SPECIES STATUS REPORT

Northern Leopard Frog

(Lithobates pipiens)

in the Northwest Territories

NORTHWEST TERRITORIES SPECIES AT RISK COMMITTEE

Threatened

December 2013

Species at Risk Committee status reports are working documents used in assigning the status of species suspected of being at risk in the Northwest Territories (NWT).

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ABOUT THE SPECIES AT RISK COMMITTEE
The Species at Risk Committee was established under the *Species at Risk (NWT) Act*. It is an independent committee of experts responsible for assessing the biological status of species at risk in the NWT. The Committee uses the assessments to make recommendations on the listing of species at risk. The Committee uses objective biological criteria in its assessments and does not consider socio-economic factors. Assessments are based on species status reports that include the best available Aboriginal traditional knowledge, community knowledge and scientific knowledge of the species. The status report is approved by the Committee before a species is assessed.

ABOUT THIS REPORT
This species status report is a comprehensive report that compiles and analyzes the best available information on the biological status of Northern Leopard Frog in the NWT, as well as existing and potential threats and positive influences. Full guidelines for the preparation of species status reports, including a description of the review process, may be found at www.nwtspeciesatrisk.ca.

Northwest Territories Environment and Natural Resources

Environment and Natural Resources, Government of the Northwest Territories, provides full administrative and financial support to the Species at Risk Committee.

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NORTHWEST TERRITORIES SPECIES AT RISK COMMITTEE

Assessment of Northern Leopard Frog

The Northwest Territories Species at Risk Committee met in Yellowknife, Northwest Territories on December 10, 2013 and assessed the biological status of Northern Leopard Frog in the Northwest Territories. The assessment was based on this approved status report. The assessment process and objective biological criteria used by the Species at Risk Committee are available at www.nwtspeciesatrisk.ca.

Assessment: Threatened in the Northwest Territories

Likely to become endangered in the Northwest Territories if nothing is done to reverse the factors leading to its extirpation or extinction.

Reasons for the assessment: Northern Leopard Frog fits criterion (b) for Threatened.

(b) – There is evidence that the range is limited and there is a decline or change in range, population size or habitat such that it could disappear from the Northwest Territories in our children's lifetime.

Main Factors:

- In the Northwest Territories, the Northern Leopard Frog is at the northern-most limit of its range in the world.
- Unlike some species of frogs, Northern Leopard Frogs are not freeze-tolerant and do not hibernate. To overwinter, they go dormant under water. These sites must be well-oxygenated and not freeze.
- Northern Leopard Frogs are therefore limited to only the very southern Northwest Territories where suitable overwintering sites exist.
- Extent of occurrence is 16,041 km^2 using all observation records, but only 5,784 km^2 using observations since 1995, providing some evidence for population and range reductions.
- Rescue of the species in the Northwest Territories is not plausible because nearby Northern Leopard Frog populations in northern Alberta and Saskatchewan have disappeared or are at risk.

Additional Factors:

Threats to Northern Leopard Frog and its habitat:

- In the Northwest Territories, emerging diseases (chytrid fungus and ranavirus), proposed hydroelectric developments, climate change (from negative effects like drought), and potential air and waterborne pollution likely pose the greatest threats to Northern Leopard Frogs.

Positive influences to Northern Leopard Frog and its habitat:

- Environment Canada is evaluating the health of wild amphibian populations close to and at varying distances from oil sands operations.
- Nonacho Lake and the South Valley spillways in the Taltson River basin constitute man-made habitats that may be beneficial to Northern Leopard Frogs.
- Northern Leopard Frogs receive some protection owing to their presence in Wood Buffalo National Park.
- Climate change may also favour earlier breeding due to advanced ice melt and may result in range expansion.

Recommendations:

- Develop guidelines and best practices for studying amphibians to avoid disease transmission.
- More studies on Northern Leopard Frog populations, biology, range, habitat and threats in the Northwest Territories are needed.
- Conduct breeding site surveys and protect known breeding sites through legislation or another effective mechanism.
- Enhance climate and hydrological monitoring activities in the range of the Northern Leopard Frog.
- The status of Northern Leopard Frogs in the Northwest Territories may need to be re-assessed if the Taltson Hydroelectric Expansion Project moves forward.
- Conduct a study, or studies, on the effect of air pollution from the oil sands operations on Northwest Territories amphibians.
- Educate residents, visitors and schools about Northern Leopard Frogs and the threats facing them and discourage them from collecting the frogs.
- Encourage people to report sightings of Northern Leopard Frogs, especially in any historical locations.

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Executive Summary

Names and classification

The Northern Leopard Frog is the only recognized English common name for the species. The French name is “la grenouille léopard”. The old scientific name of the Northern Leopard Frog, *Rana pipiens*, was proposed to be changed to *Lithobates pipiens*. The proposal is being contested in the literature. No subspecies are recognized. Four populations are recognized in Canada: the Rocky Mountain, Prairie, Western Boreal and Eastern populations.

Description

The Northern Leopard Frog is a slender, medium-sized frog that is predominantly green, but may be brown, tan or a combination of brown and green. It has conspicuous solid dark brown or olive oval-shaped spots on the back that are bordered with light halos. Two cream-coloured dorsolateral folds extend the length of the back. The underside is creamy white. Adults are 60-110 mm in length, with males rarely exceeding 80 mm.

Distribution

The Northern Leopard Frog is widespread throughout much of central and northeastern North America. In Canada the range has contracted in British Columbia and central Alberta. The Northwest Territories population is part of the Prairie-Western Boreal Designatable Unit (as defined by COSEWIC), although the Western Boreal population may be isolated from the Prairie population. Connectivity between the two is uncertain. The Western Boreal population occurs in the South Slave Region of the Northwest Territories, primarily east of the Slave River, near the Slave, Taltson and Tethul rivers, and in northeast Alberta and northwest Saskatchewan.

There has been limited search effort in its historic range and it is difficult to survey for uncommon animals in widely separated habitats. Therefore, the number of breeding populations of the Northern Leopard Frog in the Northwest Territories is probably greater than recent records would indicate. The distribution might also be more extensive than known. There is some evidence that Northern Leopard Frogs may now be absent from the Slave River, and from the area north of Trudel Lake to the Slave and Taltson River deltas, but otherwise the distribution appears to be stable in the area where recent searches overlapped the historic range.

Habitat

The Northern Leopard Frog has three primary habitat requirements: aquatic habitat, for breeding, egg laying and tadpole development; foraging habitat; and overwintering habitat. These habitats are often in close proximity, and must be connected by suitable travel corridors which are used for migration and dispersal.

Breeding takes place in a wide variety of shallow, permanent or semi-permanent wetlands without fish that contain a combination of open water and emergent vegetation. Suitable sites include beaver ponds, springs, oxbows, quiet backwaters of streams, lake edges, flooded meadows, swamps and marshes. Northern Leopard Frogs use the same breeding and over-wintering sites year after year. Summer feeding areas are frequently along the open margins of breeding ponds and stream banks. Overwintering takes place in well oxygenated water which does not freeze to the bottom.

The availability of suitable habitats is largely unknown in the Northwest Territories, but Northern Leopard Frog observations indicate that habitats are widely separated from one another, making lengthy movements along riparian corridors necessary for dispersal and repopulation of vacant habitats. Northern Leopard Frog habitat in the NWT is already impacted by dams on the Slave and Taltson rivers. People have noticed drying and shrinking of wetlands, streams and water bodies in the area, with potential impacts on frog habitat.

Biology

Northern Leopard Frogs breed in the spring when some ice may still be on the wetlands. Breeding is synchronous and communal, and usually occurs over a few days. Northern Leopard Frogs are not freeze tolerant. They become inactive underwater during winter. They obtain heat from their surroundings, and maintain a fairly stable body temperature by moving between warmer and cooler areas. They tolerate dry conditions on land by absorbing moisture from dew or damp soil. Tadpoles are primarily herbivorous, feeding on aquatic vegetation. Adult and juvenile frogs are ambush predators, feeding on moving and inactive prey, primarily insects and spiders.

Predators of Northern Leopard Frog eggs and tadpoles include the aquatic stages of many insects like dragonfly nymphs, caddisfly larvae, beetles and beetle larvae, fish, birds and Garter Snakes. Juvenile and adult Northern Leopard Frogs are preyed upon by a wide variety of fish, snakes, owls, waterfowl, raptors and mammals, such as Mink, River Otter and Red Fox. Lake Trout may eat overwintering Northern Leopard Frogs.

Population

Up to 6,000 eggs may be laid by each female, but survival rates of tadpoles and young-of- the year are extremely low. Sexual maturity is reached in one to three years and Northern Leopard Frogs live for four or five years in the wild. Young-of-the-year frogs disperse up to eight km from breeding sites. Adults occupy home ranges of up to 600 m^2 near breeding sites.

The abundance of Northern Leopard Frogs in the Northwest Territories is unknown, but an expert-opinion estimate of the number of adults, considering the number of known occurrences and the relative lack of search effort, is in the 2,500 to 10,000 range. Few breeding or overwintering sites are known. Northern Leopard Frog populations may fluctuate widely due to natural events that affect reproduction or survival (like late spring freezing or summer drought). Community and traditional knowledge holders have noticed a decline in frogs in the area, but long-term population trends specifically for Northern Leopard Frogs are not known in the Northwest Territories.

Threats and limiting factors

Amphibians face many threats globally and are declining more rapidly than either birds or mammals. Their reliance on aquatic and terrestrial environments and their permeable skin and exposed eggs contribute to their vulnerability. Major global threats include: habitat loss and fragmentation; traffic mortality; collection for food, bait, medicine and education; acid rain; chemical contaminants and pesticides; introduction of exotic species of competitors and predators; disease; ultraviolet radiation; and effects of global climate change.

The Northern Leopard Frog in the NWT is not subject to many of these threats at the present time. However, some threats of varying degree and immediacy do occur. Emerging diseases, proposed hydroelectric developments, air and waterborne pollution, and climate change likely pose the greatest threats to the Northern Leopard Frog in the NWT.

Diseases that have contributed to amphibian declines elsewhere are present in the NWT and pose an immediate threat of unknown magnitude. The main diseases of concern are chytridiomycosis, caused by the amphibian chytrid fungus, and ranaviruses. The magnitude of habitat loss, degradation and fragmentation is low and is expected to remain low in the near future, but the proposed Taltson Hydroelectric Expansion Project is a potential threat of medium to high magnitude if the project goes ahead. Environmental contamination has not been identified as a current threat to Northern Leopard Frogs in the NWT, but there is significant community concern about contaminants in the water, and upstream and upwind oil sands developments in Alberta may cause future impacts on Northern Leopard Frogs. Environmental changes due to climate change are already being observed locally and are a future threat to Northern Leopard Frogs in the NWT. The impact on Northern Leopard Frogs is believed to be minor at this time, but effects are expected to increase in the coming decades. Ozone depletion is a global issue that results in increased ultraviolet (UV-B) radiation which could affect the hatching success of frog eggs. UV-B, along with co-stressors like contaminants and disease, may act together to kill amphibians or reduce populations.

Positive influences

Northern Leopard Frogs may overwinter in the well oxygenated water in spillways below dams. This could be a minor benefit to frogs in the Taltson River basin. Some Northern Leopard Frog habitats, representing a small portion of their known distribution in the NWT, overlap with Wood Buffalo National Park. Global climate change may permit earlier breeding due to earlier snow and ice melt, and subsequent range expansion by amphibians which are presently excluded from habitats beyond their northern limit by the brief ice-free period. The effects of climate change on Northern Leopard Frogs have not been monitored in the Northwest Territories.

Technical Summary

Lithobates pipiens
Northern Leopard Frog

Population trends	
Generation time *(average age of parents in the population)* (**indicate years, months, days, etc.**)	3 years
Number of mature individuals in the NWT (or give a range of plausible values)	Unknown; expert opinion-based estimate less than 10,000; conceivably less than 2,500
Amount of change in numbers in the recent past; *Percent change in total number of mature individuals over the* ***last*** *10 years, or 3 generations, whichever is longer*	Unknown, but declines since the 1950s and 1980s noted based on traditional and community knowledge
Amount of change in numbers predicted in the near future; *Percent change in total number of mature individuals over the* ***next*** *10 years, or 3 generations, whichever is longer*	Unknown
Amount of change happening now; *Percent change in total number of mature individuals over any 10 year or 3 generation period which includes* ***both the past and the future***	Unknown
If there is a decline (*in the number of mature individuals*), **is the decline likely to continue if nothing is done?**	Unknown
If there is a decline, are the causes of the decline reversible?	Unknown
If there is a decline, are the causes of the decline clearly understood?	Unknown
If there is a decline, have the causes of the decline been removed?	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown

Distribution trends

Where is the species found in the NWT?; *Estimated extent of occurrence in the NWT (in km^2)*	Range of occurrence in NWT: South Slave Region in the vicinity of the Slave River and Taltson River below Taltson Lake. Extent of occurrence is 16,041 km^2 using all historic and recent occurrences (5,784 km² since 1995, but this is likely an underestimate). This is based on 13 occurrences since 1995, 28 recent and historical occurrences.
How much of its range is suitable habitat?; *Index of area of occupancy (IAO) in the NWT (in km^2; based on 2x2 grid)*	With insufficient information to distinguish suitable and unsuitable Northern Leopard Frog habitat within the NWT, the area of occupancy was estimated using two methods. Coastely, based on a range of 6,148 km², and finely, based on occurrences of 52 km^2. The latter method adheres to the IUCN protocol.
How many populations are there? To what degree would the different populations be likely to be impacted by a single threat?; *Number of extant locations in the NWT*	1 location (at present with disease as major threat) 5 locations (if diseases were not a major threat and the Taltson Hydroelectric Expansion Project became a threat in the future)
Is the distribution, habitat or habitat quality showing a decline that is likely to continue if nothing is done?; *Is there a continuing decline in area, extent and/or quality of habitat?*	Uncertain but some sites with frogs in the past are now noted as empty. Possible inferred decline in quality, area and extent.
Is the number of populations or amount of occupied area showing a decline that is likely to continue if nothing is done?; *Is there a continuing decline in number of locations, number of populations, extent of occupancy and/or IAO?*	Uncertain but some sites with frogs in the past are now noted as empty. Possible inferred decline in number of locations.
Are there extreme fluctuations in the range or the number of populations?; *Are there extreme fluctuations (>1 order of magnitude) in number of locations, extent of occupancy and/or IAO?*	Unknown
Are most individuals found within small and isolated populations?; *Is the total population severely fragmented (most individuals found within small and isolated populations)?*	Unknown

Immigration from populations elsewhere

Does the species exist elsewhere?	Yes
Status of the outside population(s)	Special Concern in Canada, At Risk in Alberta and Saskatchewan.
Is immigration known or possible?	Yes, from northern Alberta and Saskatchewan. Connectivity between the Western Boreal and Prairie populations is uncertain.
Would immigrants be adapted to survive and reproduce in the NWT?	Yes
Is there enough good habitat for immigrants in the NWT?	Yes
Is the NWT population self-sustaining or does it depend on immigration for long-term survival?	The populations are likely connected (metapopulation dynamics) with other western boreal populations in northern Alberta and Saskatchewan.

Threats and limiting factors

Briefly summarize the threats and limiting factors, and indicate the magnitude and imminence for each	Diseases caused by chytrid fungus and ranaviruses are an immediate threat; magnitude of the impact likely small at this time. Water management activities from the proposed Taltson Hydroelectric Expansion Project are a potential threat of medium to high magnitude, but the project is currently on hold. Water and airborne pollution are potential threats of unknown magnitude. Climate changes (negative effects such as drought) is a current threat, magnitude is likely small but expected to increase. UV-B radiation is a current threat with low magnitude, but impact may be greater in combination with other stressors such as disease. Other threats currently ranked low in magnitude and imminence include habitat loss and fragmentation (other than from hydroelectric development), non-native species, and collection and harvest.

Positive influences	
Briefly summarize positive influences and indicate the magnitude and imminence for each	Water in spillways below dams may be used for overwintering. This influence is limited in scope. Some habitats overlap with Wood Buffalo National Park and Salt River First Nation Treaty Settlement Lands. These are a small portion of the known distribution in the NWT. Climate change (positive effects) may allow earlier breeding and range expansion. The magnitude of these effects is unknown.

Preamble

In the preparation of this species status report, an effort was made to find sources of Aboriginal traditional knowledge, community knowledge and scientific knowledge. It became apparent that documented traditional or community knowledge is limited for Northern Leopard Frog. Therefore, this report is based primarily on scientific knowledge.

Names and classification

Scientific name:	*Lithobates pipiens* Schreber, 1782
Common names:	
English	Northern Leopard Frog
Chipewyan	ts'ɛli (frog; Redish and Lewis 1998-2011)
Cree	ayikis, ayîkis, ayîk (frog; Online Cree Dictionary 2011)
French	la grenouille léopard
Population	Western Boreal
Synonym	*Rana pipiens* Schreber, 1782
Class	Amphibia
Order	Anura
Family	Ranidae (True frogs)
Life form	Vertebrate, amphibian, frog

The clade of North American true frogs of the genus *Rana* (Class: Amphibia, Order: Anura, Family: Ranidae) was recently partitioned into two clades called *Rana* and *Lithobates* (Frost *et al.* 2006), which were recognized in the standard list of amphibians (Frost *et al.* 2008). The Northern Leopard Frog, formerly *Rana pipiens*, was placed in the *Lithobates* clade. Hillis (2007) and Pauly *et al.* (2009) believe that this change was unnecessary, since it was not based on new phylogenetic findings, and the result has been taxonomic chaos. Hillis (2007) and Pauly *et al.* (2009) recommend that the New World Clade of ranids (true frogs) *sensu* Hillis and Wilcox (2005), which includes *Lithobates*, be returned to their previous binomial names (i.e., *Rana pipiens*). No subspecies are recognized.

Several other common English names for the Northern Leopard Frog are no longer recognized (COSEWIC 2009).

Description

The following morphological description is based upon field guides (Environment and Natural Resources [ENR] 1998, Russell and Bauer 2000; Jones *et al.* 2005; Matsuda *et al.* 2006). The Northern Leopard Frog is a slender, medium-sized frog that is predominantly green, but may be brown,

tan or a combination of brown and green (Figure 1). It has conspicuous solid dark brown or olive oval-shaped spots on the back that are bordered with light halos. Two cream-coloured dorso-lateral folds extend the length of the back. The underside is creamy white. Juveniles have the same colouration as adults. There are rare colour morphs (see COSEWIC 2009), one of which ("burnsi", lacking dorsal spots) may have been locally propagated through the release of laboratory animals. Although there are reports of rare colour morphs elsewhere in Canada, there are no reported observations of them in Northern Alberta or the NWT (Prescott pers. comm. 2012; Kendell pers. comm. 2013). Adults are 60-110 mm in length (snout-vent length), with males rarely exceeding 80 mm in length.

Eggs are laid in a spheroid or ovoid-shaped mass, about 75-150 mm long and 50-75 mm wide. Each mass contains 600-7,000 eggs. Tadpoles are normally about 25 mm snout-vent length (total length 90 mm), dark brown or grey dorsally and speckled with gold spots. There are documented cases of tadpoles approaching 120 mm in length; however, tadpoles greater than 90 mm are assumed to be quite rare (Kendell pers. comm. 2013). The central underbelly is creamy white. The eyes are bronze-coloured.

Figure 1. Northern Leopard Frog, Benna Thy Lake, Northwest Territories (photo courtesy of Leslie Bol, Rescan) (Site SV25, 21 July 2008; Rescan 2008).

Distribution

Continental distribution

The Northern Leopard Frog occurs throughout most of central and northeastern North America from Labrador, James Bay and the Northwest Territories in the north, south to Virginia, Nebraska, and Arizona (Stebbins 2003). The Canadian distribution is shown in Figure 2. The Northern Leopard Frog was introduced to Newfoundland and Vancouver Island but they are now believed to be extirpated. Disjunct populations occur in the west, including southern British Columbia and the western United States, where recent range contractions have been observed (Stebbins 2003).

COSEWIC (2009) recognized three discrete and evolutionarily significant units (Designatable Units (DUs); *sensu* Green 2005) of Northern Leopard Frogs in Canada; the Rocky Mountain DU, the Prairie/Western Boreal DU and the Eastern DU. The boundaries were based on evidence for genetic distinction between western and eastern Northern Leopard Frog populations (Hoffman and Blouin 2004) and evidence of distinctiveness of the Rocky Mountain DU (Wilson *et al.* 2008).

Northern Leopard Frogs in the Northwest Territories (NWT) belong to the Western Boreal population of the Prairie/Western Boreal DU, which extends from western Manitoba through Saskatchewan and Alberta (Figure 3 and Figure 4). This DU is supported by the high degree of genetic uniformity of southern and northern Alberta and NWT populations (Wilson *et al.* 2008). Distribution of the Northern Leopard Frogs in the Prairie/Western Boreal DU is often shown on maps as a single, continuous range polygon (Figure 3 in COSEWIC 2009; Saskatchewan range in Didiuk 2000); however, both historic and recent observations document a potentially discontinuous distribution north of 55°N in Alberta and Saskatchewan (Figure 2; Alberta range from Alberta Sustainable Resource Development 2003; Saskatchewan range from Saskatchewan Conservation Data Centre 2006). Recent observations of Northern Leopard Frogs in the Western Boreal population of the north have been confined to an area in extreme northeastern Alberta and northwestern Saskatchewan north of Lake Athabasca, and the adjacent South Slave region of the NWT. Connectivity of northern and southern populations is considered unlikely at this time (Didiuk pers comm. 2011; Kendell pers. comm. 2011; Prescott pers. comm. 2012). There may be a connection along the Canadian Shield in Saskatchewan (Didiuk pers comm. 2011) and major rivers/drainages in the north (Kendell pers. comm. 2011).

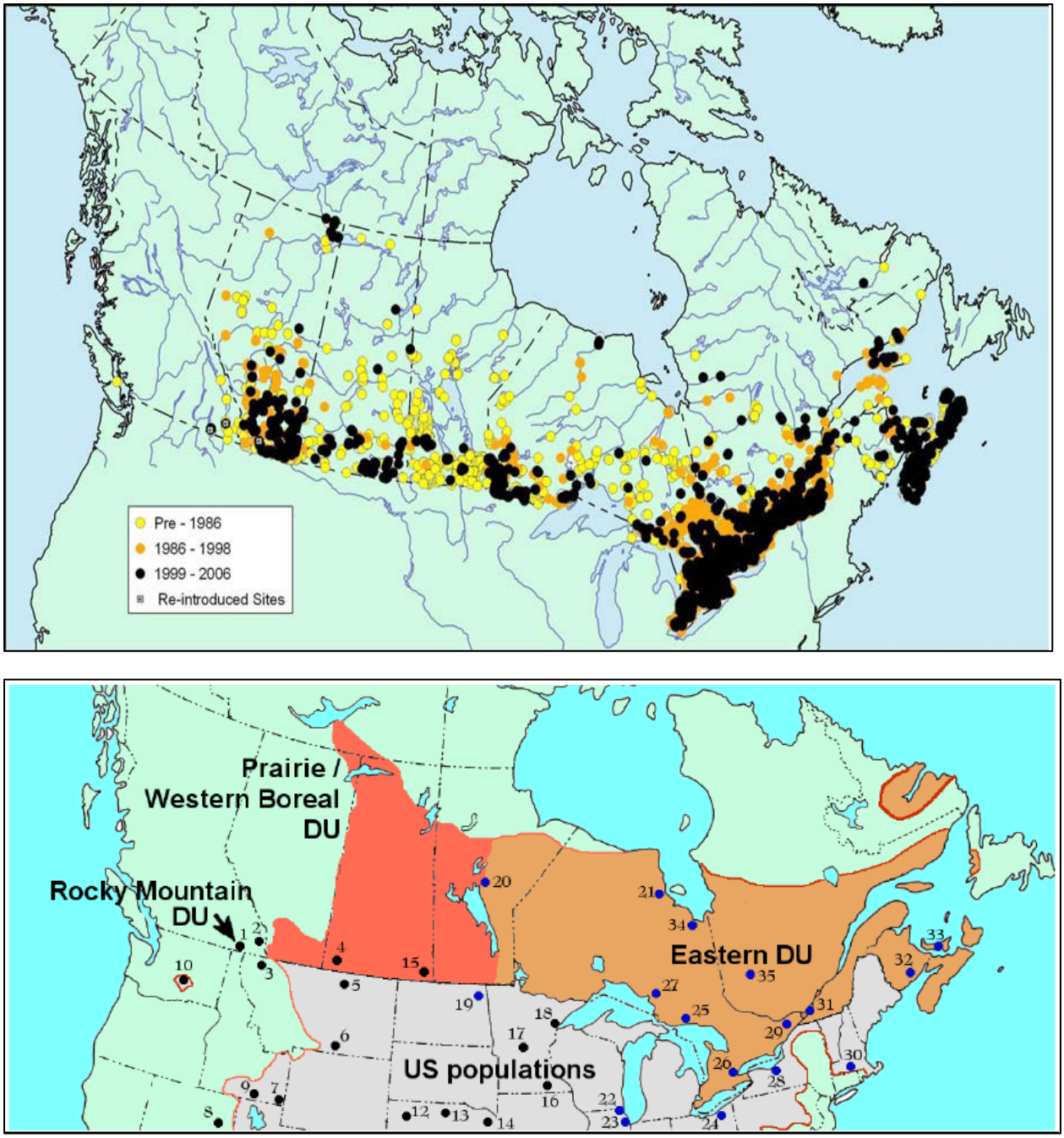

Figure 2. (a) Approximate distribution of the Northern Leopard Frog in Canada, based on museum records and confirmed occurrences to 2006. Many sightings in the NWT are not included in this figure. Reproduced with permission from COSEWIC (2009). (b) Boundaries of COSEWIC Designatable Units for Northern Leopard Frog in Canada. Please note that the Rocky Mountain Designatable Unit is represented only by the arrow pointing at the approximate location of that population (COSEWIC 2009).

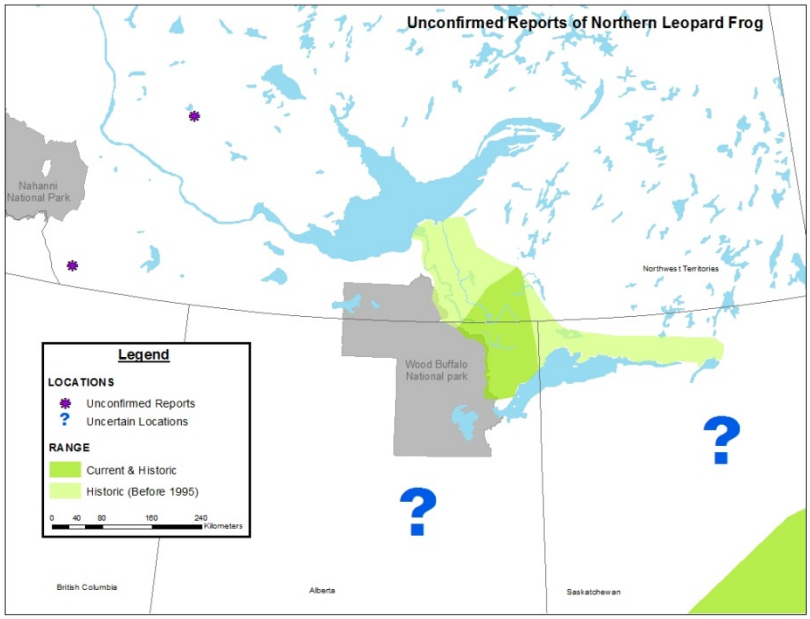

Figure 3. Distribution of the Northern Leopard Frog in Northwestern Canada. Map prepared by Rob Gau and Bonnie Fournier, Northwest Territories Department of Environment and Natural Resources. "?" indicates uncertain connectivity between Western Boreal and Prairie populations. Data provided by Environment and Natural Resources (unpubl. data 2011), Saskatchewan Conservation Data Centre (unpubl. data 2011), and Alberta Fish and Wildlife Information System (FWMIS; unpubl. data 2011). Some historic reports cannot be confirmed.

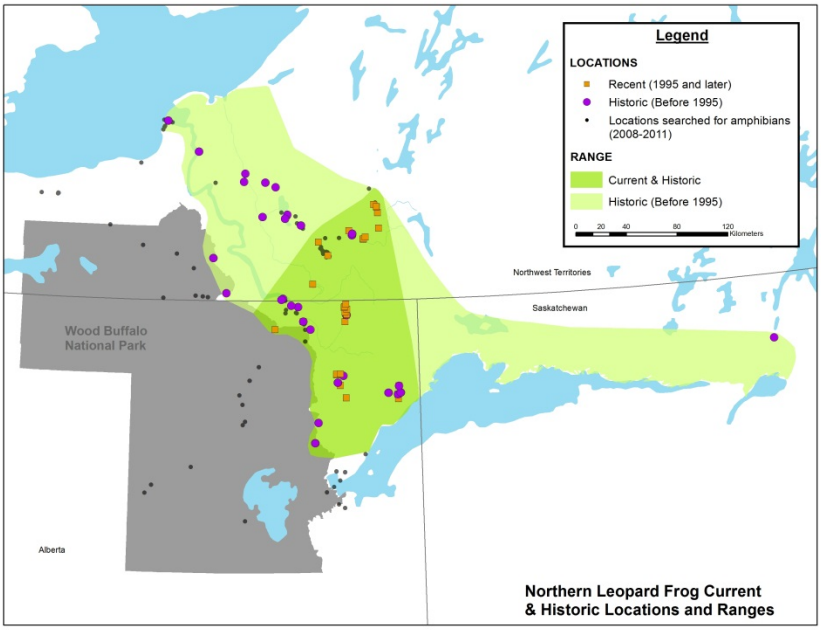

Figure 4. Distribution and search effort for the Western Boreal Population of the Northern Leopard Frog. Black dots represent areas that were searched for amphibians; they are not meant to be indicative of search success. Search

success can be inferred based on the presence of a yellow circle (1995 and later) or purple square (pre-1995) icon. Map prepared by Rob Gau, Northwest Territories Department of Environment and Natural Resources. Data provided by Environment and Natural Resources (unpubl. data 2011), Saskatchewan Conservation Data Centre (unpubl. data 2011), and Alberta Fish and Wildlife Information System (FWMIS; unpubl. data 2011). Some historic reports cannot be confirmed.

NWT Distribution

Northern Leopard Frogs in the NWT are known to occur in the Taiga Shield ecozone, mostly in the Rutledge Upland high boreal ecoregion and some sites in the Slave Plain mid-boreal ecoregion (NWT Ecosystem Classification Group 2008). The distribution also may include three ecoregions in the Taiga Plains ecozone: Slave Delta mid-boreal, Slave lowland mid-boreal and the Slave upland mid-boreal (NWT Ecosystem Classification Group 2009).

A map of place names mentioned in this report is shown in Figure 5. In the NWT, the Northern Leopard Frog is found in the South Slave Region, primarily east of the Slave River, near the Slave, Taltson and Tethul rivers (Figure 3 and Figure 4). It should be noted that some historic reports cannot be confirmed, and some specimens may have been misidentified Wood Frogs (*Lithobates sylvaticus*) (Kendell pers. comm. 2012; Schock pers. comm. 2012a). Furthermore, released or escaped bait frogs may be responsible for some occurrences (Schock pers. comm. 2012a). A genetic study of NWT Northern Leopard Frogs would confirm this hypothesis (Kendell pers. comm. 2013). The most northerly record is from the Slave River delta on Great Slave Lake and the eastern-most record is from the Taltson River (ENR 1998). The most recently reported sightings of Northern Leopard Frog were of two frogs about one kilometre apart near the Tethul River at the beginning of October 2013 (Fournier pers. comm. 2013). Aboriginal Traditional Knowledge (Beck unpubl. data 2011) documented historical range of the Northern Leopard Frog north of Trudel Lake to the Slave and Taltson River deltas (Figure 3 and Figure 4). Northern Leopard frogs have not been observed in that region of the NWT likely since the 1980s, possibly even the 1950s (Beaulieu pers. comm. 2011; Beck pers. comm. 2011). There are unconfirmed acoustic observations of Northern Leopard Frogs near Fort Liard (Schock 2009) and in the Edéhzhíe Candidate Protected Area along the Gathsaday River near Fort Simpson (Figure 4) (EBA Engineering Consultants Ltd. and Canadian Wildlife Service 2006). However, these observations are separated by more than 400 km from the known range in the Northwest Territories, and both Moore (pers. comm. 2011) and Schock (pers. comm. 2007) remain inconclusive about the identity of the frog species they heard.

'Extent of occurrence' is defined by the Species at Risk Committee (SARC) as the area included in a polygon without concave

angles that encompasses the geographic distribution of all known populations of a species (in the NWT; SARC 2010). The recent extent of occurrence (since 1995) is 5,784 km^2, significantly less than the extent of occurrence calculated using all records (16,041 km^2). Using recent data only is believed to underrepresent extent of occurrence for reasons given below under *Search effort*. There have been only 13 occurrences reported since 1995, and there is a total of 28 recent and historical occurrences.

'Area of occupancy' as defined by SARC is the area within the extent of occurrence that is occupied by a species, excluding cases of vagrancy. This measure reflects the fact that the extent of occurrence may contain some unsuitable or unoccupied habitats. The area of occupancy is measured both as an estimate of the actual area occupied (the "biological occupancy") and as an index of area of occupancy (IAO), which uses a scale-correction factor to standardize this estimate across different spatial scales (SARC 2010). With insufficient information to distinguish suitable and unsuitable Northern Leopard Frog habitat within the NWT, the area of occupancy was estimated using two methods: coarsely, as the surface area of 2 x 2 km grid cells that intersect the area of occupancy = 1,573 grid cells multiplied by 4 km^2 = 6,148 km^2; and finely, as the number of occupied habitats ("occurrences") where at least one individual was found, multiplied by 2 x 2 km grid cells = 52 km^2 (from 13 occurrences). The latter method is closer to the IUCN methods.

There is one Northern Leopard Frog 'location' in the NWT, based on the most probable threat, disease. Location is defined as a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the species present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a species is affected by more than one threatening event, location should be defined by considering the most serious plausible threat (SARC 2010). The decision to apply one location to the Northern Leopard Frog is based on the main limiting factors such as chytridiomycosis (Bd), ranavirus, and bacterial "red leg" infections (see Threats and Limiting Factors). These diseases have not been found in NWT populations of Northern Leopard Frogs as of 2012, but have been detected in other frogs elsewhere in the NWT. If and when these diseases occur, their mode of transmission suggests that they could affect all NWT Northern Leopard Frog populations almost simultaneously.

The proposed Taltson hydroelectric expansion project is another potential threat that could alter water flows and impact Northern Leopard Frogs in the core of their range. Five locations should be considered if this project takes place (Figure 6). The locations are based on four zones of impact on Northern Leopard Frog habitat (Figure 6, Hydrological Zones 1,3-5; from Dezé Energy Corporation (2009)), and all other potential Northern Leopard Frog populations that reside outside of the project's footprint.

Figure 5. Map of place names mentioned in this report. Map prepared by Bonnie Fournier, Northwest Territories Department of Environment and Natural Resources.

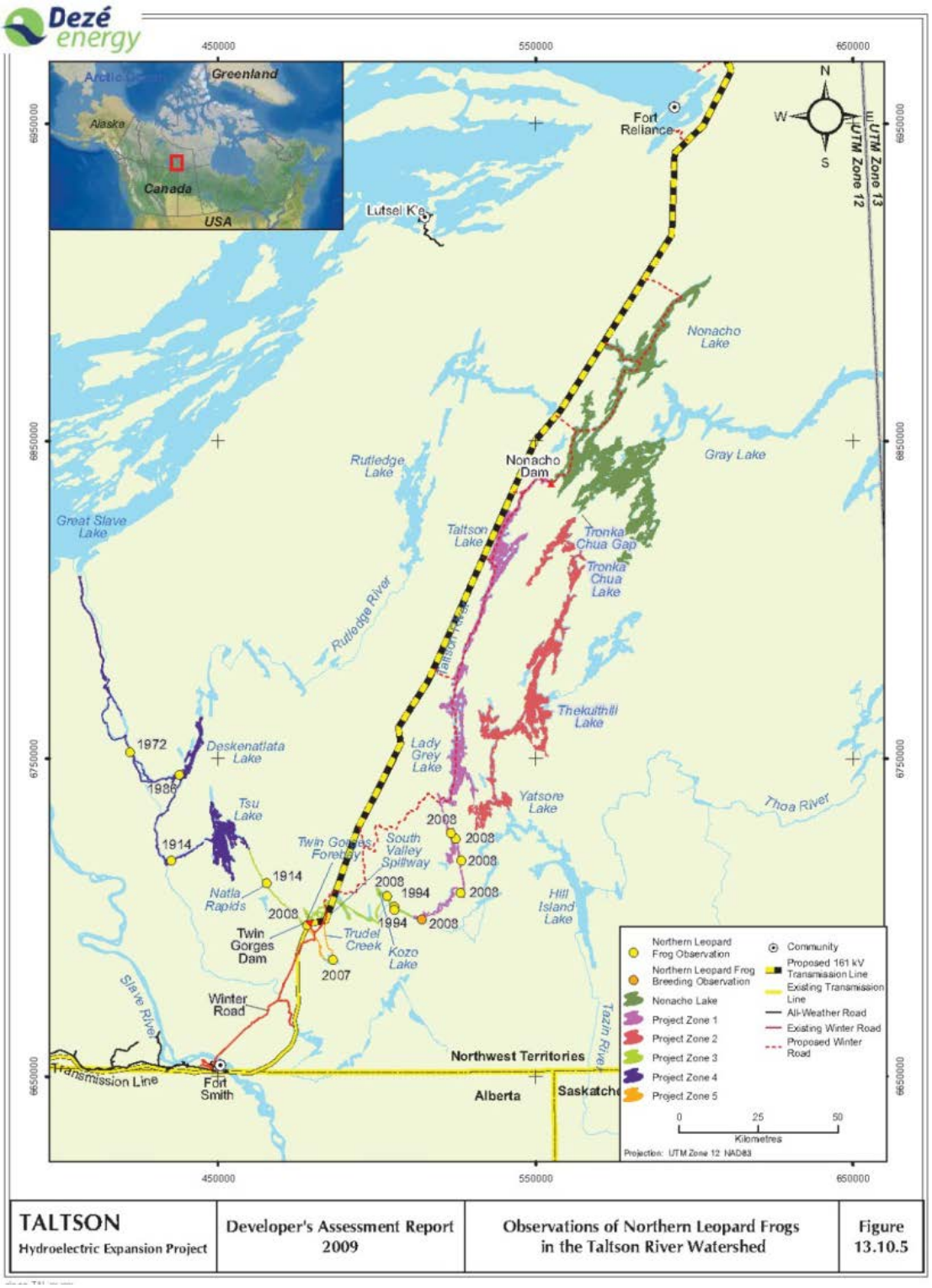

Figure 6. Historic and recent Northern Leopard Frog observations and hydrological zones in the Taltson Basin, based on potential impacts from proposed hydroelectric developments (reproduced with permission from Dezé Energy Corporation (2009)). Zone 2 is outside the known range of Northern Leopard Frog.

Search Effort

The range of the Northern Leopard Frog in the NWT is poorly understood, since this region is largely inaccessible and has not received adequate survey effort (ENR 1998). A great deal of effort is required to survey an uncommon species with widely dispersed breeding sites such as the Northern Leopard Frog. There is little doubt that the species has more occurrences and possibly a more extensive distribution in the NWT, Alberta and Saskatchewan, than are shown on Figures 3 and 4 (Didiuk pers. comm. 2011; Kendell pers. comm. 2012).

There have been two dedicated population surveys for Northern Leopard Frogs in the NWT (Rescan 2008; Schock 2010). Several observations recorded since 1901 were collected opportunistically, often by inexperienced observers, and cannot be verified as Northern Leopard Frogs (Fournier 1997). Relatively few sites have been revisited to determine population persistence or trends. Recent and historic observations, and locations searched, are shown in Figure 4. Most of the amphibian search effort has been west of the Slave River, with limited search effort having been conducted in the core historic range of the Northern Leopard Frog.

Population surveys for Northern Leopard Frogs typically use visual encounter surveys for the various life stages, which involve systematically searching terrestrial habitats, and searching and dipnetting of wetlands and other habitats, and counting the number of individuals encountered (Thoms *et al.* 1997). Other survey techniques include nocturnal calling surveys, egg mass surveys and mark-recapture techniques (Adama and Beaucher 2006). Multiple surveys improve occupancy estimates (Kendell pers. comm. 2012). Rescan (2008) used time-constrained visual encounter surveys (number of observations in a specified time) (Kendell 2002a) to determine the presence of Northern Leopard Frogs and the availability of suitable wetland breeding habitat in the Taltson Basin Hydroelectric Expansion Project area. The Northern Leopard Frog was detected at two sites on Trudel Creek (August 2007) and upstream of Elsie Falls (early July 2008). Frogs were not detected at these sites in late July 2008. Northern Leopard Frogs were observed at six sites along the Taltson River, where tadpoles were observed at one site (site SV5). Rescan (2008) also found Northern Leopard Frogs at Kozo Lake (Taltson River), where the species was found in 1994 (Fournier 1997).

In July 2005, Prescott (pers. comm. 2005) visited Leland Lake and found a total of 29 Northern Leopard Frogs at six out of 10 sites searched on both the Alberta and NWT sides. The observations were from the east side of the lake, roughly one mile north of the provincial border. Schock (2010) surveyed 32 sites in the South Slave Region in the NWT and adjoining Alberta in 2009. Nineteen sites were in the NWT, and seven of those were in Wood Buffalo National Park. Northern Leopard Frogs were found at two sites (six and five adults)

where the species had been found in 2008 (Rescan 2008; sites SV5 and SV23). In 2009 and again in 2012 (Schock 2010, updated by Schock, pers. comm. 2012b), the Northern Leopard Frog was not found at other sites surveyed in the NWT (Fort Smith, Tsu Lake, Taltson River, Klewi River, Slave River, Slave River delta, and Wood Buffalo National Park) and in northern Alberta (Fort Chipewan area).

Distribution trends

The restricted distribution of the Northern Leopard Frog in the NWT is reason for conservation concern, given the decline of the Northern Leopard Frog elsewhere in western Canada and the decline of amphibians globally (COSEWIC 2009). Available data and search effort in the NWT are insufficient to document broad distribution trends, since recent search effort has minimally overlapped sites of historic (before 1995) occurrences (Figure 4). Most of the potential range of the Northern Leopard Frog in the Northwest Territories has received no search effort. There is some evidence from recent searches (Figure 4) that Northern Leopard Frogs may now be absent from the Slave River, but otherwise the distribution appears to be stable in the area where recent searches overlap the historic range (e.g., Rescan 2008).

Habitat

Habitat Requirements

The Northern Leopard Frog has three primary habitat requirements: aquatic habitat for breeding, egg laying and tadpole development; foraging habitat; and overwintering habitat. These habitats, often in close proximity, must be connected by travel corridors that are suitable for migration and dispersal.

Breeding takes place in a wide variety of permanent and semi-permanent wetlands that contain a combination of open water and emergent vegetation (Wershler 1992; Wagner 1997). The water is usually shallow (less than 1.5 m), pH neutral, and fishless. Prescott (pers. comm. 2005) recorded a pH of 7.8 in Leland Lake in July 2005, and the Calgary Zoo has recorded pH values that include and range between 7.0 to over 10.0 (Kendell pers. comm. 2013). Warm water is required for rapid embryo and tadpole development. Suitable sites include beaver ponds, springs, oxbows, quiet backwaters of streams, lake edges, flooded meadows, swamps and marshes and man-made habitats such as roadside ditches and borrow pits (reviewed in COSEWIC 2009). Emergent vegetation at Alberta breeding sites often includes Cattail (*Typha latifolia*), Bulrush (*Scirpus* spp.) and/or sedges (*Carex* spp.) (Wershler 1991). A Northern Leopard Frog breeding site along the Taltson River in the NWT was in a shallow riparian floodplain marsh vegetated with Variegated Pond Lily (*Nuphar variegata*), Horsetail (*Equisetum arvense*) and Northwest Territory Sedge (*Carex utriculata*) (Rescan 2008). Northern Leopard Frogs show strong fidelity to breeding sites, returning to the same sites year after year (Waye and Cooper 1999).

Summer feeding areas are frequently found along the margins of water bodies (Wagner 1997) including breeding ponds and stream banks. These may be up to two kilometers from breeding sites. Northern Leopard Frogs often remain perched near the water where they can escape from predators. Preferred areas are open and semi-open with short vegetation (Merrell 1977; Wershler 1992). Heavily forested areas and areas with dense aquatic vegetation, tall grass or shrubs are avoided (Merrell 1977). Adults may move some distance from water if sufficient moisture and cover are available (Hine *et al.* 1981; Seburn *et al.* 1997).

Northern Leopard Frogs usually overwinter on the sand or mud bottoms of water bodies to escape freezing temperatures on land. Suitable water bodies must be well oxygenated and deep enough to not freeze to the bottom (Hine *et al.* 1981; Russell and Bauer 2000, Alberta Northern Leopard Frog Recovery Team 2010). Streams, creeks, rivers, lakes, deep ponds, and springs may all provide appropriate overwintering conditions (Cunjak 1986; Wershler 1991). Springs that do not freeze may be important if deep water is not available. An overwintering site was found on the Taltson River at Frog Hole (Figure 7). Five to eight frogs were observed underwater on 1 June 1972 in a hole in the middle of this island (ENR unpubl. data 2011). No frogs were observed there in the fall of 2009 (Beaulieu pers. comm. 2011). Terrestrial overwintering may occur in small mammal burrows (Waye and Cooper 2001), caves or under rocks, woody debris, or leaf litter (Emery *et al.* 1972; Wagner 1997). Moisture must be present to prevent desiccation and burrows must be below the frost line. The Northern Leopard Frog is not freeze-tolerant making above ground overwintering unlikely in the north. Northern Leopard Frogs may exhibit site fidelity to overwintering sites (Waye and Cooper 1999).

Habitat requirements for Northern Leopard Frogs during dispersal are not well known. Since they require moisture to prevent desiccation, moist habitats along streams, wetlands and seepages are preferred (Seburn *et al.* 1997). Rainfall may make overland travel through drier habitats possible (Dole 1971).

Habitat availability

The availability of suitable habitat for the Northern Leopard Frog in the Northwest Territories has not been quantified. At the very least, areas of both current and historic occurrence are assumed to contain suitable habitat (Figure 4). It is likely that suitable habitats adjacent to this range have not been adequately surveyed. The unconfirmed acoustic observations of Northern Leopard Frogs in the Fort Liard and Edéhzhíe areas suggest the possibility that suitable habitat and populations may exist elsewhere in the boreal forest of the southern NWT (EBA Engineering Consultants Ltd. and Canadian Wildlife Service 2006, Schock 2009).

Habitat limitations that likely determine the species' distribution in the NWT include the availability of suitable breeding or

overwintering sites. Wetland isolation (separation of wetlands by large distances) may also limit distribution, although the importance of this factor in the NWT is not known (this is discussed more fully in the section on *Population*).

Figure 7. Frog Hole on Taltson River, 2009. Photo courtesy of Susan Fleck, ENR, GNWT.

Habitat fragmentation

Habitats of pond-breeding amphibians in general, including those of Northern Leopard Frogs, tend to be naturally fragmented (Marsh and Trenham 2001). Species at the edges of their range and habitat suitability, like the Northern Leopard Frog in the NWT, may face even greater separation of breeding sites.

Habitat may be further fragmented if road corridors and transmission lines in the South Slave Region are changing the habitat characteristics (e.g., making terrain too dry) or blocking migration and dispersal. The actual impact of these features on Northern Leopard Frog habitat is likely negligible since most dispersal occurs along riparian corridors and wetlands. However, road mortality of migrating and dispersing frogs may be an undocumented issue in the NWT, especially if breeding ponds are located adjacent to roads.

Habitat trends

There is no scientific evidence or documented traditional or community knowledge that Northern Leopard Frog habitat has been lost in the NWT. The

Prairie population of Northern Leopard Frogs to the south is subject to wetland loss to agriculture, recreational subdivision, and seismic exploration for oil and gas (Alberta Northern Leopard Frog Recovery Team 2010). As well, wetlands in many parks have been stocked with non-native game fish. These factors do not impact wetlands in the NWT.

There has been hydroelectric power generation on the Taltson River since 1965. Existing structures include a dam and power generation facility at Twin Gorges dam, a rockfill dam and overflow spillway at Nonacho Lake, and an overflow spillway through Trudel Creek known as the South Valley spillway (Dezé Energy Corporation 2009). The proposed Taltson Basin Hydroelectric Expansion Project would add to the existing infrastructure and may have significant impacts on Northern Leopard Frog habitats and populations in the NWT, if the project goes ahead. The project infrastructure includes winter roads, a new transmission line, and a new hydroelectric plant. The winter road and transmission line require water body crossings (between Fort Smith, Twin Gorges Dam and Nonacho Dam), but with no instream works and minimal riparian brushing. The greatest impacts would result from changes to the existing hydrology regime in the Taltson River, where summer flows would be reduced and winter flows would be increased. Flows would be reduced in the Trudel Creek spillway (Dezé Energy Corporation 2007; 2009). With limited knowledge of current Northern Leopard Frog breeding and overwintering sites, impacts of this project on habitats cannot be adequately assessed. The expansion project is currently on hold while the proponent determines if there is a viable market (More pers. comm. 2012).

The flow regime of the Slave River has been affected by the upstream Bennett Dam since 1968 (Government of the Northwest Territories 2011). Significant changes in flow in the Slave River over the past 40–50 years have been noted by scientists and by Fort Smith and Fort Resolution residents. These changes include reduced overall flow, earlier peak flow, decreased summer flow, increased winter flow, and less variable annual flow. Flow regulation as well as climatic change have been identified as drivers of these changes (Dagg *in prep*. a; b; AANDC and ENR 2012). Dampened flows from mid-May through the summer months may have had an impact on the available breeding and rearing habitats for Northern Leopard Frogs along formerly flooded shorelines.

Participants at a community workshop in Fort Smith indicated that the decline in water levels in the Slave River and Delta ecosystem has led to drying of wetlands, fens, channels, and lakes, and cited this drying of frog habitat as one possible reason for the decline in frogs they had observed (Dagg *in prep*. a).

It is not conclusively known whether contamination from the Alberta oil sands is having downstream and downwind effects on Northern Leopard Frogs in the NWT, but there is a high level of community

concern about water contamination and airborne pollutants in general (see *Threats and Limiting Factors – Environmental Contamination*). Oil sand process-affected substrates and water were shown to have negative effects on Wood Frog egg and tadpole survival, growth and development (Gupta 2009). Environment Canada (2011b) is evaluating the health of wild amphibians and amphibian populations close to and at varying distances from oil sands operations. There are study sites in the NWT near Fort Smith and Fort Resolution. The Wood Frog is the primary indicator species in these studies; however, it is noted that Northern Leopard Frog is also a good indicator species, as it is a more aquatic species than the Wood Frog and part of its natural history life cycle involves over-wintering in aquatic environments. Because Northern Leopard Frogs spend more time in and exposed to water, they could be more susceptive to water-borne contaminants. Compared to Wood Frog, Northern Leopard Frog may be more sensitive to pollution, changes in habitat (induced by climate change or other), and also disease (Kendell pers. comm. 2013). However other amphibian species will be sampled if encountered. Amphibians will be screened for diseases, malformations, organic chemicals and heavy metals. Some breeding ponds are also being sampled for organic chemicals and heavy metals. Effects on populations, such as survival, are not being monitored.

Global climate change may have both negative and positive impacts on Northern Leopard Frog habitat as discussed in *Threats and Limiting Factors – Global Climate Change*. Introduced plant species such as White and Yellow Sweetclover (*Melilotus alba* and *M. officinalis*), might degrade Northern Leopard Frog shoreline habitat (see *Threats and Limiting Factors – Invasive Species*).

Biology

Life cycle and reproduction

Northern Leopard Frogs emerge from overwintering habitats early in the spring as the ice begins to melt and air and water temperatures warm. Migration from overwintering sites has been observed at water temperatures of 9 to 12°C (Pace 1974) and 7 to 10°C (Licht 1991). Merrell (1977) observed that frogs did not leave overwintering sites until the air temperature exceeded 13°C. The frogs move from deeper water to shallow, warmer water and in some cases make overland migrations if different wetlands are used for overwintering and breeding. Migration may be at night (Dole 1967a) or during the day if nighttime temperatures are cool (Merrell 1977). Northern Leopard Frogs use the same breeding sites from one year to the next.

Breeding takes place between mid-April and late June depending on weather conditions and water temperature (Eddy 1976, Kendell 2002b, Waye and Cooper 2001). Observations are not available for the NWT, but mid to late May breeding is typical for amphibians at the same latitude in the Yukon (Slough and Mennell 2006).

Wood Frogs have been observed breeding in the South Slave region in mid-May (Moore pers. comm. 2011; Langois pers. comm. 2011). Patches of ice may still be on the ponds (Wershler 1992). Sexually mature adult males arrive first at the breeding sites and begin calling, with females arriving a few days to a few weeks later (Hine *et al.* 1981). Seburn (1992a) found that male Northern Leopard Frogs called at water temperatures of greater than 10ºC and air temperatures of at least 15ºC. They mate in a sexual clasp, called amplexus, where the male's forelimbs hold the female behind her forelimbs. Males may mate with more than one female. The eggs are fertilized externally as they are being laid. Breeding is usually communal and explosive (occurring over just a few warm, calm days), but the period may be extended if air and water temperatures are less suitable (Alberta Northern Leopard Frog Recovery Team 2010), resulting in several size classes of tadpoles (Merrell 1977; Hine *et al.* 1981). A short, explosive, breeding season is expected in the NWT, where the summer season is shorter.

Amphibian species that breed early in the spring like the Northern Leopard Frog tend to be synchronous, communal breeders, also depositing their eggs communally (Waldman 1982). Early breeding maximizes the probability that tadpoles will metamorphose within the brief summer period, and before ponds dry up. Additionally, many predators have not arrived or are inactive at this time. Communal breeding ensures reproductive success, and communal egg masses provide an insulating benefit that enhances the growth and survival of embryos. The risk to synchronous breeding is that large numbers of eggs or tadpoles could be adversely affected by environmental conditions such as freezing or drought.

Eggs are laid communally near the surface in shallow water, and are either attached to vegetation or are floating (Merrell 1977; Hine *et al.* 1981; Gilbert *et al.* 1994). The time of hatching is dependent on water temperature, and usually occurs in five to nine days, but may be extended to more than two weeks in cool weather (Hine *et al.* 1981). Tadpoles metamorphose after two to three months. Newly metamorphosed frogs, known as metamorphs or froglets, may have some unabsorbed tail for about a week. From this point to maturity (two to three years old) they are known as juveniles. Overwintering begins one or two months prior to freeze-up. Additional life cycle details are provided under *Population: Structure and Rates*.

Physiology and adaptability

Northern Leopard Frogs are not freeze-tolerant (Churchill and Storey 1995). Studies have shown that they do not truly hibernate, but become inactive underwater during winter (Waye and Cooper 2001). However, recent evidence from telemetry in Alberta shows that Northern Leopard Frogs can remain active under ice, and can sometimes move several hundred metres in a day, though it is not clear how normal such movements are (Prescott pers. comm. 2012). Overwintering sites must be well-

oxygenated (Waye and Cooper 2001).

Northern Leopard Frogs have smooth moist skin making them vulnerable to desiccation. Metamorphs and smaller juveniles have a higher surface area to volume ratio and are more vulnerable to desiccation than adults. They can survive the loss of up to 50% of total body water (approximately 40% of body mass) at 5ºC (Churchill and Storey 1995). Northern Leopard Frogs have behavioural adaptations to prevent desiccation, such as burrowing in the sand, and choosing moist micro-sites and habitats (Dole 1967b).

Northern Leopard Frogs are ectotherms, regulating their body temperature by exchanging heat with their surroundings. They thermoregulate behaviourally, by moving to habitats or micro-habitats with suitable ambient temperatures, by basking in the sun (Brattstrom 1963), and by evaporative cooling from the skin and lungs (Stebbins and Cohen 1995). Lethal minimum and maximum temperatures for Northern Leopard Frogs are - 1.6°C and 35°C respectively (Brattstrom 1968). The ability of the Northern Leopard Frogs to maintain high levels of activity (such as migration to breeding sites, breeding and foraging) increases with temperature and peaks at 20-29°C (Putnam and Bennett 1981).

Northern Leopard Frogs have been successfully reared in captivity and reintroduced to the wild (Adama and Beaucher 2006; Kendell and Prescott 2007).

Interactions

Northern Leopard Frogs occur in populations, which interact at communal breeding sites and overwintering sites, but are otherwise solitary animals. Tadpoles and metamorphs do not aggregate closely, but may still remain in the same general pond area.

Northern Leopard Frog tadpoles are primarily herbivorous, feeding on aquatic vegetation, but they also feed on dead plants and animal carcasses, including dead tadpoles (Merrell 1977; McAllister *et al.* 1999).

Adult and juvenile Northern Leopard Frogs are primarily ambush predators, feeding on moving prey, but they also consume inactive prey. Foraging excursions may be made in response to rain and drops in barometric pressure (Dole 1965, 1971; Collier *et al.* 1998). They feed primarily upon arthropods, including beetles (Coleoptera), true flies (Diptera), leafhoppers (Homoptera), ants (Hymenoptera), true bugs (Hemiptera), grasshoppers (Orthoptera), moths and butterflies (Lepidoptera), dragonflies (Odonata) and spiders (Arachnida). To a lesser extent, they will consume worms (Oligochaeta) and snails (Gastropoda) (Moore and Strickland 1954; Rittschof 1975; Hine *et al.* 1981; Collier *et al.* 1998; Russell and Bauer 2000). They cannibalize smaller Northern Leopard Frogs, including metamorphs and tadpoles (Eddy 1976; Merrell 1977).

Predators of eggs and tadpoles include

dragonfly nymphs, caddisfly larvae (Trichoptera), beetles, leeches (Hirudinea) (Dickerson 1907), fish, birds and garter snakes (*Thamnophis* spp.) (McAllister *et al.* 1999). Although they are believed to be readily taken by fish, they were found to be unpalatable to most but not all sympatric fish species in Québec (El Balaa and Blouin-Demers 2011).

Juvenile and adult Northern Leopard Frogs are preyed on by a wide variety of fish, snakes, muskrats, owls, waterfowl and raptors (Merrell 1977, Oldfield and Moriarty 1994, Prescott pers. comm. 2012). Lake trout (*Salvelinus namaycush*) eat overwintering Northern Leopard Frog adults (Emery *et al.* 1972). Other predatory fish are known to prey on Northern Leopard Frogs (Hayes and Jennings 1986; McAllister *et al.* 1999; Smith and Keinath 2007). Carnivores that occur in the NWT, such as mink (*Neovison vison*), river otter (*Lontra canadensis*) and red fox (*Vulpes vulpes*) also prey on Northern Leopard Frogs (Harding 1997).

Competitors of Northern Leopard Frogs in the NWT might include co-occurring amphibians such Wood Frogs, Boreal Chorus Frogs (*Pseudacris maculata*) and Canadian Toads (*Anaxyrus hemiophrys*). Little is known about interactions among these species, but Northern Leopard Frog tadpoles can suppress the growth of co-occurring Wood Frog tadpoles (Relyea 2000) and grow faster under good conditions (Schiesari *et al.* 2006).

Diseases, parasites and invasive species are discussed under *Threats and Limiting Factors*.

Population

Structure and rates

Female Northern Leopard Frogs produce one clutch per year containing 600 to 7,000 eggs (Corn and Livo 1989). Clutch size is correlated with female body size, which is related to age (Corn and Livo 1989; Gilbert *et al.* 1994). Hatching success is highly variable (Corn and Livo 1989) and depends on several factors affecting embryo mortality (including physical breakup of egg masses, parasitism, and disease) (Eddy 1976; Hine *et al.* 1981). Hatching success ranges from 50-99% (Eddy 1976; Hine *et al.* 1981).

Metamorphosis of tadpoles takes 2 to 3 months and is temperature dependent, and possibly density dependent (Wershler 1991; Seburn 1993). Transformation was reported to be complete by late July to early August in Alberta, although cool weather can delay development into September (Seburn 1993). Early drying of semi-permanent sites leads to increased tadpole density, accelerated development, and metamorphosis at a reduced size (Merrell 1977). Survivorship from egg to metamorphosis was reported as 1-6% in Minnesota (Merrell 1977; Hine *et al.* 1981). Overwintering of Northern Leopard Frog tadpoles has not been reported in the literature but was speculated upon by Rescan (2008) and Kendell (pers. comm.

2013) for tadpoles that had well developed limbs and were developmentally advanced over sympatric Wood Frogs in late July. However, Northern Leopard Frog tadpoles can suppress the growth of co-occurring Wood Frog tadpoles (Relyea 2000) and grow faster under good conditions (Schiesari *et al.* 2006).

Young-of-the-year can comprise 95-98% of the fall population (Eddy 1976, Merrell 1977), but they may suffer 93% mortality during the first winter (Yaremko 1996). Adult mortality rates may reach 60% annually (Merrell and Rodell 1968). Sex ratios of juveniles and adults are well balanced (Hine *et al.* 1981; Merrell and Rodell 1968).

Sexual maturity is dependent on size more than age, with females reaching maturity at 55 mm (Hine *et al.* 1981; Merrell 1977) to 60 mm snout-vent length (Gilbert *et al.* 1994), and over half of one-year-old males reaching maturity at 51 mm snout-vent length (Gilbert *et al.* 1994). In less dense populations in Minnesota sexual maturity was reached in one year, while in denser populations it may have taken up to three years to reach maturity (Merrell 1977). There is currently no evidence in Alberta that Northern Leopard Frog mature in less than two years, which also likely applies to NWT frogs (Prescott pers. comm. 2012). Northern Leopard Frogs rarely live longer than four to five years (Eddy 1976) in the wild, though they can live up to nine years in captivity (Russell and Bauer 2000).

Generation time of the Northern Leopard Frog is the average age of parents in the population, which is greater than the age at first breeding (1 year) and less than the age of the oldest breeding individual (5 years). Therefore the range is 2-4 years of age, or an average of 3 years of age.

The main limitations to population growth are predation of tadpoles and metamorphs, and breeding failure due to drought and other stochastic (unpredictable) factors (Hine *et al.* 1981). Population declines however are usually caused by deterministic, or predictable, factors such as habitat loss, disease, and global climate change.

Wetlands typically occur in discrete patches surrounded by non-wetland habitat. Many wetland-dependent species therefore live in multiple local populations sustained through occasional migration – that is, in metapopulations[1] (Gibbs 2000). In a metapopulation, recolonization from neighbouring populations balances extirpations. Four conditions are necessary for the metapopulation effect (Hanski 1999): 1) habitat patches support local breeding populations, 2) no single population is large enough to ensure long-term survival, 3) patches are not too isolated to prevent recolonization, and 4) local dynamics are sufficiently asynchronous to make simultaneous

[1] A metapopulation is a group of spatially separated populations which interact genetically at some level.

extinction of all local populations unlikely.

Pond breeding amphibians such as the Northern Leopard Frog typically have strong breeding site fidelity, high vagility (ability to move) within home ranges, limited dispersal abilities, and spatially disjunct breeding sites (Smith and Green 2005). As a result, the breeding sub-populations exchange migrants, may be subject to local extinction and recolonization, and form metapopulations (Marsh and Trenham 2001; Smith and Green 2005). Smith and Green (2005) believed that Northern Leopard Frogs did not meet the conditions of a metapopulation due to their ability to disperse up to 8 km, thus synchronizing local population dynamics (condition 4, above). The wide separation of known breeding sites in the NWT suggests that breeding ponds are probably more isolated in the NWT than they are further south. However, many prairie populations are very isolated from each other (i.e. spring areas in the middle of dry prairie). Dry climate patterns compound dispersal, which makes even close populations isolated in nature (Prescott pers. comm. 2012). This makes asynchronous local population dynamics (and the metapopulation effect) a probability.

Local and regional population persistence depends on breeding site distribution and connectivity. Northern Leopard Frogs must be able to maintain a stable metapopulation in the face of stochastic events, a short life span, and high site fidelity (Gibbs 2000). Stochastic events include floods, droughts, late spring freezing, or other factors that impact the short breeding season, communal breeding and over-wintering sites, or frogs which are aggregated at other times in their life history. The ability to migrate and/or disperse in response to such events is critical to ensuring metapopulation stability.

Movements

Northern Leopard Frog metamorphs move away from their natal ponds in late summer to early fall. Dole (1971) found that they could move up to 800 m per night in Michigan and were found as adults up to 5 km from natal ponds. Seburn *et al.* (1997) found metamorphs up to 2.1 km from natal ponds in Alberta. They disperse in all directions overland or along riparian corridors (Dole 1971; Seburn *et al.* 1997). Seburn *et al.* (1997) found a yearling that had moved 8 km from its natal pond. Other dispersal movements of up to 10 km have been noted in Alberta (Alberta Northern Leopard Frog Recovery Team 2010; Romanchuk and Quinlan 2006).

Adult Northern Leopard Frogs occupy summer home ranges that are 15 to 600 m^2 in size and usually near the breeding sites (Dole 1965). Breeding sites may be up to 6 km from overwintering sites (Hine *et al.* 1981; Wershler 1991). Dispersal from the breeding sites by adults of up to 3.2 km has been reported (Merrell 1970). However, dispersal distances of Northern Leopard Frogs and other amphibians may have been underestimated by the scale at which researchers operate (Smith and Green

2005). For example Seburn *et al.*'s (1997) reported 8 km dispersal of a yearling was the longest possible distance that could have been recorded given the size of the study area.

Northern Leopard Frogs are vulnerable to disruption of movement and dispersal corridors by habitat fragmentation caused by land clearing. Northern Leopard Frogs are limited by dispersal abilities; therefore seasonal habitats and habitats used by metapopulations must be in relatively close proximity to each other (Pope *et al.* 2000). Roads pose the additional threat of road-kill mortality to dispersing metamorphs (Carr and Fahrig 2001; Eigenbrod *et al.* 2008). The degree of isolation of breeding ponds affects the ability of amphibian populations to interact and maintain stability (Marsh and Trenham 2001). Ponds that are isolated naturally or become isolated by disturbance are less likely to be recolonized after extinction.

The Northwest Territories population of Northern Leopard Frogs could be augmented by movement or dispersal of individuals from northeastern Alberta or northwestern Saskatchewan. However, if there were declines of Northern Leopard Frogs in the NWT, populations in Alberta and Saskatchewan would probably be declining as well, reducing the likelihood or rate of repopulation. There is likely movement of individuals within the Western Boreal population in the NWT, Alberta and Saskatchewan. Connectivity between the Western Boreal and Prairie populations however, is uncertain, as local populations are likely small and isolated (Didiuk 1997; Alberta Sustainable Resource Development 2003; Didiuk pers. comm. 2011; Kendell pers. comm. 2011).

Abundance

The abundance of Northern Leopard Frogs in the Northwest Territories can only be crudely estimated from the available data. The number of occurrences (n=28) can be extrapolated to estimate breeding populations and mature individuals. Given the limited search effort, and inherent difficulties in surveying a low density species, there are likely many undiscovered breeding populations.

The adult Northern Leopard Frog population in the NWT is unknown. Based on expert opinion, a broad population estimate for the number of mature individuals is probably less than 10,000 and conceivably less than 2,500 (threshold population sizes used by IUCN [IUCN Standards and Petitions Subcommittee 2010] to evaluate conservation status).

COSEWIC (2009) concluded that there were insufficient data to provide an estimate for the numbers of adult Northern Leopard Frogs within the Prairie/Western Boreal DU, or northern boreal disjunct population segment of the DU, which encompasses the Northwest Territories populations.

Fluctuations and trends

Detecting trends in amphibian numbers requires long-term data, since amphibian

populations are characterized by inherent fluctuations and are vulnerable to stochastic (random) events (Marsh and Trenham 2001). Northern Leopard Frogs are vulnerable to events occurring at sites where individuals are concentrated, such as breeding sites (adults, eggs, tadpoles and metamorphs) and overwintering sites. Random events such as freezing temperatures or drought can have major impacts on cohorts or even an entire population, resulting in extirpation.

Single surveys can greatly bias apparent trends (Skelly *et al.* 2003). Restricting surveys to historical breeding sites does not distinguish between population losses and site switching (Petranka *et al.* 2004, Pearl *et al.* 2009) and it does not detect the occupation of new habitats (Wente *et al.* 2005). However, site switching may or may not be an issue with Northern Leopard Frogs because they exhibit high breeding site fidelity (see the section on *Habitat requirements*, p.23).

Insufficient data are available to determine Northern Leopard Frog population trends. Some historical sites in the NWT have been revisited over the years with evidence of population stability (i.e. 1994 and 2008 as reported by Rescan (2008) and two sites surveyed in both 2008 (Rescan 2008) and 2009 (Schock 2010) had Northern Leopard Frogs). However, community and traditional knowledge (Beaulieu pers. comm. 2011; Beck pers. comm. 2011) suggests that Northern Leopard Frog numbers declined on the Taltson River between the 1950s and 1980s. In fact, Aboriginal traditional knowledge holders have noticed declines in all species of amphibians in general (Beaulieu pers. comm. 2011; Fraser pers. comm. 2011). At a community workshop in Fort Smith in 2012, many participants mentioned an observed decline in frog populations and a lack of frog songs in the spring in the Slave River and Delta ecosystem (species not specified; Dagg *in prep*. a). Fraser (pers. comm. 2011) cites a decline in Wood Frogs and Boreal Chorus frogs at Frog Pond in Fort Smith, and states that Salt River First Nation elders report fewer frogs in the stomachs of Jackfish (Northern Pike; *Esox lucius*).

Some data are available on Northern Leopard Frog population trends in the Prairie population (of the Prairie/Western Boreal DU). Declines were first observed in Alberta in the late 1970s and early 1980s (Wershler 1991). Prior to that time, the species was widespread and abundant in the province (Kendell *et al.* 2007). Currently, the populations in Alberta remain small and fragmented and in some cases are still declining (Kendell *et al.* 2007). Populations at the core of the species' range in southern Alberta appear to be healthy (Kendell *et al.* 2007). Little is known about Northern Leopard Frog populations in Saskatchewan, but there is anecdotal evidence that populations that declined in the 1970s are now recovering (Seburn 1992b). A similar decline was noted in Manitoba in the 1970s (Koontz 1992) followed by a recovery in the 1980s. The former range in Manitoba now appears to be re-occupied by healthy populations (Duncan pers. comm., cited in

COSEWIC 2009).

Threats and limiting factors

Amphibians face many threats globally and are declining more rapidly than either birds or mammals (Stuart et al. 2004). Major global threats to amphibians include: habitat loss and fragmentation; traffic mortality; collection for food, bait, medicine and education; acid rain; chemical contaminants and pesticides; introduction of exotic competitors and predators and diseases from non-native fish; emerging diseases (e.g., chytrid fungus, *Batrachochytrium dendrobatidis*, and ranaviruses); ultraviolet (UV-B) radiation which may reduce hatching success; global climate change which affects water levels and temperature and results in extreme weather events; or combinations of these factors (Daszak *et al.* 1999).

In the NWT, emerging diseases, proposed hydroelectric developments, air and waterborne pollution, and climate change likely pose the greatest threats to the Northern Leopard Frog. The magnitude of habitat loss, degradation and fragmentation is low and is expected to remain low in the near future (with the exception of hydroelectric developments). Anglers, float planes, and boats could be a vector for pathogen spread, depending on their cleanliness and orgins (Kendell pers. comm. 2013).UV-B radiation is a threat of low magnitude, but it may be higher in combination with other stressors. Non-native species of plants and animals, as well as collection and harvest of Northern Leopard Frogs, pose very little threat at the present time.

Diseases and parasites

Diseases and parasites are current threats to Northern Leopard Frogs in the Northwest Territories. The magnitude of the impact is unknown but believed to be minor at this time. Regardless, Northern Leopard Frogs are susceptible to diseases like chytridiomycosis and ranaviral disease that have resulted in high mortality rates and population declines elsewhere (Daszak *et al.* 1999).

Chytridiomycosis, caused by the chytrid fungus *Batrachochytrium dendrobatidis* (Bd), is widespread in amphibians across North America (Ouellet *et al.* 2005), including Northern Leopard Frogs (Woodhams *et al.* 2008). The Bd population in North America is a hypervirulent lineage that resulted from the anthropogenic mixing of two other lineages and subsequent anthropogenic spread (probably through global trade in amphibians; Farrer *et al.* 2011). It may require other co-stressors such as increased UV-B radiation for the disease to become pathogenic. It has been found on Northern Leopard Frogs in Alberta (Alberta Sustainable Resource Development 2003) and British Columbia (Adama and Beaucher 2006) and on Wood Frogs, Western Toads (*Anaxyrus boreas*) and Boreal Chorus Frogs (*Pseudacris*

maculata) near Fort Liard, Northwest Territories (Shock *et al.* 2009). The Alberta Department of Sustainable Resource Development recently completed an extensive survey of chytrid fungus in Alberta (Stevens *et al.* 2012) showing that the disease is widespread and common in a variety of amphibians. Curiously, the disease was not found in the population on the Canadian Shield, although a case of ranavirus was found in Northern Leopard Frog in the area. Bd testing is ongoing for samples obtained from Northern Leopard Frogs, Wood Frogs, Boreal Chorus Frogs and Canadian Toads (*Anaxyrus hemiophrys*) from the South Slave Region of the NWT (Schock 2009, 2010).

Bd is suspected of suppressing Northern Leopard Frog populations in British Columbia (Adama and Beaucher 2006). There is evidence that some amphibian species are able to survive Bd epidemics, either through increased immunity, which allows them to live with low-level fungal infections, the evolution of less pathogenic strains of Bd, favourable environmental conditions, low infection intensities (Briggs *et al.* 2010), or through adaptation and the evolution of better defences (such as anti-microbial peptides on their skin; Woodhams *et al.* 2010). While there is evidence that Bd is a spreading pathogen that can have negative consequences for amphibian populations (Skerratt *et al.* 2007), there is also evidence that Bd is widespread in areas where there is little evidence of harm (Longcore *et al.* 2007, Pearl *et al.* 2007) or where Bd has become endemic in apparently stabilized populations (Ouellet *et al.* 2005; Pearl *et al.* 2009; Pilliod *et al.* 2010).

Infections and mortalities due to ranavirus have been reported for Northern Leopard Frogs in captive and wild populations (Miller et al. 2011). Ranavirus testing is ongoing for samples obtained from Northern Leopard Frogs, Wood Frogs, Boreal Chorus Frogs and Canadian Toads from the South Slave Region (Schock 2009, 2010). A positive test result for ranavirus occurred in a Northern Leopard Frog at Bocquene Lake, in the Shield population of Alberta, in 2009 (Prescott pers. comm. 2012). Northern Leopard Frog die-offs have been linked to or associated with ranaviruses in southern Ontario (Greer *et al.* 2005) and near Estevan, Saskatchewan (Schock and Bollinger 2005). In the NWT, ranaviruses were recently found to be widespread in Wood Frogs across the Sahtu and Dehcho regions (Schock *et al.* 2009). Ranaviruses can be transmitted between host species, and host populations may differ in their response to infection (Schock *et al.* 2008).

"Red leg", caused by infection by the bacterium *Aeromonas hydrophila*, is most often fatal (Alberta Northern Leopard Frog Recovery Team 2010). It was the cause of high mortality in Northern Leopard Frogs in Alberta in 1976 (Roberts 1992); however, there were no population extirpations. There have been no reports of this disease from the NWT, where its prevalence is unknown.

Amphibian deformities have received considerable attention over the past 20 years (Ouellet 2000; Ballangée and Sessions 2009). Missing limbs and other limb deformities are frequently the result of physical trauma such as failed predation attempts of tadpoles by invertebrates such as dragonfly larvae (Eaton *et al.* 2004; Ballangée and Sessions 2009). Chemical contamination of amphibian habitats and UV-B radiation may also cause deformities (Taylor *et al.* 2005; Ballangée and Sessions 2009).

Schock (2009) found one adult Wood Frog, out of 225 frogs examined, with a deformed hind foot in the Dehcho and Sahtu regions in 2007 and 2008. Eleven frogs (out of 258), including three of 11 Northern Leopard Frogs examined in the South Slave region, had gross physical abnormalities including missing eyes, curved spines, and deformed hind limbs (Schock 2010). The abnormalities noted for the three Northern Leopard Frogs were a missing eye, an abnormal hind limb with an asymmetrical hind limb colour pattern, and melanistic (dark) colouration, only two of which could be considered deformities. The cause of the amphibian deformities observed in the South Slave region was not determined and the implications of the abnormalities on the population of Northern Leopard Frogs there is unknown.

Habitat loss, degradation and fragmentation

Habitat loss, degradation and fragmentation have resulted in declines and extirpations of Northern Leopard Frog populations across North America (Lannoo *et al.* 1994; Koch *et al.* 1996), including Alberta (Alberta Sustainable Resource Development 2003). They may negatively impact Northern Leopard Frogs in the NWT but the magnitude of these threats is low and expected to remain low in the near future.

Activities that threaten Northern Leopard Frog habitats in the NWT include water management activities and roads (Environment Canada 2011a). Water management activities related to hydroelectric developments that increase water levels might create excessive currents that disrupt breeding activities and over-wintering habitat, and dislodge egg masses. Decreased water levels might result in the loss of breeding ponds or in ponds drying up before metamorphosis (Environment and Natural Resources 2012). Reduced flows on the Slave River from mid-May through the summer months (due to the Bennett Dam) may have already had an impact on Northern Leopard Frog breeding and rearing habitats. If the proposed Taltson Hydroelectric Expansion Project goes ahead, impacts would include changes to the seasonal flows and water levels in the Taltson River system (Dezé Energy Corporation 2007; 2009), which could alter water flows and impact Northern Leopard Frogs in the core of their range. Artificial ponds may be colonized by Northern Leopard Frogs but these ponds may only be population sinks that have a negative effect on population persistence, especially if they are semi-permanent or provide poor

overwintering or foraging habitat (Seburn *et al.* 1997).

Roads remove woodland habitat and fragment habitat, but more importantly they represent barriers to dispersal and migration, and result in road kill events which may lead to population declines (Fahrig *et al.* 1995; Carr and Fahrig 2001; Eigenbrod *et al.* 2008). Adults and metamorphs are especially vulnerable near breeding, foraging and overwintering sites, where mass movements may occur (Carr and Fahrig 2001). Road mortalities and barriers to movement are a potential limiting factor for Northern Leopard Frogs at the western edge of their range in the NWT along Highway 5 into Fort Smith, and similarly south of Fort Smith to Fort Fitzgerald/Hay Camp in Alberta.

Environmental contamination

Environmental contamination has not been identified as a current threat to Northern Leopard Frogs in the NWT, but contaminants in the water were noted as a potential reason for frog declines observed by community workshop participants (Dagg *in prep.* a). There is a high level of community concern about contaminants in in the Slave River water and their effects on fish, birds and other wildlife. Potential sources of water contamination include oilsands, mines, agricultural activities, and garbage dumps. Airborne pollution is also of concern people living in the area (Dagg *in prep.* a; AANDC and ENR 2012).

Kelly *et al.* (2009) found levels of polycyclic aromatic compounds (PAC) in the Athabasca river basin that were likely toxic to fish embryos. The PACs were deposited to the snowpack as airborne particulates, originating from oil sands mining and processing. Airborne emissions also deposited 13 elements considered priority pollutants. Concentrations of seven pollutants in Lake Athabasca (cadmium, copper, lead, mercury, nickel, silver and zinc) exceeded guidelines for the protection of aquatic life (Kelly *et al.* 2010). These findings suggest that upstream and upwind oil sands developments in Alberta may cause future impacts to Northern Leopard Frogs in the NWT. As stated in *Habitat Trends*, Environment Canada (2011b) is evaluating the health of wild amphibians and amphibian populations close to and at varying distances from oil sands operations.

Spills of fuel oil, various chemicals such as antifreeze and glycol-based products for vehicles, lube oil and other hydrocarbons have increased in recent years (Government of the Northwest Territories 2011). Although the spills to date are mostly linked to mining developments outside of the range of the Northern Leopard Frog in the NWT, any spills along the proposed winter road for the Taltson Basin Hydroelectric Expansion Project could affect some Northern Leopard Frogs in the future. Contaminants such as mercury, PCBs (an additive in various commercial products), DDT (a pesticide), PBDEs (a flame retardant), and organohalogens (used in solvents, medicines and plastics) are being monitored in predatory fish in the NWT, including some lakes near the range of the Northern Leopard Frog (Nonacho

and Stark lakes). Like predatory fish, Northern Leopard Frogs are bioaccumulators. Levels of these contaminants in fish are increasing, especially in smaller lakes, but the impact on frogs cannot be projected from these data, which are collected to assess human health risks from fish consumption (Government of the Northwest Territories 2011).

Northern Leopard Frogs are vulnerable to environmental contaminants such as pesticides, herbicides, fertilizers and heavy metals that pollute their aquatic habitats (Bishop 1992). The pesticide malathion kills the plankton that tadpoles feed on (Relyea and Diecks 2008). Several compounds such as atrazine, DDT, dieldrin, and acids cause immunosuppression in amphibians in low concentrations (Vatnick *et al.* 1999, Gilbertson *et al.* 2003; Albert *et al.* 2007; Brodkin *et al.* 2007). Atrazine can be acutely toxic to Northern Leopard Frogs (Howe *et al.* 1998) and it can disrupt sexual development (Hayes 2004; McDaniel *et al.* 2008). In wetlands with water and sediment containing elevated levels of metals and nutrients early stage tadpole survivorship was lower, deformity frequency was higher and time to metamorphosis was reduced (McDaniel *et al.* 2004). Heavy metals including zinc (Glooschenko *et al.* 1992), and cadmium and copper (Gross *et al.* 2007; Chen *et al.* 2007) can have negative effects on amphibian growth, development and survival. Chlorinated hydrocarbons, polycyclic aromatic hydrocarbons, nutrients and heavy metals such as aluminium, cadmium, chromium and copper at study sites in Ontario that exceeded provincial guidelines for the protection of aquatic life, caused reduced tadpole survivorship, higher tadpole deformity frequency and reduced time to metamorphosis (McDaniel et al. 2004).

Road salts affect tadpoles by reducing their activity and weight, and inducing physical abnormalities (Sanzo and Hecnar 2005), and large concentrations of salt are toxic to amphibians (Collins and Russell 2009). They prefer a neutral pH (Pope et al. 2000) and are sensitive to acidic conditions, particularly after emerging from overwintering (Vatnick et al. 1999; Alberta Sustainable Resource Development 2003).

The use and prevalence of environmental contaminants in the water and sediments in the range of the Northern Leopard Frog in the NWT are unknown.

Global climate change

Environmental changes due to climate change are a future threat to Northern Leopard Frogs in the NWT. The magnitude of the impact is believed to be minor in both negative and positive aspects at this time and observed effects are expected to increase in the coming decades.

Climatic conditions can have an effect on Northern Leopard Frog populations (Corn and Fogleman 1984; Wershler 1991; Koch *et al.* 1996; Smith and Keinath 2007). The potential impacts of climate change on the Northern Leopard Frog over the next decade are unknown or ambiguous at best (Ovaska 1997, McDonald and Sayre 2008).

Climate models predict increases in temperature and precipitation in Canada (IPCC 2007), with the most warming projected for northern Canada. Long-term trends have not been predicted for the South Slave region of the NWT but recent summers have been wetter than previously recorded which have led to very low forest fire seasons. The Mackenzie District (which includes all forested parts of the NWT) is experiencing warmer and more variable weather in all seasons (Government of the Northwest Territories 2011). Precipitation is likely to increase in winter and spring, but decrease in summer. Snow season length is predicted to decrease, but increased snowfall amounts will more than make up for the shorter snow season, resulting in increased snow accumulation (IPCC 2007). Data collected in the Mackenzie District indicated that winter snowfall may in fact be declining (Government of the Northwest Territories 2011).

Effects of climate change are already being observed locally. Residents of the area have noticed a number of warmer winters with less snow, and also colder winters with lots of snow (AANDC and ENR 2012). There is less rain, less snow, and the snow is melting faster (due to more wind and higher temperatures), and evaporating instead of entering the groundwater system (Dagg *in prep.* a). Drying and shrinking of ponds, lakes, creeks, rivers, fens and wetlands in the Slave River and Delta ecosystem has been noticed by residents of the area (Dagg *in prep.* a).

A decrease in summer precipitation might increase the frequency and duration of droughts, negatively affecting the persistence of smaller wetlands used for breeding and decreasing connectivity across the landscape (Seburn and Seburn 2000). Summer droughts and late spring freezing during the Northern Leopard Frog's breeding season could lead to catastrophic reproductive failures. Drought in southern Alberta in the 1970s and 1980s was linked to some population extirpations (Alberta Northern Leopard Frog Recovery Team 2010), but not to the widespread declines (Roberts 1981, 1987, 1992; Wershler 1991).

Thawing of permafrost will change patches of boreal forest habitat, especially in areas of discontinuous permafrost. Changes in permafrost underlying peat plateau are causing mortality of overlaying vegetation, and a change from forest to bog-fen habitat (Quinton *et al.* 2010; Quinton *et al.* 2011). Rates of permafrost reduction have been measured at 0.5% (area cover) per year (Chasmer *et al.* 2010). These changes in permafrost have been studied on a small scale in the Dehcho region but how these changes apply to the range of Northern Leopard Frogs in the NWT needs further investigation.

Climate change may also have positive influences on Northern Leopard Frogs as described in the section on *Positive influences*.

Ultraviolet radiation

UV-B radiation is a current threat to Northern Leopard Frogs in the Northwest Territories. A thinner ozone layer is allowing more biologically damaging ultraviolet radiation (UV-B) to reach the Earth's surface. The magnitude of the impact is believed to be low, but may be higher in combination with other environmental stressors. UV-B radiation is lower at higher latitudes.

Increasing UV-B radiation has been proposed as a potential cause of amphibian declines through effects on hatching success. This could be especially problematic in species like the Northern Leopard Frog, which lay eggs near the water surface. Long *et al.* (1995) studied the effects of UV-B and low pH on the hatching success of Northern Leopard Frog eggs. They found no increase in mortality with either factor alone, but found that both factors together significantly lowered hatching success. UV radiation and other environmental stressors (pH, contaminants, and disease) may interact synergistically to kill amphibians and induce sub-lethal effects (Blaustein *et al.* 2003; Bancroft *et al.* 2008). Sub-lethal effects of UV-B radiation include reduced anti-predator behaviour (Kats *et al.* 2000).

Non-native species

Non-native species pose very little threat to Northern Leopard Frogs in the Northwest Territories at the present time.

Northern Leopard Frogs prefer semi-open shorelines that are not clogged with vegetation. White and Yellow Sweetclover (*Melilotus alba* and *M. officinalis*) have invaded the NWT, rapidly colonizing gravelly well-drained soils such as roadsides, river banks and bars. Although most common along roadways in the NWT, they are beginning to invade the sandbars and islands of the Liard River (Larter pers. comm. 2012). The presence of Sweetclovers in the Northern Leopard Frog's range in the NWT is believed to be restricted to major roadways (Carrière pers. comm. 2012).

Collection and harvest

The collection and harvest of Northern Leopard Frogs in the Northwest Territories is suspected to occur at a low level and with a low impact. Nonetheless, this activity has the potential to impact local populations.

Amphibians are classified as wildlife under the NWT *Wildlife Act*. In the NWT, a Wildlife Research Permit is required for the study of Northern Leopard Frogs, but they can be harvested without a permit for any use such as bait, pets, or food. Frogs (species not specified) have reportedly been used as bait by fishing guides in the Northwest Territories (Côté pers. comm., cited in Rescan 2008). The release or escape of bait frogs might lead to misleading occurrence records, the establishment of new populations, or even to disease transfer.

Positive influences

Northern Leopard Frogs have been observed overwintering in the well oxygenated water in spillways below dams in Minnesota (Merrell 1970). The Nonacho Lake and South Valley spillways in the Taltson River basin have not been investigated for overwintering frogs, but these man-made habitats likely are beneficial.

Some Northern Leopard Frog habitats, representing a small portion of their known distribution in the NWT, are protected in the 44,807 km^2 Wood Buffalo National Park in Alberta and the NWT (Figure 4).

Positive impacts from global climate change in the north may include earlier breeding due advanced ice melt, and range expansion by amphibians that are presently excluded from beyond their northern limit by the brief ice-free period. Climate change is occurring, but the degree of positive impact on Northern Leopard Frogs in the NWT is unknown.

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Brian G. Slough obtained a M.Sc. in Biological Sciences from Simon Fraser University in 1976. His thesis on beaver (*Castor canadensis*) ecology led him to a 15-year career as furbearer management biologist with the Yukon Fish and Wildlife Branch. He has published work on several furbearer species including beaver, arctic fox (*Alopex lagopus*), American marten (*Martes americana*), and Canada lynx (*Lynx canadensis*), and has also written about trapline and furbearer management in northern and western Canada. He prepared COSEWIC status reports on wolverine (*Gulo gulo*) (2003), and American marten, Newfoundland population (*M. americana atrata*) (2007).

Since leaving the Yukon Government in 1996, Mr. Slough has conducted environmental assessments, protected areas research, and research on rare amphibians and mammals, including rodents, shrews and bats. He has conducted extensive amphibian surveys in the Yukon and northern British Columbia and has sampled the region for amphibian chytrid fungus. He is currently preparing a report on the status of the Western Toad (*Anaxyrus boreas*) in Canada for a COSEWIC reassessment in 2012. He is serving in his second term as a member of the Terrestrial Mammals Specialist Subcommittee of COSEWIC.

Status and ranks

Region	Coarse filter (Ranks) To prioritize	Fine filter (Status) To provide advice	Legal listings (Status) To protect under species at risk legislation
Global	G5TNR – Species secure, subspecies not yet assessed (NatureServe)	Least Concern (IUCN 2004)	
Canada	N4 – Species apparently secure nationally (NatureServe Canada 2011)	Special Concern (COSEWIC – 2009)	Special Concern (SARA 2005)
Northwest Territories	May be at Risk (NWT General Status Ranking Program 2011)	**To be determined**	**To be determined**
Adjacent Jurisdictions			
Alberta	S2S3 – Species imperiled to vulnerable (NatureServe Canada)	At Risk (Alberta Endangered Species Conservation Committee 2003)	Threatened (Alberta Wildlife Act regulations)
British Columbia	S1 - Species critically imperiled (NatureServe Canada)	Red list (BC Conservation Data Centre)	Endangered (SARA 2005 – Southern Mountain population)
Saskatchewan	S3 – Species vulnerable (NatureServe Canada)		
Manitoba	S4 – Species apparently secure (Natureserve Canada)		

Collections examined

No collections were examined for the preparation of this status report.

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