marks / Hardings Pond Area	Moreland Adam	455000	5495000	21
14	12	1993	West Side Killdevil	Warden	445000	5485000	21
17	1	1994	Narrow Pond	Moreland Adam	455000	5505000	21

16	2	1994	Sams Rock	Moreland Adam	445000	5485000	21
17	2	1994	Moose Pond	Moreland Adam	465000	5515000	21
17	2	1994	Little Island Pond	Moreland Adam	455000	5505000	21
17	2	1994	Stag Pond	Moreland Adam	455000	5495000	21
17	2	1994	Stag Pond	Moreland Adam	455000	5495000	21
7	3	1994	WS/Sam's Rock Pond	Moreland Adam	445000	5485000	21
13	3	1994	Top of Millbrook Trail	Warden	445000	5485000	21
21	3	1994	Long Pond	Moreland Adam	455000	5515000	21
22	3	1994	Ten Mile Gulch	Warden	445000	5495000	21
12	4	1994	N Rim Western Brook Pond	Warden	455000	5505000	21
12	4	1994		Warden	455000	5505000	21
12	4	1994	Heather Pond	Warden	455000	5515000	21
12	4	1994		Warden	465000	5495000	21
12	4	1994	North Rim Trail	Warden	455000	5515000	21
13	4	1994	Near Wood Pond	Warden	445000	5515000	21
14	4	1994	Big E Bk Pond	Warden	465000	5525000	21
14	4	1994	Big Gulch	Warden	465000	5525000	21
14	4	1994	Bills Pond	Warden	455000	5515000	21
14	4	1994	Near Big Gulch	Warden	465000	5525000	21
14	4	1994	Big Eastern Brook Pond	Warden	465000	5525000	21
5	6	1994	Near Pilgrim Pond	McCarthy Chris	455000	5505000	21
20	6	1994	GM Mountain Near Ten Mile Pond Lookoff	Moreland Adam	445000	5495000	21
9	7	1994	Backside Gros Morne Mountain	Bob&Sue Rendall	445000	5495000	21
15	7	1994	Gros Morne Mountain	McCarthy Chris	445000	5495000	21
3	8	1994	Chain of Ponds	Moreland Adam	445000	5495000	21
25	8	1994	Gros Morne	O'Callaghan Mike	445000	5495000	21
7	9	1994	Gros Morne Mountain	O'Callaghan Mike	445000	5495000	21
19	10	1994	Gros Morne Mountain	Staff	445000	5495000	21
19	10	1994	Gros Morne Mountain	Staff	445000	5495000	21
3	3	1995		Reid Clem	455000	5505000	21
4	3	1995	Black Cliff / Candlestick	Reid Clem	455000	5495000	21
13	3	1995	Killdevil	McCarthy Chris	445000	5485000	21
29	3	1995	Big Hill	McCarthy Chris	445000	5485000	21
5	6	1995	Big Level	Pollock Beth	445000	5505000	21
15	6	1995		Pollock Beth	445000	5505000	21
16	6	1995		Pollock Beth	445000	5505000	21
8	7	1995	Long Range	Taylor Scott	445000	5495000	21

7	10	1995	Gros Morne	Pollock Beth	445000	5495000	21
22	1	1996	Gros Morne Mountain	O'Callaghan Mike	445000	5495000	21
20	3	1996	Gros Morne Mountain	Visitor	445000	5495000	21
21	4	1996	Big Hill	Keith Todd	445000	5485000	21
30	4	1996	The Crossing Place	O'Callaghan Mike	455000	5515000	21
30	4	1996	Big Level	O'Callaghan Mike	445000	5495000	21
29	5	1996	Long Range West Slope	Keith Todd	435000	5505000	21
29	5	1996	Grassy Brook	Keith Todd	445000	5505000	21
29	5	1996		Keith Todd	445000	5505000	21
4	6	1996	East Boundary	Anions Marilyn	465000	5495000	21
7	6	1996	Big Level	McCarthy Chris	445000	5505000	21
23	6	1996	Big Level	Climate Crew	445000	5505000	21
29	6	1996	Big Level	Climate Crew	445000	5505000	21
29	6	1996	Big Level	Climate Crew	445000	5505000	21
29	6	1996	Big Level	Climate Crew	445000	5505000	21
29	6	1996	Big Level	Climate Crew	445000	5505000	21
6	7	1996	Big Level	Climate Crew	445000	5505000	21
6	7	1996	Big Level	Climate Crew	445000	5505000	21
15	7	1996	Big Level	Climate Crew	445000	5505000	21
26	7	1996	Big Level	Climate Crew	445000	5505000	21
26	7	1996	Big Level	Keith Todd	445000	5505000	21
31	7	1996	Big Level	Climate Crew	445000	5505000	21
3	8	1996	Big Level	McCarthy Chris	445000	5505000	21
4	8	1996	Big Level	Gerrow Shawn	445000	5505000	21
4	8	1996	Big Level	Gerrow Shawn	445000	5505000	21
4	8	1996	Big Level	Climate Crew	445000	5505000	21
25	8	1996	Big Hill	Taylor Scott	445000	5485000	21
26	8	1996	Long Range	Wentzell Carson	455000	5515000	21
4	9	1996	Rocky Harbour Hills	Gerrow Shawn	445000	5495000	21
9	9	1996	Rocky Harbour Hills	McCarthy Chris	445000	5495000	21
9	9	1996	Rocky Harbour Hills	Gerrow Shawn	445000	5495000	21
9	9	1996	Rocky Harbour Hills	Gerrow Shawn	445000	5495000	21
29	3	1997	Grassy Brook Weather Stn.	McCarthy Chris	435000	5505000	21
5	6	1997	Big Island Pond	McCarthy Chris	455000	5505000	21
5	6	1997	Rocky Harbour Hills	McCarthy Chris	445000	5495000	21
19	8	1997	Top of Scree, Gros Morne Mountain	Wagener Dave	445000	5495000	21
25	3	1997	Big Island Pond South	S. Gerrow, G. Brown	455000	5505000	21

25	3	1997	Big Island Pond South	S. Gerrow, G. Brown	455000	5505000	21
25	3	1997	Big Island Pond South	S. Gerrow, G. Brown	455000	5505000	21
13	4	1997	Arm Pond South	S. Gerrow, G. Brown	465000	5515000	21
20	3	1999	Big Island Pond South	S. Gerrow, T. Gallant	455000	5505000	21
20	3	1999	Big Island Pond South	S. Gerrow, T. Gallant	455000	5505000	21
20	3	1999	Big Island Pond South	S. Gerrow, T. Gallant	455000	5505000	21
20	3	1999	Big Island Pond South	S. Gerrow, T. Gallant	455000	5505000	21
28	3	1999	Black Cliff/ Candlestick	S. Gerrow, T. Gallant	455000	5495000	21
28	3	1999	Black Cliff/ Candlestick	S. Gerrow, T. Gallant	455000	5495000	21
28	3	1999	Black Cliff/ Candlestick	S. Gerrow, T. Gallant	455000	5495000	21
29	3	1999	Grassy Brook	S. Gerrow, T. Gallant	445000	5505000	21
29	3	1999	Grassy Brook	S. Gerrow, T. Gallant	445000	5505000	21
29	3	1999	Two Rock Pond	S. Gerrow, T. Gallant	445000	5505000	21
29	3	1999	Two Rock Pond	S. Gerrow, T. Gallant	445000	5505000	21
29	3	1999	Grassy Brook	S. Gerrow, T. Gallant	455000	5505000	21
29	3	1999	Grassy Brook	S. Gerrow, T. Gallant	455000	5505000	21
28	3	1999	Black Cliff/ Candlestick	S. Gerrow, T. Gallant	455000	5495000	21
12	3	2000	Black Cliff/ Candlestick	S.Gerrow, R. Thompson	455000	5495000	21
12	3	2000	Black Cliff/ Candlestick	S.Gerrow, R. Thompson	455000	5495000	21
12	3	2000	Black Cliff/ Candlestick	S.Gerrow, R. Thompson	455000	5495000	21
19	3	2000	Big Island Pond South	S. Gerrow, B. Roberts, C. Roberts,	455000	5505000	21
19	3	2000	Big Island Pond South	S. Gerrow, B. Roberts, C. Roberts,	455000	5505000	21
19	3	2000	Big Island Pond South	S. Gerrow, B. Roberts, C. Roberts,	455000	5505000	21
19	3	2000	Big Island Pond South	S. Gerrow, B. Roberts, C. Roberts,	455000	5505000	21
19	3	2000	Big Island Pond South	S. Gerrow, B. Roberts, C. Roberts,	455000	5505000	21
19	3	2000	Big Island Pond South	S. Gerrow, B. Roberts, C. Roberts,	455000	5505000	21
21	3	2000	Two Rock Pond	S.Gerrow, R. Thompson, B. Roberts, C.Roberts	445000	5505000	21
21	3	2000	Two Rock Pond	S.Gerrow, R. Thompson, B. Roberts, C.Roberts	445000	5505000	21
21	3	2000	Two Rock Pond	S.Gerrow, R. Thompson, B. Roberts, C.Roberts	445000	5505000	21
21	3	2000	Two Rock Pond	S.Gerrow, R. Thompson, B. Roberts, C.Roberts	445000	5505000	21
24	3	2000	Little Island Pond East	S.Gerrow, S. Flemming, C.Roberts, E. Muntz	455000	5505000	21
24	3	2000	Little Island Pond East	S.Gerrow, S. Flemming, C.Roberts, E. Muntz	455000	5505000	21
24	3	2000	Little Island Pond East	S.Gerrow, S. Flemming, C.Roberts, E. Muntz	455000	5505000	21
24	3	2000	Little Island Pond East	S.Gerrow, S. Flemming, C.Roberts, E. Muntz	455000	5505000	21
24	3	2000	Little Island Pond East	S.Gerrow, S. Flemming, C.Roberts, E. Muntz	455000	5505000	21
4	4	2000	Big Hill North	S.Gerrow	445000	5485000	21
4	4	2000	Big Hill North	S.Gerrow	445000	5485000	21

8	4	2000	Arm Pond South	S. Gerrow, T. Gallant	465000	5515000	21
8	4	2000	Arm Pond South	S. Gerrow, T. Gallant	465000	5515000	21
8	4	2000	Arm Pond South	S. Gerrow, T. Gallant	465000	5515000	21
16	4	2000	Glassy Brook	S.Gerrow, T. Gallant	445000	5505000	21
16	4	2000	Glassy Brook	S.Gerrow, T. Gallant	445000	5505000	21
16	4	2000	Glassy Brook	S.Gerrow, T. Gallant	445000	5505000	21
16	4	2000	Glassy Brook	S.Gerrow, T. Gallant	445000	5505000	21
16	4	2000	Glassy Brook	S.Gerrow, T. Gallant	445000	5505000	21
16	4	2000	Glassy Brook	S.Gerrow, T. Gallant	445000	5505000	21
16	4	2000	Black Cliff/ Candlestick	S.Gerrow, T. Gallant	455000	5495000	21
19	4	2000	Nipple Pond East	S.Gerrow, T. Gallant	465000	5515000	21
21	3	2000	Two Rock Pond	S.Gerrow, R. Thompson, B. Roberts, C.Roberts	455000	5505000	21
5	4	2003	Big Hill	S.Gerrow, T. Gallant	445000	5485000	21
9	4	2003	Big Island Pond	S.Gerrow, S.Taylor, T.Gallant	455000	5505000	21
9	4	2003	Big Island Pond	S.Gerrow, S.Taylor, T.Gallant	455000	5505000	21
9	4	2003	Big Island Pond	S.Gerrow, S.Taylor, T.Gallant	455000	5505000	21
10	4	2003	Little Island Pond	S.Gerrow, S.Taylor, T.Gallant	455000	5505000	21
22	4	2003	Candlestick/Black Cliff	S. Gerrow, T. Gallant, S. Taylor	455000	5495000	21

Appendix B. Supplementary Details

Hypotheses for the historic decline of arctic hare range subsequent to the introduction of snowshoe hare in Newfoundland include the snowshoe hare's agonistic behavior toward arctic hare (interference competition; Howley 1913), its more efficient exploitation of the common winter food resource (exploitation competition; Cameron 1958, Dodds 1960), and increased predation of arctic hare by lynx (*Lynx canadensis*) populations at greater abundance following irruption of snowshoe hare (Bergerud 1967). A progression of studies (Mercer et al. 1981, Hearn et al. 1987, Barta et al. 1989, Fitzgerald and Keith 1990, and Small et al. 1992a, 1992b) tested hypotheses of arctic hare decline with field (mainland populations) and experimental (hares and predators introduced to off-shore islands) studies. In summary, their findings suggested that: 1) arctic hare populations persist at low densities (~ 1 / km^2) on the island of Newfoundland; 2) arctic hare population growth is limited on the island of Newfoundland by red fox (*Vulpes vulpes*) predation on juveniles; 3) arctic hare are socially (behaviourally) dominant over snowshoe hares thus their absence from forested areas likely did not result from interspecific competition (antagonism); 4) in the absence of snowshoe hares and mammalian predators, forested regions where interspersed with small patches of barrens, can support arctic hare populations at low densities; 5) arctic hare are significantly more vulnerable than snowshoe hare to fox predation; and 6) arctic hare are less efficient at utilizing food resources in forested environments. However, both the lynx and red fox increased in numbers following the introduction of the snowshoe hare (Dodds 1960, Dodds 1965). Thus, Small (1990) concluded that is it appeared plausible that some retraction of arctic hare populations from forested regions, particularly those areas interspersed with smaller patches of barrens, may have occurred following introduction of the snowshoe hare. This indirect effect is consistent with predator-prey models (Holt 1977) in which one prey species negatively affects the distribution and abundance of another through a shared predator. These conclusions may be of particular importance when considering **Threats and Limiting Factors** to the current and future distribution of arctic hare on the island of Newfoundland.