STATUS REPORT

on

The Canada Lynx in Nova Scotia

Loup-Cervier
***(Lynx canadensis* (Kerr 1792))**

by

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FINAL

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TECHNICAL SUMMARY

DISTRIBUTION

Extent of occurrence: approximately 12,000 k2 (Cape Breton Island)

Area of Occupancy: approximately 4,800 km2 (Cape Breton Highlands)

POPULATION INFORMATION

Total number of individuals in the Cape Breton Island population: Uncertain but at the high in the cycle densities possibly range from 10-11 lynx/100km2 (~475-525 individuals) and at the low in the cycle from 2-3 lynx/100 km2 (~95-140 individuals)

Number of mature individuals in the Cape Breton Island population (effective population size): Depends upon the point in the population cycle; at lows most individuals are mature (>2 years old) while at cyclical highs only ~20-30% of population are mature.

Generation time: 2-5 years, varying with the cycle in reproduction. Recruitment may fail for 3-4 years during the low of the 10-year snowshoe hare cycle.

Population trend: _____ declining _____increasing
__**X**___ stable _____unknown

Number of sub-populations: Probably only one (1), most of which breed on the Cape Breton Highlands.

Is the population fragmented? Generally not; small numbers (10-30) may breed east of Bras d'Or Lake.

Number of historic sites from which species has been extirpated: since ~1950, all of mainland Nova Scotia.

Does the species undergo fluctuations? Yes, ~10-year cyclical fluctuations closely allied with the 10-year cycle of snowshoe hare.

THREATS

Main threats for the Cape Breton Island population are identified as interspecific

competition with coyotes and bobcats, global warming and ameliorating winters, and reduced population viability through population isolation and limited genetic diversity. Consideration should be given to possible threats from human harvest (at cyclical lows), disease and habitat change from forestry operations.

RESCUE POTENTIAL

Does species exist outside Nova Scotia? Yes, across boreal/taiga zone of continental North America and in limited numbers in New Brunswick and several of the northern contiguous states, such as Maine in the northeast.

Is immigration known or possible? Not likely for Cape Breton Island population; possible into mainland Nova Scotia from New Brunswick.

Would individuals from the nearest foreign population be adapted to survive in Cape Breton Island? Yes.

Would sufficient suitable habitat be available for immigrants? Probably available habitat currently at capacity.

RESPONSE STATEMENT

[This page is not for authors. It will be completed by the Nova Scotia Species at Risk Working Group (NSSRWG) Chair after the species has been considered and designated by NSSRWG.]

NSSRWG DESIGNATION AND SUMMARY OF REASONS

[Category assigned by NSSRWG to the species]

[Summary of reasons clearly stating the facts, criteria-based rationale and other factors that led to the above conclusion.]

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EXECUTIVE SUMMARY

Description

The Canada lynx *(Lynx canadensis*) and the bobcat (*Lynx rufus*) are the two wild felids native to the province of Nova Scotia. The Canada lynx, although similar in appearance to the bobcat, is longer limbed with larger paws, has longer ear tufts, a totally black-tipped tail and a somewhat less spotty and lighter-coloured pelage, especially in winter. Only one species (*L. canadensis*) is recognized throughout North America. Adult male and female lynx in Nova Scotia weigh approximately 8 and 10 kg., respectively.

Distribution

Lynx were once distributed on mainland Nova Scotia, especially the Cobequid Mountain, Pictou Uplands and Musquodoboit Hills Districts of the Maritime Uplands Ecoregion in the northern and northeastern portions of the province. However, for the past 40-50 years, the breeding range of lynx has been restricted to Cape Breton Island, and there mainly to the Highlands of Victoria and Inverness Counties (~4,500 km2) and several small areas on the eastern shore of Bras d'Or Lake (~270 km2). The absence of lynx on the mainland has reduced historic breeding range in Nova Scotia by at least 50-60%. The distribution of lynx on Cape Breton Island has remained stable for at least the past 30 years.

Habitat

Continental lynx populations reach their highest densities in boreal and mixed wood forests, and prefer a habitat of diversified age which supplies habitat required for denning, cover and food. Lynx are highly dependent on snowshoe hare (*Lepus americanus*) for food, and hares are most common in young (10-25 years), dense, mixed regenerating forest stands. On Cape Breton Island, most lynx are found on the western Highlands where a balsam fir (*Abies balsamea*) dominated mixed forest, susceptible to periodic infestations of the spruce budworm (*Archips fumiferana*), has traditionally provided a landscape supporting an attractive landscape mosaic of older-aged and regenerating conifer-mixed forest stands. From this core breeding range lynx, during periods of abundance and in the first years following a crash of snowshoe hares, have regularly dispersed onto adjacent lowlands at ~10 year intervals.

Population Size and Trend

Total numbers of lynx on Cape Breton Island may vary from approximately 475-525 (10-11 lynx/100 km2) in times of abundant snowshoe hare and high lynx productivity to 95-140 (2-3 lynx/100 km2) during intervening years of low snowshoe hare densities. These densities are

comparable to northern mainland taiga lynx populations where productivity and survival are highly dependent upon abundance/availability of snowshoe hare. These density estimates operate within a fairly well-defined ~10-year cycle and, similar to range limits, appear to have changed little over the past 30-40 years.

Limiting Factors and Threats

The most significant threat identified for northern taiga lynx populations is over-trapping during years of suppressed productivity and reduced densities. Most jurisdictions now recognize that threat and regulate harvests accordingly. Except for a small aboriginal harvest (~4-5 per year), which was closed several years ago for conservation reasons, the trapping of lynx in Nova Scotia has been illegal since 1980. A small number of lynx (~5-7 per year) are now accidentally taken each year in traps and snares set for other furbearers such as bobcat (*Lynx rufus*), fox (*Vulpes vulpes*) and eastern coyotes (*Canis latrans*). Although of concern, this source of mortality, if it does not measureable increase, should not by itself pose a threat to the overall viability of the population.

A substantial portion of the Highlands has received extensive disturbance from forest harvesting operations over the past 30 years, especially during the period of spruce budworm salvage operations in the late-1970s and early-1980s. Evidence for healthy snowshoe hare and lynx population peaks on the Highlands in 1988-90 and 1998-2000 suggests that both species managed to survive that era of "single resource" exploitation and significant deforestation. That encouraging observation, combined with a new era of "multi-resource" ecological landscape management based upon sustainability and ecological processes suggests that, with future resource management strategies developed through coopperative planning between industry and government and enhanced programs of ecological research and wildlife population monitoring, the habitat for lynx appears secure for the foreseeable future.

Both the bobcat and coyote have been identified as potential threats to viable lynx populations, especially in southern boreal/montane habitats, and both potential competitors are found on Cape Breton Island. In the absence of cause/effect research into interspecific competition and which might show otherwise, there is no historical correlational evidence that either has adversely affected lynx densities or range limits in the past 20-30 years. More subtle and longer-term threats include global warming and subsequent climate change, decline in population viability through limited gene flow and genetic diversity and disease, such as the recent isolation of canine distemper.

Lynx Management

Except for a small aboriginal harvest (~4-5 per year), which was recently eliminated for conservation reasons, there has been no public trapping of lynx in Nova Scotia since 1980. The current restriction of occupied range, susceptibility of lynx to being trapped, and the uniqueness of this small and isolated population to the faunal diversity and richness of the province, suggests that the species should receive continued protection from public trapping. Also, if

population monitoring indices show densities significantly below those expected within the normal limits of the 10-year cycle, total closure to human exploitation would be appropriate. Lynx research and management recommendations are provided.

Existing Protection

In the United States south of the 49th parallel, the Canada lynx was listed as threatened in March, 2000 under the United States Endangered Species Act. The most recent (May, 2001) COSEWIC status for lynx in Canada is "Not at Risk." Except for New Brunswick and Nova Scotia (and Prince Edward Island where they are extirpated), lynx are managed in all provinces and Territories of Canada by regulated trapping seasons. In New Brunswick the lynx was listed as an endangered species in 1982 under the provincial Endangered Species Act and receives full protection. In Nova Scotia the lynx receives protection by not being included among those game animals which can be hunted and/or trapped. In 1996 the species was assigned "RED" status, indicating the species is at risk.

Evaluation of Proposed Status

The most recent (2000) COSEWIC status report recommended the status "NOT AT RISK" to the Canada lynx at the national level, a recommendation approved by COSEWIC in May, 2001.That report could find no evidence of decline in populations or distributions of lynx over the past two decades and given their high potential productivity and extensive pattern of dispersal combined with reduced harvests and a greater awareness of the need for proactive lynx management, the future of the species in Canada was considered to be secure. However, that report also recognized examples of local southern populations which have experienced reductions in both numbers and distribution.

The lynx population of Nova Scotia is one of those examples and although its range in the province appears to have remained stable for the past 40-50 years, lynx do remain isolated in distribution to parts of Cape Breton Island and do not benefit from immigrants from other populations. For this reason, and because of potential threats to Cape Breton Island lynx from sympatric bobcats and eastern coyotes, forestry operations and possibly other localized factors not yet fully understood (e.g. canine distemper), it appears prudent for Nova Scotia to assess the status of the Cape Breton Island lynx in a more conservative fashion. For those reasons it is recommended that the lynx of Nova Scotia be assigned "SPECIAL CONCERN" under the Nova Scotia Endangered Species Act, a status which means that the species is particularly sensitive to human activities and specific natural events but, at this time, is not an endangered or threatened species.

SPECIES INFORMATION

Name, Classification

The distribution of the Canada lynx (*Lynx canadensis* (Kerr 1792)) across most of Canada, from Newfoundland/Labrador and eastern Quebec west and northwest through Yukon and into Alaska is generally considered continuous although, especially during cyclical continental population lows, certain "metapopulation" or core breeding areas may be considered temporarily isolated. Such geographical foci of distribution, however, are normal and with the extensive pattern of lynx dispersal during years of high densities, and immediately following crashes of snowshoe hares, genetic interchange is considered sufficient to classify it as one subspecific monotype. Although there remains considerable debate on the proper taxonomy of the global felid family (Werdelin 1996), it is generally accepted that the North American lynx (*Lynx canadensis*) is sufficiently distinct from the Eurasian lynx (*Lynx lynx*) to justify full species status (Hall 1981; Wozencraft 1993).

In North America there has been disagreement on whether the lynx on insular Newfoundland represent a distinct subspecies (*L. canadensis subsolanus (*Bangs 1897) (Banfield 1974; Tumlison 1978) or not (van Zyll de Jong 1975). Until current DNA analyses of lynx tissue samples collected from various regions of North American lynx range are completed, it is perhaps advisable to consider lynx as monotypic throughout North America. Tissue samples from Cape Breton Island lynx are included in those analyses.

Although on occasion there are lynx recovered on the mainland of Nova Scotia, which presumably would have emigrated from Cape Breton Island, there is little possibility of lynx from other geographical populations crossing the Canso Strait onto Cape Breton Island - the small numbers of lynx in New Brunswick are restricted to the extreme northwest with only occasional recoveries in the southeast, and dispersion from that source onto Cape Breton Island is highly unlikely. Current genetic analyses of lynx tissue samples (muscle, heart, kidney, liver) from Maine, Quebec, New Brunswick, Nova Scotia and Newfoundland are being conducted at the National Cancer Institute's Laboratories of Genomic Diversity in Frederick, Maryland. The main objective is to understand the felid genome and disease associations - these analyses will prove critical to state, provincial, and federal wildlife management agencies relative to lynx metapopulation dynamics in eastern North America. These analyses will elucidate the degree of isolation versus mixing of adjacent lynx populations. For this report, and until the results of the genetic analyses are completed, the lynx on Cape Breton Island are considered to be an eastern extension of the continental monotypic species *Lynx canadensis*.

DISTRIBUTION

North America

Throughout North America, Canada lynx are generally considered to be distributed in one of two spatial and demographic patterns: 1/ a broad northern and fairly continuous continental distribution which, in general, includes that vast area from the southern terminus of the boreal forest north to the edge of the treeline, and extends from Newfoundland/Labrador to Alaska, often referred to as the *northern taiga population,* and 2/ small fragmented and often threatened "metapopulations" scattered in favoured habitats in a few northern states south of the 49th parallel, in northwestern New Brunswick and, in Nova Scotia, on Cape Breton Island, and referred to as *southern boreal populations* (Mowat et al. 1999; Aubry et al. 1999) (Figure 1). Lynx habitat quality is believed to be lower in the southern periphery of its range because landscapes are more heterogeneous in terms of topography, climate, and vegetation (Buskirk et al 2000).

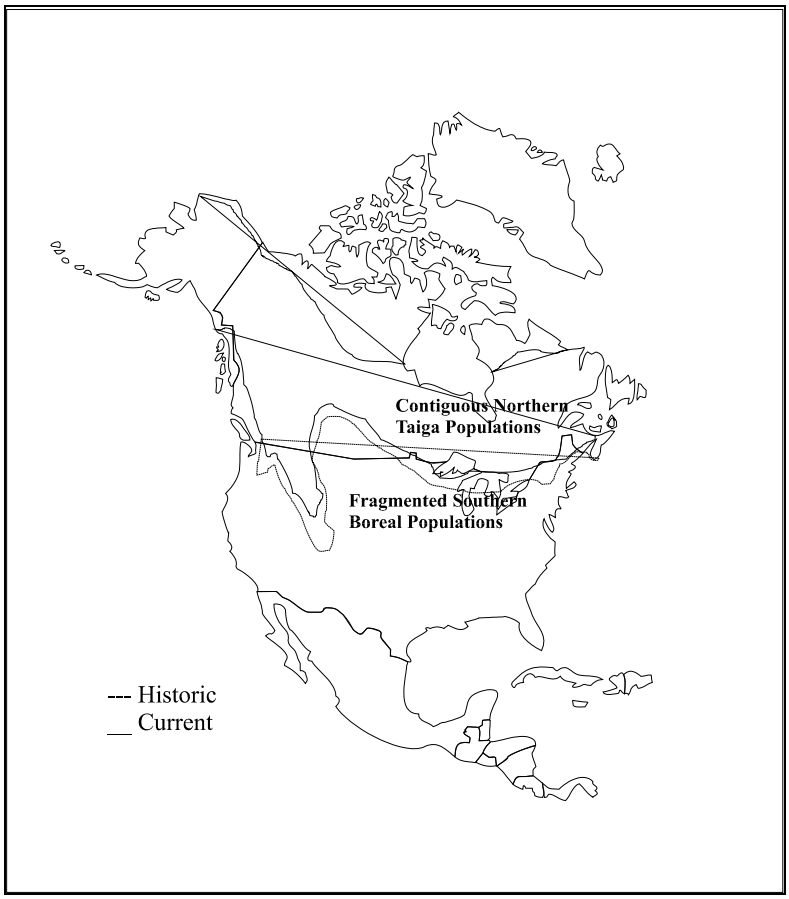

Figure 1: Current and historic distribution of Canada lynx in North America (Poole, 2000).

Northern populations "crash" approximately 1-2 years following the decline in snowshoe hares, a period when lynx experience significant declines in productivity and increases in dispersal and emigration (Brand et al. 1976; Keith 1963; Mowat 1993). Densities of lynx in northern populations vary from 10-11/100 km2 during peak years of productivity to 2-4/100 km2 during intervening years of low food availability. Southern boreal populations, such as those found in parts of Washington and northern Maine, do not appear to experience such predictable and measurable changes in abundance as those in northern forest systems. This may be due to more stable hare populations in southern portions of their range (Adams 1959; Keith 1963; Dolbeer and Clark 1975; Wolff

1980) which in turn may be a response to fragmented and diversified landscapes. Southern populations appear to maintain densities at suppressed levels of 2-3/100 km2, densities comparable to those during the lows of the northern taiga lynx cycle (Keith 1963; Koehler and Aubry 1994).

In Canada, the lynx is distributed in parts of all Provinces and Territories, except Prince Edward Island where it is extirpated, and, with the exception of Nova Scotia and New Brunswick, is recognized as a furbearer and managed through regulated harvests (Quinn and Parker 1987). In New Brunswick the lynx is considered to be "Regionally Endangered" - threatened with imminent extirpitation throughout all or a significant portion of its range (Cumberland et al. 1998), and in Nova Scotia was classified as a RED species (species of special concern) in 1996 under the provincial Status of Wildlife Assessment Process and are protected throughout the province. The lynx will probably be listed under the Nova Scotia Endangered Species Act (NSESA). Until this process is completed, a "best interim" Special Management Practices for Lynx was drafted in March, 2000.

This report was commissioned by the Nova Scotia Department of Natural Resources to evaluate the past, present and projected status of lynx in Nova Scotia and to serve as a reference document for the Nova Scotia Species at Risk Working Group when considering a recommendation for legal status of lynx in the province.

The United States Fish and Wildlife Service considers lynx to have at one time been a resident species in 16 states in the contiguous United States (Hickenbottom et al., 1999). By 1999, four of those states had classified the lynx as endangered (Vermont - 1972; New Hampshire - 1980; Michigan - 1987; Colorado - 1976) while in Washington it is classified as threatened. Utah recognizes the lynx as a sensitive species, Massachusetts and Pennsylvania classify the lynx as extirpated, in Maine, where in 1999 nine lynx were radio-collared and kittens found, the species is recognized as one of special concern and in Wisconsin the lynx has been reclassified as a state protected species with a closed season. Several states, such as New York, Minnesota, Wyoming, Idaho and Oregon recognize the lynx as a small game or furbearer but is fully protected from legal harvest. In these states lynx occur almost exclusively in the southern extensions of the boreal forest habitat type (McKelvey et al., 1999) where they occupy a mosaic between boreal forests and subalpine coniferous forest or northern hardwoods (Barbour et al., 1980; McCord and Cardoza 1982; Koehler and Aubry 1994). In most instances lynx are more common in areas with higher than average elevations.

Chris Hoving (MS student, University of Maine, Orono, pers com.) gathered information on lynx sightings in the northeast for the 15 year period 1985-1999 and found no records for Vermont, Massachusetts, Rhode Island, Connecticut or New York (excluding the attempted reintroduction in the 1990s). Hoving found 3 records for New Hampshire and 50 for Maine. To put this into a Maritime perspective, but realizing that the data are not weighted for "degree of searching effort," he found 200 from Nova Scotia and 21 for New Brunswick.

In the northeastern states most plotted lynx occurrences fall within the Mixed Forest - Coniferous Forest - Tundra province and associated with elevations of 250 - 500 m asl (800 - 2,460 ft asl). Prevalent habitats include coniferous and mixed coniferous/deciduous vegetation types dominated by spruce (*Picea* spp), balsam fir, pine (*Pinus* spp), northern white cedar (*Thuja occidentalis*), hemlock (*Tsuga canadensis*), aspen (*Populus* spp) and paper birch (*Betula*

papyrifera) (Ruediger et al., 2000). Elevation and conifer dominated habitat are predominant factors in lynx distribution in those northern states - in the western United States most occurrences were within the 1,500 - 2,000 m asl (4,920 - 6,560 ft asl) elevation zones of the Rocky Mountain Conifer Forest (McKelvey et al. 2000).

In 1882, the American Naturalist Dr. C. Hart Merriam wrote the following on the distribution and abundance of lynx in New York. "The lynx is and so far as I can learn has always been a rather rare inhabitant of this region" (*in* Miller 1899). Merriam also reported that the bobcat, "...which once ranged throughout the state, appears to be now exterminated except in the wilder parts of the Adirondacks, the Catskills and the Hudson Highlands. It is, however, an animal that resists the progress of forest clearing much more than the lynx" (*in* Miller 1899). By the turn of the last century, Miller believed that "The Canada lynx is rapidly approaching extinction in New York and in fact throughout the eastern part of its range" (Miller 1899). In Vermont, Osgood (1938) stated that the Canada lynx was "Formerly taken occasionally. The last record actually checked was in 1928." Bobcat were also reported as "occasional," with bounties paid on only 20 in 1936. And in 1930 Crane reported that the Canada lynx was very rare in Massachusetts, and as early as 1840 was considered a "straggler." The bobcat, however, was fairly common, and was "...increasing throughout New England in recent years, following a long period of relative scarcity" (Crane, 1930).

In New York, the lynx is currently classified by state law as a small game animal, but Department of Environmental Conservation (DEC) regulations do not permit a lynx harvest. Although Canada lynx were historically found in New York, it is uncertain whether there were ever self-sustaining resident populations. Most likely lynx in New York were sustained by immigration from other adjacent regions. Between 1989 and 1992, the New York State College of Environmental Science and Forestry at Syracuse University (CESF) conducted an experimental program of lynx releases in northern New York. Over 80 lynx were caught in northwestern Canada and released in the Adirondacks. All of the lynx were radio-collared at the time of release, and the radios provided information on survival and dispersal of these animals. Some of the released lynx dispersed farther than anyone expected. Lynx from the CESF release showed up in Pennsylvania, New Jersey, Massachusetts, New Hampshire, Quebec, Ontario, New Brunswick, and other parts of New York. One lynx was found a straight line distance of 485 miles from the release site, 8 months later and 2 pounds heavier than at the time of release. Home ranges of the released lynx were large, and there is still no firm evidence of lynx reproduction. The success of the New York lynx introduction remains in doubt (from New York State Department of Environmental Conservation home page - Canada Lynx Fact Sheet)

In March, 2000, the National Wildlife Federation issued a statement claiming that the decline of lynx in the lower 48 states of USA "**. . .** stemmed from forest destruction and human encroachment into its deep-woods habitat, excessive trapping in the 1970s and 1980s and expansion of competitors such as bobcats and coyotes." On March 21, 2000, the USFWS listed the Canada lynx as "Threatened" under the Endangered Species Act in the contiguous United States. A species is listed as threatened when "**. . .** it is likely to become endangered throughout all or a significant portion of its range in the foreseeable future." As well, in most of those northern states in which lynx currently, or at one time did occur, the lynx is classified as "Endangered" or "Threatened" and are fully protected. At the national level in Canada, the most

recent Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Report recommended that the status of lynx in Canada should be "Not at Risk" (Poole, 2000), a recommendation approved by COSEWIC in May, 2001.

Maritimes

Historical records show that lynx have an extended history in New Brunswick (Cumberland et al. 1998). Squires (1946) considered the "....position of the two lynxes in our fauna have been reversed - that the Canada lynx was formerly so much the more common that it was the only one that came to the attention of many of the [early] writers, whereas of late years it has become almost extinct in the Province while the wildcat is now abundant. The Chief Game Warden stated that a Canada lynx trapped in Albert County in 1943 was the first which had been reported to him in fifteen years." It is likely that the bounty placed on "wildcats" in New Brunswick in 1898 and which continued through to 1962 contributed to the decline in lynx in that province as the carcass or parts of carcass would have qualified for the bounty [in many instances only the skinned carcass or the nose or snout were required for payment]. By the mid-1800s, Chamberlain (1844) listed the Canada lynx, Loup-cervier or Loocervee and the Bay lynx or Wild Cat as both common in the province of New Brunswick. By the late-1940s, Morris (1948) described the lynx of New Brunswick as "...formerly common, but now very rare and restricted to the more remote parts of the Province.... Within the present century... it has greatly decreased in numbers and is now on the verge of extirpation."

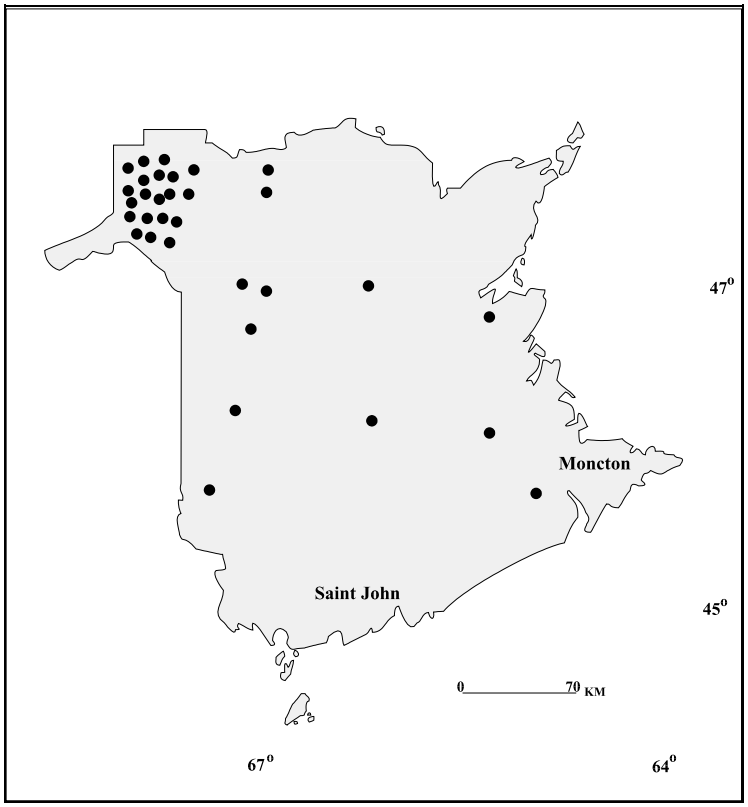

Figure 2: Distribution of 32 lynx recovered in New Brunswick: 1973-2000 (from Cumberland et al. 1998 - revised to 2000).

The last year that lynx were legally exported from New Brunswick was in 1929, when 29 lynx were trapped (McAlpine and Heward 1993). Banfield (1974) believed that the lynx became absent from New Brunswick around 1943 although some believe that the species was never completely extirpated from the province (McAlpine and Heward 1993). Around 1950 Bruce Wright, reporting on the status of lynx in New Brunswick, wrote "The last report that I have of a lynx was one shot in Charlotte County on November 12, 1943, and the chief game

warden states that he had not heard of one being taken in the previous 15 years. That would date the virtual extirpation of the species [in New Brunswick] about 1928, or earlier" (de Vos and Matel 1952). The province-wide decline is similar to that documented for Nova Scotia. However, with the elimination of bounties on bobcats in 1961, the proclamation of the New Brunswick Endangered Species Act (NBESA) in 1976 and admendment of the NBESA in 1982 to list the lynx as an endangered species with full legislative protection, lynx appear to have recovered over the past 25-30 years, especially over the past decade. Twenty-nine lynx have been "accidentally" recovered in New Brunswick from 1992 through 2000, most in the extreme northeast portion of the province (Figure 2). The spatial distribution of those recoveries are interesting relevent to the apparent isolation of the lynx on Cape Breton Island from mainland populations. Evidence of breeding was recorded in 4 of 7 female carcasses, suggesting a small and certainly vulnerable breeding population. Recent ground-based surveys have been established to better define abundance and distribution in north-western New Brunswick and to determine whether lynx have established a resident population or represent transients crossing over from Quebec (Forbes et al. 1999).

Lynx were extirpated from Prince Edward Island during the early 1800s, probably due to settlement and habitat destruction (Stardom, 1988). Although fur returns for Prince Edward Island show several lynx caught there in 1969 and 1971, they were believed to have been brought to the province from Newfoundland (Stardom 1988). However, it is quite possible that they were dispersers from Cape Breton Island (it is interesting that fur records show the highest number of lynx trapped on Cape Breton Island was in 1969- see Figure 5).

The historic distribution of lynx in the Maritime Provinces most likely corresponded quite closely with the Maritime Uplands, New Brunswick Highlands and Gaspe - Cape Breton Ecoregions (as described by Loucks 1962). Most of these areas are from 500 - 1200 ft asl and represent some of the most elevated regions of the Maritime Provinces. However, the absence of a significant balsam fir component to all but the Cape Breton Highland and Green River Districts of the Gaspe - Cape Breton Ecoregion appears to be the one factor which limits the cyclical nature of snowshoe hare and, consequently, suppressing lynx densities. It is interesting that today most of the regions of the Maritimes which appear to support breeding lynx lie within the Gaspe - Cape Breton Ecoregion.

Nova Scotia

For this report I have chosen to review the distribution of lynx in Nova Scotia relative to: 1/ historic (<1920 - prior to credible fur trapping records), 2/ recent (1920 to 1955 - completion of the Canso Causeway and subsequent ingression of the bobcat to Cape Breton Island), and 3/ current (since lynx have been restricted to Cape Breton Island i.e. ~1955 to the present).

First, however, it must be recognized that most of the forested landscape in the Maritime Provinces does not represent what is generally considered favoured lynx habitat. Most continental lynx populations are closely tied to regional abundance and distribution of snowshoe hares, and hare populations throughout much of the circumpolar boreal region typically exhibit fluctuations which closely follow a ~10 year cycle. In more temperate regions where forested landscapes have been fragmented from human disturbances (agriculture, forestry, urbanization),

hare populations seldom exhibit predictable and well defined numerical fluctuations. Rather, regional hare populations often show local differences in levels of abundance, most likely driven by the wide array of habitat change at the woodlot level, combinations of which provide a virtual unlimited diversity of preferred food and cover.

Second, there is evidence to suggest that the Maritime Provinces have experienced periodic long-term changes in prevailing climatic conditions and consequent changes to native fauna and flora. It was not until the early 1800s, for instance, that white-tailed deer reoccupied extreme southern New Brunswick and did not reach Nova Scotia (through natural ingression and several introductions from New Brunswick) until the latter part of the century. White-tailed deer brought with them the parasite *P. tenuis,* and the subsequent spread of that parasite among resident moose and caribou certainly contributed to their decline and, in the case of the caribou, extirpation. The bobcat, historically a resident of Nova Scotia and New Brunswick, was most likely present in low numbers due its frequent association with more temperate climate and food species associated with diversified and disturbed habitat. The bobcat is less dependent upon snowshoe hare than the lynx (Parker and Smith 1983) and also appears to be a direct and more efficient competitor with lynx. The aforementioned is important relative to understanding the historic and current abundance and distribution trends of lynx in Nova Scotia.

Historic (<1920) - The earliest written records suggest that the Canada lynx has a long history of occurrence throughout the Maritime Provinces. As early as the mid 1600s, Nicolas Denys described how the Micmac Indians frequently used dogs to pursue and tree lynx, which were then killed, the furs of which were used for "winter robes" (Denys 1672). But it was not until the early 1860s that Bernard Gilpen left us the following descriptive account that we have some published records on the abundance and distribution of lynx, or "Loupcervier," in Nova Scotia (Gilpen 1864).

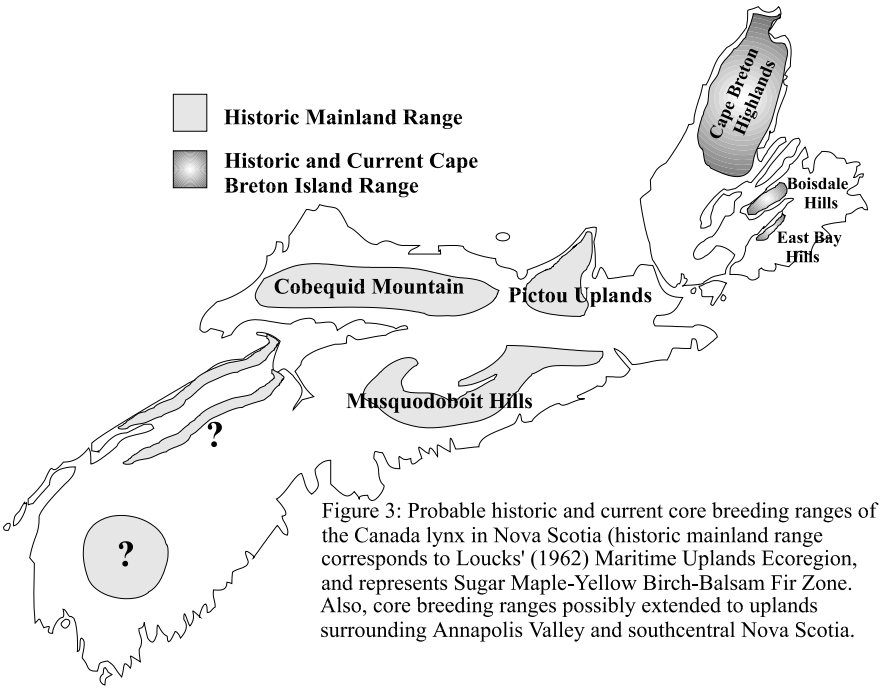

Figure 3: Probable historic and current core breeding ranges of the Canada lynx in Nova Scotia (historic mainland range corresponds to Loucks' (1962) Maritime Uplands Ecoregion, and represents Sugar Maple-Yellow Birch-Balsam Fir Zone. Also, core breeding ranges possibly extended to uplands surrounding Annapolis Valley and southcentral Nova Scotia.

"This true boreal species, reminding us of the alpine hare, the ptarmigan, the spruce grouse, and the snow owl, in his well-furred limbs, is abundant

in the Province. He loves the thick covers and dense spruce-pine woods of the midland counties of King's and Annapolis, in which he hunts the varying hare, and surprises the dusky grouse, and from which he descends at night to the barns and sheepfolds in the cleared land. He is very destructive to sheep. He rarely is found near the seaboard, or amongst the scanty cover of the granite hills where the red cat [bobcat] abounds, and never like the latter comes out in the open, or into the town in daylight...About twenty-five years ago the country about Annapolis Royal was infested with them, when George Hardwicke, a young farmer, with a love for hunting, introduced hunting them with a foxhound."

It is interesting that Gilpen describes the hills of Kings and Annapolis Counties as favoured habitat for the lynx. This indicates that the lynx may have had a wider distribution in the province than generally believed. Gilpen continues to describe the bobcat, or Wild Cat of Nova Scotia. "Where it [the bobcat] abounds, few or no Loupcerviers are seen. Its food is the same, and it is equally destructive to sheep. Its bolder nature brings it down into open country." When comparing the arrival of the lynx and bobcat to Nova Scotia, Gilpen thought that "....the Loupcervier is a true boreal animal with a limited range...On the other hand, the Wild or Red Cat has become indigenous at a far later period." He considered the bobcat to be from "....a more southern centre of origin."

Gilpen found it strange that "...the less boreal animal [the bobcat] is the more abundant - the Wild Cat skin being exported at the rate of five hundred and fifty or more and the Loupcervier is becoming scarce and is exported at the rate of about two hundred and forty."

Given the current "restriction" of most southern lynx populations to forested wilderness landscapes usually above 500 ft asl, the historic core breeding areas for lynx on mainland Nova Scotia may have approximated the uplands of the northern and northeastern sectors of the province, and described by Loucks (1962) as the Cobequid Mountain, Pictou Uplands and Musquodoboit Hills Districts of the Maritime Uplands Ecoregion (Figure 3). As well, and as described by Gilpen (1862), during times of population peaks lynx probably dispersed from these core areas throughout most parts of the province, and there may have been small and isolated core areas within other elevated topography such as the North and South Mountains which lie on either side of the Annapolis Valley, and which might explain periodic abundances of lynx in such places as Annapolis Royal around 1837. There are also references to lynx in southwestern Nova Scotia although there may have been some confusion between lynx and bobcat.

Recent (1920 - 1955)- A.L. Rand came to Nova Scotia from Cornell University in the summers of 1929 and 1931 to study wildlife in western Nova Scotia (Rand 1933). He saw no lynx and reported it to be rather rare, the species having continued to decline since Gilpen's observations some 65 years earlier, with only 35 lynx skins exported from Nova Scotia in 1927 compared to 1,142 "wildcat skins." In 1940, R.W. Smith, from the California Museum of Vertebrate Zoology, published on the land mammals of Nova Scotia and described the lynx as having been "... formerly [distributed] throughout most of the Province but now extinct or exceedingly rare on the mainland but found still on Cape Breton Island" (Smith 1940). He remarked that the lynx had been decreasing in the province through the 1930s and many people considered them to be extirpated from the mainland. He attributed the decline to the loss of undisturbed forests from

fire and excessive cutting. He cautioned that even on Cape Breton Island lynx were becoming fewer each year.

In 1950, C.W.I. Creighton, Deputy Minister for Nova Scotia Department of Lands and Forests, reported that lynx, which had once been found throughout the entire province, were then confined to Cape Breton Island. "We do not know of any animal having been trapped on the mainland during the past thirty years or more [i.e. since 1920], although it is possible that a few animals do remain" (de Vos and Matel 1952). The first year that a license was required for residents to trap lynx was i 1976. Prior to that, residents only required a license to trap beaver. There was, however, a 50 cent royalty collected for each lynx pelt exported from the province. Although only a few lynx were taken in western Nova Scotia from 1932 to 1949, they were commonly trapped in the highlands (Cobequid/Antigonish Uplands) of eastern mainland Nova Scotia up to 1945 but harvests dwindled rapidly in this area between 1945 and 1953 (letter from Neil vanNostrand, Nova Scotia Wildlife Biologist, Kentville to Dr. C.G. van Zyll de Jong, Dept. of Mines and Natural Resources, Winnipeg - Feb. 8, 1971).

"The Canso Causeway caused the strait to freeze solid thus forming a 'bridge' for the first time about 1955. Bobcats were first reported from Cape Breton Island in the early 1960s, and by 1970 that species was increasing rapidly over the Cape Breton Island lowlands, a factor which will likely further shrink the lynx range to include only the highlands of Cape Breton" (letter from Neil vanNostrand, Nova Scotia furbearer biologist to Dr. van Zyll de Jong, Dept. of Mines and Natural Resources, Winnipeg - Feb. 8, 1971).

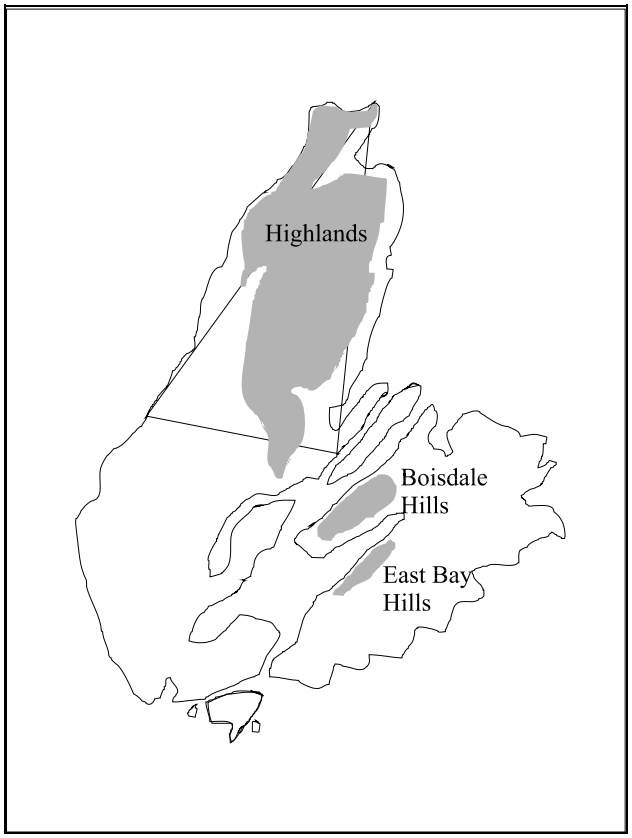

Figure 4: Approximate current distribution of core lynx breeding habitat on Cape Breton Island.

"By winter of 1948-49 records showed that only 34 lynx pelts were exported from the province, and in 1951-52 only 5 pelts were exported. In the winter of 1940-41 lynx were very abundant in the Cape Breton Highlands National Park according to wardens reports. Lynx had become so scarce by 1940 that a cycle was not evident in the records maintained by the Nova Scotia Dept. of Lands and Forests. According to data compiled by the Nova Scotia Dept. of Lands and Forests on the number of lynx pelts exported from the province, approximately 50% are taken on Cape Breton Island" (Cameron 1958). Cameron (1958) also believed that "The bobcat is much less common on [Cape Breton Island] than in peninsular Nova Scotia while the reverse is true with regard to the lynx. According to provincial

fur returns for the period 1932 to 1949, a total of fifteen wildcats were taken on the island, chiefly from Cape Breton County ..... Anderson (1942) states that there are no claims of these mammals occurring on the island, but Clarke (1942) reports that Warden Roach stamped six pelts from the National Park area before the Park was established. No evidence for the occurrence of this species on the island was found by the 1953 field party, and no definite reports were received from woodsmen or trappers. Both the lynx and the bobcat are generally referred to as 'wildcats' with the result that the records are unreliable" (Cameron 1958).

Current - Although the lynx of Cape Breton Island have been considered an eastern extension of the southern boreal populations, their high dependence upon snowshoe hare, low dependence on red squirrels (*Tamiasciurus hudsonicus*) (Parker et al. 1983) [a trait more common to northern than southern populations (Aubry et al. 1999)], and cyclical nature suggest, rather, that they are more similar to northern taiga populations. Northern taiga populations are characterized by periodic, and often predictable numerical fluctuations driven by the 10-year snowshoe hare cycle. The record of lynx trapped and exported from Nova Scotia from 1920 - 1980 (Novak et al 1987; Nova Scotia DNR files) show an approximate 10-year cycle of abundance (Figure 5; Note - almost all lynx exported after 1950 came from Cape Breton Island).

The similarity between northern continental and Cape Breton Island lynx is probably due to one or more of the following factors: 1/ the isolated and wilderness nature of the Highlands; 2/ the elevated topography which favours a spruce-fir-birch dominated boreal-like ecosystem over much of the plateau; 3/ prolonged winters with deep snow cover comparable to northern boreal systems; and 4/ a snowshoe hare prey base which experiences well-defined 10 year numerical cycles. This combination of physical and biological features has created an ecological phenomenon on the Cape Breton Highlands - one where lynx exhibit demographic features comparable to, although significantly isolated from, northern continental taiga populations and which represents a unique ecological feature of the Nova Scotia landscape.

The breeding range of lynx on Cape Breton Island consists of the following three geographically distinct units: 1/ the Cape Breton Highlands; 2/ the Boisdale Hills; and 3/ the East Bay Hills (Figure 4).

The Cape Breton Highlands (~ 4500 km2) - The predominant core of lynx breeding range in Nova Scotia lies above 1000 ft asl and includes portions of Inverness and Victoria Counties of northwestern Cape Breton Island. It includes all of the Cape Breton Plateau (Spruce Taiga Zone $\geq$ 1500 ft asl) and Cape Breton Highland Ecoregion (Fir-Pine-Birch Zone 1000 - 1500 ft asl) and parts of the Cape Breton Hills District (500 - 1000 ft asl) of the Maritime Uplands Ecoregion (Sugar Maple - Yellow Birch - Fir Zone) as described by Loucks (1962).

The Boisdale Hills (~150 km2)- A small portion of the Sugar Maple - Yellow Birch - Fir Zone, characteristic of the Cape Breton Hills District, lies east of the Highlands proper on a peninsula jutting out into the Bras d'Or Lake. Lynx from this small refugium are occasionally seen and killed, often as bycatches by trappers or highway fatalities, within and near the Eskasoni region and east as far as Sydney, especially in years of population highs and subsequent lynx emmigration following a crash in snowshoe hares.

The East Bay Hills (~120 km2)- Similar to the Boisdale Hills, this small area of lynx breeding habitat is located on the eastern shore of Bras d'Or Lake just to the south of East Bay

and possibly represents an extension of the Boisdale breeding range. Lynx from this core breeding area occasionally wander to the south and southwest as far as St. Peters Bay.

We know little of the distribution of lynx on Cape Breton Island prior to the 1960s, a time when bobcats first crossed from the mainland via the Canso Causeway and were rapidly occupying most of the Lowlands. It is reasonable to assume that lynx would have had a greater area of distribution although the core breeding areas would probably have remained as they are today, in synchrony with the boreal-like snowshoe hare population cycle. It is also reasonable to assume that lynx would have experienced significant human exploitation on the Lowlands given their accessibility and susceptibility to trapping, the absence of required trapping licences and subsequent harvest regulations and control and bounty on "wildcats."

HABITAT

Definition

In southern boreal populations of the Northeast, lynx and hare generally prefer conifer and conifer-deciduous habitats above 500 ft asl (Brocke 1982; McCord and Cardoza 1984; Litvaitis et al. 1991). Historic processes of disturbance that create early successional stages exploited by snowshoe hares include fire, insect infestations, catastrophic wind events, and disease outbreaks (Veblen et al. 1998; Kilgore and Heinselman 1990; Agee 2000). Wind and insects are particularly dominant natural processes of forest disturbance on the Cape Breton Highlands. Today, however, the dominant form of forest disturbance is large-scale forestry operations.

Nova Scotia

Review - Since the early part of the 1900s, the lynx of Nova Scotia have been most common on Cape Breton Island, and there, at least since the early 1950s, predominantly restricted to the western Highlands. Even in earlier times the lynx of New Brunswick and Nova Scotia appear to have been restricted to the areas of higher elevations with a moderate component of softwood, especially balsam fir. Such regions supported cyclical populations of snowshoe hare and in winter, due to deep winter snow, were selected against by the bobcat, an apparent superior competitor with sympatric lynx.

Elevated regions of mainland Nova Scotia that likely supported low to moderate densities of lynx in earlier times would have included districts within Loucks' Maritime Uplands Ecoregion, specifically the Cobequid Mountain, Pictou Upland and Musquodoboit Hills Districts (Loucks 1962). This "suggested" historical distribution of lynx is generally supported by early records of lynx abundance and distribution, such as those by Gilpen (1862). With the presence of bobcat throughout the Lowlands of Cape Breton Island at least since the mid-1950s, and the occupation of much of Cape Breton Island by the coyote since the early 1980s, it appears certain that most of the breeding population of lynx will remain restricted to the western Highlands,

with several other small and vulnerable areas of breeding to the east of Bras d'Or Lake, the latter being threatened with extirpation from mortality during lows in the population cycle and/or substantive habitat change through intensive forestry management.

The physiography of the Highlands is characterized by a high plateau, generally over 1000 ft asl and supporting a forest comprised largely of balsam fir, white birch, yellow birch on the Southern Highlands, and spruce. The outside border is characterized by tolerant hardwoods, usually between the 700 - 1,100 ft contours, and dominated by beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*). The soils are variable and consist mainly of sandy loams derived from sandstones, conglomerates, igneus and metamorphic rocks, and granite. Shallow soils and bare bedrock are frequent. An extreme rugged terrain results from the many narrow valleys throughout the District. Short dense spruce and fir alternate with shrub barrens and peat bogs on the flat central portion of the Cape Breton Plateau (Loucks 1962).

Historically, the demographics of lynx on the Cape Breton Highlands have been driven by the 10-year snowshoe hare cycle (Elton and Nicholson 1942) which in turn was influenced by patterns of disturbance and regeneration within the balsam fir dominated forests. Recurring outbreaks of forest disease, especially spruce budworm, was the most common form of disturbance. The "boreal" nature of the Highlands with deep and prolonged snow cover and balsam fir - white birch dominated pattern of successional forest favoured the classical lynx-snowshoe hare cycle.

Over the past 30 years, beginning with the last large outbreak of spruce budworm in the early 1970s, much of the forested landscape on the Highlands has been influenced by large-scale forest harvest operations. Much of the harvesting in the late 1970s and 1980s represented "salvage"operations following the effects of the budworm infestation (Kelly and Routledge 1993). It is important to assess how the application of mechanized forest harvesting and subsequent intensive silviculture has influenced the natural pattern of forest change and patterns of succession within the balsam fir dominated forest on the Highlands.

Initially, during the period of hastily planned and executed salvage operations, the resulting "manicured" landscapes with extensive network of roads would not have compared well to the natural one. At that time (1970s - 1980s) little thought was given to "ecological function" when developing harvest and silviculture prescriptions for the landscape. The main objective was to remove maximum timber with maximum efficiency and, through intensive site preparation and planting, to ensure regeneration of a conifer forest in as short a period of rotation as possible. Management prescriptions included clearcuts, site scarification, planting and application of herbicides to discourage deciduous competition.

However, neat and tidy is not nature's way. Forests ravaged by the spruce budworm die a slow death - dead and dying snags remain for years, and those that fall create a tangle of down woody debris. Regeneration can be rapid and prolific with fir, birch and shrubs creating a dense and expansive undergrowth which, over the following several decades, represents excellent food and cover for snowshoe hare and, as a consequence, excellent habitat for lynx (Parker et al. 1983; Parker 1981; Koehler and Brittell 1990; Aubry et al. 1999). But as much as we profess to understand what represents good hare habitat, we are less clear on the "limits of tolerance" for hare populations when the natural patterns of forest disturbance are disrupted by forest

management interventions, especially those which completely remove large contiguous tracts of forest cover (clearcutting) and standing and down woody material (hauling roadside; burning and scarification), proliferate conifer plantations, discourage deciduous regeneration (through herbicide application and/or intensive mechanical thinning) and encourage human encroachment and wildlife resource exploitation through intricate networks of hauling and service roads.

Lynx do use silviculturally thinned stands with at least 420-640 trees/ha (Koehler 1990) and hares are often very abundant in spruce plantations (Parker 1984). It is reasonable to assume, albeit we have no supporting data, that many of the spruce plantations established on the Cape Breton Highlands in the 1980s (15-20 years old) now serve as acceptable habitat for snowshoe hare and, consequently, for Canada lynx. Winter tracking studies and summer snowshoe hare pellet sample plots, especially when hare densities are high, would serve to support/refute that assumption.

The scanty information available suggests that snowshoe hare and lynx on the Highlands continued to cycle through the period of intensive forest managementt (1975 - 1985) to the present. A study of lynx in the late 1970s, although limited to a 60 km2 study area outside of, although adjacent to, landscape subjected to wood salvage operations, found high populations of both hares and lynx (Parker et al. 1983). Both reached peak numbers in the first year of that study and lynx recruitment was high. Concurrent with the subsequent crash of hares, lynx recruitment declined significantly in the last year of the study. Much of that study area represented ~20 year old mixed regeneration. More recent data on hare pellet counts, lynx and hare tracks at bait stations and appearance of lynx on adjacent Lowlands all indicate that the most recent peak in hares occurred around 1998, and the peak of lynx in 1999 with subsequent dispersion of lynx off of the Highlands in 2000 following the crash in hares. We are less clear, however, on the extent and intensity of the hare and lynx cycle prior to intensive forest management on the Highlands.

We do know, however, that most of the productive forested land on the Highlands has now been harvested and much of that land is now in stages of regeneration varying from 0 - 25 years in age. We also know that forestry operations are changing harvest and silviculture prescriptions to be more compatible with natural patterns of forest disturbance and succession. By attempting to manage the forests at the ecological landscape level with consideration given to ecological processes and historic patterns of disturbance, and by designing harvest prescriptions which include innovative block designs and edge considerations, leaving islands of standing trees, protection of forested buffers along streams and lakes, establishment of wildlife corridors, elimination of herbicides and promotion of natural processes of tree selection and allowances for retention of standing and down woody debris, it may be possible to reduce the perceived and/or real threats that intensive forest operations may have posed to "lynx habitat" in the recent past.

Forest Harvesting - a Brief History - There is little information on forest harvesting on the Highlands prior to 1900. Given the remote and uninhabited nature of much of the region, it is likely that the dynamics of balsam fir dominated forests were basically driven by the 20 - 30 year spruce budworm cycle. Although fires were once common on the adjacent mixed wood slopes, the cool, wet climate common on the interior plateau discourages fire as a major disturbance

factor there. A balsam fir - dominated forest subject to periodic, intense and wide-spread disturbance from the ravages of the spruce budworm suggests one favourable to creation of preferred snowshoe hare habitat and, consequently, prime lynx habitat.

The earliest record of organized and government sanctioned timber harvesting on the Highlands was in 1899 at which time the Province of Nova Scotia leased 620,000 acres to parties from Massachusetts, and managed by F.J.D. Barnjum, for a 99 year lease. This was mainly a high-grading operation which closed down in 1907. In 1915 Mr. Barnjum, still manager of the lease on the properties, began construction of a rossing mill which was completed in 1916. On January 2, 1917, the properties and mill were taken over by the Cape Breton Pulp and Paper Company Limited, affiliated with the Oxford Paper Company and later, on April 10, 1920, absorbed by the Oxford Paper Company (Kelly and Routledge 1993).

From 1917 to 1931 inclusive a total of 325,000 rough cords of pulpwood were harvested within the watersheds of the East, Middle and West Branchs of North River and Timber Brook. The annual production varied from 7,000 cords in 1931 to 57,000 cords in 1920-21. In all, 36,000 acres were cutover. By 1931 the Oxford Paper Company ceased operation and in 1936 the Nova Scotia Government expropriated 178,000 acres for the establishment of the Cape Breton Highlands National Park. In the early 1950s the Mariana Timber Company obtained stumpage rights from the Oxford Paper Company and in the period 1953 - 1956 produced 28,000 cords of high quality pulpwood for export. Approximately 5,000 acres were cutover during this period. In 1960 the Nova Scotia Government terminated the lease held by the Oxford Paper Company and subsequently leased it to Nova Scotia Pulp Limited. In 1961 work on clearing road right-of-way was carried out and in 1962 an extensive road construction program began.

In 1960 it became evident that there was serious Hemlock Looper (*Lambdina fiscellaria*) infestation in areas of balsam fir on the Plateau. Roads were built to infected areas and in 1963, 5,500 cords of insect killed wood were salvaged. This increased to 18,000 cords in 1964 and over 21,000 cords were salvaged in 1965 along with 40,000 cords of green wood. In 1966 the Beloit Harvester was first used and in 1970 the first Koehring Processor in the Maritime Provinces was introduced on the Cape Breton Highlands - a second one was put into operation early in 1971. Wood harvesting operations gradually expanded from less than 10,000 cords in 1963 to 65,000 cords in 1971. In 1972 and 1973 the annual harvests increased to 80,000 - 90,000 cords, a rate of annual harvest which at that time was considered near maximum sustainability.

Nineteen seventy-five (1975) might be considered the last year of normal production for the Cape Breton Highlands. It was then that the spruce budworm infestation spread over most of the island and forced dramatic changes in harvesting and forest management activities. In that year the budworm had caused significant defoliation on about 12,000 acres of Highland timber and high egg counts indicated a very dangerous situation for 1976. Defoliation was rampant throughout most of the Highlands and continued for the next 4-5 years when, by 1981, some decrease in budworm populations became evident. Applications by Nova Scotia Forest Industries (Stora) to spray chemical insecticides over the Highlands in 1976 and again in 1977 were denied by the Nova Scotia Government at which time the company initated salvage operations which totalled 180,000 cords in 1977.

In 1978 the Province of Nova Scotia and Nova Scotia Forest Industries (NSFI) entered into a salvage/storage agreement for the Crown lands, with the objective of salvage and storage

of wood volume in excess of the immediate requirements of NSFI. Provision was made for the storage of up to 500,000 cords of pulpwood during the 1978 - 1981 period. NSFI produced and placed the surplus pulpwood in storage and after a joint roadside scale the Province bought the stored wood. NSFI agreed to re-purchase all the pulpwood from the Province by 1984. In the four years from 1978 - 1981 slightly over one million cords of wood were harvested on the Highlands, 500,000 cords being placed in storage and the balance trucked directly to the mills at Point Tupper.

In summary, the early forest harvesting activities of Stora Forest Industries can be divided into two distinct periods: 1/ the pre-budworm period 1963 to 1975 when the first network of roads were built and 750,000 cords of green softwood were delivered to the mills at Point Tupper, and 2/ the budworm harvest period of 1976 to 1987 when 1,550,000 cords of dead and damaged softwood were harvested and delivered.

Spruce budworm defoliation resulted in nearly 100% mortality of balsam fir trees on the Highlands - a few patches of black spruce (*Picea mariana*) survived. Some stands harvested by Bowater Mersey Paper Company in the mid-1950s have allowed limited harvesting in the late 1990s but over those expansive areas which are regenerating following the budworm epidemic there will be little harvesting until around 2010.

Ecosystem Management - Forestry operations currently employ an Ecological Landscape Planning approach for Crown lands under licence on Cape Breton Island and elsewhere in Eastern Nova Scotia. The founding principle of this approach is the selection and implementation of forest management strategies and techniques which are compatible with the natural processes that shape forest communities. Ecological landscape planning provides a means to ensure a sustainable flow of forest products consistant with society's demands, while interfering as little as possible with natural forest processes. For instance, in the birch - balsam fir forests which occupy elevated sites in Cape Breton, forest harvesting, in an attempt to simulate the natural forest cycle where recurrent insect attacks, such as the spruce budworm and hemlock looper, and blowdown periodically remove older fir trees and create gaps in the canopy, employs partial cutting systems which remove mature trees while leaving the hardwood canopy and young balsam fir intact.

Although clear-cutting remains the harvest method of choice in most balsam fir dominated stands, current harvesting operations differs significantly from those employed 10-15 years ago. More attention is paid to what is left behind, often referred to as retention harvesting, where large live trees, snags, rotting logs and clumps of undisturbed mature forest remain to enhance forest biodiversity by sustaining biologically important processes. As well, and adhering to Nova Scotia's Forest/Wildlife Guidelines, managed areas accommodate riparian buffers, wildlife corridors, residual tree clumps, coarse-woody debris retention and careful stream crossing techniques. Ecological landscape planning, simulating natural patterns of forest disturbance and retention harvesting all serve to minimize the disruption from forest harvesting to natural patterns of ecological diversity, which in turn improves the value of that forested landscape to snowshoe hare and, indirectly, to lynx.

An analysis of the history (1967-2000) of silvicultural treatments on the Cape Breton Highlands Plateau shows several interesting trends which may impact both snowshoe hare and

lynx (Table 1). Most clear-cutting (14,915 of 15,298 ha - 97%) occurred in the 1980s and partial cutting (final harvest where >10%, and often 25%-30%, of the mature forest overstory is left standing) has become the predominant form of timber harvesting in the 1990s. Also, associated silvicultural treatments such as site preparation (96% of 2,742 ha), use of herbicides (94% of 11,425 ha) and replanting (88% of 8,464 ha) also occurred in the 1980s. Much of this trend, of course, is due to supply, i.e. most of the available productive balsam fir-dominated forests on the Highlands for which clearcutting is the prescription of choice, have been harvested. Partial cutting is the prescription for stands of balsam fir/yellow birch common to the Southern Highlands and Cape Breton Uplands. The number of hectares planted annually declined in approximate proportion to the area subjected to clearcutting. As well, most precommercial spacings in plantations (~15 years after planting) have occurred in the 1990s.

It is difficult to assess just how the elimination of herbicides may effect regeneration in disturbed sites, especially in regenerating conifer plantations. The most likely result is a greater component of deciduous trees and shrubs in younger sites, which if correct, would benefit snowshoe hare, and ultimately lynx. On the other hand, the release spacings (stand thinning) will reduce deciduous trees and shrubs which modelling exercises at University of Maine suggest could be quite harmful to snowshoe hare habitat (Chris Hoving, MS student, and Dan Harrison, Professor of Ecology, University of Maine, Orono, pers com.). Those models further suggest that more extensive forest disturbances (e.g. spruce budworm and clear-cutting) tend to promote large and relatively contiguous areas of dense, mixed forest regeneration favourable to both hare and lynx. Furthermore, lynx and hare densities were positively correlated with regenerating forests but negatively correlated with partial cuts, recent clear-cuts and mature conifer stands. Measurements of densities and vertical and horizontal cover of trees and shrubs in stands subjected to various silvicultural treatments are needed to evaluate past, current and projected programs of silviculture on both hares and lynx.

The history of intensive forest harvesting on the Cape Breton Highlands, prompted in large part by the ravages of the spruce budworm, did not begin until the late 1970s and was virtually complete by 1990. In the early years, little attention was given to protecting or conserving landscape biodiversity - salvage operations relied on clearcutting to remove dead and dying timber as quickly and efficiently as possible. If the lynx were ever in danger of extirpitation from habitat change on the Highlands that would have been the time. However, lynx did survive that period of significant deforestation and, although even approximations of immediate demographic responses are unavailable, there is evidence that a population peak of hares and lynx occurred, as expected, around 1989-90. Today, much of the landscape that was clearcut some 20-25 years ago has regenerated into preferred habitat for snowshoe hare, and, given the current awareness and application by Stora of contemporary sustainable forestry management practices, habitat should not represent a threat to lynx on the Highlands in the near or long-term. Given the real threat of a renewed outbreak of spruce budworm in eastern Canada within the next 10 years, forest management provisions should now be developed to avoid another threat to lynx such as the largescale clear-cutting and salvage operations of several decades earlier.

It is important to note, of course, that a significant (~20%) amount of potential lynx habitat on the Highlands falls within the boundaries of the Cape Breton Highlands National

Park. This is certainly fortuituous and may have played the role as a population source from which lynx dispersed to occupy forested lands exploited earlier by extensive clear-cutting and timber salvage operations.

In summary, the future of the forests on the Highlands to continue to represent snowshoe hare and lynx habitat looks positive. Through an innovative policy of ecosystem management, an operational plan which encourages landscape diversity with measures reviewed earlier, as well as encouraging a natural regenerating mixed forest through elimination of herbicides, an adequate supply of snowshoe hare habitat should be sustained which in turn should continue to encourage a dynamic snowshoe hare and lynx 10-year cycle.

Protection/Ownership

Most of the Cape Breton Highlands falls either within the protection afforded by the Cape Breton Highlands National Park (950 km2) or within pubic-owned lands leased for commercial forestry (~3,550 km2). Crown ownership of that portion of the Highlands leased for commercial forestry provides the potential for public input into forest management planning and presents the opportunity for flexible and innovative resource management strategies to ensure the long-term availability of lynx habitat and the viability of lynx and snowshoe hare populations. The challenge is commitment, both by the province of Nova Scotia and forestry industry. The process, if not the precise mechanisms, is clear - a diversified landscape which promotes a reasonable mix of stand age and tree and shrub composition and which uses the prevailing natural patterns of forest disturbance and succession as the template in the forest management decision process.

GENERAL BIOLOGY

Nova Scotia

General -The occurrence of lynx on Cape Breton Island, similar to populations across the continental range, is highly dependent upon abundance and availability of snowshoe hare (Parker et al. 1983). As well, available although fragmented information suggests that the two species follow a classic 10-year predator/prey cycle. The intensities of numerical fluctuations in lynx numbers on Cape Breton Island may approach a magnitude of change of 5-6X and therefore more closely resembles northern taiga than southern boreal lynx populations, the latter occurring in several northern states, typically in densities comparable to the lows of northern taiga lynx populations (~2-3/100 km2) and which appear to depend upon occasional immigration from northern populations for long-term viability.

On Cape Breton Island the core breeding areas for lynx appear to be the western Highlands and two smaller centres situated on the eastern shore of Bras d'Or Lake and which appear most vulnerable to extirpation, especially during lows in the hare cycle. The demographics of these populations resemble those described in great detail for western and

northern continental populations i.e. rapid population increases which closely follow recovery of snowshoe hares and equally swift declines 2-3 years following the crash in hares (Keith et al. 1977; Poole 1994; Slough and Mowat 1996; O'Donoghue et al 1997). Demographic changes appear driven by availability of hares which influence lynx recruitment i.e. over-winter survival of young and juvenile fecundity. Yearlings that do survive seldom breed during years of hare scarcity. Reports of lynx recovered in areas adjacent to the Highlands immediately following hare declines suggests that many dispersers die from food scarcity, disease and predation.

Reproduction and Survival - Most information available on lynx reproduction and survival on Cape Breton Island comes from samples collected from trappers during the last three years of open public trapping - 1977-78 through 1979-80 (Parker et al 1983). By chance, those 3 years corresponded to a peak and crash in snowshoe hares and consequent declines in the productivity and survival of lynx. Basically, the decline in available food measureably affected lynx productivity and survival by 1/ a decline in pregnancy rates (placental scar counts) of yearlings (67% to 0%) and, 2/ a decline in representation of yearlings in the population, presumeably through direct mortality related to starvation, disease and predation. Reproduction in adult females declined only slightly while mean number of young per litter (mean count of placental scars) remained unchanged over the three years of declining food. The reproductive dynamics described for the Cape Breton Island lynx during highs and lows of snowshoe hare compares well to those which control the cyclical abundance of lynx in northern boreal ecosystems, and cited above.

When hares are abundant and lynx populations are increasing there is little reason for lynx to leave the Highlands and survival of lynx there appears to be high. Parker et al (1983) found that a high proportion (52% - 69%) of the lynx examined in years of hare abundance consisted of 2-year olds, suggesting high survival rates of lynx during their first year of life. In years of hare scarcity and reduced lynx productivity, the proportional representation of 2-year olds declined (39%), yearlings were virtually absent while older aged classes increased. The scarcity of older aged lynx in trapper catches during years of hare abundance reflects the abundance of food, the greater availability of younger lynx and the susceptibility of younger lynx to being trapped. In years of food scarcity, younger lynx are more scarce while older lynx become more susceptible to being attracted to traps by bait.

Studies in the Yukon (O'Donoghue et al. 1995) and the Northwest Territories (Poole 1994) have shown that, in times of snowshoe hare and lynx decline, lynx may be killed by wolves (*Canis lupus*), coyotes and other lynx. Mortality, combined with emigration may combine to depress lynx densities in specific areas by as much as 90%-100%. In the first year of hare decline many lynx emigrate, especially the younger cohorts, but in the subsequent 1-2 years of decline, loss of lynx is by direct mortality, usually by starvation and predation.

Diet - The distribution of lynx throughout North America is concurrent with the distribution of snowshoe hare (McCord and Cardoza 1984; Bittner and Rongstad 1984). The universal dependence of lynx on snowshoe hare, both winter and summer, is well documented (for a review see Quinn and Parker 1987; Mowat et al. 1999; Aubry et al, 1999). Although lynx on Cape Breton Island are often considered to represent a southern boreal population (Aubry et al.

1999), a comparison of seasonal diets suggests otherwise. The high dependence on snowshoe hare by lynx on Cape Breton Island, especially in winter, compares more favourably to the diet of northern taiga populations (Alberta - Brand et al. 1976, Brand and Keith 1979; Yukon - O'Donoghue et al. 1998; Alaska - Kesterson 1988) than for southern boreal lynx (Koehler 1990). The size of home ranges of lynx on Cape Breton Island (Parker et al. 1983) are also more similar to those for northern than for southern populations (i.e. smaller than most southern populations - for a review of lynx home ranges see Aubry et al. (1999)). As well, red squirrels were virtually absent in the diet of Cape Breton Island lynx, again similar to the diet of northern taiga lynx during years of hare abundance (at which time the Cape Breton Island lynx were studied). Red squirrels may occur in 25-30% of scats and kills of southern populations (Koehler 1990). Red squirrels are common on the Highlands and may become more important to lynx when snowshoe hares are scarce. The "taiga similarity" between the forests (balsam fir-white birch), climate (deep and prolonged snow cover), and well-defined snowshoe hare cycle of the Cape Breton Highlands and northern taiga environments most likely explains the similarities in lynx demographics between the two ecosystems.

In times of hare scarcity when many lynx disperse from the Highlands and onto the adjacent Lowlands of Cape Breton Island, their diet, from necessity, would be considerably more diverse. This is suggested by incidental observations of lynx killing chickens and pets and often being in emaciated condition.

Habitat Use - Habitat selection by lynx within a 60 km2 study area on the Cape Breton Highlands was measured by snowtracking in winter 1977/78 (Parker 1981) and by radio-telemetry in 1979 (Parker et al. 1983). Snowtracking showed that lynx preferred (i.e. used more than expected relative to availability) to travel in open mature conifer, early and advanced successional and open black spruce bog habitat types. Hares were most common in advanced mixed regeneration stands (22-28 yrs) dominated by balsam fir and white birch with average stem height of 2-6 meters and mean crown closure of 75-80%. This habitat type was selected by lynx for hunting snowshoe hare. The preference of hares for similar habitat has been reported for other regions of Nova Scotia (Orr and Dodds 1982). The abundance of hares during winter in the various habitats, as measured by summer pellet counts, showed a positive correlation with lynx use in the early and late successional habitats but a negative correlation for mature conifer and spruce bogs. Lynx activity - travel, resting, hunting, socializing - varies among habitat types. This allocation of behavioural activities to specific habitat types is similar to lynx in other regions of North America (Koehler and Brittell; 1990Murray et al 1994) and to other predators, such as the eastern coyote (Parker and Maxwell 1989). Radio telemetry studies in 1979 supported the habitat selection reported for the 1977/78 snowtracking study**.**

Although lynx need food (hares) to survive, which is undoubtedly the most important factor that influences the presence or absence of most predators in specific regions, most other habitats within defined home ranges are used for other less understood reasons, and often at specific seasons of the year. A diversified landscape which emulates natural patterns of forest disturbance and regeneration should be the objective of the forest and wildlife managers.

Disease - On occasion, sick and debilitated lynx and bobcat are collected and submitted for

necropsy and examination for disease. In 1996-97 six lynx specimens were collected on Cape Breton Island and submitted to the Canadian Cooperative Wildlife Health Centre (Atlantic Veterinary College) in Charlottetown, Prince Edward Island. Common symptoms of these lynx were lack of fear, aberrant behaviour and debilitated condition. None of these specimens were rabid but all displayed microscopic lesions and severe inflammatory reaction in the meninges, brain and spinal cord sufficient to explain individual behaviour and physical abnormalities (Canadian Cooperative Wildlife Health Centre. 1997. Wildlife Health Centre Newsletter 5 (1) Charlottetown, PEI). Common cause of the neurological disease was identified as a morbillivirus, an infection previously diagnosed in two bobcats from New Brunswick (Canadian Cooperative Wildlife Health Centre. 1995. Wildlife Health Centre Newsletter 35 (1) Charlottetown, PEI) and closely related to canine distemper virus.

The unusually high number of lynx recovered by Nova Scotia DNR staff in 2000 provided the opportunity for more specimens to be examined for disease at the Atlantic Veterinary College. I found 3 individual records for lynx carcasses recovered in 2000, and blood samples from 8 lynx captured on Cape Breton Island (five of which were held captive at Shubenacadie Wildlife Park), which had been submitted and examined by the Atlantic Veterinary College and for which there were corresponding diagnostic services reports (DSR). The 3 lynx carcasses, all juveniles, were emaciated with moderate to heavy parasitism - the cause of death was attributed to starvation. "...[evidence] supports the original hypothesis that a recent crash in the population of snowshoe hare on Cape Breton Island was responsible for an inordinate prevalence of emaciated lynx in this region .... Emaciation and heavy parasitism are often found concurrently in wild animals." - summary comment on DSR.

The five live lynx held captive at Shunenacadie Wildlife Park were generally emaciated but with no apparent evidence of disease. Blood samples did show evidence of exposure to "canine distemper-like virus" which led to the following summary comment. "This disease has not yet been reported by others in free-ranging wild cats elsewhere in North America although we have confirmed it also in a few bobcats from New Brunswick ... Therefore, I believe that this is a new disease for lynx and that the population of this species on Cape Breton Island probably still has a low level of immunity against the virus. Because of this, I am personally tempted to ascribe much significance to high levels of antibody in an individual lynx, particularly one that has been found in a weak condition in the wild" (letter from Dr. Pierre-Yves Daoust, DVM, Atlantic Veterinary College, Charlottetown to Dan Banks, Nova Scotia Department of Natural Resources, May 26, 2000).

In addition to the above, the DNR Baddeck office completed lynx necropsy reports for 7 lynx carcasses and dated December, 2000. Two were snared or trapped, 2 were killed by vehicles, 1 was shot in a chicken coop, and cause of death for one was not recorded. Measurements of body fat varied from "no fat" to "very fat" and tissue samples were submitted to DNR office in Kentville for future DNA analyses.

In summary, most lynx recovered on the Lowlands in 2000 and which were examined by DNR personnel and/or by the Atlantic Veterinary College showed signs of emaciation and parasitism, the latter probably the result from immuno-suppression stemming from starvation which in turn was most likely prompted by a crash of snowshoe hare on the Cape Breton Highlands. This appears to be a normal functional response by lynx across their northern

continental taiga range to the sudden and significant cyclical declines in snowshoe hares. Some evidence of exposure by several lynx to "canine distemper-like virus" may be cause for concern for the impact of this disease at the population level, but further study is required.

Movements/Dispersal - In the context of this report any discussion on movement of lynx on Cape Breton Island can be conveniently classified as local (e.g. home range limits, daily rates of travel) and long-range (dispersal patterns from core areas of distribution during lows in the hare population). Lynx commonly disperse 100 km or more, and have been reported to travel as far as 400-500 km (Mech 1977; Brittell et al. 1989). Information on local movements was gathered by Parker et al (1983) during 2 years (1978-79 and 1979-80) of radio-tracking several lynx within a 60 km2 study area near the Norman Fire Tower on the Upper Mariana Road. That information was useful in describing seasonal home range limits of several lynx during a peak and early decline in the snowshoe hare population, but prior to extensive lynx dispersion.

Home ranges were well defined, were larger in summer (Male - 26 km2; Female - 32 km2) than winter (Male - 12 km2; Female - 19 km2) and lynx maintained a core area of occupation at all seasons. Distances traveled per 24 h (DCD - daily cruising distance) were slightly greater in summer (7-10 km) than in winter (6-8 km), and travel activity was greatest in evening and early morning. These local data on home range limits, movements and daily activity patterns, although interesting, contribute little to understanding the current status of lynx in Nova Scotia. More important is information on dispersion, although that is lacking at the individual level due to the absence of a mark/recapture program. However, from the information at hand it is possible to generate hypotheses on lynx dispersal on Cape Breton Island. It is almost certain that lynx on Cape Breton Island represent an isolated metapopulation removed from ingression of lynx from other mainland populations. There are no known lynx breeding on mainland Nova Scotia, while in New Brunswick the status of a breeding population remains uncertain, and if it does breed in that province, it appears to be restricted to the extreme northwestern sector - dispersion to Cape Breton Island from that source appears very unlikely.

What we do know is that in approximate 8-10 year intervals, coinciding with crashes of snowshoe hares on the Highlands of Cape Breton Island, lynx are recovered on the Lowlands, especially on Lowlands of Victoria and Inverness Counties adjacent to the Highlands. On occasion, and coincidental to snowshoe hare declines, lynx are recovered from mainland Nova Scotia, and are presumed to be dispersers from Cape Breton Island.

There has been some concern expressed over the fate of the cyclical migrants from the Highlands. Do they represent an "expendable" element of the population which, compatible with the normal dynamics of a 10-year predator-prey cycle, move out of traditional breeding ranges due to food shortage and, especially in contiguous mainland populations, serve as colonizers for new habitats? This "inherent" demographic response is normal, even though on Cape Breton Island there appears to be no new favourable and unoccupied habitats to colonize. Thus, in this scenario, they are expendable to the long-term viability of the Cape Breton Island breeding population of lynx. It is assumed that a core breeding population remains on the Highlands during periods of hare scarcity and represent the "seed stock" for a renewed population increase.

However, and this is the concern, does a core breeding component remain on the Highlands during years of snowshoe hare scarcity, or, do those lynx which move to the adjacent

Lowlands and beyond, and which survive for 3-4 years, move back onto the Highlands and serve as the breeding core of a renewed lynx cycle? The increasing frequencies of lynx tracks at bait stations on the Highlands through the winters of 1996-97, 1997-98 and 1998-1999 suggest that, during periods of hare decline, lynx search for other sources of food, including carrion, but how many actually remain on the Highlands is unknown. The recent colonization of Cape Breton Island by the eastern coyote, especially the Lowlands, and the documented predation of coyotes on lynx, may be cause for concern. If a portion of those lynx which disperse from the Highlands during times of hare scarcity represent the core breeding stock for the next cyclical phase, does mortality from coyotes on the Lowlands pose a threat to sufficient numbers of lynx returning to the Highlands to breed? Do coyotes remain on the Highlands in winter during periods of hare scarcity, and if so, do they pose additional competitive stress on lynx which are already stressed from food shortage?

POPULATION SIZE AND TRENDS

Historic Fur Returns

The annual harvests of major furbearers in North America over the past several hundred years were compiled by Novak et al. (1987). The records for Nova Scotia begin around 1920, although there may have been some confusion between lynx and bobcat in the first few years. Since 1950 most lynx from Nova Scotia have been trapped on Cape Breton Island. The public trapping season has been closed for the past 20 years. The plotted distributions of lynx harvests for Nova Scotia show a long-term 10-year cycle of abundance (Figure 5), a demographic characteristic common to northern taiga lynx populations and which are driven by the 10-year

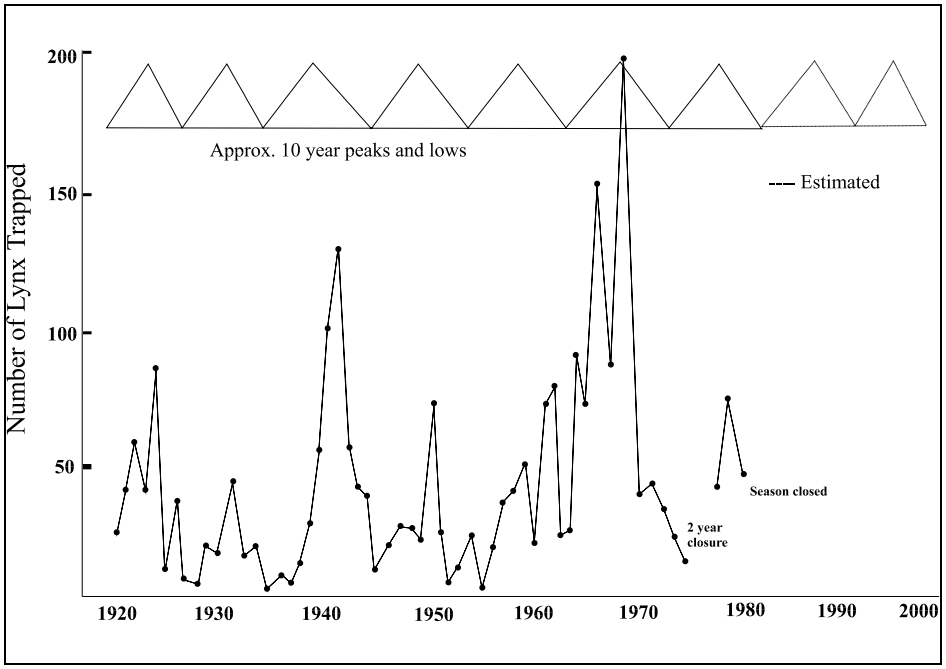

Figure 5: Lynx harvests in Nova Scotia (after Novak et al. 1987) and approximate 10-year peaks in abundance.

cycle of snowshoe hare.

Variations in amplitude of cyclical peaks among years could represent true temporal differences in population densities, changes in fur prices and trapping pressure, or a combination of these and other more subtle and less obvious factors. If we include only harvests since 1950, the time when most if not all lynx exported from Nova Scotia were trapped on Cape Breton Island, harvests have fluctuated between 44 (1931/32) and 218 (1969/70) during population peaks and between 2 (1934/35) and 24 (1963/64) during population lows. Although we do not know the trapping pressure in the 1930s, we do know that the average price per lynx pelt in 1934-35, when only 2 lynx were trapped, was $67.13, certainly an incentive for most trappers at that time. The highest annual harvest through the 1930s was only 44 lynx. The average price per lynx pelt in 1969-70, a year with the record number of lynx trapped, was only $27.48. These data suggest that lynx were more numerous in the 1960s than in the 1930s. It is interesting that the second highest annual harvest of lynx was in 1941-42 or approximately 30 years prior to the 1969-70 peak and similar to the approximate interval between spruce budworm outbreaks. This suggests that the budworm outbreaks occurred approximately 15-20 years earlier i.e. ~1920-25 and 1950-55. It is also interesting that the most recent outbreak of spruce budworm occurred in the late 1970s and early 1980s (~30 year interval) and that the unusually high number of lynx on the Lowlands occurred in 1999-2000, approximately 30 years since the record harvest of lynx in 1969-70. Is this an indication that exceptionally high peaks in hare and lynx cycles are because of periodic (~30 year intervals) abundance of optimum regenerating habitat? Mere speculation but worth noting. One caveat to this budworm-lynx correlation theory is that the first network of roads into the Highlands was built in the early and mid-1960s. This event increased access and may have contributed to high numbers of lynx trapped in the mid- to late-1960s (see Figure 5; Appendix 1).

Although population estimations from historic harvest statistics can be misleading, it appears that, within expected limits of cyclical variation**,** the lynx population on the Cape Breton Highlands has remained stable over the past 50 years.

Estimations and Indices

Telemetry Study - In years of hare scarcity and extreme lynx population lows, few lynx are seen or recovered outside of the three identified core population areas. Most sightings and recoveries of lynx beyond those areas are during the first several years following a crash in hares and while lynx numbers are still relatively high. The amount of breeding within and among these three zones is important to ensure genetic interchange and diversity of lynx throughout Cape Breton Island. Based on live-trapping, radio-telemetry and snow-tracking during the three years 1977-78 through 1979-80, Parker et al (1983) estimated 11 lynx occupied approximately 60 km2 - a time of cyclical highs of both snowshoe hares and lynx (hares began to decline in 1978-79), for a density of approximately 20 lynx/ 100 km2. The authors cautioned that the habitat in that particular study area represented an uneven-aged mixed forest providing optimum food and cover for hares and consequently optimum habitat for lynx. As well, the study area was adjacent to an extensive area of the Highlands subjected to intensive wood salvage operations. At that time displaced lynx may have been temporarily concentrated in such areas of favoured habitat

creating artificially high densities.

Recognizing that the density of lynx in that 60 km2 study area was exceptionally high and probably not representative of most forested landscape occupied by lynx on Cape Breton Island, it would be prudent to revise that estimate downward to an overall density estimate of 10-11 lynx/100 km2, a density compatible with estimates for northern taiga lynx during population highs. Given that conservative revision, estimated numbers of lynx during the 1978-80 population peak would have been: Highlands - 450-500; Boisdale Hills - 15-16; East Bay Hills - 12-13. During lows in the population cycle, and applying the average for continental taiga populations of 2-3 lynx/ 100 km2, population estimates would be reduced to: Highlands - 90-135; Boisdale Hills - 3-4; East Bay Hills - 2-3. Even if those density and population estimates were correct for the late 1970s, it remains uncertain how they might compare to those of today some 20 years and perhaps two full population cycles later. McKelvey et al. (1999) argue for ecoprovince wide planning for effective management of small and often isolated southern boreal populations of lynx. Based on estimates of 2 lynx per 100 km2 in north-central Washington and a estimated minimum required population size of 25 lynx, they recommended a management planning area of at least 1,250 km2. Although it appears that the contiguous Highlands can continue to provide sufficient habitat for a healthy lynx population even at cyclical lows, the two smaller core areas appear insufficient without significant immigration of lynx from the Highlands.

The relatively frequent visits of lynx to bait stations on the Highlands in 1997 through 1999 and the high number of lynx being seen and killed on the adjacent Lowlands in 2000, suggest that lynx numbers peaked approximately 20 years after the 1978-79 peak and were in the dispersal/decline phase of the cycle in 2000, again suggesting a 10-year lynx-snowshoe hare cycle on the Highlands. Although we do not have compatible information on the frequencies of lynx recovered on the Lowlands in years immediately following the 1978-79 peak in the lynx population, the information that is available suggests that densities and distributions of lynx on Cape Breton Island have changed little over the past several decades. As well, fur returns suggest that lynx densities vary between/among individual cycles - such variation is probably a function of changing conditions of the forested landscape and consequent availability of snowshoe hares.

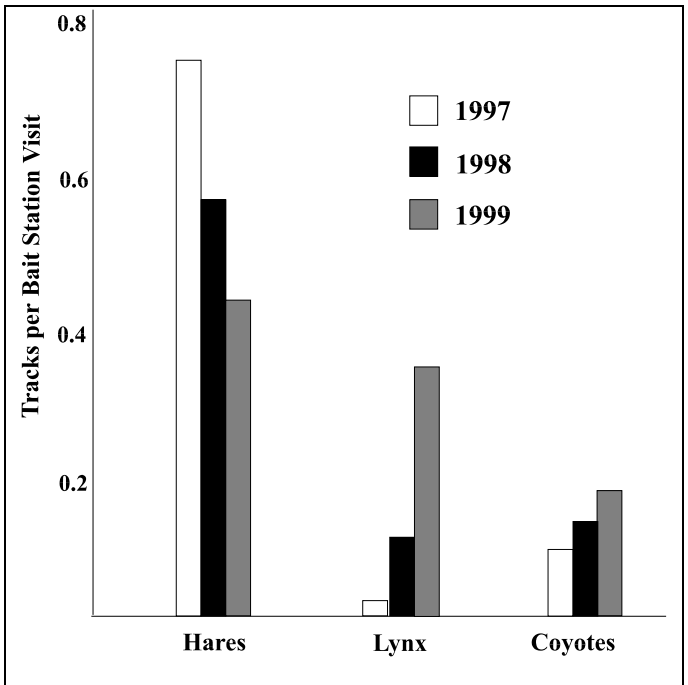

Figure 6: Comparative track indices (tracks/bait station visit) for snowshoe hare, Canada lynx and eastern coyotes for the years 1997, 1998 and 1999.

Bait Stations - In winter 1996/97, the Nova Scotia DNR and Cape Breton Highlands National Park initiated a pilot project to obtain indices of abundance and distribution for American marten (*Martes americana*) and other mammals, especially Canada lynx, in scattered locations on the Cape Breton Highlands (Mills and O'Brien 1997). The bait station survey was continued, with modifications, in 1997/98 (Nocera et al 1999) and 1998/99 (Miner 2000).

The project consisted of positioning bait (white-tailed deer (*Odocioleus virginianus*)) stations on transects established either along roads or snowmobile trails. Sample points were chosen from DNR and Park files containing historical reports of trapped marten, marten tracks or sightings. Individual bait stations consisted of a piece of deer meat suspended by wire from a tree 50 - 800 meters from the edge of the trail at approximately one kilometer intervals. A piece of cloth scented with marten or skunk (*Mephitis mephitis*) lure was also tied to the bait wire. Stations were checked for five consecutive days or as close as possible when weather permitted. All tracks and animal sign was recorded within a 20 meter radius of each bait tree. In areas inaccessible by snowmobile, stations were established by using a DNR MacDonnell-Douglas 500 helicopter (35 of the 159 stations along one kilometer transects through blocks of potential habitat).

In 1997/98 all bait stations (n= 197) were positioned and visited (n = 503) by helicopter (Nocera et al 1998). This allowed the survey to be more efficient and to sample more remote parts of the Highlands than in 1996/97. Prior to positioning of bait stations, preferred sites were selected from a GIS digital image of forest cover and clear-cuts which originated from 1993 aerial photographs (Nova Scotia DNR proprietary data). Potentially suitable American marten habitat was pre-selected for mature stands of coniferous forest with a continuous distribution. The positioning of bait stations, and subsequent track counts, followed that established in 1996/97 (see Mills and O'Brien 1997). Bait stations were visited between February 9 and April 9, 1998. The mean number of visits was 2.5 (range 1 - 4). The bait station survey was repeated in 1998/99 using a helicopter to position 57 sites, each of which was visited only once on either March 18 or March 24, 1999 (see Miner 2000).

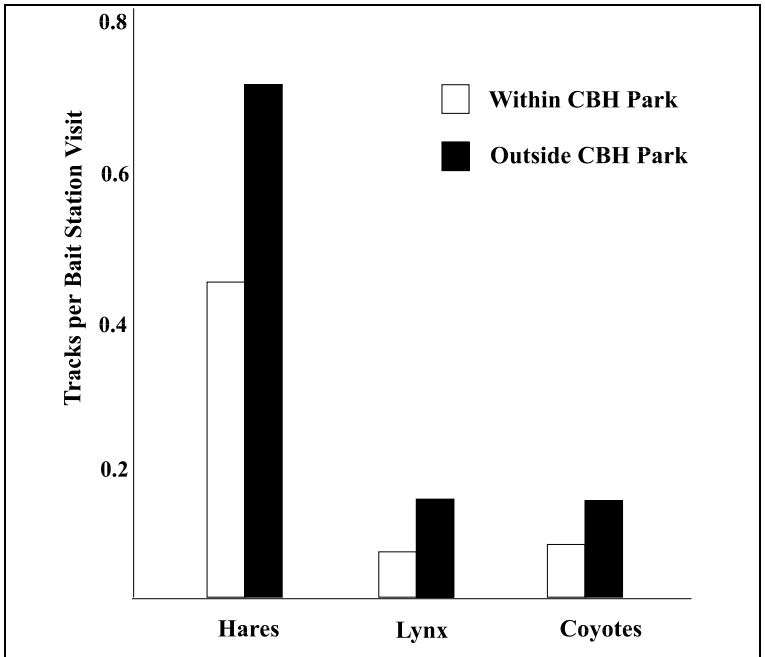

Figure 7: Track indices (tracks/bait station visitation) for snowshoe hare, Canada lynx and eastern coyotes for bait stations inside (n=97) and outside (n=100) Cape Breton Highlands National Park (1998 only).

Although the American marten track survey was hampered by changes to design and sampling intensity among

the three years, it does suggest several interesting temporal trends. 1/ The density of hare tracks per bait station visited declined from 1997 through 1999 (Figure 6). This measured decline in abundance of snowshoe hares at bait stations agrees with the decline in hare pellet counts within permanent sample plots and described elsewhere. 2/ As the frequencies of hare tracks at bait stations declined from 1997 through 1999, counts of lynx tracks increased. This inverse correlation between declining hare tracks and increasing lynx tracks near bait stations is not surprising. A declining hare population forces lynx to rely on other sources of food which explains their increasing reliance on carrion at bait stations. In times of hare abundance, lynx feed more on freshly killed prey. 3/ Coyotes appear to be distributed throughout the Highlands in winter and, similar to lynx, their attraction to bait stations was greatest in 1999 when hares were least available. Coyote tracks were more frequent than lynx tracks at bait stations surveyed in 1997 and 1998. 4/ Using the 1998 data only (for reasons of consistancy in methodology), hare, lynx and coyote tracks were more abundant at bait stations outside than inside Cape Breton Highlands National Park (Figure 7). This is not surprising considering that the forested landscape within the park is protected from harvesting while the general landscape outside the park, where forest management is active, supports a greater representation of regenerating forest stands which in turn provides preferred habitat for snowshoe hare, and consequently, a greater abundance of preferred food for both lynx and coyotes. However, as many of the 1998 bait stations outside of the park were positioned within older stands of conifers thought to represent American marten habitat, the reasons for the apparent discrepancy in lynx densities within and outside Cape Breton Highlands National Park may be more complex.

Although the data upon which these demographic scenarios are based are correlational, they do agree with studies elsewhere in northern latitudes that have demonstrated dependence of hares upon regenerating mixedwood habitats following fire, disease or timber harvesting and the subsequent dependence of both lynx and coyotes upon hares as the stable component of their winter diets and the classical predator-prey demographic relationship between abundance of hares, lynx and coyotes (McCord and Cardoza 1984; Keith et al. 1977; O'Donoghue et al. 1998; Nellis et al. 1972; Brand et al. 1976; Brand and Keith 1979; Mowat et al. 1996).

Carcass Collections - Concern over the long-term health and viability of lynx in Nova Scotia prompted the province to close the public trapping season in 1975/76. On Cape Breton Island a restricted season (2 lynx per licensed trapper) was reopened in 1977/78 to facilitate the collection of carcasses for a lynx population study by Canadian Wildlife Service (Parker et al. 1983). The restricted seasons remained open for 3 years (1977/78 through 1979/80) during which time the lynx and snowshoe hare populations were at or near their numerical peaks in the 10-year cycle. Trappers were required to submit all lynx carcasses to Canadian Wildlife Service for analysis. A total of 154 lynx were trapped and examined during that 3 year period (1977/78 - 42; 1978/79 - 57; 1979/80 - 55). Analysis of lynx carcasses provided important reproductive, morphologic, dietary and demographic information on Cape Breton Island lynx during a cyclical peak. Some of those data have been reported elsewhere in this report.

Although the public trapping season has remained closed since 1979/80, lynx are killed from other sources and some of those carcasses have been submitted to DNR regional offices at Baddeck and Coxheath. Until recently there had been a small aboriginal hunt (4-5 per year),

which was closed for reason of conservation, while a few lynx continue to be recovered as incidental catches by non-native trappers, road kills and assorted other sources. The data bank for these carcasses is maintained in DNR Head Office in Kentville.

The introduction of the Wildlife Investigation Report system in 1985 served to provide a standardized data collection format for field staff. Sorting through these lynx carcass files supplied by DNR served to identify 77 entries with sufficient information on date, location and means of death to allow a rudimentary assessment meaningful to the objectives of this report (Sex ratio of 31 of 77 carcasses - 13 Males : 18 Females).

First, the allocation of that sample through time (1987 - 2000) shows an interesting although curious distribution (Table 2). We know that the lynx population peaked during the 1977-80 study, and we also believe that it recently peaked in 1999-2000. It is probable, although less certain, if we hold to a 10-year population cycle, that an intervening peak was reached sometime around 1988-90. The few carcasses collected at that time do not confirm a peak although all dispersers from the Highlands which may have been killed were probably not recovered by DNR field staff. As well, the population peak in 1988-89 may have been less intense than that of 1999-2000 which would explain the apparent lack of dispersers.

There is, however, fragmented and anecdotal information which sheds some light on hare and lynx populations on the Highlands in the late 1980s. S.B. MacLeod, DNR Baddeck office noted "...quite a bit of coyote sign and lynx tracks..." during a Highlands Patrol on January 22, 1985 while Jack Mackillop, Supervisor Forest Resources at Baddeck, noted heavy rabbit sign during a patrol on February 14, 1986. Later, Carl Thibault of the Baddeck office noted in an October 19, 1990 letter that he had recently been made aware of "...four different cases of lynx in very poor condition in Inverness County. Starvation is believed to be the cause in all four cases. Two of these were near the village of Cheticamp, one at the Wreck Cove area in the Highlands and the most recent one at Ainslie Glen. Unfortunately, one had to be destroyed after jumping through a window of a chicken pen and suffering severe injuries. One of our staff managed to live trap the one at Ainslie Glen after it was seen killing domestic geese at a farm. This animal is extremely thin and we are feeding it regularly to bring its weight up before being released....The lack of small game and especially rabbits has been noticed in this County for a number of years now....For several days, one lynx was being hand fed with trout by fishermen in the Wreck Cove area. Another was killing chickens in broad daylight with people present. The last one was killing domestic animals with people present."

These reports suggest a peak in snowshoe hares sometime around 1985-1987 with a subsequent peak and dispersion of lynx around 1989-90. That is, of course, 10 years earlier than the latest (1999-2000) peak and dispersion of lynx and is continued evidence for a 10-year cycle of hares and lynx on the Cape Breton Highlands. The absence of recovered carcasses from 1992 through 1994 suggests a population low and is consistant with a numerical trough between the peaks of 1989 and 1999.

What is most interesting with the temporal trend in carcass recoveries is that over 50% of lynx recovered by DNR staff during that 13 year period occurred in 1999 and 2000. This might be explained because of an exceptionally high peak in lynx numbers on the Highlands and subsequent crash in snowshoe hares. Many of those lynx were recovered on adjacent Lowlands indicative of dispersal from the Highlands. But it is less clear why so many lynx were recovered

in 1999-2000 relative to previous years following a decline in hares on the Highlands. Reasons may include one or more of the following: 1/ lynx were killed during earlier dispersals but were not recovered by DNR staff for one reason or another, 2/ the recent concern expressed by DNR for lynx in Nova Scotia may have prompted greater public awareness and a greater effort for carcass recoveries, 3/ the density of lynx on the Highlands in 1999 was exceptionally high and there were more lynx to disperse and be recovered. Could this be a response by snowshoe hare and lynx to the large amount of successional habitat created during the intensive wood salvage operations of the late 1970s and early 1980s? Those regenerating areas would have then been 18-25 years old - optimum age for snowshoe hare habitat.

An alternate hypothesis might be that a much greater proportion of lynx left the Highlands in 1999/2000 due to unsuccessful competition with coyotes for the few remaining snowshoe hare. Bait stations in 1997-1999 showed coyotes to be common on the Highlands in those three winters - their relative abundance on the Highlands 10 years earlier is less clear.

It should be noted that most completed Wildlife Information Reports for lynx and submitted by DNR Field Staff to Kentville office do not involve a dead animal. Most involve sightings by the public. Due to the possibility of misidentification of bobcats for lynx, I have chosen to exclude those WIRs from these analyses. Most of the 39 lynx carcasses recorded in 1999 and 2000 were distributed in Victoria and Inverness Counties (Figure 8) although several were recovered east of Bras d'Or Lake, the farthest at Mira River. These lynx may have been dispersers from the Boisdale Hills and/or East Bay Hills. The spatial pattern for these 39 recoveries shows a wide distribution throughout Cape Breton Island and suggests considerable genetic flow throughout the island population during 10-year peaks in densities.

There is considerable merit in continuing to gather and collate information from lynx carcasses, especially if specific measurements/materials are collected and recorded in a standardized procedure and format. Information on sex and age structure, reproductive history and physical condition (fat deposits) represent a useful long-term monitoring protocol. Some work has already been started on a collection

Figure 8: Distribution of lynx carcasses (n=39) recovered by Nova Scotia DNR in 1999 and 2000 (from NSDNR files).

of tissue samples for DNA analyses and subsequent taxonomic verification.

Of 50 lynx carcasses recovered by DNR staff from 1995 - 2000 and for which cause of death was known, 22 (44%) were legally or accidentally snared or trapped, some by aboriginals before total closure several years ago. Another 6 were trapped or shot illegally (presumeably by non-aboriginals), and 8 were destroyed due to injury or disease. Other assorted mortality factors included predation by dog (1), unknown predator (8), depredation control (4) and accident (1). Do the 22 lynx trapped/snared by aboriginals, and the 8 by non-aboriginals, represent a threat to the population (~ 5-6 per year)? If confined to those numbers, and all other factors remaining constant, probably not. But, if fur prices escalate those numbers could also rise substantially, at which time the conservation of the species must take precedent over human exploitation.

Snowshoe Hare Pellet Counts - Indices of snowshoe hare abundance are important for tracking demographic trends of the main food source of lynx, searching for correlations between abundances of lynx and hare and measuring the magnitude and assessing the importance of a 10-year cycle to the long-term viability of lynx on Cape Breton Island. In 1993 the Nova Scotia DNR began a province-wide program for measuring snowshoe hare population trends by counting the pellets within permanent one m2 circular sample plots. These hare pellet plots were positioned at 100 m intervals along 1000 m ungulate pellet group inventory (PGI) transects.

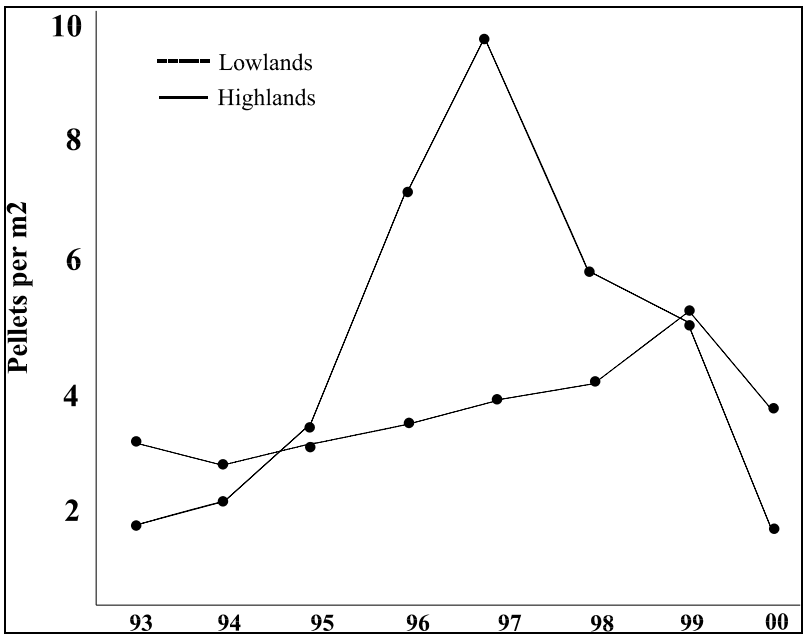

Figure 9 Densities of snowshoe hare pellets on the Highlands (Inverness/Victoria Counties) and Lowlands (Cape Breton/Richmond Counties) of Cape Breton Island (from NSDNR files).

The pellet count index as a measure of snowshoe hare populations on Cape Breton Island shows an interesting trend for the seven year period 1993 through 2000. By separating those data into two sets, one representing the Western Highlands (Inverness/Victoria Counties) and the other representing the Eastern Lowlands (Cape Breton/Richmond Counties), a spatial (altitudinal) difference in temporal hare population trends is apparent (Figure 9). The Highlands data set shows a very clear cycle in hare abundance, with an approximate 10 fold increase occurring over the 4 year period 1993 through 1997, followed by a decline of similar amplitude over the subsequent 3 years (1998 through 2000). These data agree well with other hare abundance indices for the Highlands for years within that 7 year period, e.g. trend figures at

winter bait stations and wildlife abundance rankings from volunteer hunter license returns for those 2 western counties.

The most recent hare peak (1996-97) and crash (1998-2000) on the Highlands relates well to what we know of the most recent demographic trends and behaviour of resident lynx populations e.g. track frequencies at winter bait stations (decline from 1997 through 1999) and appearance of emaciated lynx and lynx displaying aberrant behaviour at scattered locations on the adjacent Lowlands, as well as several lynx recovered on mainland Nova Scotia which most likely represent recent long-range migrants from Cape Breton Island. Long-range movements of lynx are frequent when snowshoe hare, their main food source, experience cyclical population lows (Nellis and Wetmore 1969; Mech 1977; Ward and Krebs; Slough and Mowat 1996; Poole 1997).

Hunter License Returns - Nova Scotia small game hunters were first asked to keep record of specific wildlife observations in 1994 and, at the end of the season, to complete and submit a "report card" which assigned each species an "abundance ranking" on a scale of 0 - 4 (4 = highest score). For snowshoe hares, small game hunters were asked to record abundance rankings on the report card attached to their license, along with his/her personal harvest information for the season. These wildlife abundance indices were to be used by Nova Scotia DNR to complement other measures of the health and dynamics of provincial wildlife populations.

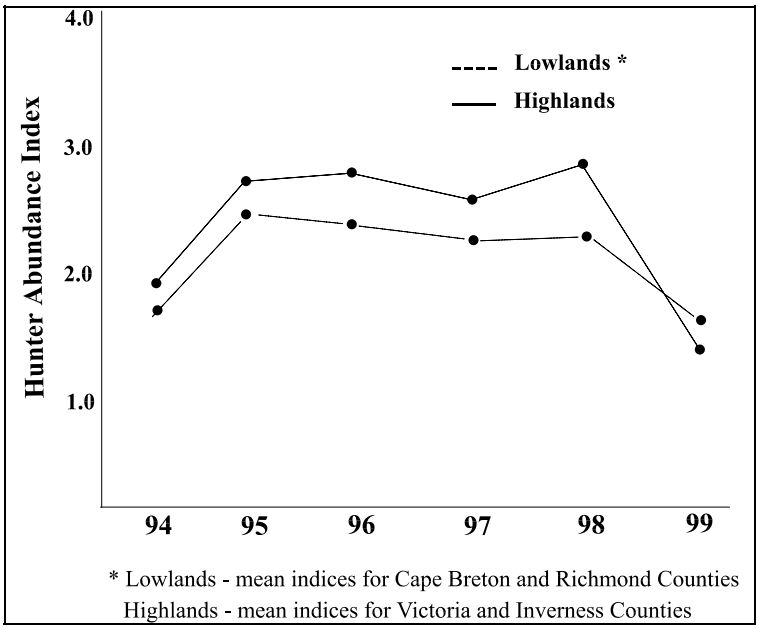

Figure 10 Annual snowshoe hare abundance ranking indices from small game hunter license returns for the Cape Breton Highlands and Lowlands (from NSDNR files).

This 5-year data set (1994 - 1999) shows trends of moderate increases in hare numbers in 1995 for both the Highlands (Victoria and Inverness Counties) and Lowlands (Cape Breton and Richmond Counties) sectors of Cape Breton Island followed by three years of relative stability and then a decline in 1999, the decline on the Highlands (-55%) markedly greater than that on the Lowlands (-26%) (Figure 10). The 5-year trend in hare abundance ranking on the Highlands is similar, although less markedly so, to the hare pellet abundance indices i.e. increase in 1994 through 1997 followed by a decline in 1998 and 1999. The "anecdotal" nature of the license report and the uncertainty of exactly where those observations were made, especially in Inverness and Victoria Counties relative to the Highlands proper i.e. many observations may have been near coastal communities and therefore not subject

to environmental factors which might be driving population changes on the Highlands, limit the credibility of conclusions from this data set. However, both indices do confirm a significant decline in snowshoe hares in 1999. (Note: pellet counts, made in the summer, are an indicator of abundance the preceding autumn/winter, whereas hunter observation indices are a measure of wildlife abundances at the time of recording i.e. potential one year difference between indices).

Summary - Of the three data sets available for analyses to assess abundance of snowshoe hare populations on the Cape Breton Highlands over the past decade, the count of hare pellets within permanent sample plots from 1993 through 2000 is considered to be the most reliable for measuring demographic trends. First, it is objective and with minimal bias. Accuracy of trends and subsequent implications for resource (timber and wildlife) management decisions, however, might be improved through independent assessment of pellet densities relative to habitat types sampled, with possible modifications to sampling methodologies to ensure sample sizes adequate for statistical verification. Second, it is repeatable with permanent plots and standardized sampling procedures.

The other two estimates of snowshoe hare population trends are subject to human and environmental variations. For instance, tracks at bait stations are influenced by current snow conditions and time since last snow fall. A difference of one and three days since last snow can greatly influence counts of hare tracks. As well, visitations to bait stations, especially when helicopters are used, can be costly. The biases associated with indices derived from voluntarily submitted small game licenses are many, the most notable being individual reporting biases (abundant hares to one hunter may be considered moderate by another) and the uncertainty of location of hare observations relative to Highlands vs Lowlands.

LIMITING FACTORS AND THREATS

Interspecific Interactions

The two main competitors, and potential threats, of lynx on Cape Breton Island appear to be the bobcat and the eastern coyote. Lynx and bobcat have managed to coexist on Cape Breton Island for at least the past 45 years, most likely due to spatial separation - lynx on the Highlands and bobcats on the Lowlands. Lynx have evolved for a life in northern boreal conditions - cold winters with deep and prolonged snow cover. Morphologically, the lynx is longer-legged with widely splayed furred paws which provide weight supporting capacity twice that of bobcat (Parker et al 1983). The bobcat is more adaptable than the lynx and occupies a wide range of habitats in North America, ranging from southwestern deserts to the southern edge of the boreal forests. The southern edge of lynx range closely approximates the northern limits for bobcats. Although the bobcat has a more diversified diet than the lynx, both species rely heavily on snowshoe hare in northern environments (Parker et al. 1983; Parker and Smith 1983).

Interspecific competition can be classified as either 1/ exploitation competition (competing for the same food source), or 2/ interference competition (direct aggressive

interaction) (Buskirk et al. 1999). In Atlantic Canada, the bobcat, Canada lynx and eastern coyote all rely on snowshoe hare for a major proportion of their diet, especially in winter, so when sharing a common range and mutual food resource, exploitation competition among all three predators is probable. Competition for snowshoe hare, when that food source is in the decline or low phase of its 10-year cycle, could prove detrimental to the least efficient predator(s). Given that the lynx is the most adapted and skilled of the three predators for capturing snowshoe hares during harsh winter conditions, the advantage in this instance must go to the lynx. However, both the coyote and bobcat appear to have the advantage over the lynx in interference competition encounters. Bobcats are physically larger than lynx (Parker and Smith 1983; Hall 1981) and, although direct evidence is lacking, it is reasonable to expect that the larger and more aggressive bobcat would be successful in direct encounters between the two species. The eastern coyote successfully competes with the bobcat in Maine (Litvaitis and Harrison 1989) and are known to kill bobcats on occasion (Anderson 1986; Jackson 1986; Toweill 1986). Although without supporting evidence, Parker et al. (1983) postulated that interference competition is responsible for the current restriction of lynx to the Cape Breton Highlands, and probably helps to explain why the southern limit of lynx, except in several incidences at higher elevations, seldom penetrates into the northern range limits of bobcats.

Of greater concern to lynx is the potential for interference competition with the eastern coyote. The eastern coyote is a new predator to eastern North America and has been on Cape Breton Island for only the past 20 years (Parker 1995). Coyotes are known to occasionally kill lynx (O'Donoghue et al 1995) and in central Alberta lynx were more concentrated where coyotes were less dense and not where hares were more dense (O'Donoghue 1997). However, winter conditions were less severe in central Alberta than on the Cape Breton Highlands. Coyotes are also distributed on the Highlands in both winter and summer. Track counts at winter bait stations on the Highlands showed coyotes to be 5 times more common than lynx in 1997 when hares were abundant, about equal to lynx when hares began to decline in 1998, and only one-half as common as lynx when hares crashed in 1999 (Figure 6). It appears that coyotes avoid the Highlands in winter when snowshoe hare densities are low, a time when many lynx disperse from the Highlands onto the adjacent Lowlands in search of alternate sources of food.

But even though coyotes are more common in high elevations during winter than previously thought (Bider 1962; Ozoga and Harger 1966; Murray et al. 1995), separation of lynx and coyotes by deep winter snows has been documented (Murray et al. 1994; Todd et al. 1981; Murray and Boutin 1991; Litvaitis 1992). Coyotes appear to prefer harder packed snow surfaces than lynx which may be why coyotes often switch prey in late winter, preferring ungulates over snowshoe hare (Parker 1995). Dead and emaciated lynx have been found on the Lowlands of Cape Breton Island which appeared to have been killed and/or fed upon by coyotes (Dan Banks, pers com.)

In the Yukon, coyotes and lynx shared a common winter range, although coyotes were generally more common at lower elevations (Murray and Boutin 1991). Both preyed heavily on snowshoe hare (Murray and Boutin 1994), although lynx, with a smaller foot-load sank less in the snow and were more successful at catching snowshoe hares. The authors speculated that coyotes might follow other predator trails (e.g. lynx) and scavenge on remains of kills. That study certainly illustrates the importance that snowmobile trails might have in facilitating coyote

dispersal onto the Highlands in winter. Although they reported no interspecific interactions, it remains uncertain what effects, if any, the eastern coyote will have on the lynx of Cape Breton Island. Further study of the interaction among the three predators to learn more of the real threats which the bobcat and coyote pose to lynx on Cape Breton Island appears warranted.

Although measured demographic and spatial responses of bobcats and lynx to the eastern coyote are lacking (Aubry et al. 1999), the coyote has been identified as a "concern" to the long-term numerical stability of both felid species (Buskirk et al 1999). Although justification for that concern remains to be validated, the situation on Cape Breton Island, where lynx are already restricted in core breeding range to the western Highlands, requires attention. Coyotes are currently distributed throughout the island, including the Highlands, and track counts at winter bait stations show them to be quite common there, even during winter. This is surprising, given the "barrier" which deep winter snow on the Highlands appears to present to bobcats, a predator of comparable morphology and weight-supporting capacity. But the advantage for interspecific competition between the two species on the Highlands in winter must be with the lynx, an animal which evolved to survive under those extreme climatic conditions. Coyotes often use roads as travel routes in both winter and summer. Forestry operations have created a wide network of roads throughout much of the Highlands - the extent that those "highways into the wilderness" have facilitated occupation of the Highlands by the coyote is uncertain, although their contribution is generally accepted (see Appendix I for map of road network into the Highlands).

Human Exploitation

The vulnerability of lynx during lows in their population cycle is obvious, especially within the Boisdale and East Bay Hills distribution units. Although a limited harvest on the Highlands might be demographically acceptable during the several years of population high, the economic benefits are limited and social justification questionable. The valued lynx resource on Cape Breton Island should remain protected from public exploitation. If not trapped, lynx appear to tolerate moderate levels of human disturbance (Aubry et al. 1999). Radio-collared lynx on Cape Breton Island showed little concern for snowmobiles (G. Parker, personal observation).

Global Warming

Evidence for a long-term warming trend at the global scale is building, and that trend is apparent in Atlantic Canada. The winter "snow line" is receeding north and the duration and severity of winter conditions are ameliorating. To the lynx, a predator evolved to survive under severe winter conditions, moderating winters pose a threat (Chris Hoving, MS graduate student, University of Maine, Orono, pers com.). Most important to long-term viability of lynx populations might be disruption of the 10-year snowshoe hare cycle and greater access to winter ranges by both coyotes and bobcats. Long-term changes to lynx and hare demographics should be monitored and perhaps interpreted relative to evidence of a regional warming trend.

Habitat Loss

There is no evidence for permanent loss of habitat for either snowshoe hare or lynx on the Cape Breton Highlands. There is some evidence for habitat change as a result of forest management practices. On some sites subjected to earlier clear-cutting prescriptions conifer plantations have now been established and more recently both naturally regenerating stands and plantations have received various intensities of thinning and spacing (see Table 1). It is uncertain how snowshoe hare will respond to these stand interventions. Reducing the density of undergrowth may result in reduced densities of hares which, we must assume, will also reduce the value of those stands to lynx. Research is needed to address these uncertainties.

SPECIAL SIGNIFICANCE OF SPECIES

In Canada there is a growing public recognition and appreciation for wilderness ecosystems and the need for their conservation. Nova Scotia is fortunate to have, on the Cape Breton Highlands, a unique, although quite limited taiga/boreal ecosystem, made possible by a combination of geology, physiology and climate. Historically the dynamics of a balsam fir-dominated plateau are driven by 20-30 year episodes of spruce budworm, a situation which assured a continuous rotation of regenerating mixed forest interspersed with black spruce bogs and older-aged spruce-fir dominated conifer stands. This landscape mosaic, combined with deep and prolonged winter snowcover, promotes and perpetuates a well defined 10-year snowshoe hare cycle. It is here that the last viable population of Canada lynx exists in the Maritime Provinces, the demographics of which are closely linked to the 10-year cycle of hare. Although there are perceived and possibly real threats to the continued survival of lynx on Cape Breton Island, the current situation, where both snowshoe hare and lynx populations appear to be functioning well within the 10-year cycle, provides the opportunity for the province of Nova Scotia to develop a lynx management plan which will ensure the long-term health and viability of both predator and prey.

The Cape Breton Highlands National Park occupies the northern extension of the plateau and provides some security for the continued presence of lynx. However, the remainder of the plateau is under lease to forestry operations and it is here that cooperative landscape management
planning is needed to ensure an adequate and continued supply of hare and lynx habitat

Although the lynx was once ($\geq$50 years ago) found in several elevated although spatially restricted regions on mainland Nova Scotia, the reestablishment of a breeding population there is very unlikely. The extirpation of lynx from the mainland was probably the result of one or more of the following: 1/over-trapping, 2/ habitat alteration and fragmentation, and 3/ interference competition with the bobcat. Unlike the isolated and wilderness boreal ecosystems of the Cape Breton Highlands, the lynx on mainland Nova Scotia had no sanctuary from the encroachment of human settlement and development. So the lynx, like the American marten, now appears to be dependent upon the Cape Breton Highlands for continued survival and should be recognized as being of special significance to the overall faunal diversity of the province. Both represent unique features of a very limited boreal/taiga ecosystem in Nova Scotia.

LYNX MANAGEMENT

A Review

Lynx were managed as a furbearer in Nova Scotia until the season was closed in 1975-76. Following 3 years of a restricted quota season (2 per trapper and mandatory submission of carcass) as part of a 3-year lynx research study in 1977-78 through 1979-80, the season has since remained closed except for a small aboriginal harvest (~4-5 per year) which was also closed several years ago for reason of lynx conservation. Nova Scotia DNR personnel continued to collect and examine lynx carcasses which happened to be trapped/snared either legally (aboriginal harvest) or accidentally by non-aboriginal trappers or in some manner were killed or died, usually during periods of hare scarcity on the Highlands and subsequent lynx dispersal to the Lowlands. As well, some monitoring of hare and lynx populations was recently established through permanent hare pellet plots, winter bait stations and occasional winter patrols.

To address the concern that lynx on Cape Breton Island were declining and were perhaps approaching endangered status, the lynx was assigned the General Status Assessment "RED" in 1996, indicating that lynx was a species known, or thought to be at risk, with the intent for preparation of a lynx status report and eventual status designation under the Nova Scotia Endangered Species Act. In March, 2000 a set of interim special management practices for lynx in Nova Scotia were developed by staff from Regional Services and the Wildlife Division of the Nova Scotia DNR. Those recommendations, which have no force under law, resulted from consideration of the best available information on the lynx in Nova Scotia and from the exhaustive and comprehensive synthesis of current scientific knowledge and thought on the ecology and management of southern lynx populations in North America (USDA Forest Service et al. 1999).

In general, the draft document accepts the targets of the existing Nova Scotia Forestry/Wildlife Guidelines and Standards as providing minimal habitat for lynx on Crown land. Additional measures included in the draft document included: 1/ providing habitat for alternate prey of lynx, especially red squirrels, and 2/ discouraging incursions of aggressive competition, especially coyotes, to core lynx habitat on the Highlands. Specific recommendations included maintaining wider buffers (50 - 100 meters) of unharvested forest around all bogs to accommodate habitat requirements of red squirrels, and decommissioning secondary roads, reforest old road beds and discourage travel/recreational use by blocking, pulling bridges and culverts, etc., among others.

EVALUATION AND PROPOSED STATUS

Existing Legal Protection or Other Status

In the United States south of the 49th parallel, the Canada lynx was listed as threatened in March, 2000 under the United States Endangered Species Act. The most recent (May, 2001) COSEWIC status for lynx in Canada is "Not at Risk." Except for New Brunswick and Nova Scotia (and Prince Edward Island where they are extirpated), lynx are managed in all provinces and Territories of Canada by regulated trapping seasons. In New Brunswick the lynx was listed as an endangered species in 1982 under the provincial Endangered Species Act and receives full protection. In Nova Scotia the lynx is currently protected from hunting and trapping. As well, in 1996 the province assigned "RED" status to the species, indicating that it is recognized as being at risk. Some protection to lynx habitat is afforded by the Forest/Wildlife Guidelines and Standards for Nova Scotia which must be implemented on Crown lands and incorporated into forest management programs for private lands. As well, in March, 2000, the Nova Scotia DNR prepared a list of Special Management Practices for lynx as an interim document, without force under law, prior to this status report and subsequent listing under the Nova Scotia Endangered Species Act. Approximately 20% of occupied lynx range on Cape Breton Island lies within the Cape Breton Highlands National Park. Records suggest ~5-7 lynx are killed by humans each year (exact numbers depend upon point in 10-year cycle of abundance and subsequent availability). This number should not significantly influence the overall population dynamics of the lynx on Cape Breton Island.

Assessment of Status and Author's Recommendation

The current breeding range of the Canada lynx in Nova Scotia is restricted to the western Highlands of Cape Breton Island and several smaller sites on the eastern shore of the Bras d'Or Lake. That distribution appears to have changed little over the past 50 years, a time during which lynx were extirpated from mainland Nova Scotia, probably caused from over-trapping, interference competition with the bobcat and habitat fragmentation and loss. Lynx harvest statistics and lynx and hare population indices suggest that the demographics of both species have historically operated within a fairly well-defined 10-year predator-prey cycle. It is probable that the intensity of the snowshoe hare cycle on the Highlands is influenced by the availability of preferred balsam fir dominated regeneration habitat which has historically been created by periodic outbreaks (20-30 years) of spruce budworm.

Although ~20% of lynx breeding range on Cape Breton Island is within the protected confines of Cape Breton Highlands National Park, most of the remainder is on Crown Lands leased for timber harvest. Although a considerable portion of lynx range on the Highlands was subjected to clear-cutting and timber salvage in the 1980s following the most recent spruce budworm outbreak in the 1970s, both hares and lynx have continued to cycle within the altered landscape. Much of the harvested landscape now supports 15-25 year old planted or natural conifer-dominated regeneration, a forest which should now represent optimum snowshoe hare habitat (see forest cover type maps of lynx breeding range on Cape Breton Island in Appendix II).

In 1996 a scientific review committee assigned "RED" status to the lynx of Nova Scotia, indicating the species to be at risk. In preparation for listing under the new Nova Scotia Endangered Species Act (NSESA), the Nova Scotia Species at Risk Working Group

commissioned this lynx status report in January, 2001. It is here recommended that the lynx be listed as "**SPECIAL CONCERN**," a status defined by COSEWIC as recognizing that the species in Nova Scotia is particularly sensitive to human activities and specific natural events but, at this time, is not an endangered or threatened species. Endangered means that a species faces imminent extirpation or extinction while threatened means that a species is likely to become endangered if limiting factors are not *reversed*. Currently, I cannot identify any limiting factors that, if not reversed, will lead to the species becoming endangered. Although there are factors of concern, such as forestry operations and potential competition from bobcats and coyotes, none of these, albeit in the absence of specific cause/effect research, have been been shown to have impacted adversely upon lynx populations within core breeding areas of Cape Breton Island. Forest management planning should consider recognizing the lynx as a featured species when developing long-term landscape management strategies and shorter-term timber harvest operations. A landscape managed for lynx will be one managed for a diversified forest compatible with the patterns of natural forest disturbance and ecological processes. A landscape managed for lynx is also one compatible with the habitat requirements of most plants and animals endemic to the Highlands of Cape Breton Island.

Although lynx habitat might well be maintained on the Highlands over the foreseeable future through prudent land management strategies sensitive to maintaining ecological processes and biological diversity, this restricted population of lynx does represent a valuable, irreplaceable and unique component of the Nova Scotia fauna which should receive high priority in resource management planning.

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LITERATURE CITED

Adams, L. 1959. An analysis of a population of snowshoe hares in northwestern Montana. Ecological Monographs 29: 141-170.

Agee, J.K. 1999. Disturbance ecology of North American boreal forests and associated northern mixed/subalpine forests. *In* Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires. (Tech. Eds.). Ecology and conservation of lynx in the United States. USDA Forest Service General Technical Report. RMRS-GTR-30.

Anderson, E.M. 1986. Bobcat behavioral ecology in relation to resource use in southeastern Colorado. Ph. D. Dissertation, Colorado State University, Fort Collins, CO.

Anderson, R.M. 1942. Mammals of North Cape Breton Highlands National Park, Nova Scotia. National Parks Bureau, Ottawa. pp. 21-25. mimeo.

Aubry, K.B., G. M. Koehler and J.R. Squires. 1999. Ecology of Canada lynx in southern boreal forests. *In* Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, .J. Krebs, K.S. McKelvey, and J.R. Squires. (Tech. Eds.). Ecology and conservation of lynx in the United States. USDA Forest Service General Technical Report. RMRS-GTR-30.

Banfield, A.W.F. 1974. The mammals of Canada. University of Toronto Press, Toronto, Canada.

Barbour, M.G., J.H. Burk and W.D. Pitts. 1980. Terrestrial plant ecology. Benjamin/Cummins Publishing Co., Menlo Park, CA.

Bider, J.R. 1962. Dynamics and the temporo-spatial relations of a vertebrate community. Ecology 43:634-646.

Bittner, S.L. and O.J. Rongstad. 1984. Snowshoe hare and allies. pp. 146-163. *In* Chapman, J.A. andG.A. Feldhamer (Editors). Wild mammals of North America. Johns Hopkins University Press. Baltimore, MD.

Brand, C.J., L.B. Keith, and C.A. Fischer. 1976. Lynx responses to changing snowshoe hare densities in central Alberta. Journal of Wildlife Management 40: 416-428.

Brand, C.J. and L.B. Keith. 1979. Lynx demography during a snowshoe hare decline in Alberta. Journal of Wildlife Management. 43: 827-849.

Brittell, J.D. R.J. Poelker, S.J. Sweeney, and G.M. Koehler. 1989. Native Cats of Washington. Section III, Lynx. Unpublished. Washington Dept. of Wildlife, Olympia, WA.

Brocke, R.H. 1982. Restoration of the lynx *Lynx canadensis* in Adirondacks Park: a problem analysis and recommendations. Unpublished; Fed. Aid Project E-1-3 and W-105-R. New York State Dept. Environmental Conservation, Study XII, Job 5.

Buskirk, S.W., L.F. Ruggiero, and C.J. Krebs. 1999. Habitat fragmentation and interspecific

competition: implications for lynx conservation. *In* Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires. (Tech. Eds.). Ecology and conservation of lynx in the United States. USDA Forest Service General Technical Report. RMRS-GTR-30.

Buskirk, S.W., W.H. Romme, F.W. Smith, and R.L. Knight. 2000. An overview of forest fragmentation in the southern Rocky Mountains. *In* R.L. Knight, F.W. Smith, S.W. Buskirk, W.H. Romme, and W.L. Baker. Editors. Forest fragmentation in the southern Rocky Mountains. University Press of Colorado, Boulder, CO.

Cameron, A.W. 1958. Mammals of the islands in the Gulf of St. Lawrence. National Museum of Canmada Bulletin No. 54, Biological Series No. 153. Ottawa. 165 pp.

Chamberlain, M. 1844. Mammals of New Brunswick. Bulletin of the Natural History Society 3 (4): 37-41.

Clarke, C.H.D. 1942. Investigation of Cape Breton Highlands National Park. National Parks Bureau, Ottawa. pp. 1-25. mimeo.

Cooney, R. 1832. A compendium history of the northern part of the Province of New Brunswick, and the District of Gaspe in Lower Canada. Halifax, Nove Scotia.

Crane, J. 1930. Mammals of New Hampshire County, Massachusetts. Journal of Mammalogy. pp 267-273.

Cumberland, R. R. Doucette and T. Byers. 1998. A historical perspective of Canada lynx (*Lynx canadensis*) in New Brunswick. Furbearer Report #19, Department of Natural Resources and Energy, Fredericton, New Brunswick. Typewritten ms., 15 pp.

Denys, Nicolas. 1672. The description and natural history of the coasts of North America (Acadia). Translated by William F. Ganong for The Champlain Society, Toronto. 1908.

de Vos, A. and S.E. Matel. 1952. The status of the lynx in Canada, 1920-1952. Journal of Forestry 50 (10): 742-745.

Diereville, Sieur de. 1708. Relation du Voyage du Port Royale de l'Acadie, ou de la Nouvelle France, Rouen. Translated by the Champlain Society, Toronto. 1933.

Dolbeer, R.A. and W.R. Clark. 1975. Population ecology of snowshoe hare in the central Rocky Mountains. Journal of Wildlife Management 39: 535-549.

Elton, C., and M. Nicholson. 1942. The ten year cycle in numbers of lynx in Canada. Journal of Animal Ecology 11: 215-244.

Fisher, P. 1825. Sketches of New Brunswick by an inhabitant. St. John, New Brunswick. Reprint: First history of New Brunswick by Peter Fisher. St. John. 1921.

Forbes, G., I. Stone, P. Boutot and J. Higdon. 1999. Survey of lynx abundance in Green River Area, New Brunswick. Report submitted to New Brunswick Wildlife Council. New Brunswick Cooperative Fish and Wildlife Research Unit, University of New Brunswick, Fredericton, New Brunswick. 22 pp.

Gilpen, J. Bernard. 1864. On the Mammalia of Nova Scotia. Transactions of the Nova Scotian Institute of Natural Science. pp. 8-15.

Hickenbottom, J.R., B. Summerfield, J. Aardahl, G. Halekas, M. Hilliard, L. Jackson, D. Prevedel and J. Rupe. 1999. Biological assessment of the effects of National Forest land and resource management plans and Bureau of Land Management use plans on Canada Lynx. United State Department of Agriculture, Forest Service. 149 pp.

Jackson, D.H. 1986. Ecology of bobcats in east-central Colorado. Ph.D. Dissertation, Colorado State University, Fort Collons, CO.

Keith, L.B. 1963. Wildlife's ten-year cycle. University of Wisconsin Press, Madison, WI.

Kelly, W. and H. Routledge. 1993. History of pulpwood operations on the Cape Breton Highlands. Nova Scotia Pulp Ltd. - Stora Forest Industries Ltd. 7 pp. Typewritten.

Kesterson, B.A. 1988. Lynx home range and spatial organization in relation to population density and prey abundance. Unpublished M.S. Thesis, University of Alaska, Fairbanks, AK.

Kilgore, B.M. and M.L. Heinselman. 1990. Fire in wilderness ecosystems. pp 297-335. *In* Hendies, J.C., G.H. Stankey, and R.C. Lucas (Editors). Wilderness management. 2nd Edition, North American Press, Golden, CO. 546 pp.

Koehler, G.M. 1990. Population and habitat characteristics of lynx and snowshoe hares in northcentral Washington. Canadian Journal of Zoology 68: 845-851.

Koehler, G.M. and J.D. Brittell. 1990. Managing spruce-fir habitat for lynx and snowshoe hares. Journal of Forestry 88: 10-14.

Koehler, G.M. and K.B. Aubry. 1994. Lynx. Pages 74-98. *In*: Ruggiero, L.F., K.B. Aubry, S.W.Buskirk, L.S. Lyon and W.J. Zielinski. 1994. The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the western United States. General Technical Report RM-254. United States Department of Agriculture,

Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, COL. 184 pp.

Levinge, Capt. R.G.A. 1846. Echoes from the backwoods. London.

Litvaitis, J.A. 1992. Niche relations between coyote and sympatric Carnivora. pp. 73-85. *In* A.H. Boer, Editor. Ecology and management of the eastern coyote. University of New Brunswick, Wildlife Research Unit, Fredericton, N.B.

Litvaitis, J.A. and D.J. Harrison. 1989. Bobcat-coyote niche relationships during a period of coyote population increase. Canadian Journal of Zoology 67: 1180-1188.

Litvaitis, J.A., D. Kingman, Jr., J. Lanier, and E. Orff. 1991. Status of lynx in New Hampshire. Trans. NE Section Wildl. Soc. 48: 70-75.

Loucks, O.L. 1962. A forest classification for the Maritime Provinces. Proceedings Nova Scotia Institute of Science 25 (2): 85-167.

McAlpine, D.F. and A.D.B. Heward. 1993. Lynx in New Brunswick. Chickadee Notes - A Series on the Natural History of New Brunswick. No. 5. New Brunswick Museum, St. John, N.B. 3 pp.

McCord, C.M. and J.E. Cardoza. 1982. Bobcat and lynx. pp. 728-766. *In* Chapman, J.A. and G.A. Feldhamer (Editors). Wild mammals of North America. Johns Hopkins University Press. Baltimore, MD.

McKelvey, K.S., K.B. Aubry and Y.K. Ortega. 1999. History and distribution of lynx in the contiguous United States. Pages 207-264 *In*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey and J.R. Squires (Tech. Eds.). Ecology and conservation of lynx in the United States. USDA Forest Service General Technical Report.MRS-GTR-30.

McTaggart Cowan, I. 1971. Summary of the symposium on the native cats of North America. *In*: S.E. Jorgenson and L.D. Mech (Editors). Proceedings of a symposium on native wild cats of North America: their status and management. United States Department of Interior
and Bureau of Sport Fisheries and Wildlife. Portland, Oregon. 139 pp.

Mech, L.D. 1977. Record movement of a Canadian lynx. Journal of Mammalogy 58: 676-677.

Miller, G.S. Jr. 1899. Preliminary list of the mammals of New York. New York State Museum Bulletin 29: 273-390

Mills, P. and M. O'Brien. 1997. Cape Breton Island American marten pilot project summary -

1997. Nova Scotia Department of Natural Resources Internal Report. 10 pp.

Miner, J. 2000. 1999 Cape Breton Island American marten (*Martes americana*) bait station project summary. Nova Scotia Department of Natural Resources Internal Report. 8 pp.

Morris, R.F. 1948. The land mammals of New Brunswick. Journal of Mammalogy 29 (2): 165-176.

Mowat, G., B.G. Slough, and S. Boutin. 1996. Lynx recruitment during a snowshoe hare population peak and decline in southwest Yukon. Journal of Wildlife Management 60:441-452.

Mowat, G., K.G. Poole and M. O'Donoghue. 1999. Ecology of lynx in northern Canada and Alaska. *In* Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires. (Tech. Eds.). Ecology and conservation of lynx in the United States. USDA Forest Service General Technical Report. RMRS-GTR-30.

Murray, D.L. and S. Boutin. 1991. The influence of snow on lynx and coyote movements:does morphology affect behaviour? Oecologia 88: 463-469.

Murray, D.L., and S. Boutin. 1994. Winter habitat selection by lynx and coyotes in relation to snowshoe hare abundance. Canadian Journal Zoology 72: 1444-1451.

Murray, D.L., S. Boutin and M. O'Donoghue. 1994. Winter selection by lynx and coyote in relation to snowshoe hare abundance. Canadian Journal of Zoology 72: 1444-1451.

Murray, D.L., S. Boutin, M. O'Donoghue, and V.O. Nams. 1995. Hunting behavior of a sympatric felid and canid in relation to vegetative cover. Animal Behavior 50: 1203-1210.

Nellis, C.H. and S.P. Wetmore. 1969. Long-range movements of lynx in Alberta. Journal of Mammalogy 50: 640.

Nellis, C.H., S.P. Wetmore, and L.B. Keith. 1992. Lynx-prey interactions in central Alberta. Journal of Wildlife Management 36: 320-329.

Nocera, J.J., D. Crossland, M.S. O'Brien, T. Horsman and T. Duke. 1999. 1998 Cape Breton Island American marten project summary. Nova Scotia Department of Natural Resources Internal Report. 18 pp.

Novak, M., M.E. Obbard, J.G. Jones, R. Newman, A. Booth, A.J. Satterthwaite and G. Linscombe. 1987. Furbearer harvests in North America, 1600-1984. Ministry of Natural Resources, Toronto, Ontario.

O'Donoghue, M. 1997. Responses of coyotes and lynx to the snowshoe hare cycle. Ph. D. Dissertation, University of British Columbia, Vancouver.

O'Donoghue, M., E. Hofer, and F.I. Doyle. 1995. Predator versus predator. Natural History 104 (3): 6-9.

O'Donoghue, M., S. Boutin, C.J. Krebs, and E.J. Hofer. 1997. Numerical responses of coyotes and lynx to the snowshoe hare cycle. Oikos 80: 150-162.

O'Donoghue, M., S. Boutin, C.J. Krebs, G. Zuleta, D.L. Murray, and E.J. Hofer. 1998. Functional responses of coyotes and lynx to the snowshoe hare cycle. Ecology 79: 1193-1208.

Orr, C.D. and D.G. Dodds. 1982. Snowshoe hare habitat preferences in Nova Scotia spruce-fir forests. Wildlife Society Bulletin 10: 147-150.

Osgood, F.L. Jr. 1938. The mammals of Vermont. Journal of Mammalogy 19: 435-441.

Ozoga, J.J. and E.M. Harger. 1966. Winter activities and feeding habits of northern Michigan coyotes. Journal of Wildlife Management 30: 809-818.

Parker, G.R. 1981. Winter habitat use and hunting activities of lynx (*Lynx canadensis*) on Cape Breton Island, Nova Scotia. *In*: Proceedings Worldwide Furbearer Conference. Frostburg, Md., 1980. *Edited by*: J.A. Chapman and D. Pursely, Worldwide Furbearer Conference, Inc. pp. 221-248.

Parker, G.R. 1984. Use of spruce plantations by snowshoe hare in New Brunswick. The Forestry Chronicle, June. pp. 162-166.

Parker, G.R. 1986. The seasonal diet of coyotes, *Canis latrans*, in northern New Brunswick. Canadian Field-Naturalist 100: 74-77.

Parker, G.R. 1995. Eastern coyote: the story of its success. Nimbus Publishing, Halifax, Nova Scotia. 254 pp.

Parker, G.R. and D.E.J. Smith. 1983. Sex- and age-specific reproductive and physical parameters of the bobcat (*Lynx rufus*) on Cape Breton Island, Nova Scotia. Canadian Journal of Zoology 61 (8): 1771-1782.

Parker, G.R., J.W. Maxwell, L.D. Morton and G.E.J. Smith. 1983. The ecology of the lynx (*Lynx canadensis*) on Cape Breton Island. Canadian Journal of Zoology 61 (4): 770-786.

Parker, G.R. and J.W. Maxwell. 1989. Seasonal movements and winter ecology of the coyote, *Canis latrans*, in northern New Brunswick. Canadian Field-Naturalist 103: 1-11.

Poole, K.G. 1994. Characteristics of an unharvested lynx population during a snowshoe hare decline. Journal of Wildlife Management 58: 608-618.

Poole, K.G. 1997. Dispersal patterns of lynx in the Northwest Territories. Journal of Wildlife Management 61: 497-505.

Poole, K.G. 2000. Update COSEWIC status report on Canada lynx. 53 pp.

Quinn, N.W.S. and G. Parker. 1987. Lynx. pp 682-695. *In* Wild Furbearer Management and Conservation in North America. M. Novak, J.A. Baker, M.E. Obbard, and B.Malloch (Editors). Ministry of Natural Resources, Ontario, Canada.

Rand, A.L. 1933. Notes on the mammals of the interior of western Nova Scotia. Canadian Field-Naturalist 47: 41-50.

Ruediger, B., J. Claar, S. Gniadek, B. Holt, L. Lewis, S. Mighton, B. Naney, G. Patton, T. Rinaldi, J. Trick, A. Vandehey, F. Wahl, N. Warren, D. Wenger and A. Williamson. 2000. Canada lynx conservation assessment and strategy. United States Department of Agriculture Forest Service, United States Department of Interior Fish and Wildlife Service, United States Department of Interior Bureau of Land Management, and United States Departmet of Interior National Park Service. Missoula, MT. 122 pp.

Slough, B.G., and G. Mowat. 1996. Population dynamics of lynx in a refuge and interactions between harvested and unharvested populations. Journal of Wildlife Management 60: 946-961.

Smith, R.W. 1940. The land mammals of Nova Scotia. The American Midland Naturalist 24: 213-241.

Squires, W.A. 1946. Changes in mammal populations in New Brunswick. Acadian Naturalist 2 (7): 26-41.

Stardom, R. 1988. Status report on the lynx (*Lynx canadensis*). COSEWIC Status report.

Stora. n.d. Long-term planning - overview of Stora Port Hawkesbury Limited's long-range planning process. 11 pp.

Todd, A.W,, L.B. Keith, and C.A. Fischer. 1981. Population ecology of coyotes during a fluctuation of snowshoe hares. Journal of Wildlife Management 45: 629- 640.

Toweill, D.E. 1986. Resource partitioning by bobcats and coyotes in a coniferous forest. M.S. Thesis, Oregon State University, Corvallis, OR.

Tumlison, R. 1987. *Felis lynx*. Mammalian Species 269: 1-8.

USDA Forest Service, USDI Bureau of Land Management, USFWS, and USDI National Park Services. 1999. Canada lynx conservation assessment and strategy, Unpublished Draft (November, 1999).

van Zyll de Jong, C.G. 1971. The status and management of the Canada lynx in Canada. *In*: S.E. Jorgenson and L.D. Mech (Editors). Proceedings of a symposium on native wild cats of North America: their status and management. United States Department of Interior and Bureau of Sport Fisheries and Wildlife. Portland, Oregon. 139 pp.

van Zyll de Jong, C.G. 1975. Differentiation of the Canada lynx, *Felis (lynx) Canadensis subsolana*, in Newfoundland. Canadian Journal of Zoology 53: 699-705.

Veblen, T.T., K.S. Hadley, E.M. Nels, T. Kitzberger, M. Reed and R. Villaba. 1998. Disturbance regimes and disturbance interactions in a Rocky Mountain subalpine forest. Journal of Ecology 82: 125-135.

Ward, R.M.P. and C.J. Krebs. 1989. Behavioral responses of lynx to declining snowshoe hare abundance. Canadian Journal of Zoology 63: 2817-2824.

Wolff, J.O. 1980. The role of habitat patchiness in the population dynamics of snowshoe hare abundance. Ecological Monographs 50: 111-130.

BIOGRAPHY OF AUTHOR

Gerry Parker (BS-1964; MS-1966, Acadia University) retired in October, 1997 after a 31 year career as research biologist/scientist with Canadian Wildlife Service. His career focused on wildlife research and included the study of barren-ground caribou, muskoxen, Peary caribou and Arctic hare in northern Canada (1966-1975), muskrat (New Brunswick) and moose (Newfoundland) (1976-77), Canada lynx on Cape Breton Island (1978-80), coyotes and impacts of forest silviculture on wildlife in New Brunswick (1981-84), black ducks and waterfowl ecology (1985-90) and forest ecosystems and sustainable forestry in the Maritime Provinces (1991-97). Through his career Mr. Parker published results of his research in scientific journals (~45 peer-reviewed papers), gave presentations at scientific conferences and was on editorial review committees for a number of scientific journals. He also published two books - *Eastern Coyote, the Story of its Success* and *The Eastern Panther, Mystery Cat of the Appalachians*. His

published research on the ecology of the Canada lynx on Cape Breton Island remains the sole source of reference on this isolated and vulnerable Nova Scotia predator. Mr. Parker is currently Research Scientist Emeritus with Canadian Wildlife Service in Sackville, New Brunswick.

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Table 1: Silvicultural treatment history on Cape Breton Highlands Plateau - 1967-2000 (ha). Courtesy of Stora Port Hawkesbury Ltd.

Year	Clearcut	Partial Cut Shelterwood	Site Preparation	Hardwood Control	Planted	Release Spacing Plantation	Release Spacing Natural	Corridor Spacing	Regular Spacing
1967				20					174
1968				406					
1969				1399	6				34
1970									105
1971					16				183
1972					85				148

1973									335	
1974					74				374	
1975									183	
1976				36					113	
1978					33				20	
1980	4898						75		393	
1981	3554								476	
1982	1554								669	
1983	616							434	510	
1984	1271				32			91	735	
1985	546		163	47	1503				933	
1986	531		1082	4703	1634	51			941	
1987	667		367	993	1345				980	
1988	536		275	421	1264				336	
1989	742		416	1001	315				462	
1990	155		323	1742	1015				517	
1991	128			657	328				705	

Table 1 (cont'd)

1992	25	78	116		490			507	1108	
1993		42					735	1282	776	
1994	7	180			8	22	944	188	14	
1995		15			14	1479	380			
1996	7	151			25	1663	13		18	
1997		154			1	478	909			
1998	23	182				445	685			
1999	11	358			99	247	214			9

2000	27	228			177	1019	64
			108				
Totals	15298	1387	2742	11425	8464	5403	4018
	2502	11242	117				

Table 2: Distribution of lynx carcass recoveries by year, 1987 -2000.

Year	Number of Carcasses
1987	2
1988	6
1989	2
1990	4
1991	6
1992	0
1993	0
1994	0
1995	3
1996	5
1997	6
1998	4
1999	11
2000	28
Totals	77