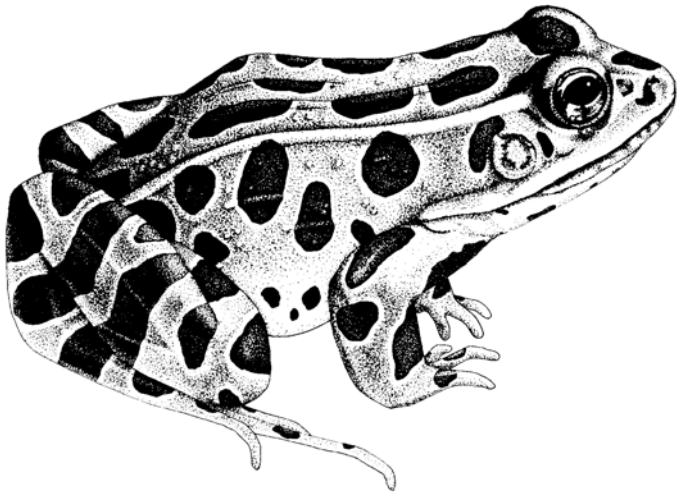
COSEWIC
Assessment and Update Status Report

on the

Northern Leopard Frog
Lithobates pipiens

Rocky Mountain population
Western Boreal/Prairie populations
Eastern populations

in Canada



Rocky Mountain population - ENDANGERED
Western Boreal/Prairie populations - SPECIAL CONCERN
Eastern populations - NOT AT RISK
2009

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous reports:

COSEWIC. 2000. 2002. COSEWIC assessment and update status report on the Northern Leopard Frog *Rana pipiens*, Rocky Mountain population, Western Boreal/Prairie populations and Eastern populations, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 39 pp.

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COSEWIC
Assessment Summary

Assessment Summary – April 2009

Common name
Northern Leopard Frog - Rocky Mountain population

Scientific name
Lithobates pipiens

Status
Endangered

Reason for designation
Although previously found in many localities in southeastern British Columbia and the Okanagan, this frog has suffered severe declines in both distribution and abundance, and now exists in extremely small numbers at only a single native population in the Creston valley.

Occurrence
British Columbia

Status history
Designated Endangered in April 1998. Status re-examined and confirmed in May 2000 and in April 2009. Last assessment based on an update status report.

Assessment Summary – April 2009

Common name
Northern Leopard Frog - Western Boreal/Prairie populations

Scientific name
Lithobates pipiens

Status
Special Concern

Reason for designation
This species remains widespread but has experienced a considerable contraction of range and the loss of populations in the past, particularly in the west. This has been accompanied by increased isolation of remaining populations, which fluctuate widely in size, with some showing signs of recovery. The species is adversely affected by habitat conversion, including wetland drainage and eutrophication, game fish introduction, collecting, pesticide contamination and habitat fragmentation that curtails recolonization and rescue of declining populations. The species is also susceptible to emerging diseases.

Occurrence
Northern Territories, Alberta, Saskatchewan, Manitoba

Status history
Designated Special Concern in April 1998. Status re-examined and confirmed in November 2002 and in April 2009. Last assessment based on an update status report.

Assessment Summary – April 2009

Common name
Northern Leopard Frog - Eastern populations

Scientific name
Lithobates pipiens

Status
Not at Risk

Reason for designation
Although this species has shown evidence of declines, it remains widespread and common in eastern Canada.

Occurrence
Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador

Status history
Designated Not at Risk in April 1999 and in April 2009. Last assessment based on an update status report.

COSEWIC
Executive Summary

Northern Leopard Frog
Lithobates pipiens

Rocky Mountain population
Western Boreal/Prairie populations
Eastern populations

Species information

The Northern Leopard Frog (*Lithobates pipiens*) is 60 to 110 millimetres in length, with females generally larger than males. It may be either green or brown on the dorsal surface, which is covered with large, rounded dark spots outlined with light halos. The underside is white. Two light-coloured dorsolateral ridges line its back, one on each side, from behind the eyes to the lower back.

Three designatable units (DUs) are recognized in order to accurately portray the status of the Northern Leopard Frog in Canada. These are based on evidence for genetic distinction between western and eastern populations and the isolation of populations west of the Rocky Mountains. The Rocky Mountain DU consists of populations in British Columbia. The Prairie/Western Boreal DU contains the populations in the Alberta, Saskatchewan, the Northwest Territories and Manitoba approximately west of the Canadian Shield. The Eastern DU consisting of all those populations of the Canadian Shield, Great Lakes/St. Lawrence, Appalachian/Atlantic Coast and Carolinian faunal provinces.

Distribution

The Northern Leopard Frog is widely distributed in North America, from southeastern British Columbia to Labrador and from the southcentral Northwest Territories down through the central and southwestern United States near to Mexico. The Northern Leopard Frog was introduced to Vancouver Island and Newfoundland, but is believed now to be extirpated from these areas. In British Columbia, the Northern Leopard Frog is currently restricted to only one historic location in the southeast corner of the province. In Alberta, the majority of extant populations are now restricted to the southeastern portion of the province. Current distribution information for Saskatchewan is largely lacking. Small populations are known to exist in the region north of Lake Athabaska in northeast Alberta and northwest Saskatchewan, into adjacent southern

Northwest Territories. The Northern Leopard Frog is believed to be relatively widespread in southern Manitoba. In eastern Canada, despite some regional declines, the species continues to be relatively widespread.

Habitat

The Northern Leopard Frog uses three distinct habitat types during its lifecycle. Overwintering occurs in cold, well oxygenated water bodies that do not freeze solid. Breeding and larval life occur in pools, ponds, marshes and lakes, and may occasionally occur in slow moving streams and creeks. Moist upland meadows and native prairie are used during the summer. Riparian areas and ponds facilitate dispersal and provide additional corridors for movement between habitats.

Biology

The Northern Leopard Frog emerges from overwintering sites shortly after ice has melted in early spring. Calling by the males, indicating breeding activity, occurs as early as mid-April in some locations, and can continue until June in other, more northerly regions. Females can deposit up to 7,000 eggs, which are attached to submerged vegetation. The rate of embryonic development depends on water temperature and may take nearly two weeks in cool water temperatures. Tadpoles take approximately two to three months to reach metamorphosis, after which, as small frogs, they move into summer foraging habitat to feed on a variety of insects. The Northern Leopard Frog typically lives for a maximum of four to five years.

Population sizes and trends

Prior to the large-scale declines observed in the early 1970s, the Northern Leopard Frog was widespread and locally common to abundant throughout its range. Since the 1970s, populations in western Canada have experienced the greatest declines. Reintroduction efforts have been initiated in British Columbia and Alberta. Despite these extensive efforts, only a single, very small and isolated native population remains in British Columbia. In much of Alberta, the species has likewise steadily declined in abundance and remaining populations are small and isolated. A general lack of information hampers appropriate assessment in Saskatchewan. The Northern Leopard Frog recovered from sharp declines in Manitoba in the mid-1970s, where it is now believed to be common throughout the southern regions of the province. Populations in Manitoba are not currently monitored. Although recent declines have been noted in Ontario, populations in eastern Canada are believed largely to be healthy and the species remains widespread. Population monitoring effort varies among the eastern provinces.

Limiting factors and threats

The Northern Leopard Frog is threatened by emerging diseases such as *chytridiomycosis*, and the introduction of non-native species, including fishes that prey upon tadpoles and adults and invasive species of plants. Introduced bullfrogs are an added source of predation in western Canada. The species' varying habitat requirements make it particularly susceptible to anthropogenic habitat change, thus habitat loss, habitat fragmentation, environmental contamination and increased incidence and severity of drought are all threats.

Special significance of the species

Amphibians can serve as indicators of ecosystem health. The Northern Leopard Frog plays an important ecological role as both a predator and a prey species. It remains one of the most widespread amphibians in Canada, and has been extensively used in research and education.

Existing protection or other status designations

In British Columbia the Northern Leopard Frog is provincially Red Listed as Endangered. In Alberta, the species is listed as Threatened. The Northern Leopard Frog is currently on Saskatchewan's Interim Species at Risk List, and is protected in provincial and national parks. In Eastern Canada, the species is afforded protection in lands administered by Parks Canada, Environment Canada and the Department of National Defence. Other government and private conservation initiatives, including the ecological gift and habitat stewardship programs, and conservation easements and purchases administered by non-profit organizations, also provide some protection for the species.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2009)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

Update
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Northern Leopard Frog
Lithobates pipiens

Rocky Mountain population
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in Canada

2009

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SPECIES INFORMATION

Name and classification

The Northern Leopard Frog, *Lithobates pipiens* (Schreber) (Fig. 1), was described in 1782 and is a member of the family Ranidae, or "true frogs". The species name "*pipiens*" comes from the erroneous association of this frog with the call of the Spring Peeper, *Pseudacris crucifer*, which is small frog that breeds at the same time as the Northern Leopard Frog and co-occurs with it throughout the northeastern portion of its range (Pace 1974). Older and no-longer recognized common English names for the species include Meadow Frog, Grass Frog, Shad Frog, Common Frog, Spotted Frog, Water Frog, Peeping Frog, Olive-colored Frog, and Herring Hoppers (Breckenridge 1944; Wright and Wright 1949). In French, it is known as “la grenouille léopard” (Deroches and Rodrigue 2005).

Figure 1. Northern Leopard Frog, *Lithobates pipiens*, adult (green phase). John Russell photo for the Nature Conservancy of Canada.

All North American ranid frogs were until recently considered to belong to the single genus *Rana*. However, the revision by Frost *et al*. (2006) has placed most North American species into the genus *Lithobates*, with only the western species allied to the Northern Red-legged Frog, *Rana aurora*, remaining within the genus *Rana*. This taxonomic arrangement has been recognized in the new standard list by Crother *et al.* (2008).

Although the Northern Leopard Frog is still considered to have an extensive range (Fig. 2), leopard frogs from throughout North and Central America were once considered to be a single wide-ranging species with considerable geographic variation (Moore 1944). Wright and Wright (1949) recognized, though, that this was probably incorrect and the “Leopard Frog” was eventually resolved into a complex of many species (Pace 1974; Hillis 1988) based on differences in call structure (Littlejohn and Oldham 1968; Pace 1974), morphology (e.g. Post and Pettus 1966, Hillis *et al.* 1983; Pace 1974) and genetic differentiation (Hillis 1988). Phylogenetic analyses based upon mitochondrial DNA by Hillis and Davis (1986) indicated that *L. pipiens*’ closest relatives were *L. magnaocularis* (Northwest Mexico Leopard Frog), *L. palustris* (Pickerel Frog) and *L. sphenocephalus* (Southern Leopard Frog) but, subsequently, Hillis and Wilcox (2005), using nuclear ribosomal DNA sequences, found it instead to be most closely related to *L. chiricahuensis* (Chiricahua Leopard Frog), *L. dunni* (Pátzcuaro Leopard Frog), *L. montezumae* (Montezuma Leopard Frog), and *L. subaquavocalis* (Ramsey Canyon Leopard Frog). *Lithobates pipiens* is the only member of the complex found in Canada.

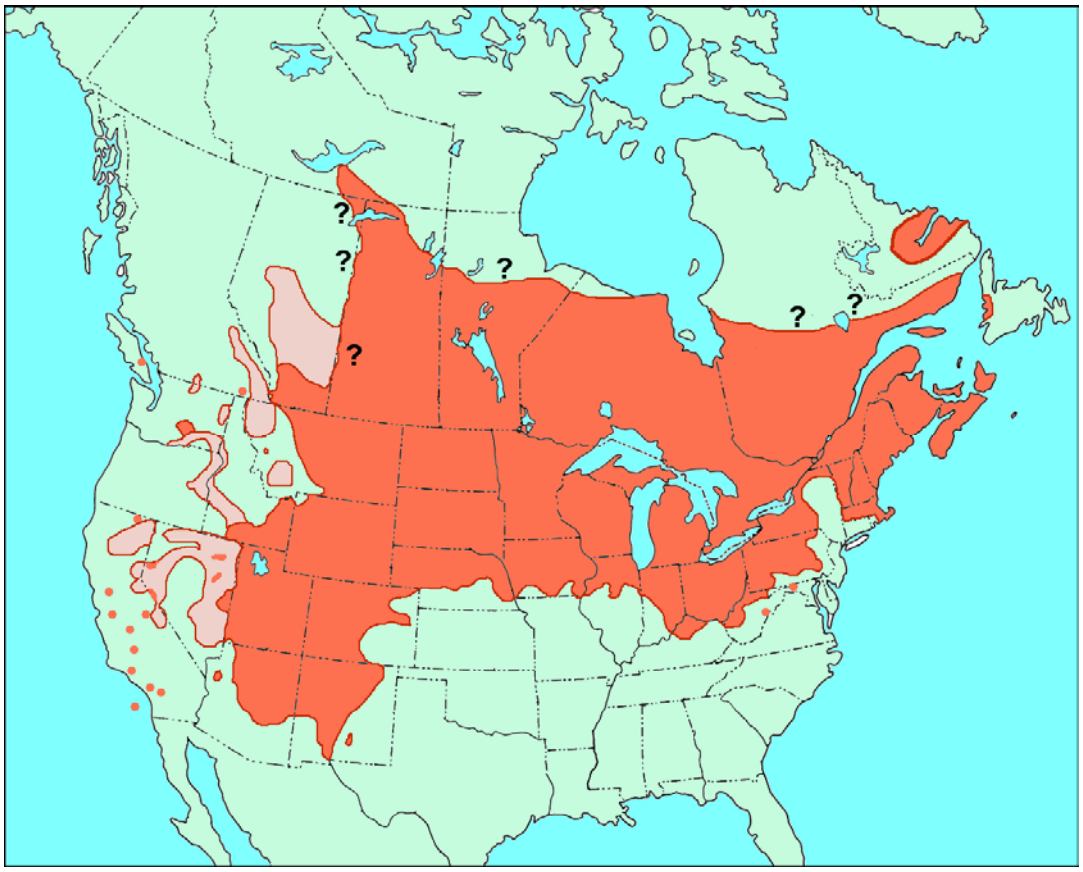

Figure 2. Distribution of the Northern Leopard Frog in North America. Question marks indicate uncertainties. Lighter shading indicates areas of apparent extirpation in western North American. After Stebbins (2003) and Smith and Keinath (2007).

Morphological description

The Northern Leopard Frog is a medium-sized, semi-terrestrial frog characterized by conspicuous, dark dorsal spots that are bordered with light coloured rings. It has a white underside, and two prominent, light coloured dorsolateral folds extending down its back (Fig. 1). Its dorsal colour is predominantly green, but can be brown or even a combination of both colours. Dorsal colour is not sex-linked and is determined by a two allele, one locus Mendelian genetic system (Fogleman *et al.* 1980). This polymorphism has been recognized for over 100 years (Cope 1889). Schueler (1982) contended that the green colour phase appeared to be more common in forested areas and the brown phase more common in areas of extensive marsh and lakes but Hoffman *et al.* (2006) found no evidence for any kind of selection on the green/brown colour locus. Dark spotting appears to be more extensive in warmer, moister climates. Rare colour morphs known as “burnsi” (lacking dorsal spots) and “Kandiyohi” (spots present but difficult to observe due to light tan background with black mottling throughout) exist (Merrell 1972; Schueler 1982). An anomalously golden-coloured morph, probably a partial albino lacking the idiriophores responsible for blue colouration in the skin, has been documented in the Cypress Hills of Alberta (K. Kendell, pers. comm.). Along beach/dune areas such as Rondeau Provincial Park and Long Point National Wildlife Area in Ontario, some Northern Leopard Frogs have little or no dorsal spotting, instead displaying only a tan background colour. This has been interpreted as either an adaptation to sandy sites (S. Gillingwater pers. comm.) or due to the release of imported laboratory animals with the “burnsi” colour variation (F.R. Cook, pers. comm). At low temperatures upon emerging from overwintering habitat, a Northern Leopard Frog can appear to be virtually black in colour (Romanchuk and Quinlan 2006).

Adult snout-to-vent length ranges from 50-100 mm. The maximum known length is 111 mm (Conant and Collins 1998). Female Northern Leopard Frogs are typically larger than males. Like many anurans, the forelimb muscles are significantly heavier in males (Yekta and Blackburn 1992). Males also develop dark, swollen nuptial pads on the innermost fingers during the breeding season.

In Canada, the Northern Leopard Frog is most likely to be confused with the Pickerel Frog, *Lithobates palustris*, which similarly has large spots on its back (Conant and Collins 1998; Natural Resources Canada 2007). However, the Pickerel Frog is slightly smaller (snout-to-vent length = 40-70 mm), its spots are square-shaped and in two parallel rows down the back, its dorsolateral folds are light yellow and its overall colour is always brownish, never green. The Pickerel Frog’s underside is bright yellow or orange in adults, especially in the groin. Pickerel Frogs are found only in eastern North America.

Genetic description

Both mitochondrial DNA (mtDNA) sequence variation in the 5' region of the NADH dehydrogenase subunit 1 gene (ND1) and evidence from eight nuclear DNA microsatellite loci (Hoffman and Blouin 2004a,b; Fulton *et al.* 2007; Wilson *et al.* 2008) have recently been employed to study the phylogeography and genetic population structure of Northern Leopard Frog populations. Hoffman and Blouin (2004a) employed a 644 base-pair fragment of ND1 whereas Fulton *et al.* (2007) and Wilson *et al.* (2008) used an 812 base-pair fragment of the same gene. Hoffman and Blouin (2004b) studied microsatellite variation from historical and extant populations from the interior and former periphery of the species' range whereas Fulton *et al.* (2007) and Wilson *et al.* (2008) concentrated on populations from western Canada, with extensive sampling from Alberta and southern Manitoba.

The mtDNA evidence indicates that there are distinct eastern and western clades of Northern Leopard Frogs (Fig. 3) and a general westward trend to the species' recolonization of previously glaciated territory in the west (Fig. 4), all suggestive that Northern Leopard Frogs recolonized previously glaciated regions of Canada from differing southern refugia during the Holocene (Hoffman and Blouin 2004a; Fulton *et al.* 2007; Wilson *et al.* 2008). Hoffman and Blouin (2004a,b) further concluded that the current genetic composition of Northern Leopard Frog populations in western and eastern regions of North American, respectively, could be related to isolation-by-distance resulting from these distinct recolonization histories, rather than to any more recent episodes of range contraction or population bottlenecks.

Western populations have less mtDNA diversity than eastern populations (Hoffman and Blouin 2004a) reflecting the likelihood that during the last major glacial event population contractions were more severe in the west whereas glacial refugia were more numerous in the east. Based on allelic diversity from microsatellite loci, Hoffman and Blouin (2004b) deduced further that historic peripheral populations already had reduced levels of genetic variation before the recent range contraction in the west. Fulton *et al.* (2007) and Wilson *et al.* (2008) refined this demonstration of diminishing genetic diversity from east to west in the Prairie, Western Boreal and Rocky Mountain regions, showing that populations in both southern and northern Alberta, as well as the Northwest territories, demonstrate a high degree of uniformity compared to Manitoba populations (Fig. 4). British Columbia populations are distinct and fixed for an allele that is not observed in any other population of Northern Leopard Frogs in western Canada (Wilson *et al.* 2008).

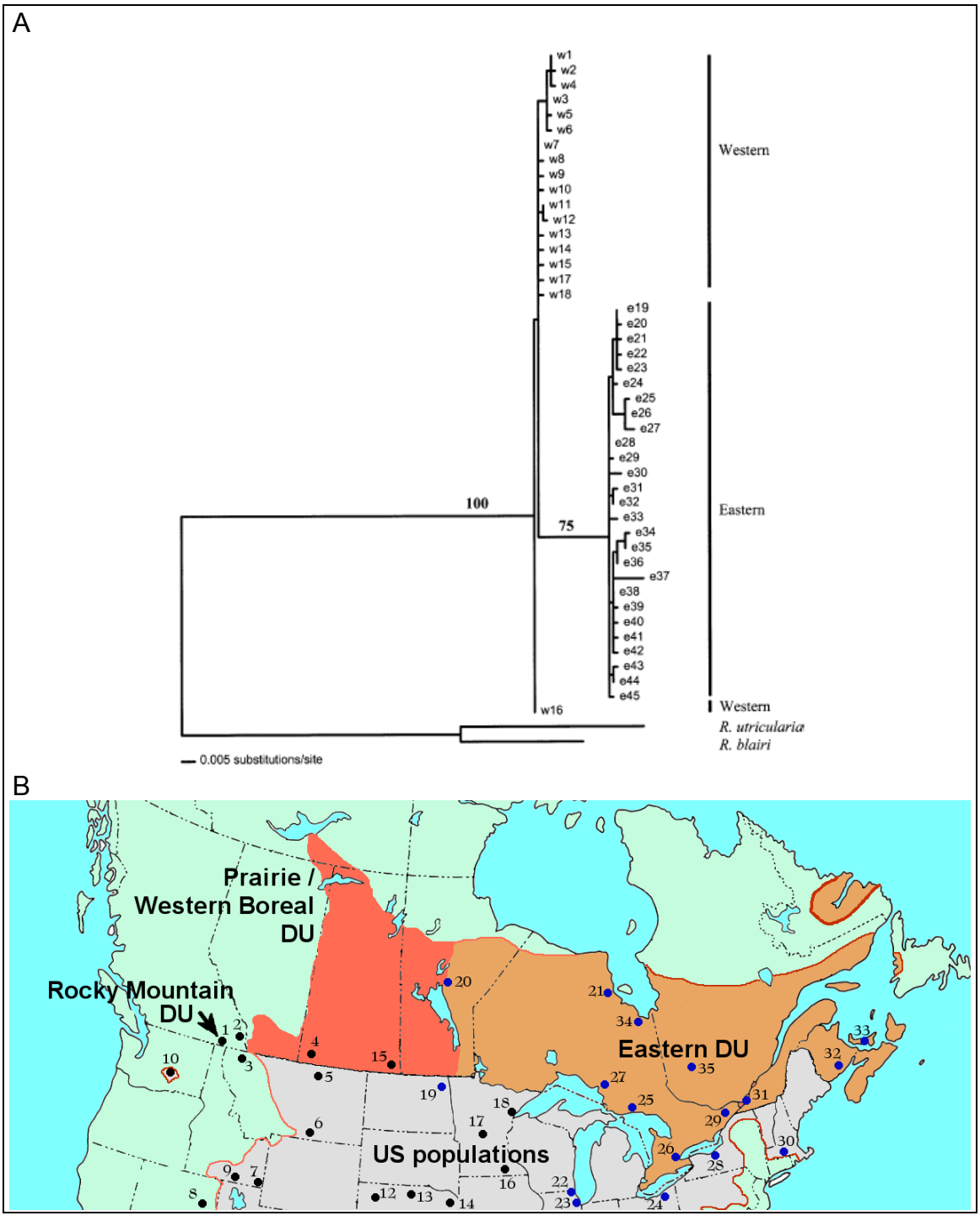

Figure 3. Relationships of *Lithobates pipiens* haplotypes based on a 644 bp sequence of the mtDNA ND1 gene. Maximum-likelihood tree (A), rooted with *L. blairi* and *L. utricularia* as outgroups, from Hoffman and Blouin (2004a). Numbers on the tree are bootstrap values and endgroup labels correspond to localities on the map (B), which depicts also the currently recognized DUs for this species in Canada. Locality No. 11 is in Arizona, off the map.

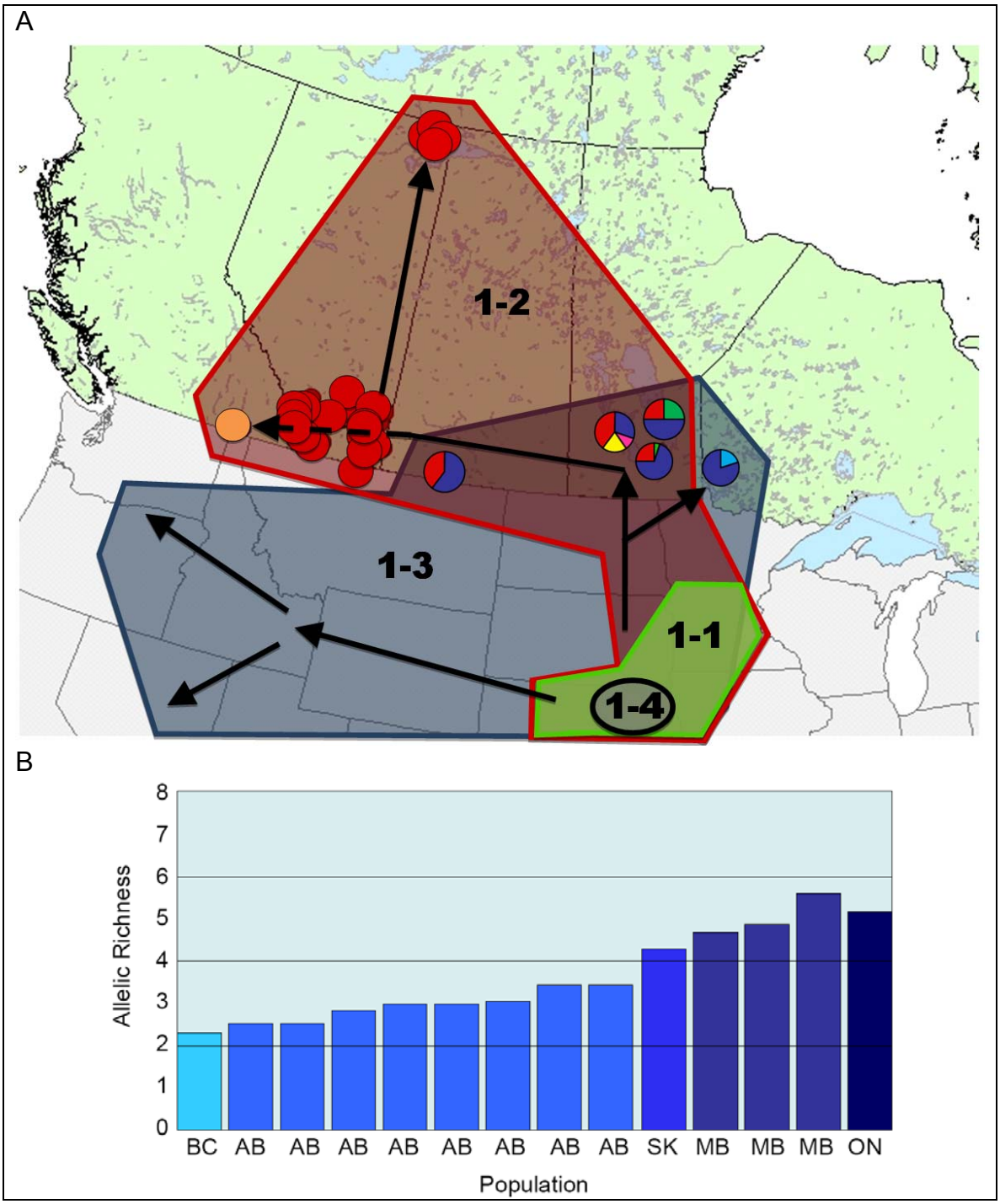

Figure 4. Genetic diversity of western Canadian populations of the Northern Leopard Frog. A) Mitochondrial haplotype diversity and historical spread into western Canada. Each population sampled for *ND1* haplotypes is indicated by a pie-chart representing the haplotypic frequency in that population. The geographic spread of the first level nesting clades (1-1 to 1-4) is indicated by shading corresponding to each clade. Arrows indicate the hypothesized movement of frogs into western Canada. B) Decreasing genetic diversity among populations from east to west based on nuclear microsatellite DNA allelic richness (from Fulton *et al.* 2007).

Hoffman *et al.* (2004) found that the genetic structure of Northern Leopard Frog populations in southern Ontario and northern New York State was temporally stable over the 11–15 generations, suggesting that these populations were not undergoing frequent extinctions and recolonizations. They also estimated the effective population size (N_e) of each population based on changes in allele frequencies over time and found that N_e of typical Northern Leopard Frog populations in this part of the range are on the order of hundreds to a few thousand frogs.

Designatable unit

The previous assessments of the status of the Northern Leopard Frog in Canada (Seburn and Seburn 1998, 1999) were done on the basis of three designatable units (Green 2005). They are (Fig. 3):

1) the Rocky Mountain DU (originally termed the Southern Mountain population), which consists of populations in British Columbia
2) the Prairie/Western Boreal DU containing population in the Alberta, Saskatchewan, the Northwest Territories and Manitoba approximately west of the Canadian Shield and
3) the Eastern DU consisting of populations of the Canadian Shield, Great Lakes/St. Lawrence, Appalachian/Atlantic Coast and Carolinian faunal provinces.

In the original assessment of western populations of Northern Leopard Frogs, the populations in Alberta, Saskatchewan, Manitoba, and the Northwest Territories were termed simply the “Prairie populations” but it was subsequently recognized that this left out those populations, including the ones in the Northwest Territories, that reside not on the prairies but in the boreal ecozone. Thus the name was corrected.

In the previous assessment, the three DUs, with boundaries in alignment with COSEWIC’s faunal provinces, were deemed appropriate to accurately portray the status of the Northern Leopard Frog in Canada. They remain so in consideration of the evidence for genetic distinction between western and eastern Northern Leopard Frog populations (Fig. 3; Hoffman and Blouin 2004a) and the evidence of distinctiveness of the Rocky Mountain DU (Fig. 4; Fulton *et al.* 2007; Wilson *et al.* 2008). There are difficulties, notwithstanding, in interpreting Hoffman and Blouin’s (2004a) results in terms of recognizing boundaries between putative DUs. Hoffman and Blouin (2004a) had very sparse sampling from Canada, and no samples from either Alberta or from northern Ontario west of the vicinity of Wawa. The affinities of the sample from western James Bay and of a sample from southern Minnesota are ambiguous. It is clear, however, that there are two major clades, east and west, and a line drawn between them (Fig. 3) can be placed coincident with the border between the Prairies and the Canadian Shield. Fulton *et al.* (2007) and Wilson *et al*. (2008) used only a single sample, from northwestern Ontario, that would represent the putative Eastern DU and found that it contained a unique mtDNA haplotype compared to more westerly samples (Fig. 4). Their sampling regime could confirm only that this sample was a sister-group to all the western Northern Leopard Frog populations.

The putative boundary between Prairie/Western Boreal and Eastern Northern Leopard Frog DUs also conforms to the east-west division line between other phylogeographically distinguishable entities among anurans, including the toads *Anaxyus* (= *Bufo*) *americanus* and *A. hemiophrys* (Green and Pustowka 1995) and eastern and western phylogroups of Wood Frogs, *Lithobates sylvaticus* (Lee-Yaw *et al*. 2008). Thus although the range of the Northern Leopard Frog appears to be continuous across central Canada, there is a significant historical and genetic division between populations stemming from glacial refugia east or west of the Great Lakes (Hoffman and Blouin 2004a).

Pooling all populations east of the Prairie and Western Boreal regions into one Eastern DU is justifiable because the species is more or less continuously distributed within this region and there is no genetic or ecological evidence to support further subdivision.

DISTRIBUTION

Global range

Northern Leopard Frogs (*Lithobates pipiens*) occurred historically throughout most of west-central and northeastern North America (Stebbins 2003; Conant and Collins 1998; NatureServe 2006), from Labrador and southern Quebec, south through to West Virginia, and west across the Canadian provinces and northern and central portions of the United States to the Rocky Mountains (Fig. 2). In the west it occurs from southern British Columbia south near to the US-Mexico border. Although Northern Leopard Frogs presently occur throughout most of their historical range, population declines and loss since the 1960s (Gibbs *et al.* 1971) or earlier have resulted in extirpation from some areas, particularly in the western two-thirds of the species' range (Stebbins 2003).

Canadian range

The Northern Leopard Frog is widespread in Canada and, despite range contractions in the west (Figs. 2, 5), has an overall Extent of Occurrence (EO) of about 2.6 million km², with an Index of Area of Occupancy (IAO) on the order of 81,000 km². It reaches its northernmost limit in the Northwest Territories south of Great Slave Lake and its native range extends from southeastern British Columbia in the west to Labrador in the east. The species was introduced to Anticosti Island (Desroches and Rodrigue 2004), western Newfoundland (Maunder 1997; Conant and Collins 1998) and Vancouver Island (Green 1978).

Rocky Mountain DU (British Columbia)

The Northern Leopard Frog historically was found in the southern Rocky Mountain Trench near the headwaters of the Kootenay and Columbia River valleys, and in the vicinity of Creston at the southern end of Kootenay Lake (Orchard 1991). Carl (1949) reported a population at Osoyoos and Green (1978) documented the presence of an evidently introduced population near Parksville on Vancouver Island. The number of populations of Northern Leopard Frogs declined dramatically in British Columbia beginning in the 1980s (Orchard 1992) and, since 2002, they are known to be extant only in the Creston Valley Wildlife Management Area, within an area well under 50 km² in extent (Adama and Beaucher 2006). An intensive captive breeding culminated in the re-introduction of the species also into the Bummers Flats Wildlife Management Area (Adama and Beaucher 2006), with only marginal success.

Prairie/Western Boreal DU

The Northern Leopard Frog's range in the Prairie and Western Boreal regions, historically, occupied an Extent of Occurrence totalling some 940,000 km² (IAO = ca. 14,000 km²).

In Alberta and prior to the 1970s, the Northern Leopard Frog ranged widely south of 55°N latitude, throughout most of the southern and central regions of the province (Figs. 2, 6) as well as in the province's northeastern corner (Alberta Northern Leopard Frog Recovery Team 2005). The historic western limit of the species in Alberta is the foothills and lower eastern slopes of the Rocky Mountains. Today, its occurrence is primarily associated with major river drainages and areas of intact native habitat in the southeastern portion of the province. The species has disappeared from central Alberta and is greatly reduced in southern Alberta (Roberts 1992; Seburn 1992b; Wagner 1997; Takats and Willis 2000), where declines were first noted in 1979 (Roberts 1981).

In Saskatchewan (Fig. 5), the Northern Leopard Frog was widespread throughout the province with the exception of the northeastern corner (Secoy 1987). Except for one location on Lake Athabasca (Secoy 1987) and a report from between Black and Bompas Lakes, east of Athabasca Lake (Heard 1985), it ranged across the province south of about 55°N latitude. The historic distribution of the Northern Leopard Frog in Saskatchewan roughly coincided with the ecological transition from predominantly boreal forest to northern forest and barrens (Rowe 1972). Extant populations appear to be associated with major river drainages, including those of the North Saskatchewan, South Saskatchewan, Qu'Appelle, Frenchman, and Souris Rivers. Population numbers evidently reached a low point in the early to mid-1970s (Seburn 1992a; Didiuk 1997).

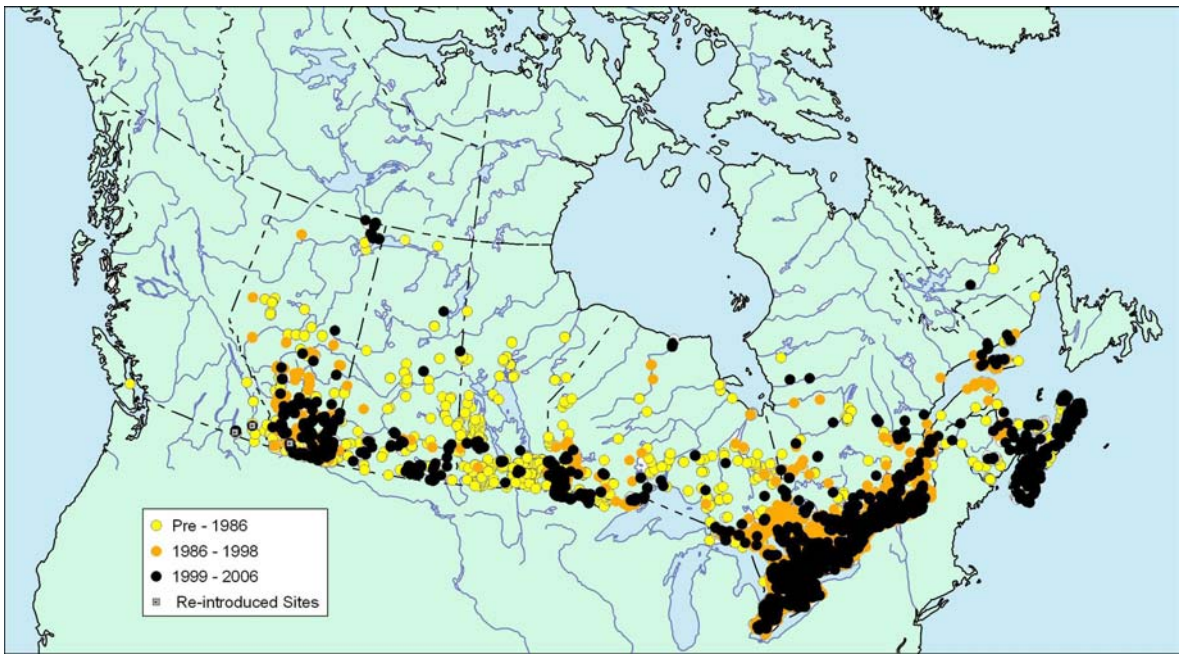

Figure 5. Distribution of the Northern Leopard Frog in Canada.

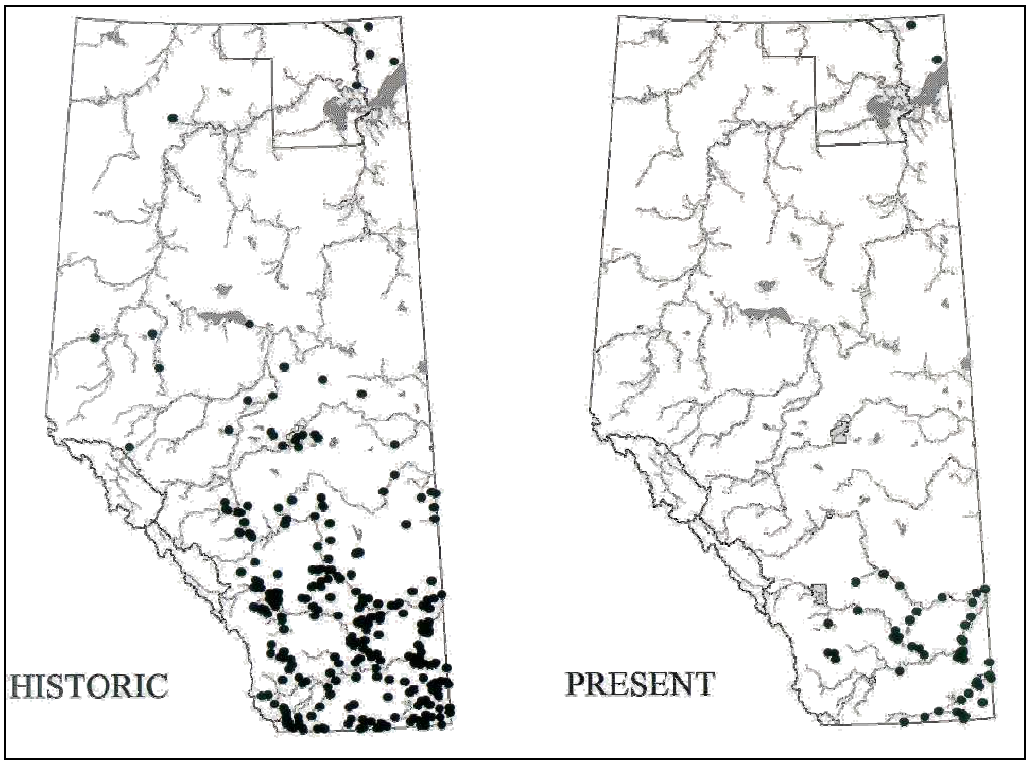

Figure 6. Historic (pre-2000) and recent (post-2000) Northern Leopard Frog distribution in Alberta (Kendell *et al.* 2006. Data from 2000/2001 provincial inventory).

In Manitoba, the Northern Leopard Frog was historically widespread west and south of Lake Winnipeg (Fig. 5; Preston 1982). The northern limit of distribution is Southern Indian Lake, with the boreal forest and Canadian Shield serving as the possible northern boundary. It was abundant in the marshes along the southern shores of both Lake Winnipeg and Lake Manitoba up until 1975 (Eddy 1976). The range of the species contracted significantly when, and where, an extensive die-off in 1975-1976 resulted in what has been described as “heaps of dead and dying frogs” up to 1 m high on the shores of frog ponds (Koonz 1992). No specimens were salvaged from this episode of disease and so, although the epidemic fungal disease chytridiomycosis is a plausible explanation, there is no information or materials available to allow diagnosis. Today, the Northern Leopard Frog occurs in the Interlake area and the rest of the southern portion of the province.

The species has been known from the Northwest Territories near Fort Smith since 1901 (Fournier 1997) and its range in the territory encompasses the region of the Slave and Taltson Rivers north as far as Bulmer Lake at 62.69ºN latitude (Seburn and Seburn 1998, S. Carriere, pers. comm.). Recent surveys in 2007 and 2008 by Rescan Inc. for Taltson Hydro EA have confirmed the continuing presence of Northern Leopard Frogs in the Taltson River drainage.

Eastern DU

In eastern Canada, including the Canadian Shield populations of eastern Manitoba, the Northern Leopard Frog’s range has a very large Extent of Occurrence (approximately 1.7 million km² and IAO (approximately 67,000 km²).

The Northern Leopard Frog is widespread throughout southern Ontario and southwestern Quebec (Fig. 5). The most northerly observation in Ontario is at Polar Bear Provincial Park (55°N latitude) near the Hudson Bay coast in 2000 (Ontario Herpetofaunal Summary Database 2000). In Quebec, it is found as far north as 53.5°N latitude and in scattered localities eastward along the St. Lawrence Valley to the Gaspé and New Brunswick border, including Anticosti Island (Bider and Matte 1994; Atlas des amphibiens et des reptiles du Québec 2008), to which it had been successfully introduced in 1899 (Desroches and Rodrigue 2004).

In the Maritimes, the Northern Leopard Frog's distribution is patchy along the east coast of Nova Scotia as far as Kejimkujic National Park and relatively extensive in southern and central New Brunswick (Gilhen 1984; McAlpine 1997). It is distributed throughout Prince Edward Island (Cook 1967). In Labrador, it is known to occur in Paradise River and several localities near Happy Valley-Goose Bay (Maunder 1997). Its distribution may be more extensive in Labrador but few comprehensive amphibian surveys have been conducted in the region. An additional northern population is known from near Lac-Baker on the Quebec border. The species is not native to the island of Newfoundland but was introduced in 1966 to Corner Brook and a site near Little Rapids (Maunder 1983) and, sometime between 1978 and 1981, to Gros Morne National Park (Maunder 1997). The last reported sightings were in 1989 and it may now be extirpated from the island (Rorabaugh 2005).

HABITAT

Habitat requirements

The Northern Leopard Frog requires distinct breeding, foraging, and overwintering habitat types during the different stages of its life history. Contiguity between these habitats is necessary for its survival (Seburn *et al.* 1997; Pope *et al.* 2000).

Breeding typically occurs in any of a variety of permanent and semi-permanent shallow, open wetlands (Wright and Wright 1949; Gilbert *et al.* 1994) that typically are no deeper than of 1.5 to 2.0 m, are pH neutral, and lack fish (Merrell 1968; Hecnar 1997). Breeding sites in Creston Valley, British Columbia, tend to be small, less than 1.0 m across (B. Houston, pers. comm.). Preferred bottom substrate is highly variable although breeding sites tend to have substrates overlain with decomposing vegetation. Known breeding habitats include beaver ponds, springs, oxbows, quiet backwaters of streams (Merrell 1977; Seburn 1992b), roadside ditches, borrow pits, lake edges (Corkran and Thoms 1996), channels, permanently flooded meadows (Eddy 1976), shallow swamps and marshes (Gilbert *et al.* 1994). In dry years, successful breeding may be limited to areas with permanent water (Eddy 1976). In Quebec, Northern Leopard Frogs have been associated with both permanent and intermittent water bodies (Bonin *et al.* 1997). Emergent vegetation at Alberta breeding sites often includes cattail, *Typha latifolia*, bulrush, *Scirpus* spp., and sedges, *Carex* spp., either separately or together (Wershler 1991). In Saskatchewan, the Northern Leopard Frog has been observed in golf course ponds where the dominant vegetation is star duckweed*, Lemma trisulca* (Bailey 2004). In British Columbia, the Northern Leopard Frog appears to exhibit strong breeding site fidelity (Waye and Cooper 1999).

Habitats used by Northern Leopard Frogs during summer foraging are typically fresh meadow, shallow marsh or unmown pasture (Merrell 1977). The species is generally not found in heavily treed areas, in grass more than one meter tall, or in open, sandy areas lacking vegetation, although it is found on beaches and at night at Long Point, Ontario. It is rarely found in heavily grazed pasture but has been observed in

ponds used by cattle where otherwise favourable breeding and overwintering conditions exist (K.J. Pearson pers. comm.). Preferred foraging habitat in the prairie regions consists of low vegetation no more than 30 cm tall (Merrell 1977), as well as areas of higher structural diversity. In New Brunswick, the height of vegetation where the Northern Leopard Frog was found averaged 32.0 cm, up to 85 cm (McAlpine and Dilworth 1989). In Alberta, summer habitat is known to be quite diverse (Wershler 1991), including shorelines with little or no vegetation, such as badlands, as well as along grassland and parkland rivers, and shorelines and river banks with abundant vegetation that includes grasses, sedges and willows. Although Merrell (1977) and the Alberta Northern Leopard Frog Recovery Team (2005) note that the Northern Leopard Frog typically avoids heavily wooded areas, Seburn (1994) observed no difference in leopard frog density in wooded *versus* non-wooded areas in the Cypress Hills of Alberta. The species has been found around man-made ponds at golf courses in Alberta (Seburn 1992b; Kendell, pers. comm.). Juveniles are rarely found far from water (Whitaker 1961). In British Columbia, the Northern Leopard Frog may use vole (*Microtus* spp.) burrows as temporary refuges during the foraging season (Waye and Cooper 2001).

The Northern Leopard Frog overwinters in cold (~4^{o}C or colder) well oxygenated water bodies (7-10 parts per million) that do not freeze to the bottom (Russell and Bauer 2000; Alberta Northern Leopard Frog Recovery Team 2005; Hine *et al.* 1981). Thus streams, creeks, rivers, spillways below dams, deep lake ponds and springs may all provide appropriate overwintering conditions (Cunjak 1986; Wershler 1991). Populations in southern Alberta, especially, appear to be closely associated with springs (K. Kendell, pers. comm.). Northern Leopard Frogs in British Columbia appear to exhibit fidelity to hibernation sites (Waye and Cooper 1999).

Habitat trends

Rocky Mountain DU

The sole remaining native Northern Leopard Frog population in British Columbia is at Creston Valley, where habitat quality is an evident limiting factor (Adama and Beaucher 2006). Roughly 65% of the 6,970 ha area in the Creston Valley where Northern Leopard Frogs are found has been dyked (Frazier 1996). As a result, water levels have stabilized and the establishment of vegetation communities in former mud flats may have created potential habitat; breeding activity has been noted in areas of habitat improvement (Adama and Beaucher 2006). Nevertheless, overall habitat within the Creston Valley is declining due to habitat modification and degradation (P. Govindarajulu, pers. comm.). Fertilizers and herbicides are applied within 40 m of the Creston Valley National Wildlife Area and soil tillage occurs during the spring and fall (Adama and Beaucher 2006). Outside of the Creston Valley, information on habitat trends pertinent to the Northern Leopard Frog is limited. Urbanization and agricultural use has notably risen in the Osoyoos area since 1940 when the species was last reported (Ohanjanian and Paige 2004) and cattle grazing is permitted at Bummer's Flats, where the species has been re-introduced.

Prairie/Western Boreal DU

Between approximately 1950 and 1990, Alberta lost 50% of its 4,000 km^2 of wetlands, with accelerated loss during the 1980s (*Alberta Northern Leopard Frog Recovery Team* 2005). Recreational subdivision in rural southwestern Alberta is increasing and agricultural land use remains widespread throughout this and the other prairie provinces. In Waterton Lakes National Park, intensive game fish stocking occurred between 1920 and 1975 (Seel *et al.* 1984). Today, many historical Northern Leopard Frog habitats in this and other protected areas in Alberta contain non-native fish species. Seismic exploration for oil and gas in southwestern Alberta has increased as of late; pond water is used for lubrication and blasting occurs within metres of known and suspected Northern Leopard Frog habitats, including breeding, summer, and overwintering sites.

It is estimated that 59% of all wetland basins and 78% of all wetland margins in southern Saskatchewan have been affected by agriculture (Turner *et al.* 1987 in Didiuk 1997). Current habitat trends in this province are unknown, although intensive agricultural land use likely continues.

In western Manitoba, circa 1950, there were approximately 2,000 km^2 of prairie wetlands (Sinclair *et al.* 1995), roughly 20% of which had been lost by 1990. The amount of wetlands has apparently stabilized since the early 1980s. Habitat deterioration at Delta Marsh on Lake Manitoba has occurred over the past 40 years, and may be associated with the abundant, introduced common carp, *Cyprinus carpio* (Dyszy *et al.* 2004) as well as water stabilization on adjacent Lake Manitoba.

Eastern DU

It is estimated that approximately 69% of southwestern Ontario consisted of wetlands before settlement (Snell 1987; Hecnar 1997). The Regional Municipality of Ottawa-Carleton (1993) reports wetland losses of 75% south of the Canadian Shield in Ontario. In Zorra township in southern Ontario, 4% of “provincially significant”, 20% of “locally significant” and 45% of total wet areas were lost during the period 1978–2000 (Walters and Shrubsole 2005). In the Great Lakes region, the loss of inland and coastal wetlands exceeds 90% (Hecnar 2004). Seburn and Seburn (2000) report the loss of approximately 90% of wetlands in southwestern Ontario. Now only 3% of the southern portion of Ontario is covered by wetlands. Similar patterns of wetland loss have occurred in southern Quebec (Daigle 1997) and today wetlands are rare in southern Quebec’s agricultural areas. It is unknown how much of this wetland loss south of the Canadian Shield involved prime leopard frog habitat. Nor is it known how much compensation there has been in the form of man-made ponds, though the effect is likely minor. In southern Quebec, intermittent watercourses, such as ditches, are more common than ponds or marshes (Bonin *et al.* 1997). Wetland loss on the Canadian Shield has not been substantial.

In the Maritimes, forest clearing for agriculture may have increased the amount of habitat available in the past, although forest regrowth since the 1880s appears to be reversing that trend (Silva *et al.* 2003; Stevens *et al.* 2002). Timber harvesting and agricultural activities in Prince Edward Island have highly fragmented the landscape (Silva *et al.* 2003), and the area of land used for potato production has increased, going from 18,785 ha in 1959 to 46,500ha in 1999 (Stevens *et al.* 2002). Although information regarding amphibian diversity in and use of altered habitats on the island varies (Silva *et al.* 2003) agricultural soil loss in PEI averages 20 tons/ha./year (Prince Edward Island Department of Fisheries and Environment *et al.* 1999), and such sedimentation and nutrient loading negatively affects amphibian habitat (Gibbs 1993; Semlitsch and Bodie 1998). The North American Waterfowl Management Plan has conducted wetland restoration by dredging in Prince Edward Island and, although this is aimed at enhancing waterfowl habitat (Stevens *et al.* 2003), amphibian call surveys at these sites have shown increases in the number of occurrences of the Northern Leopard Frog in restored versus unrestored wetlands (Stevens *et al.* 2002).

Habitat protection/ownership

Rocky Mountain DU

Creston Valley National Wildlife Area, containing the sole remaining native Northern Leopard Frog population in British Columbia, is protected by the British Columbia government and by the RAMSAR International Convention on Wetland Protection (Frazier 1996). It contains 6,970 hectares of apparently excellent Northern Leopard Frog habitat (Ohanjanian and Paige 2004). The Columbia National Wildlife Area also contains otherwise suitable habitat (Ohanjanian and Paige 2004). Roughly 82,720 ha of wetland habitat is located within National Wildlife Areas, Wildlife Management Areas and other management zones in the Columbia Valley; however, within some of these, recreational and industrial activity is permitted and it is unknown how much of these areas represents suitable Northern Leopard Frog habitat (Ohanjanian and Paige 2004). In addition to the provincial *Wildlife Act*, other forms of provincial legislation including the *Fish Protection Act*, *Creston Valley Wildlife Act*, *Integrated Pest Management Act and Regulation*, *Riparian Areas Regulation*, and the *Water Regulation* may offer habitat protection (Government of British Columbia 2007). The results-based legislation requires riparian buffers on wetlands, lakes, and streams however, non-classified wetlands and fishless streams; do not receive such protection and habitat connectivity addressed by the *Results-Based Code* (Ohanjanian and Paige 2004).

Prairie/Western Boreal DU

In Alberta, the majority of current and historic Northern Leopard Frog habitat is unprotected. Protected habitat exists within the Milk River conservation area (Seburn 1992c), Suffield National Wildlife Area, Kin Coulee Municipal Park in Medicine Hat (Powell *et al.* 1996), Cypress Hills Inter-Provincial Park, and two National Parks in the province: Waterton Lakes National Park and Wood Buffalo National Park. The Nature

Conservancy of Canada owns and administers conservation agreements that may protect known historic and current Northern Leopard Frog habitat in Alberta from additional rural residential development. However, these areas are not protected from industrial activity, overgrazing, and pesticide application. Across Canada, the Nature Conservancy of Canada has conserved approximately 600,000 hectares of land throughout the Canadian range of the Northern Leopard Frog (K.J. Pearson, pers. comm.). Habitat is likely found in Lesser Slave Lake Provincial Park and Saskatoon Island Provincial Park, and on the Blood and Peigan Indian Reservations in southern Alberta. Ducks Unlimited projects and three stewardship initiatives involving fencing and off-site watering are also protecting Northern Leopard Frog habitat in Alberta (K. Kendell, pers. comm.).

Grasslands National Park and Prince Albert National Park protect suitable Northern Leopard Frog habitat in Saskatchewan. Rangeland stewardship initiatives adjacent to Grasslands National Park may provide some habitat continuity. The Northern Leopard Frog has been observed on Battle Creek near Cypress Hills Inter-Provincial Park near the Saskatchewan-Alberta border.

In western Manitoba, the Northern Leopard Frog occurs in Riding Mountain National Park and most provincial parks, Wildlife Management Areas and refuges in the southern region (Manitoba Wildlands 2008). The population studied by Eddy (1976) was on the University of Manitoba Field Station property at Delta Marsh, on Lake Winnipeg.

Eastern DU

In eastern Manitoba, the Northern Leopard Frog occurs in Whiteshell and other provincial parks and protected areas (Manitoba Wildlands 2008). In Ontario, Northern Leopard Frogs are found in the St. Clair and Long Point National Wildlife Areas and dozens of provincial parks. Ontario's *Planning Act* offers protection for provincially significant wetlands in Ontario, despite caveats and other legislation such as the province's *Drainage Act* that enable wetland alteration and degradation (Environment Canada 2005). The Provincial Policy Statement under the *Planning Act* was, however, amended in 2005, making for stronger protection for wetlands designated as provincially significant. Conservation easements in Ontario may provide further habitat protection (Environment Canada 2005).

Tens of federal and provincial areas in Quebec, including four NWAs, legally protect Northern Leopard Frog habitat. If non-legally protected areas (i.e. Environmental NGO lands) are added, there is a considerable extent of protected habitat (S. Giguère pers. comm.).

Northern Leopard Frog habitat is found within four NWAs in Nova Scotia and two in New Brunswick, plus several additional conservation lands. Prince Edward Island has a wetland policy of no net loss and its *Environmental Protection Act* makes it illegal to destroy wetlands without a permit. If wetlands are destroyed or their function is compromised, the policy insists that new wetlands must be made (R. Curly, pers,

comm.). Similar policy and regulations have been adopted in New Brunswick (New Brunswick Wetlands Conservation Policy 2002). Habitat is also protected in various eastern National Parks: Bruce Peninsula, Pukaskwa, Georgian Bay Islands, St. Lawrence Islands, and Point Pelee (Ontario), Forillon, La Mauricie, Mingan Archipelago (Quebec), Cape Breton Highlands and Kejimkujik (Nova Scotia), Kouchibuguac (New Brunswick), and Prince Edward Island (PEI).

BIOLOGY

Life cycle and reproduction

The Northern Leopard Frog emerges from overwintering ponds when the water temperature rises to 7-10°C (Licht 1991). Adults emerge before juveniles (Dole 1967a). Migration to breeding ponds can occur on warm, rainy nights (Dole 1967a), but in those areas where the nighttime temperature is substantially lower than the daytime temperature it can occur during the day (Merrell 1977). Male Northern Leopard Frogs call at water temperatures of greater than 10°C and air temperatures of 15°C (Seburn 1992b).

Breeding generally occurs during late April and the first three weeks of May in Manitoba (Eddy 1976), May to June in Quebec (Rorabaugh 2005) and mid-April to late June in Alberta (Kendell 2002a) and B.C. (Waye and Cooper 2001). Breeding may occur over a few days to a few weeks depending on weather conditions and water temperatures (Alberta Northern Leopard Frog Recovery Team 2005). Females often tend to conceal themselves in aquatic vegetation near calling males (Merrell 1977) and, as a result, the observed operational sex ratios during the breeding season are strongly skewed towards males, up to 9:1 (Merrell 1968), although the population sex ratio overall is more approximately 1:1 (Merrell 1968; Hine *et al.* 1981; Leclair 1983).

Egg-laying sites are often concentrated. Up to 23 egg masses in 10 m^2 have been observed in Quebec (Gilbert *et al.* 1994). The density of egg masses varies from 12-1075 egg masses per hectare with a mean of 277/hectare (Hine *et al.* 1981). Egg masses are attached to submerged vegetation or laid at the surface (Merrell 1977; Hine *et al.* 1981; Gilbert *et al.* 1994). Egg masses from Manitoba have been reported from the bottom of flooded areas, 31-38 cm under water (Eddy 1976). Egg masses have been observed in flooded pastures in Alberta, and within 10cm of the water surface in Quebec (Gilbert *et al.* 1994; Waye and Cooper 2001).

Females may lay 6000 - 7000 eggs each (Hupf 1977), although half this amount is more common (Corn and Livo 1989). The number of ovarian eggs is positively correlated with body length (Gilhen 1984; Gilbert *et al.* 1994). Egg masses are about 60 to 90 mm in diameter (Hine *et al.* 1981) and range in volume from 50 ml -180 ml, with an average of 90 ml (Eddy 1976). Egg density averages 21.3 embryos/ml and, using this density, Eddy (1976) estimated over one million Northern Leopard Frog eggs were laid at one of her study sites that was 60 m x 80 m in size.

The eggs are small (1.5 mm in diameter) and velvety black on top (Dickerson 1907) with white undersides. The eggs can hatch in 9 days or less, depending on water temperatures (Hine *et al.* 1981). Hatching of eggs in Manitoba has been reported from May 7-29 and May 17-25, on average 11 days and 10 days after oviposition, respectively (Eddy 1976). Dickerson (1907) described egg development in detail.

Hatching success can be highly variable (Corn and Livo 1989). At one site in Manitoba, hatching success was estimated to be only 50% (Eddy 1976). Failure to develop accounts for approximately 20% of egg mortality, while physical displacement and/or egg mass break-up accounts for the remainder. Approximately 5% of eggs are lost to parasitism, disease, or other factors (Hine *et al.* 1981). Eggs can be killed at temperatures of 2.5°C or lower (Moore 1939). Eggs can survive exposure to 5.0°C and normal development can occur in water temperatures above 8.4°C. The thermal maximum is approximately 28°C, although embryos have developed normally at 30°C.

Metamorphosis is temperature and, possibly, density dependent and takes approximately 60 to 90 days after the eggs have hatched (Wershler 1991). In Alberta, tadpoles transform in late July or early August (C.N.L. Seburn 1993), while emergence at Creston Valley has occurred in July (Waye and Cooper 2001). Premature drying of ponds may encourage rapid transformation of late stage tadpoles. Tadpoles initially remain close to the egg mass after hatching and disperse after a few days. Complete mortality can occur if breeding ponds dry up before tadpoles become fully transformed. Metamorphs that developed during drought conditions are only 25-30 mm snout-to-vent length (svl) compared with the usual size range of 35-40 mm svl (Merrell 1977).

The ratio of young-of-the-year individuals to sexually mature Northern Leopard Frogs was found to vary from 15:1 to 20:1 in Minnesota (Merrell 1977). But because of great, and asynchronous, variability in recruitment success and adult population size, young-of-the-year frogs after transformation can comprise anywhere up to 98% of the population (Eddy 1976). Annual mortality rates among adults may reach 60% (Merrell and Rodell 1968), while overwintering young-of-the-year may suffer as much as 93% mortality (Yaremko 1996). Sexual maturity is more likely size-dependent than age-dependent, as is the case for most ectotherms. Females reach sexual maturity at 55 mm (Hine *et al.* 1981; Merrell 1977) to 60 mm svl (Gilbert *et al.* 1994). Just over half of one-year-old males are mature at 51 mm svl (Gilbert *et al.* 1994). Wild Northern Leopard Frogs will rarely live longer than four or five years, but longevity of nine years has been known in captive individuals (Froom 1982; Leclair and Castanet 1987; Russell and Bauer 2000).

The Northern Leopard Frog is an indiscriminate predator, eating anything of appropriate size that moves. There is marked seasonal variation in stomach contents corresponding to prey abundance in Manitoba (Eddy 1976). Insects are found in 50% of stomachs in early fall and 96.5% in the spring. Prey items include nocturnal and diurnal species, suggesting that Northern Leopard Frogs feed both day and night. The frogs feed primarily upon arthropods, including beetles (Coleoptera), true flies (Diptera), leafhoppers (Homoptera), ants (Hymenoptera), true bugs (Hemiptera), grasshoppers

(Orthoptera), moths and butterflies (Lepidoptera), and dragonflies (Odonata). To a lesser extent, they will also eat worms (Oligochaeta, Nematoda) or snails (Gastropoda) (Moore and Strickland 1954), small birds and smaller conspecifics (Eddy 1976; Merrel 1977). Larger frogs, both males and females, are apt to be cannibalistic; however, cannibalism occurs in all age classes older than one year. Although tadpoles are primarily herbivorous they also feed on detritus and scavenge dead animals, including other tadpoles (McAllister *et al.* 1999; Merrell 1977).

Predation

Predation affects all life stages. Predators of tadpoles include dragonfly nymphs, caddisfly larvae (Trichoptera), beetles, leeches (Hirudinea) (Dickerson 1907), Belted Kingfishers (*Ceryle alcyon*), Hooded Mergansers (*Lophodytes cucullatus*), Common Garter Snakes (*Thamnophis sirtalis*) and neotenic Tiger Salamanders (*Ambystoma tigrinum*) (McAllister *et al.* 1999). Introduced and native fish also feed on Northern Leopard Frog tadpoles.

Juvenile and adult Northern Leopard Frogs are preyed upon by a large variety of native and introduced predators. Known natural predators include turtles (Merrell 1977), herons, raccoons (*Procyon lotor*), owls (Oldfield and Moriarty 1994), snakes, waterfowl, and raptors (Breckenridge 1944). Lake trout (*Salvelinus namaycush*) eat Northern Leopard Frogs in the spring (Emery *et al.* 1972). McAlpine and Dilworth (1989) reported that 20.6% of identifiable stomach contents from introduced bullfrogs, *Lithobates catesbeianus* (= *Rana catesbeiana*) in Nova Scotia were recently transformed Northern Leopard Frogs. Other likely sources of mortality in Alberta include introduced brook (*Salvelinus fontinalis*), brown (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*) that persist in otherwise pristine amphibian habitats in national and provincial parks and other areas. Predatory fish are also known to prey upon Northern Leopard Frogs in other regions of the species' range (Hayes and Jennings 1986; McAllister *et al.* 1999; Smith, and Keinath 2007).

Physiology

Adult Northern Leopard Frogs can tolerate levels of salinity as great as 6.0 parts per thousand (ppt) for at least three months, though frogs die within three hours of exposure to concentrations of 13 ppt (Ruibal 1959). For embryos, the minimum lethal concentration is 5 ppt (Ruibal 1959). Between 3.8 and 4.6 ppt, development is usually successful, although abnormalities such as enlarged yolk-plugs and stunted growth are common. Below 3.8 ppt, development is always successful although abnormalities are still present at concentrations as low as 2.5 ppt. Yolk-plug size is positively correlated with salinity.

Northern Leopard Frogs are known to be more sensitive than most other frogs to acidic conditions, particularity after emerging from hibernation (Vatnick *et al.* 1999; Alberta Sustainable Resource Development 2003). Schlichter (1981) found that fertilization of eggs at pH below 6.5 was reduced, although Freda (1986) questioned the validity of this result because toxic sodium acetate/acetic acid buffers were used in the study. Other studies report that egg fertilization is not influenced by pH (Karns 1983; Freda 1986; Andren *et al.* 1988). Freda and McDonald (1990) found that embryos could survive in relatively acidic water; over 50% of embryos survive in water with a pH of 4.4; however, at pH 4.2, mortality is almost 100%. Pope *et al.* (2000) found that the abundance of Northern Leopard Frogs was highest at near neutral pH compared to waters that are either acidic or basic. Larvae may develop best in water with a pH of 6.5 (Nace *et al.* 1996). Breeding sites in southern Alberta can have a pH of 8.5 - 9.5. (D.C. Seburn 1993).

Northern Leopard Frogs can survive loss of up to 50% of total body water (approximately 40% of body mass) at 5°C (Churchill and Storey 1995). Their skin has a permeability of about 10 mg of water hour^{-1} cm^{-2} (Schmid 1965). Typically there is 0.814 g of water for every gram of body mass (Churchill and Storey 1995). Frogs from Michigan that were dehydrated to 65-75% of their normal weight completely re-hydrated within 48 hours simply by sitting on sand with a 20% moisture content (Dole 1967b). On sand with moisture content of 10%, frogs regain almost 60% of the lost water in 48 hours. When forced to remain in very arid conditions Northern Leopard Frogs bury themselves in the soil.

Northern Leopard Frogs are not freeze-tolerant (Churchill and Storey 1995) and do not truly hibernate (Waye and Cooper 2001). During the winter, individuals usually become inactive and overwinter in well-oxygenated waters (Waye and Cooper 2001). While conducting research on fish in an ice-covered pond in Ontario, Emery *et al.* (1972) observed overwintering leopard frogs resting in mud excavations. Significant winter kill can result due to lack of oxygen in overwintering habitat (Merrell 1977). Overwintering in small mammal burrows has also been documented (Waye and Cooper 2001).

Dispersal

Dispersal occurs largely along mesic corridors, especially where surrounding terrain is dry (Seburn *et al.* 1997). Recently transformed Northern Leopard Frogs disperse in all directions from the breeding pond (Bovbjerg and Bovbjerg 1964; Dole 1971; Seburn *et al.* 1997). Young-of-the-year individuals have dispersed at least 500 m after metamorphosis in southwestern Alberta (Romanchuck and Quinlan 2006). In the Creston Valley of British Columbia, young-of-the-year individuals have been observed 1 km from natal ponds (Waye and Cooper 2001) and frogs released at one of the breeding sites, as part of the captive rearing program, were found at a site over 3 km away in the spring of 2005 (B. Houston, pers. comm.). Adult Northern Leopard Frogs may move up to 160 m on a rainy night (Waye and Cooper 2001) but generally remain in the vicinity of breeding areas. Seasonal dispersal distances of 8 - 10 km have been

documented in Alberta (Dole 1971; Seburn *et al.* 1997; Alberta Northern Leopard Frog Recovery Team 2005; Romanchuk and Quinlan 2006). In the Cypress Hills of southeastern Alberta, this dispersal occurs equally during the day and night, and rainfall appears to trigger movement (Seburn *et al.* 1997). Bovbjerg (1965) concluded that dispersal of metamorphosed frogs is strictly neither weather- nor density-dependent.

Northern Leopard Frogs exhibit good homing abilities and they tend to return to their home range after a rain. Adults can orient correctly towards home after being displaced up to 1 km (Dole 1968). Adults maintain small home ranges varying from 15 to 600 m^2 (Dole 1965). In southern Alberta, where emergence from overwintering ponds begins in early April (Romanchuk and Quinlan 2006), adults may travel up to 1.6 km from hibernation sites to breeding habitats (Hine *et al.* 1981; Wershler 1991; Souder 2000). Waye and Cooper (2001) confirmed that male frogs exhibit breeding site fidelity, and believe females do as well.

Northern Leopard Frogs begin moving toward overwintering sites in late summer or early fall. Large numbers of frogs may migrate on warm evenings after a cold spell, and during or after rain. Late migrants move in large numbers at temperatures as low as 4°C. The fall migration begins in September in southeastern British Columbia, where it appears to be synchronous, rapid, and triggered by climatic events (Waye and Cooper 2001).

Northern Leopard Frogs require connectivity between habitat types so that they may move among them. Fragmentation, alteration or losses of habitat types constitute barriers to movement and dispersal. Anthropogenically disturbed areas that are devoid of cover, such as mined peatlands and agricultural fields, disrupt the ability of Northern Leopard Frogs to disperse and find their required habitats (Mazerolle and Desrochers 2005). In Alberta, large tracts of unsuitable habitat now separate existing populations (Kendell 2004). Road traffic, particularly, can cause significant amphibian mortality upon Northern Leopard Frog populations (Eigenbrod *et al*. 2008; Carr and Fahrig 2001). Based on studies in Quebec, Mazerolle *et al.* (2005) showed that Northern Leopard Frogs, and other species of anurans, tend to remain immobile at the approach of a vehicle, increasing their vulnerability to road traffic.

Interspecific interactions

Werner (1992) found that Northern Leopard Frog tadpoles depressed the growth of co-occurring Wood Frog, *Lithobates sylvaticus* (= *Rana sylvatica*) tadpoles. Conversely. Wood Frog tadpoles and predators can alter the morphology of Northern Leopard Frog tadpoles (Relyea 2000). Schiesari *et al.* (2006) found that Northern Leopard Frog tadpoles grew faster than Wood Frog tadpoles under good conditions but suffered higher mortality rates than Wood Frogs when raised under conditions of reduced productivity. In this way, Leopard Frogs are excluded from the unproductive ponds that are dominated by Wood Frogs.

POPULATION SIZES AND TRENDS

Search effort

Rocky Mountain DU

Standard amphibian census techniques (i.e. nocturnal calling surveys, egg mass surveys, visual surveys, and mark-recapture surveys) have all been employed to locate and monitor individuals in the Creston Valley and Bummer's Flats National Wildlife Areas (Adama and Beaucher 2006; Waye and Cooper 2001). From 2000 to 2005, approximately 1,606 total hours of survey effort was expended (Adama and Beaucher 2006) including roughly 196 person hours spent conducting spring surveys (Davidson 2006). Adama and Beaucher (2006) calculated population estimates for the Creston Valley source population in 1999, 2000, 2003, and 2005 using the Peterson index. The "Marked" sample included the total number of frogs from all age classes caught and photographed in one year and the "Capture" sample included the number of adult and juvenile frogs captured and photographed in the next year. This protocol is virtually guaranteed to overestimate the actual number of frogs due to the certainty that many frogs will have died in the interim year's time. Adults were not assayed separately from juveniles. Egg mass counts, which frequently are a reliable method of estimating numbers of adult females, are available for 2000 – 2007 (Adama and Boucher 2006; B. Houston, pers, comm.).

Prairie/Western DU

The most intensive search effort for the Northern Leopard Frog in the Prairie Provinces has occurred in Alberta. Standard amphibian search methods have been employed throughout the province during numerous surveys for the species (Kendell 2002; Taylor and Smith 2003; Kendell *et al.* 2006; Romanchuk and Quinlan 2006). Wilkinson and Hanus (2003) and Wilkinson and Berg (2004) employed pitfall trapping for amphibian monitoring. Catch per unit effort for Alberta is unknown, although the search effort for the species has been extensive. Northern Leopard Frog occurrence tracking is limited in Saskatchewan although, in 2007, the Saskatchewan Watershed Authority began a mark/recapture study to evaluate the abundance and distribution of Northern Leopard Frogs on the Upper Qu'Appelle River Conveyance Channel. Most of the limited Northern Leopard Frog records in Saskatchewan's current database are from the Qu'Appelle River valley (Bennett pers. comm.). Manitoba's Conservation Data Centre is not now tracking Northern Leopard Frog occurrences.

Eastern DU

Trends in Northern Leopard Frog occurrences in southern Ontario have been investigated by the Marsh Monitoring Program and Ontario Backyard Frog Survey. In Quebec, observations by volunteers and professionals have been compiled in the Atlas des amphibiens et des reptiles du Québec since 1988 and a call survey has been in place since 1993. Otherwise, FrogWatch, and other citizen monitoring programs

have facilitated the collection of the majority of presence, absence, and abundance information currently available for the species in the Eastern DU; however, most of these occurrence records are dated. At present, the total search effort for the Northern Leopard Frog in eastern Canada is unreported and there is a lack of recent distribution information.

Abundance

Using mark-recapture data and Peterson estimates of the numbers of individuals of all age classes in the Creston Valley source population in the Rocky Mountain DU, Adama and Beaucher (2006) estimated there to have been 654 juvenile and adult frogs in 1999, 1213 in 2000, 272 in 2003 and 368 in 2005. However, this is based on recaptures of only 2 to 13 frogs in any year, with a year between capture and recapture. Egg mass counts, indicative of the number of adult females, average 8.75/year (range = 4 – 16) over the years 2000 – 2007, inclusive, at Creston Valley (Adama and Beaucher 2006; B. Houston, pers. comm.) indicating there to have been, on average, under 20 adult frogs present, assuming no egg masses were missed.

There are no estimates for the numbers of adult Northern Leopard Frogs within the Prairie/Western Boreal DU or the Eastern DU.

Fluctuations and trends

Rocky Mountain DU

The Northern Leopard Frog was described as numerous in the Creston area of southeastern British Columbia during the mid-1970s (Ohanjanian 1996). By 1981, it was considered uncommon and surveys conducted there from 1988 to 1990 were unsuccessful (Orchard 1992). In 1991, four frogs were found at Creston Valley. Call surveys in 1996 located three or four males at one location at Creston Valley; however, evidence of reproduction was not observed (Ohanjanian 1996). It was observed at Creston again in 1997. Additional surveys in the past decade have failed to locate additional populations in the province (Ohanjanian and Teske 1996; Orchard and Ohanjanian 1995; Ohanjanian *et al*. 2006; Gillies and Franken 1999; Adama and Beaucher 2006).

The Creston Valley population peaked in 2000-2001 at approximately 1,213 - 1,992 animals, based on the Peterson index (Adama and Beaucher 2006). Estimated numbers plummeted to approximately 125 - 752 individuals in 2001 – 2002. The fungal diseases chytridiomycosis and saprolegniosis are suspected (Adama and Beaucher 2006), though not proven. Nevertheless such fluctuations in population size are frequent among pond-breeding frogs of many species (Green 2003).

As a result of recovery efforts initiated in 2001, the Northern Leopard Frog has been reintroduced to the historic location of Bummer's Flats (Adama and Beaucher 2006). This effort began in 2003 when 3,639 captive-reared young-of-the-year individuals and 493 captive-reared tadpoles were released (Adama and Beaucher 2006). Some signs of success have been noted at Bummer's Flats, and seven juvenile frogs were located during spring surveys in 2005, indicating at least some successful reproduction. Three adults (previously marked with visible implant elastomer (VIE) after being reared in captivity and released) were recovered during fall surveys in the same year, indicating that overwintering had occurred (Adama and Beaucher 2006). During surveys conducted in 2006, however, no calling males were heard and thus no egg mass surveys were conducted (Davidson 2006). Nevertheless, seven juveniles were captured during visual surveys later in the 2006 season (Davidson 2006) indicating that had been some successful, though undetected, breeding.

At Creston Valley, 4,283 captive-reared young-of-the-year individuals and 1,928 captive reared tadpoles have been released since 2001 (Adama and Beaucher 2006). Despite the assertion of Adama and Beaucher (2006) that these introductions had failed, B. Houston (pers. comm.) reported regular sightings of frogs with the VIE markers that indicated that they stemmed from the captive rearing program. During the spring breeding season of 2007, 8 of 15 individuals captured had been marked with blue VIE markers, indicating that they were frogs released in 2005 (B. Houston, pers. comm.). In addition, there is photographic evidence, based on individual spot patterns, that frogs released during the captive rearing program have survived beyond the first winter. Although no egg masses were found at this site in 2006 (Davidson 2006), 5 of the 13 egg masses found in 2007 were located there (B. Houston, pers. comm.). Adama and Beaucher (2006) reported breeding in another location at Creston Valley where it had not been observed in the past, likely a result of habitat improvements that were made in 2004. Mean maximum and minimum numbers of calling males heard during 2006 surveys at Creston Valley were 7.3 and 5.5, respectively (Davidson 2006).

Despite recovery efforts, the number of adult Northern Leopard Frogs in the Rocky Mountain DU of remains exceedingly small and continues to decline (Adama and Beaucher 2006). The 2004 and 2005 capture rates for the source population were roughly one third of those in 2000, breeding activity and egg-laying has declined at some locations, and evidence of chytridiomycosis disease has been found in frogs in both reintroduction sites and in the source population at Creston Valley (Adama and Beaucher 2006). Chytridiomycosis has infected captive reared young-of-the-year individuals within three months after their release (Adama and Beaucher 2006). Only 41 frogs were caught during spring surveys in 2006 (34 at Creston Valley, seven at Bummer's Flats). Six of these frogs were noticeably unhealthy and three showed signs of chytridiomycosis (Davidson 2006). The mean number of egg masses per breeding site at Creston Valley is low (3.2 + 3.9) (Adama and Beaucher 2006). When compared to other regions such as Quebec, where 244 egg masses have been observed at a 6 ha site (Gilbert *et al*. 1994), this is very low.

A 2004 population estimate (Adama and Beaucher 2006) for the source population at Creston Valley was in the low to mid-hundreds, previous estimates being in the high hundreds or in the thousands. Mindful of the limitations of the abundance estimates, the apparent downward trend in the population's numbers is corroborated by declines in catch effort, calling activity, and number of egg masses located (Adama and Beaucher 2006).

Prairie/Western Boreal DU

Northern Leopard Frog declines in Alberta were first observed in the late 1970s and early 1980s (Wershler 1991). Prior to that, it was widespread and abundant in the province (Kendell *et al.* 2006). Provincial inventories in 1990 and 1991 found 24 sites occupied (Wershler 1991), and in 2000 and 2001, only 20% (54) of 269 historical sites were occupied (Kendell 2002b). Northern Leopard Frogs were not located during a comprehensive search in Waterton Lakes National Park and on adjacent lands in 2003 (Taylor and Smith 2003). Remaining populations in Alberta are not only small, but fragmented and in some cases still declining (Kendell *et al.* 2006).

Alberta has implemented a Northern Leopard Frog recovery strategy (Alberta Northern Leopard Frog Recovery Team 2005). Phase one of this strategy was the 2005 provincial Northern Leopard Frog survey, which located frogs at 73 (41%) of the 177 historic locations monitored (Kendell *et al.* 2006). More than 20 frogs were observed per hour of search time at approximately five locations but only 13 breeding locations were identified (Kendell *et al.* 2006). Populations in the southeastern portion of the province were the healthiest; however, like those observed in the Northwest Territories, the northeastern corner of Alberta and the northwestern corner of Saskatchewan, they are localized, isolated, and subject to low recruitment (Kendell pers. comm.). Two sites are known in the province that have good recruitment levels and are perhaps reminiscent of conditions currently observed within the Eastern DU (K. Kendell, pers. comm.). In central Alberta formerly occupied habitats are the most prevalent, and a notable absence of Northern Leopard Frogs has been observed in the Bow and Milk River drainages (Kendell *et al.* 2006). At present, many areas of high habitat quality that have supported Northern Leopard Frogs in the past 15 years are devoid of the species (Kendell *et al.* 2006).

Three reintroduction projects have occurred in Alberta to date. More than 13,000 tadpoles were captive reared at the Raven Brood Trout Station and released into three historical locations between 1999 and 2004 (Alberta Northern Leopard Frog Recovery Team 2005). From 2003 to 2005, 8502 tadpoles were released in southwestern Alberta and successful overwintering, breeding, and dispersal has been observed (Romanchuk and Quinlan 2006). Romanchuk and Quinlan (2006) observed an average tadpole survival rate of 94.1% during this reintroduction project. In 2007, Waterton Lakes National Park successfully translocated 3.5 Northern Leopard Frog egg masses into historic habitat within the park (Smith pers. comm.). Approximately 0.5% of 13,625 tadpoles survived to metamorphosis, dispersal has been observed, and monitoring is ongoing (Smith pers. comm.). Egg mass translocation is scheduled to occur in 2008 and 2009 in Waterton Lakes National Park as well (Smith pers. comm.).

The number of Northern Leopard Frog populations in Saskatchewan is unknown, and there is insufficient data on the current status of the species (Didiuk 1997). Anecdotal information suggests that populations in Saskatchewan reached a low in the early to mid-1970s, but may now be now recovering (Seburn 1992a; Weller *et al.* 1994). Schock and Bollinger (2005) reported a decline in the Estevan area from 2000 to 2004, possibly a result of a 1999 - 2000 die-off when hundreds of dead frogs were observed. The implications of this mortality event on the regional population are unknown. The Northern Leopard Frog is known to inhabit areas in the extreme northwest corner of Saskatchewan, but its numbers there are not known (Kendell pers. comm.).

In Manitoba, the Northern Leopard Frog began dying off in 1975 and within a year was noticeably absent from major population centres (Koonz 1992). Very large numbers of dead frogs were observed. However, small isolated populations survived and recovery was first noted in 1983. Today, populations occupy formerly decimated areas in Manitoba and it is now ranked as S4 (“apparently secure”). Northern Leopard Frogs are not monitored in Manitoba, largely due to this apparent rebound (Duncan pers. comm.) and the number and distribution of extant populations remain unknown.

Eastern DU

The Northern Leopard Frog is one of the most common frogs in southern Ontario and populations in the region appear to be widespread. However, Weller *et al.* (1994) reported that the species is not as common in northern Ontario as it was historically. Surveys in 1997 failed to locate the species north of Sault St. Marie (Seburn and Seburn 1997). There is no monitoring of Northern Leopard Frogs in eastern Manitoba.

Mass mortality events resulting from *Ranavirus* have been observed in Ontario, and a four-year study in eastern and central regions of the province has noted a decline in abundance (Ontario Ministry of Natural Resources 2006). Regional Northern Leopard Frog declines of 23% (1992-93) and 5% (1993-94) were observed in a southern Ontario area monitored between 1992 and 1994 (Hecnar and M’Closkey 1997). The Marsh Monitoring Program in the southern Great Lakes region noted significant, basin-wide

declines in occurrence (2.8-3.5%/yr from 1995 to 2004), particularly in the Lake Erie and Lake Huron regions (Crewe *et al.* 2005, 2006; Weeber and Valliantos 2000). Other surveys in Ontario (i.e. road call surveys and backyard surveys) have observed extinction rates of 14% per year, while recolonization from surrounding sites is approximately 12% per year (de Solla *et al.* 2006). In Quebec, the Northern Leopard Frog is believed to be widespread (Rorabaugh 2005), and it appeared to be widespread and common in New Brunswick and the other Maritime provinces at least until the mid-1990s (McAlpine 1997). The species is at the edge of its range in Labrador and is known from only a few localities, but its abundance appears to be stable or perhaps increasing in the vicinity of Goose Bay (I. Schmelzer, pers. comm.).

Rescue effect

Rocky Mountain DU

Immigration of Northern Leopard Frogs from the northwestern United States into southern British Columbia is limited by terrain and declining populations west of the continental divide in both regions. No evidence of the Northern Leopard Frog was detected during 31 surveys of historic sites in Montana from 1993 and 2001 (Werner 2003). It was observed at 2 of 1,324 locations surveyed during this same time period and these constitute the only known extant populations west of the Continental Divide in Montana (Werner 2003). Attempts are ongoing to reintroduce the Northern Leopard Frog to Montana's Flathead Indian Reservation (J. Lichtenberg pers. comm.), where native Northern Leopard Frogs were last observed in 1980 (Werner 2003). In Washington, Leonard *et al.* (1999) found only three Northern Leopard Frog populations while surveying 27 historic sites. Habitat destruction has been documented in Washington State (Leonard *et al.* 1999).

Prairie/Western Boreal DU

Northern Leopard Frog immigration from the United States may only benefit populations present in the central and eastern extent of the Prairie/Western Boreal DU (i.e. southeastern Alberta, Saskatchewan and western Manitoba). However, in adjacent United States, the species is considered to be in decline (Smith and Keinath 2007; Table 1). In eastern Montana, many of the natural streams and larger wetlands persist; however, most of the native grassland has been subject to agricultural and urban development (Werner 2003) and droughts have had effects upon populations in Colorado (Corn and Fogleman 1984; Alexander and Eischeid 2001).

Table 1. Current abundance and population trends for the Northern Leopard Frog across the northern United States adjacent to Canada, arranged west to east (from Smith and Keinath 2007).

State	Present Abundance	Population Trend	References
Washington	Uncommon	Declining	Leonard *et al.* (1999)
Idaho	Uncommon	Declining	Koch and Peterson (1995)
Montana	Uncommon	Declining	Reichel (1996), Werner *et al.* (2004)
North Dakota	Unknown	Unknown	-
Minnesota	Common	Declining	Moriarty (1998)
Wisconsin	Common	Declining	Mossman *et al.* (1998), Hine *et al.* (1975, 1981), Dhuey and Hay (2000)
Michigan	Unknown	Declining	Collins and Wilbur (1979)
Ohio	Common	Stable	Orr *et al.* (1998)
Pennsylvania	Unknown	Unknown	-
New York	Unknown	Unknown	-
Vermont	Unknown	Unknown	-
New Hampshire	Unknown	Unknown	-
Maine	Unknown	Unknown	-

Eastern DU

Extensive land alteration in favour of agriculture has occurred throughout the Midwest of the United States (Rorabaugh 2005) and the species is noted to be declining in Minnesota, Wisconsin and Michigan (Moriarty 1998; Mossman *et al*. 1998; Hine *et al*. 1975, 1981; Dhuey and Hay 2000; Collins and Wilbur 1979). The Great Lakes and the wider, swifter reaches of the Detroit, Niagara, and St. Lawrence Rivers may represent substantial barriers to the movement of Northern Leopard Frogs between the USA and Ontario. Immigration from the United States into Quebec and New Brunswick is possible but, aside from the corridor of the Lake Champlain Valley and Richelieu River, likely neligible.

LIMITING FACTORS AND THREATS

Habitat loss and modification

Northern Leopard Frog declines observed in many areas of North America are associated with habitat loss, degradation, and fragmentation (Lannoo *et al.* 1994; Koch *et al.* 1996). Northern Leopard Frogs require more than one habitat to carry out their life cycle, and therefore populations are extremely vulnerable to habitat loss and fragmentation (Pope *et al.* 2000). Removal or modification of even one of the three habitat types used by Northern Leopard Frogs may render the landscape unsupportive

of the species' requirements (Pope *et al.* 2000). Habitat fragmentation (e.g. roads, dams, cropland, etc.) may disrupt the life cycle of the species, negatively affect a population's ability to persist through time and/or may cause local extinction (Pope *et al.* 2000). Amphibian post-metamorphic growth is lower in compromised habitats (Gray and Smith 2005; Adama and Beaucher 2006) and habitat loss may lead to local extirpations (Alberta Sustainable Resource Development 2003). Pressures on leopard frog habitat, such as wetland drainage and pipeline and highway construction, are continuing occurrences in Saskatchewan (J. Pepper, pers. comm.).

The amount of land under cultivation on the prairies has lately increased roughly 25 million hectares and there is continuing pressure to alter remaining areas such as wetlands and riparian zones. To ensure the longevity of some agricultural watering sites used for cattle during recent drought conditions in southwestern Alberta (2007), some land users requested permission to alter wetlands to make them deeper and so prevent them from drying up. Recreational subdivisions in rural areas and riparian areas threaten quality and quantity of summer foraging habitat for the frogs, and this activity is increasing in southern Alberta.

In jurisdictions where wetland drainage may be legally permitted (Environment Canada 2005), remaining wetlands may be put at risk (Seburn and Seburn 2000). However, provincially significant wetlands under the *Ontario Planning Act* are protected if they are the subject of a development proposal, and wetland drainage is not legally permitted in New Brunswick. The wetland ecosystem in the Great Lakes region is, in general, considered by Hecnar (2004) to be unhealthy.

Although many Northern Leopard Frog habitat conservation initiatives are underway, many are focusing on the protection of breeding habitat only. Wetland conservation initiatives may fail if aquatic and terrestrial habitats are not integrated (Buhlman 1995). Northern Leopard Frog survival in southwestern Alberta may be limited by a lack of summer habitat and dispersal opportunities (Roberts 1992). The reduction in the frogs' abilities to disperse in agricultural and disrupted habitats can explain their reduced abundance in such environments (Mazerolle and Desrochers 2005).

Northern Leopard Frog populations suffer considerably from road mortality (Merrell 1977), which may lead to population declines (Carr and Fahrig 2001; Eigenbrod *et al*. 2008; Mazerolle *et al.* 2005). Of the recorded mortality at Creston Valley, 20% has been caused by roads (Adama and Beaucher 2006). Northern Leopard Frogs make up over 85% of the vertebrates killed on the causeway at Long Point in southern Ontario where it is estimated that more than 1,900 Northern Leopard Frogs are killed per kilometre per year, most of which are young-of-the-year individuals (Ashley and Robinson 1996). This rate indicates, in part, the normally high abundance of Northern Leopard Frogs in this habitat but it is unknown whether such carnage is sustainable. Road mortality does not appear to be a limiting factor for the species in Alberta (Alberta Northern Leopard Frog Recovery Team 2005).

Grazing cattle and other livestock can damage Northern Leopard Frog breeding, foraging, and overwintering habitat (Saskatchewan Conservation Data Centre 2006) on the prairies. Livestock trample and reduce emergent vegetation and vegetative cover, facilitate erosion, contaminate and influence the characteristics of water (e.g. temperature, flow, turbidity, pH, and nitrate and dissolved oxygen concentrations), and disturb egg masses (Alberta Northern Leopard Frog Recovery Team 2005; Alberta Sustainable Resource Development 2003).

Disease

The Northern Leopard Frog is susceptible to diseases that can result in high mortality rates (Daszak *et al.* 1999). Although, it is not known for certain if any of the diseases afflicting Northern Leopard Frogs are emerging or enzootic, sustained increase in either incidence or prevalence of any disease can constitute a significant threat.

Greer *et al.* (2005) showed that die-offs of Northern Leopard Frog metamorphs near Bobcaygeon and Bolton in southern Ontario were due to epizootic, systemic disease caused by *Ranavirus* (Family: Iridoviridae). Another prevalent cause of Northern Leopard Frog mortality is "red leg" associated with infection by the bacterium, *Aeromonas hydrophila*. Red leg is most often fatal (Alberta Northern Leopard Frog Recovery Team 2005), High mortality of Northern Leopard Frogs in Alberta in 1976, attributed to red leg, resulted in reductions in abundance though not the elimination of populations (Roberts 1992). Disease is seriously hampering Northern Leopard Frog rearing and reintroduction efforts in British Columbia (Adama and Beaucher 2006).

Chytridiomycosis, caused by the chytrid fungus *Batrachochytrium dendrobatidis*, has been linked to Northern Leopard Frog declines across North America. The pathogen is widespread in amphibians across North America (Ouellet *et al*. 2005). Longcore *et al.* (2007) found a 25.7% rate of infection with *B. dendrobatidis* among Northern Leopard Frogs throughout Maine. The disease is known in British Columbia in young-of-the-year individuals at Creston Valley, and suspected at Bummer's Flats (Adama and Beaucher 2006) as well as in Alberta (Alberta Sustainable Resource Development 2003), Washington and Montana and has been associated with Northern Leopard Frog declines in Arizona and Idaho (Adama and Beaucher 2006). Symptoms of the disease include vascularization of extremities, skin peeling or sloughing, lethargy, behavioural changes, and unusual posturing (Speare and Berger 2004; Adama and Beaucher 2006). By altering the behaviour of Northern Leopard Frog tadpoles, chytridiomycosis is more likely to complete its life cycle (Pope *et al.* 2006). Parris *et al.* (2006) demonstrated that chytrid-infected Northern Leopard Frogs significantly lower their activity. These changes in behaviour may also translate into slower tadpole development and growth (e.g. via reduced foraging) and reduced fitness after metamorphosis (Parris *et al.* 2006). Chytridiomycosis is possibly compromising anti-microbial peptide production in Northern Leopard Frogs in British Columbia (Adama and Beaucher 2006). Columbia Spotted Frogs (*Rana luteiventris*) have tested positive for the chytrid fungus at Creston Valley, and it is suspected that the species is serving

as a reservoir-host for chytridiomycosis there (Adama and Beaucher 2006). Precisely how chytridiomycosis results in mortality is unknown (Alberta Northern Leopard Frog Recovery Team 2005).

Saprolegniasis (common water mould disease) has caused substantial Northern Leopard Frog egg and larval mortality at Creston Valley (Adama and Beaucher 2006). Associated with *Saprolegnia ferax* and *S. parasitica*, this condition is not known in Alberta. However, *S. ferax* is a common fish pathogen and the introduction of fish could result in its occurrence (Alberta Northern Leopard Frog Recovery Team 2005; Alberta Sustainable Resource Development 2003).

Ranavirus and herpes virus may result in or contribute to the mortality of adult and embryonic frogs (Alberta Sustainable Resource Development 2003). *Ranavirus* FV3 was associated with hundreds of Northern Leopard Frog mortalities in 1999 and 2000 in the Estevan area of Saskatchewan (Schock and Bollinger 2005). Greer *et al.* (2005) showed that die-offs of Northern Leopard Frog metamorphs near Bobcaygeon and Bolton in southern Ontario were due to epizootic, systemic disease caused by *Ranavirus*. The transfer of Northern Leopard Frogs across the southern region of Ontario and the conditions in which Northern Leopard Frogs are kept in bait shops contributes to the spread of *Ranavirus* (Ontario Ministry of Natural Resources 2006). A herpes virus known as Lucke's tumour virus causes kidney tumours and may infect eggs and young embryos (Davison *et al.* 1999).

Helminth parasites are common among Northern Leopard Frogs. Small frogs are more susceptible than adults to infection by parasitic lung flukes (Bolek and Janovy 2007). The trematode *Ribeiroia ondatrae* causes Northern Leopard Frog limb deformities and mortality at various stages of tadpole development (Schotthoefer *et al.* 2003). Tadpoles infected with the parasite at the pre-limb bud stage suffer significant mortality, while those exposed at the limb-bud stage experience elevated rates of malformation (Schotthoefer *et al.* 2003). *Ribeiroia ondatrae* infections are responsible for a significant amount of the malformations observed in Northern Leopard Frogs (Blaustein and Johnson 2003). The parasite could eliminate entire cohorts of Northern Leopard Frog tadpoles (Schotthoefer *et al.* 2003) although Skelly *et al.* (2007) contend that infection with *Riberoia* may not be the sole cause of limb deformities among Northern Leopard Frogs in Vermont. Trematode cyst infection in Northern Leopard Frogs is suspected in Alberta (K. Kendell, pers. comm.).

Non-native species introduction

Fish stocking is a threat to the Northern Leopard Frog and other amphibians (Saskatchewan Conservation Centre 2006; Emery *et al.* 1972; Alberta Northern Leopard Frog Recovery Team 2005; Pearson 2004; Smith and Keinath 2007). Introduced fish are likely partly responsible for declines of western ranid frogs that have evolved in relatively fish-free environments. Introduced fish can cause local extirpation and change the behaviour of amphibians (Pearson 2004). Introduced fish may also indirectly impact amphibians by introducing pathogens into the environment (Blaustein *et al.* 1994a).

Northern Leopard Frogs normally breed in fishless ponds (Merrell 1968) and likely have no natural defence against predation by introduced fish (Smith and Keinath 2007). In Ontario, Northern Leopard Frogs are less frequent in water bodies containing predatory fish species (Hecnar and M'Closkey 1997). Introduced fish prey on overwintering Northern Leopard Frogs (Emery *et al.* 1972). Fish have been introduced into many historic and present Northern Leopard Frog habitats throughout Canada. Orchard (1992) suggests that the modification and linking of wetlands for game fish introduction could be detrimental to the Northern Leopard Frog. Fish also have more access to earlier ranid life stages (Hayes and Jennings 1986). Bullfrog embryos and larvae are adapted to coping with fish (McAllister *et al.* 1999) and their expansion may even be facilitated as introduced fish reduce other ranid frogs.

Common carp can displace Northern Leopard Frogs by modifying habitat (e.g. destroying emergent vegetation and increasing turbidity) and can reduce or eliminate algae and invertebrate populations (Leonard and McAllister 1996; McAllister *et al.* 1999). Common carp exist at Creston Valley (Adama and Beaucher 2006) and are prevalent in the Delta Marsh area of Manitoba (Dyszy *et al.* 2004).

Bullfrogs are linked to Northern Leopard Frog declines in the Colorado and Washington (Hammerson 1982; Leonard and McAllister 1996; McAllister *et al.* 1999; Hayes and Jennings 1986; Corn and Fogleman 1984). Although Bullfrogs are natural predators of Northern Leopard Frog tadpoles, juveniles and possibly adults in eastern Canada, it does not naturally occur west of Ontario. It has been introduced into British Columbia, and although its range is expanding it does not yet overlap with the Northern Leopard Frog. Nevertheless, Bullfrogs are now established and increasing in the panhandle of Idaho, at least as far north as Latah County (D. Fraser, pers. comm.). Bullfrogs have not been directly linked to extirpation of Northern Leopard Frog populations (McAllister *et al.* 1999) and evaluation of whether the Bullfrog is responsible for the declines of other ranids in western North America failed to find unequivocal evidence (Hayes and Jennings 1986). Hayes and Jennings (1986) suggest habitat modification is as much of a cause for Northern Leopard Frog declines.

Non-native plants, such as purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*) and Eurasian milfoil (*Myriophyllum spicatum*), alter the structure of wetland environments (McAllister *et al.* 1999). Purple loosestrife exists at Creston Valley (Adama and Beaucher 2006) and is a major threat to native aquatic species (vegetative and non-vegetative) throughout central and eastern Canada (Environment Canada 1995). Wetlands can dry out if invaded by purple loosestrife (Environment Canada 1995). The invasive strain of the common reed (*Phragmites australis*) is posing a growing and considerable threat to wetland habitats throughout southern Ontario, Quebec and the Maritimes (Wilcox *et al.* 2003; T'ulbure *et al.* 2007). In Long Point and Rondeau, the invasion of *Phragmites* into marsh areas is drastically altering the habitats of many wetland-dependant species as the reeds now completely dominate many sites (Badzinski *et al*. 2008).

Environmental contamination

Northern Leopard Frogs are very sensitive to environmental contaminants and there is a large body of literature on the effects of pesticides on amphibians (see Bishop 1992). Pesticides can reduce food levels by killing off invertebrates and algae, and have caused reduced growth rates, paralysis and mortality in tadpoles. Even agricultural chemicals that break down rapidly, such as the popularly applied insecticide malathion will have profoundly negative effects on Northern Leopard Frogs (Relyea *et al.* 2008). Although malathion does not directly kill amphibians, its application will initiate a trophic cascade by killing off phytoplankton and zooplankton upon which frog tadpoles ultimately depend, resulting indirectly in substantial amphibian mortality. Northern Leopard Frogs exposed to pesticides have a diminished chemiluminescence and antibody response, and increased hypersensitivity (Gilbertson *et al.* 2003). Chena *et al.* (2008) showed that the detrimental effects of the herbicide contaminant, triclopyr (sold as Release®) upon Northern Leopard Frog tadpoles in western Vermont, were exacerbated by the presence of additional stressors, specifically low pH and reduced food availability.

The pesticide atrazine is used to control broadleaf and grassy weeds in various plantations (e.g. corn, apple, Christmas trees, etc.) and is applied for weed control in industrial areas and on fallow lands (Supelco 1999). Atrazine can be acutely toxic to Northern Leopard Frogs (Howe *et al.* 1998), and has caused demasculinization and feminization of amphibians in low concentrations, both in the laboratory and in the wild (Hayes 2004). Environmental contaminants, such as atrazine, DDT, and dieldrin, and environmental acidification are known to disrupt the immune system (Vatnick *et al.* 2006; Brodkin *et al.* 2007; Albert *et al.* 2007) and endocrine system (McDaniel *et al.* 2008) of larval and adult Northern Leopard Frogs. Leopard frog tadpoles exposed to estrogenic compounds such the synthetic estrogen, ethinylestradiol, during mid-metamorphosis are developmentally delayed immediately following exposure and tadpoles exposed early in development display a strong female-biased sex ratio (Hogan *et al.* 2008)

Anurans exposed to contaminants are more susceptible to pathogens (Taylor *et al.* 1999; Kiesecker 2002). Immunosuppression in Northern Leopard Frog tadpoles caused by the presence of atrazine has been shown to make them more susceptible to infection by parasitic trematode worms (Rohr *et al.* 2008). Gendron *et al.* (2003) demonstrated that Northern Leopard Frogs exposed to agricultural pesticides experience accelerated migration of the lungworm *Rhabdias ranae.* Individuals exposed to higher concentrations of pesticides can be infected with twice as many lungworms.

Agricultural run-off may result in increased algal blooms and anoxic waters, and may have a deleterious effect on Northern Leopard Frog recruitment. Anuran larvae exposed to agricultural runoff develop higher rates of limb deformities (Kiesecker 2002). High levels of hind-limb deformities in the Northern Leopard Frog and other amphibians have been reported from areas in the St. Lawrence Valley, which are exposed to high levels of pesticide runoff (Ouellet *et al.* 1997). Large numbers of dead tadpoles observed by Eddy (1976) may have been caused by agricultural runoff. Gilbertson *et al.* (2003) demonstrated immune system suppression in Northern Leopard Frogs from agricultural regions of southwestern Ontario.

Fertilizers such as nitrates may be linked to amphibian declines (Hecnar 1995). Nitrate concentrations in some North American watersheds are high enough to cause deformities and mortality in amphibians (Rouse *et al.* 1999). Rouse *et al.* (1999) reported concentrations of nitrate in surface water in southwestern Ontario ranged from 1-40mg/L. Hecnar (1995) demonstrated reduced activity, weight loss, physical abnormalities and decreased tadpole survivorship in Northern Leopard Frogs exposed to ammonium nitrate fertilizer (10mg/L maximum) below concentrations exceeded in agricultural areas. Waye and Cooper (2001) suggest that low numbers of Northern Leopard Frogs at Creston Valley may be associated with ammonium nitrate (NH_4NO_3), but acknowledge this link is not clear. In the states and provinces bordering the Great Lakes, Rouse *et al.* (1999) found 19.8% of collected water samples contained nitrate concentrations exceeding levels that cause sublethal effects in amphibians.

Approximately four to five million tonnes of road salts are applied for de-icing purposes in Canada each year, however, the impact of increasing road salt concentrations on aquatic organisms has received little attention (Sanzo *et al.* 2002). Sanzo and Hecnar (2005) found that road salts in Ontario negatively affected tadpoles by reducing their activity and weight, and inducing physical abnormalities. Collins and Russell (2009) found that environmentally significant NaCl concentrations were acutely toxic to adult amphibians.

Amphibians are sensitive to a variety of heavy metals. The distribution of the Northern Leopard Frog near Sudbury, Ontario is negatively correlated with levels of zinc in the water (Glooschenko *et al.* 1992). Cadmium and copper adversely affect development, growth, survival, and behavior of Northern Leopard Frogs at ecologically relevant concentrations (Gross *et al.* 2007; Chen *et al.* 2007). Heavy metal contamination is unlikely a major problem on the prairies, although smelting occurs in Flin Flon and Thompson, Manitoba..

Gibbs *et al.* (2005) found that disappearances of Northern Leopard Frog populations over the past 30 years in western, central, and northern New York State was associated with elevated levels of acid deposition.

Collection and harvest

Collection of Northern Leopard Frogs in British Columbia and Alberta is prohibited; however, recreational collection likely continues in Alberta (Alberta Northern Leopard Frog Recovery Team 2005). Continued harvest in these provinces for fishing or frog rearing may facilitate further local declines. The species is not commercially exploited in Saskatchewan (Seburn 1992a; Saskatchewan Conservation Data Centre 2006), and its use as bait there has been banned. The Ontario Ministry of Natural Resources has also banned the commercial collection of Northern Leopard Frogs for use as bait, though individual anglers may still collect and possess up to 12 Northern Leopard Frogs as bait.

The Northern Leopard Frog has been commercially harvested in Manitoba since at least 1920. Records from dealers indicate that up to 49,907 kilograms of Northern Leopard Frogs were collected annually during the early 1970s (Koonz 1992). If there are approximately 20-26 frogs in a kilogram, this annual harvest likely removed over one million frogs per year. By 1974, the harvest had declined to 5,900 kilograms despite no apparent change in the market. There was no commercial harvesting in 1993 or 1994, but in 1995 5,800 kg of Northern Leopard Frogs were collected. Commercial and recreational harvest in Manitoba is still permitted (J. Duncan pers. comm.). In Quebec a survey of frog harvesting conducted by the Ministère des Ressources naturelles et de la faune showed that 53% of catches were Northern Leopard Frogs, making for an estimated of 27,000 individuals harvested by persons having a permit during 1998 (Daigle and Jutras 2001).

Additional considerations

Drought and other climatic factors are known to have major influence on Northern Leopard Frogs (Merrell 1977; Corn and Fogleman 1984; Koch *et al.* 1996; Smith and Keinath 2007), especially on the prairies. Drought has been linked to the widespread Northern Leopard Frog declines observed in southern Alberta during the 1970s and 1980s (Alberta Northern Leopard Frog Recovery Team 2005); however, some biologists disagree with this possibility (Roberts 1981 1987, 1992; Wershler 1991). Given that subpopulations are susceptible to drought (Hecnar 1997), metapopulation persistence is in part governed by recolonization (Seburn and Seburn 2000), and Northern Leopard Frogs depend on landscape complementation (Pope *et al.* 2000), the combined effects of drought and a lack of habitat may result in regional collapses (Seburn and Seburn 2000). Repeated premature drying of ponds can lead to population extirpation (Corn and Fogleman 1984). Increased irrigation due to drought in some areas of the prairies may result in a low water table (Seburn 1992c). Water used in resource exploration and extraction may also affect aquifers (Alberta Northern Leopard Frog Recovery Team 2005). These activities in turn may accelerate the drying of breeding habitats, and winterkill could be exacerbated by drought conditions, as shallower ponds are more

prone to freeze completely to the bottom. Northern Leopard Frogs may be particularly vulnerable on the prairies because it is the only Canadian anuran in the region that over-winters under water. Drought does not appear to be affecting the population at Creston Valley, British Columbia (Ohanjanian and Paige 2004).

Embryo mortality in the genus *Rana* has been attributed to ultraviolet radiation (Blaustein *et al.* 1994a), and Northern Leopard Frog egg masses may be especially susceptible as they are often deposited close to the water surface (Alberta Northern Leopard Frog Recovery Team 2005). Long *et al.* (1995) may have found a link between pH and level of radiation exposure and their impacts on Northern Leopard Frogs. Northern Leopard Frog eggs exposed to both a low pH and high ultraviolet radiation had significantly reduced hatching success. Also, the effects of ultraviolet radiation and environmental contamination may be enhanced through the synergistic interactions of radiation and contaminants (Blaustein *et al.* 2003).

SPECIAL SIGNIFICANCE OF THE SPECIES

The Northern Leopard Frog is an important link in the food chain. It consumes large numbers of invertebrates and, in turn, is food for fish, waterfowl, snakes, large invertebrates, and anurans throughout its life cycle. Northern Leopard Frog tadpoles are important primary consumers of algae in breeding ponds (Smith and Keinath 2007). Like other amphibians, Northern Leopard Frogs are indicators of ecosystem health (Hecnar 2004).

Northern Leopard Frogs are used in education and research and were once the most commonly used frog species in high school dissections. Prior to the mid-1970s, up to one million frogs were commercially harvested for biological supply houses from Manitoba each year (Koonz 1992), while in Quebec 100,000 frogs a year once were collected for research and teaching purposes (Marcotte 1981 in Gilbert *et al.* 1994).

The Northern Leopard Frog has become a high profile species, and the public responds to it readily. A poster campaign in Alberta to solicit information about remaining populations has been highly successful (D.C. Seburn 1993). In 2005 the Alberta Northern Leopard Frog Recovery Team launched a new poster campaign to gain information in areas of the province where occurrence information is limited, and this survey is ongoing (K. Kendell, pers. comm.).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Northern Leopard Frog is globally ranked as G5 and nationally ranked in Canada as N5, or "very secure or demonstrably secure under current conditions" (NatureServe 2006). It is one of the most widespread amphibians in Canada (Cook 1984; Weller and Green 1997). Protection for the Northern Leopard Frog varies from one jurisdiction to another within Canada (Table 2). In British Columbia the Northern Leopard Frog is provincially Red Listed as Endangered. In Alberta, the species is listed as Threatened. The Northern Leopard Frog is currently on Saskatchewan's Interim Species at Risk List, and is protected in provincial and national parks. In eastern Canada, the species is afforded protection in various lands administered by federal departments including Parks Canada (National Parks and Historic Sites), Environment Canada (National Wildlife Areas), and the Department of National Defence. It is protected under Nova Scotia's *Wildlife Act*. Other government and private conservation initiatives across the country also provide protection for the species. Examples include the ecological gift and habitat stewardship programs, and conservation easements and purchases administered by non-profit organizations.

The Northern Leopard Frog in Canada is currently assessed by COSEWIC as three designatable units. The Southern Mountain populations (renamed the Rocky Mountain DU in this report in accordance with COSEWIC's map of faunal provinces) is listed under SARA as Endangered. The Prairie and Western Boreal populations are listed under SARA as "Special Concern." The Eastern DU is considered to be Not at Risk.

Table 2. Summary of Canadian protection and status designations for *Lithobates pipiens*.

	NatureServe (N- or S-)Rank[1]	Known Protection	Protected Areas[4]	Notes
Federal				
Canada	N5	*National Parks Act* *Species at Risk Act* *Wildlife Act*		
Provincial and Territorial				
B.C.	S1	*Provincial Wildlife Act* *Species at Risk Act* Ramsar Site (Convention on Wetlands of International Importance)	<100 km^2	
AB	S2/S3	National Parks *Provincial Wildlife Act*		Collection not permitted
NWT	Not Ranked	Unknown	Unknown	
SK	S3[2]	National Parks		Provincial Species at Risk Interim List, Fish and Wildlife Branch, 2002[2]
MB	S4	National Parks Provincial Parks[3]		Permit required for commercial collection
ONT	S5	National Parks National Wildlife Areas[7] Provincial Parks		Collection policy under review[5] Commercial harvest and sale for bait has been banned.
QC	S5	National Parks National Wildlife Areas[6] Environmental NGO lands and private nature reserves Program[6] Provincial Parks Ramsar sites	41.8 km^2 166.5 km^2	
NFLD	S3S4 (Labrador) XT (Newfoundland)			Introduced population no longer present
PEI	S4	National Parks		
NS	S5	National Parks	10.3 km^2	
NB	S5	National Parks	56.2 km^2	

[1] NatureServe Explorer 2006.
[2] Saskatchewan Conservation Data Centre 2006.
[3] Duncan, J., pers. comm.
[4] Estimated.
[5] Ontario Ministry of Natural Resources 2006.
[6] Giguère, S., pers. comm
[7] Slezak *S.* pers. comm.

TECHNICAL SUMMARY - Rocky Mountain population

Lithobates pipiens **(Rocky Mountain population)**
Northern Leopard Frog Grenouille léopard
Range of Occurrence in Canada : British Columbia

Demographic Information

Generation time (average age of parents in the population)	2-3 years
Observed percent reduction in total number of mature individuals over the last 10 or 5 years.	Observed reduction unquantified
Suspected percent reduction in total number of mature individuals over the next 10 or 5 years.	unknown
Estimated percent reduction in total number of mature individuals over any 10 or 5 year period, over a time period including both the past and the future.	unknown
Are the causes of the decline clearly reversible?	no
Are the causes of the decline understood?	no
Have the causes of the decline ceased?	no
Observed trend in number of populations	Previous decline has resulted in one remaining population
Are there extreme fluctuations in number of mature individuals?	Yes, as is generally true for all pond-breeding frogs
Are there extreme fluctuations in number of populations?	no

Extent and Area Information

Estimated extent of occurrence Source: Assessment Section, COSEWIC Secretariat	322 km²
Observed trend in extent of occurrence	Significantly reduced historically to a single native population
Are there extreme fluctuations in extent of occurrence?	no
Index of area of occupancy (IOA) Source: Assessment Section, COSEWIC Secretariat	268 km²
Observed trend in area of occupancy	Significantly reduced but currently stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented? Meets the definition for fragmented as all individuals are found in a small and completely isolated population, resulting in zero probability of recolonization.	Yes, as there is only one native population remaining
Number of current locations	One, plus one introduced population that has likely been extirpated
Trend in number of locations	significantly reduced historically to a single original location
Are there extreme fluctuations in number of locations?	no
Trend in area and/or quality of habitat	Increasing habitat quality resulting from habitat management

Number of mature individuals in each population

Population	N Mature Individuals
Creston Valley	Ca. 50
Bummer's flats (introduced)	< 10
Total	<60
Number of populations (locations)	One, plus one introduced population that has likely been extirpated

Quantitative Analysis

	Not undertaken

Threats (actual or imminent, to populations or habitats)

Disease, non-native species introduction, environmental contamination.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: S1 (Washington), S3 (Idaho)	
Is immigration known?	no
Would immigrants be adapted to survive in Canada?	yes
Is there sufficient habitat for immigrants in Canada?	no
Is rescue from outside populations likely?	**no**

Current Status

COSEWIC: Endangered (April 2009) British Columbia: Provincial Red List/S1

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	C2a(i); D1
Reasons for designation: Although previously found in many localities in southeastern British Columbia and the Okanagan, this frog has suffered severe declines in both distribution and abundance, and now exists in extremely small numbers at only a single native population in the Creston valley.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): After a period of severe decline during which all but one native population in the region was lost, decline rate has levelled off and this criterion is no longer applicable to the present situation.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable; although the species is restricted to a single locality occupying an area under 50 km² (IAO) and exists in only one native and one introduced population.
Criterion C (Small and Declining Number of Mature Individuals): Qualifies as Endangered C2a(i) due to the small number of mature individuals.
Criterion D (Very Small Population or Restricted Distribution): Qualifies as Endangered D1 as there are fewer than 250 mature individuals.
Criterion E (Quantitative Analysis): not undertaken

TECHNICAL SUMMARY - Western Boreal/Prairie populations

***Lithobates pipiens* (Western Boreal/Prairie populations)**
Northern Leopard Frog Grenouille léopard
Range of Occurrence in Canada :Alberta, Saskatchewan, Manitoba, Northwest Territories

Demographic Information

Generation time (average age of parents in the population)	2-3 yrs
Observed percent reduction in total number of mature individuals over the last 10 or 5 years.	Reduction unquantified
Projected percent reduction in total number of mature individuals over the next 10 or 5 years.	unknown
Inferred percent reduction in total number of mature individuals over any 10 or 5 years period, over a time period including both the past and the future.	unknown
Are the causes of the decline clearly reversible?	no
Are the causes of the decline understood?	no
Have the causes of the decline ceased?	no
Observed trend in number of populations Although the detection of previously unknown sites is increasing with more intensive surveys, the trend among previously known sites is a decline.	decline
Are there extreme fluctuations in number of mature individuals?	Yes, as is generally true for all pond-breeding frogs
Are there extreme fluctuations in number of populations?	no

Extent and Area Information

Estimated extent of occurrence Source: Assessment Section, COSEWIC Secretariat	937,273 km²
Observed trend in extent of occurrence	decline
Are there extreme fluctuations in extent of occurrence?	no
Index of area of occupancy (IOA) Source: Assessment Section, COSEWIC Secretariat Note: Area includes Northwest Territories	13,884km²
Observed trend in area of occupancy	decline
Are there extreme fluctuations in area of occupancy?	no
Is the total population severely fragmented?	yes
Number of current locations	uncounted
Trend in number of locations Decline inferred from range contraction	AB: Declining SK: Unknown, suspected decline, MB: possibly stable NWT: Unknown
Are there extreme fluctuations in number of locations?	no
Trend in area and quality of habitat	Extent of occurrence and habitat quality are declining particularly towards the west.

Number of mature individuals in each population

Population	Number of Mature Individuals unkown
Insufficient information to identify discrete populations or their number	AB: Declining SK: Unknown MB: Increasing NWT: unknown
Total Progressive rebound of leopard frog abundance following the mid-1970s die-off in Manitoba does not offset the decline in numbers in the west related to extirpation of populations.	Unknown with any certainty
Number of populations (locations)	uncounted

Quantitative Analysis

	Not undertaken

Threats (actual or imminent, to populations or habitats)

Disease, habitat fragmentation/alteration, non-native species introduction, environmental contamination.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: N5 By State: S3 (Montana), S4 (Minnesota), Not Ranked (North Dakota)	
Is immigration known?	no
Would immigrants be adapted to survive in Canada?	yes
Is there sufficient habitat for immigrants in Canada?	yes
Is rescue from outside populations likely?	no

Current Status

COSEWIC: Special Concern (April 2009) AB: Threatened (S2/S3), SK: Special Concern (S3), MB: Secure (S4)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	Not applicable
Reasons for designation: This species remains widespread but has experienced a considerable contraction of range and the loss of populations in the past, particularly in the west. This has been accompanied by increased isolation of remaining populations, which fluctuate widely in size, with some showing signs of recovery. The species is adversely affected by habitat conversion, including wetland drainage and eutrophication, game fish introduction, collecting, pesticide contamination and habitat fragmentation that curtails recolonization and rescue of declining populations. The species is also susceptible to emerging diseases.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Insufficient information on abundances to quantify decline.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. This species' range has contracted considerably in the west yet, overall, it remains too widespread to qualify for Threatened in the Prairie/Western Boreal region.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Despite declines, total population size remains above the threshold level for Threatened.
Criterion D (Very Small Population or Restricted Distribution): not applicable
Criterion E (Quantitative Analysis): not applicable

TECHNICAL SUMMARY - Eastern populations

Lithobates pipiens (Eastern populations)
Northern Leopard Frog Grenouille léopard
Range of Occurrence in Canada : Manitoba, Ontario, Quebec, Labrador, New Brunswick, Nova Scotia, Prince Edward Island

Demographic Information

Generation time (average age of parents in the population)	2-3 yrs
Observed, estimated, inferred, or suspected percent reduction in total number of mature individuals over the last 10 or 5 years.	unknown
Projected or suspected percent reduction in total number of mature individuals over the next 10 or 5 years.	unknown
Observed, estimated, inferred, or suspected percent reduction in total number of mature individuals over any 10 or 5 year period, over a time period including both the past and the future.	unknown
Are the causes of the decline clearly reversible?	no
Are the causes of the decline understood?	no
Have the causes of the decline ceased?	unlikely
Observed, inferred, or projected trend in number of populations	ON: probably declining QC: Unknown Maritimes: unknown
Are there extreme fluctuations in number of mature individuals?	Yes, as is generally true for all pond-breeding frogs
Are there extreme fluctuations in number of populations?	no

Extent and Area Information

Estimated extent of occurrence Source: Assessment Section, COSEWIC Secretariat	1,692,111km²
Observed, inferred, or projected trend in extent of occurrence	stable
Are there extreme fluctuations in extent of occurrence?	no
Index of area of occupancy (IOA) Source: Assessment Section, COSEWIC Secretariat	66,751km²
Observed, inferred, or projected trend in area of occupancy	decline
Are there extreme fluctuations in area of occupancy?	no
Is the total population severely fragmented?	no
Number of current locations	thousands
Trend in number of locations	ON: probably declining QC: Unknown Maritimes: unknown
Are there extreme fluctuations in number of locations?	no
Trend in area and/or quality of habitat	Localized declines

Number of mature individuals in each population

Population	N Mature Individuals
Total	unknown
Number of populations (locations)	unknown

Quantitative Analysis

	n/a

Threats (actual or imminent, to populations or habitats)

Disease, habitat fragmentation/alteration, non-native species introduction, environmental contamination.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: N5 S3 (New Hampshire, Maine, Pennsylvania), S4 (Vermont, Minnesota), S5 (Michigan, New York), Not Ranked (Ohio),	
Is immigration known?	no
Would immigrants be adapted to survive in Canada?	yes
Is there sufficient habitat for immigrants in Canada?	yes
Is rescue from outside populations likely?	**no**

Current Status

COSEWIC: Not At Risk (April 2009) Ont: S5, QC: S5, NFLD: S3-S4 (Labrador), EX (Newfoundland), NB: S5, NS: S5, PEI: S4

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Not at Risk	Not applicable.
Reasons for designation: Although this species has shown evidence of declines, it remains widespread and common in eastern Canada.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

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Michael Taylor is from southwestern Alberta. He has gained considerable knowledge of Northern Leopard Frog biology, conservation, and management while working and volunteering on various amphibian research projects in southwestern Alberta since 2002. He has a Diploma in Environmental Science from Lethbridge Community College (2001) and a B.Sc. in Environmental Science from the University of Lethbridge (2003). He has designed and implemented amphibian surveys, and has conducted visual encounter, call, and dip-net surveys for all life stages of leopard frogs. He has researched and prepared a variety of documents such as technical reports, sampling protocols and newsletter articles, some of which have dealt specifically with the Northern Leopard Frog.

DATA SOURCES AND COLLECTIONS EXAMINED

Northern Leopard Frog occurrence data was obtained from the following sources.

<u>British Columbia</u>

British Columbia Conservation Data Centre, Doug Adama.

Alberta

Fish and Wildlife Information Management System, Kris Kendell, Waterton Lakes National Park.

Northwest Territories

Suzanne Carriere, Dave Prescott.

Saskatchewan

Saskatchewan Conservation Centre, Government of Saskatchewan, Grasslands National Park.

Manitoba

Manitoba Conservation Data Centre, Riding Mountain National Park.

Ontario

Natural Heritage Information Centre, Ontario Herpetofaunal Summary, Canadian Museum of Nature, Royal Ontario Museum, Ecological Monitoring and Assessment Network (EMAN)/NatureWatch/Frog Watch Program for Canadian Provinces, Bruce Peninsula National Park, Georgian Bay Islands National Park.

Quebec

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Newfoundland and Labrador

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New Brunswick

Atlantic Canada Conservation Data Centre, Canadian Wildlife Service, New Brunswick Museum, Kouchibouguac National Park.

Nova Scotia

Atlantic Canada Conservation Data Centre, Canadian Wildlife Service, Nova Scotia Herp Atlas, Cape Breton Highlands National Park.

Prince Edward Island

Atlantic Canada Conservation Data Centre, Prince Edward Island National Park.