***Species at Risk Act***
Management Plan Series

# Management Plan for the Northern Leopard Frog (*Lithobates pipiens)*, Western Boreal/ Prairie Populations, in Canada

## Northern Leopard Frog, Western Boreal/ Prairie Populations

**2013**

Canada

**Recommended citation:**

Environment Canada. 2013. Management Plan for the Northern Leopard Frog (*Lithobates pipiens*), Western Boreal/Prairie Populations, in Canada. *Species at Risk Act* Management Plan Series. Environment Canada, Ottawa. iii + 28 pp.

For copies of the management plan, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry (www.sararegistry.gc.ca).

**Cover photo:** Kelly Boyle

Également disponible en français sous le titre
« Plan de gestion de la grenouille léopard (*Lithobates pipiens*), populations des Prairies et de l'ouest de la zone boréale, au Canada »


ISBN 978-1-100-20966-1
Catalogue no. En3-5/37-2013E-PDF

# PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed Special Concern species and are required to report on progress within five years.

The Minister of the Environment and the Minister responsible for the Parks Canada Agency are the competent ministers for the management of the Northern Leopard Frog, Western Boreal/Prairie Populations and have prepared this management plan as per section 65 of SARA. It has been prepared in cooperation with the Provinces of Manitoba, Saskatchewan, Alberta and the Northwest Territories, and Agriculture and Agri-Food Canada.

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Environment Canada and the Parks Canada Agency or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this plan for the benefit of the Northern Leopard Frog, Western Boreal/Prairie Populations, and Canadian society as a whole.

Implementation of this plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

# ACKNOWLEDGMENTS

This management plan was prepared by Andrew Didiuk in collaboration with: Debbie Nordstrom (contractor), David Prescott and Lisa Wilkinson (Alberta Sustainable Resource Development), Kris Kendell (Alberta Conservation Association), Cindy Paszkowski (University of Alberta), Jeanette Pepper and Sue McAdam (Saskatchewan Ministry of Environment), Ken DeSmet (Manitoba Conservation), Robert Gau (Northwest Territories Department of Environment and Natural Resources), Robert Sissons (Parks Canada), Bill Bristol (Agriculture and Agri-Food Canada), and Marie-Christine Bélair, Medea Curteanu, Paul Johanson and Mark Wayland (Environment Canada). The Northwest Territories Department of Environment and Natural Resources is acknowledged for providing shapefiles to create the species' distribution map. Additional comments and assistance in preparing the draft were generously provided by Diane Casimir (Parks Canada), Dean Nernberg (Deparment of National Defence), Danna Schock (Keyano College) and Matthew Weiss (Saskatchewan Ministry of Environment).

# EXECUTIVE SUMMARY

The Northern Leopard Frog, Western Boreal/Prairie Populations, is found across the Prairie Provinces and in the Northwest Territories of Canada. Although it was once widespread and abundant throughout the Prairie Provinces, many natural and anthropogenic factors are suspected to have led to dramatic declines in abundance and area of occupancy in the mid 1970s and 1980s. The species appears to have recovered considerably in Manitoba and continues to persist in traditional areas in Saskatchewan. Large areas of its historical range in Alberta and the Northwest Territories are unoccupied, and remaining local populations are isolated due to habitat fragmentation, such that there is limited potential for recolonization of their former range. Population size in the Northwest Territories is uncertain.

Northern Leopard Frogs are medium-sized frogs that utilize three types of seasonal habitat: shallow marshes for breeding, moist uplands for summer foraging, and permanent water bodies for wintering. Since there is a limited dispersal capability for this species, these habitats must be available within close proximity to each other and there must be some connectivity between habitats. The breeding period differs within provinces and the territory, and hatching success is highly variable due to a number of factors such as failure to develop, physical displacement, low temperature, parasitism and diseases.

Threats to Northern Leopard Frog Western Boreal/Prairie Populations include drainage and filling of water bodies, conversion of upland habitat, urbanization, livestock operations, alteration of water regimes, introduction or increase incidence of disease and parasites, the increased frequency in drought periods, environmental contaminants, fish stocking, mortality from road traffic, and commercial harvesting and collecting. These threats vary in extent and magnitude among jurisdictions where the species occurs.

The objective of this management plan is to maintain and, where feasible, increase the distribution of the Northern Leopard Frog, Western Boreal/Prairie Populations, by identifying and reducing or eliminating threats to the species and its habitat where possible. This will be accomplished through monitoring and assessment of local populations and habitat, habitat conservation, stewardship, information and outreach, research, and reintroduction of the species where possible and in habitats that would support it.

# TABLE OF CONTENTS

# 1. COSEWIC* SPECIES ASSESSMENT INFORMATION

**Date of Assessment:** April 2009

**Common Name (population):** Northern Leopard Frog, Western Boreal/Prairie Populations

**Scientific Name:** *Lithobates pipiens*

**COSEWIC Status:** Special Concern

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

**Canadian Occurrence:** Northwest Territories, Alberta, Saskatchewan, Manitoba

**COSEWIC Status History:** Designated Special Concern in April 1998. Status re-examined and confirmed in November 2002 and in April 2009.

*COSEWIC – Committee on the Status of Endangered Wildlife in Canada

# 2. SPECIES STATUS INFORMATION

The Northern Leopard Frog (*Lithobates pipiens*) is globally ranked as G5 and nationally ranked in Canada as N5, or "very secure or demonstrably secure under current conditions" (NatureServe, 2011). However, the species has not been ranked higher than S4 (apparently secure) in the provinces that make up the Western Boreal / Prairie Populations: Manitoba – apparently secure (S4), Saskatchewan – vulnerable to extirpation (S3), Alberta – imperilled (S2) and Northwest Territories – not ranked (SNR) (see Appendix A, Table 3).

The Canadian distribution of the species' Western Boreal / Prairie Populations represents approximately 15% of the Northern Leopard Frog's global range (IUCN and NatureServe, 2004; COSEWIC 2009). The Endangered Species Conservation Council (2011) has ranked the species as "Secure" in Manitoba, "At Risk" in both Alberta and Saskatchewan, and "May be at Risk" in the Northwest Territories. The Northern Leopard Frog, Western Boreal/Prairie Populations, was also listed as Special Concern under the federal *Species at Risk Act* in 2005. In Alberta, the species is listed as Threatened under Alberta's *Wildlife Act* (Alberta Sustainable Resource Development [ASRD], 2003), while it has not been listed in Manitoba, Saskatchewan or the Northwest Territories.

More eastern populations in Manitoba and adjacent Minnesota appear to have recovered from past population declines or at least appear to have persisted in a greater area, and populations in Idaho and Montana, adjacent to prairie Canada, are considered to be declining (see Appendix A, Table 4).

# 3. SPECIES INFORMATION

## 3.1 Species Description

The Northern Leopard Frog is a medium-sized (ca. 60 to 110 mm snout-vent length), semi-terrestrial frog characterized by long hind legs, which are extensively webbed and are adapted for jumping and swimming (Kendell, 2002b; Russell and Bauer, 2000). The body has very conspicuous, dark dorsal spots bordered with light coloured rings. The underside is white and there are two distinct, light coloured dorsolateral folds extending along the sides of the back. The dorsal background colour is predominantly green, but can be brown or a combination of both, and there is a rare yellow form. Males develop dark, swollen nuptial pads on the innermost fingers during the breeding season.

## 3.2 Populations and Distribution

### *Distribution*

The Northern Leopard Frog has a wide distribution in North America (Figure 1). In the United States, it ranges from Montana south into Arizona and New Mexico, northeast into Nebraska, east through West Virginia and north into Maine. There are isolated observations and areas of extirpation within the western States. In Canada, it occurs in all of the provinces and in the Northwest Territories (Figure 1). Previously, three designatable units have been defined for the Northern Leopard Frog in Canada (COSEWIC, 2000; Seburn and Seburn 1998; COSEWIC, 2009), with the local populations in western Manitoba, Saskatchewan, Alberta and the Northwest Territories included in the Prairie /Western Boreal designatable unit. Recent genetic investigations (Hoffman and Blouin, 2004a, 2004b; Fulton et al., 2007; Wilson et al., 2008) have demonstrated no significant differences in genetic composition in the Prairie and Western Boreal Populations that would justify any partitioning of this designatable unit. The current COSEWIC (2009) designation of Western Boreal / Prairie Populations is the new name for the local populations found in: Alberta, Saskatchewan, western Manitoba and the Northwest Territories.

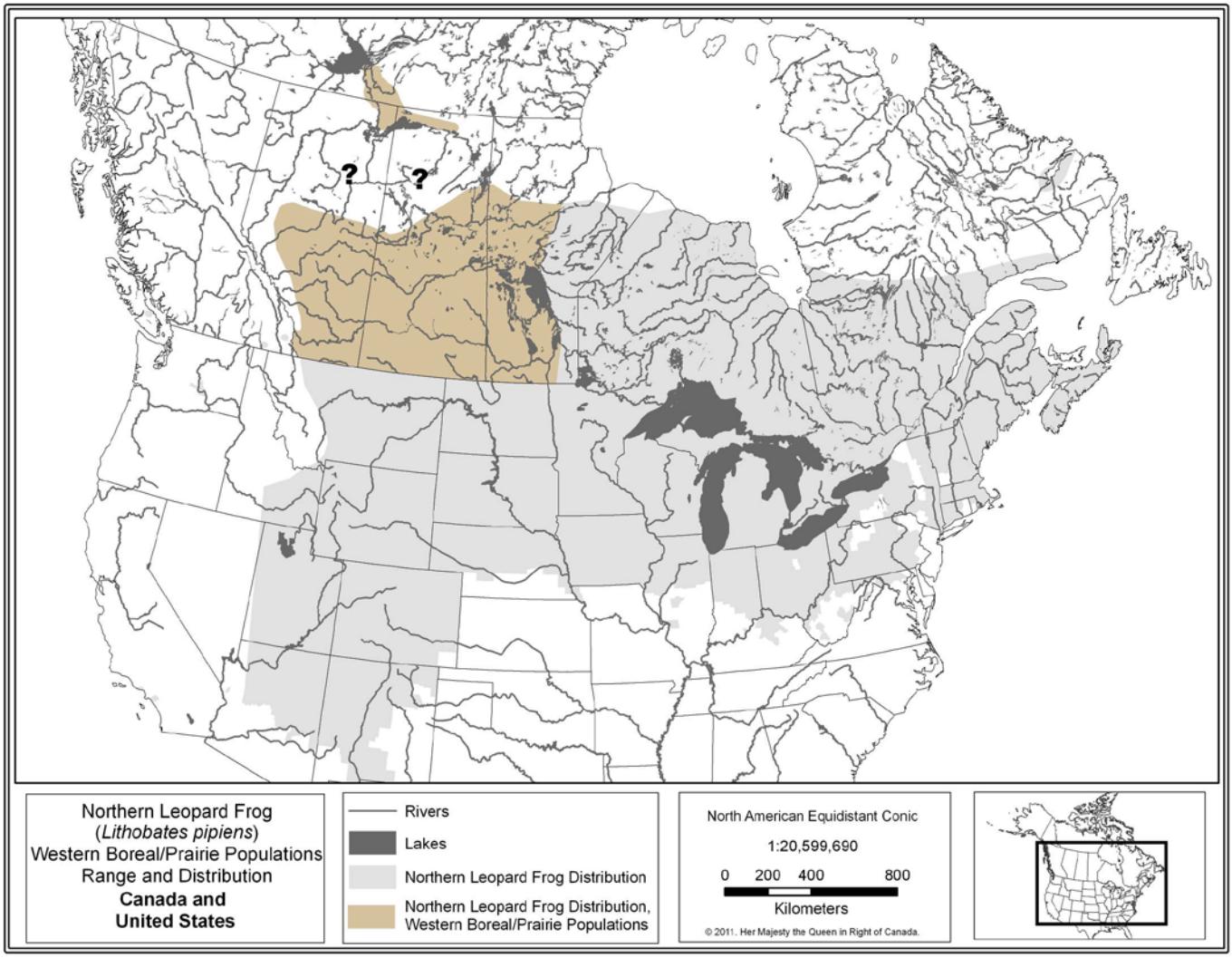


Figure 1. Global distribution of the Northern Leopard Frog, including the Prairie /Western Boreal. Question marks represent uncertainties.

### *Canadian Distribution*

The Northern Leopard Frog, Western Boreal/Prairie Populations, is found in Manitoba, Saskatchewan, Alberta, and the Northwest Territories. The extent of the Western Boreal / Prairie Populations covers approximately 35% of the species' total range in Canada (COSEWIC, 2009).

In Alberta, the Northern Leopard Frog historically occurred throughout the province south of 55ºN latitude and in the province's northeastern corner (Alberta Northern Leopard Frog Recovery Team [ANLFRT], 2005), west to the foothills and lower eastern slopes of the Rocky Mountains. However, many records in the more central and northern areas are questionable, and the species may not have occurred with any frequency in areas north of Edmonton except within the shield regions. In the 1970s, the Northern Leopard Frog was extirpated from most of central Alberta and the area of occupancy was greatly reduced in southern Alberta (Roberts, 1992; Seburn, 1992b; Wagner, 1997). It is now mainly associated

with major river drainages and areas of intact native habitat in the southeastern portion of the province (*see* ANLFRT, 2005 for a detailed map). Local populations appear to have been extirpated in the North Saskatchewan River and Sounding Creek watersheds of Alberta. There are also isolated local populations in the Lake Athabasca and Slave River drainages in northeastern Alberta (Kendell et al., 2007). Several reintroductions have been attempted in the past to reestablish the Northern Leopard Frog in select areas of the province. A self-sustaining local population has been established near Magrath, AB (Kendell and Prescott, 2007), and several other reintroduction sites are showing initial signs of success (D. Prescott, pers. comm., 2011).

In Saskatchewan, the species was found throughout the province except within the more northeastern regions (Secoy, 1987), although there is very little information to determine extent of occurrence and area of occupancy in the boreal forest regions. It has been reported in the vicinity of Lake Athabasca, SK (Secoy, 1987) in an area between Black and Bompas Lakes, east of Athabasca Lake (Heard, 1985). Most known local populations in Saskatchewan are associated with major river drainages, including the North Saskatchewan, South Saskatchewan, Qu'Appelle, Frenchman, and Souris Rivers. It is apparent that there were also die-offs in the early to mid-1970s (Seburn, 1992a; Didiuk, 1997).

In Manitoba, the Northern Leopard Frog, Western Boreal/Prairie Populations, was historically widespread both west and south of Lake Winnipeg (Preston, 1982), reaching as far north as Southern Indian Lake. It was particularly abundant in marshes along the southern shores of southern lakes such as Lake Winnipeg and Lake Manitoba (Eddy, 1976). The Manitoba range of the species contracted significantly following extensive die-offs in 1975 and 1976 (Koonz, 1992). Local populations appear to have increased considerably in the last thirty years. However, there is little information to confirm the degree of recovery in size of the local populations and their area of occupancy (W. Watkins, pers. comm., 2009).

The species was first reported from the Northwest Territories near Fort Smith in 1901 (Fournier, 1997). Traditional and local community knowledge identified previously occupied areas and that Northern Leopard Frogs were an important bait species used in fishing and other hunting activities. The range appears to include the regions of the Slave and Taltson Rivers and used to go as far north as the Slave River delta (Seburn and Seburn, 1998; Government of the NWT unpublished data).

### *Canadian Populations*

There is no information on the abundance of the Western Boreal / Prairie Populations of the Northern Leopard Frog in Canada. The most intensive assessments have occurred in Alberta, where standard amphibian search methods have been applied throughout the province during several surveys (e.g. Kendell, 2002b; Kendell et al., 2007). These surveys have included assessments of historical sites and new sites. The most recent province-wide survey conducted in 2005 indicated that local populations in Alberta were not detected at more than half of the sites where the species once occurred, and that numerous sites which had supported Northern Leopard Frogs within the previous 15 years were now devoid of them (Kendell et al., 2007). The species is no longer found in the Battle River, North Saskatchewan River and Sounding Creek basins of

Alberta, although it historically occupied these locations. The remaining local populations in the province are fragmented. Dramatic declines in extent of occurrence and number of local populations in Alberta have led to reintroduction projects at the Raven River near Caroline, in the Pine Lake region of central Alberta near Magrath, on the North Saskatchewan River near Rocky Mountain House and near Red Deer (ANLFRT, 2005; Kendell and Prescott, 2007), in Waterton Lakes National Park (Boutin and Smith, 2008; Smith and Hewitt, 2007), and several provincial parks in the southern part of the province. Following the release near Magrath, AB in 2002, young of year Northern Leopard Frogs were observed in July 2005 and 2006. A self-sustaining population has been established at this location where eggs are now being used as a source for other reintroductions. There are indications of successful reproduction of Northern Leopard Frogs at several other reintroduction sites, and a full assessment of the success and feasibility of the reintroduction program will continue for the next several years (D. Prescott, pers. comm., 2011)

Monitoring of the species is limited in Saskatchewan. There is no information available to determine the degree to which the die-off of the mid-1970s affected the size of local populations and the extent recovery since that time (Didiuk, 1997; Seburn, 1992a; Weller, et al. 1994).

The Northern Leopard Frog, Western Boreal/Prairie Populations, is not monitored in Manitoba. Historically, this species was harvested commercially which provided an indication of local population size. However, local population size estimates must be interpreted with caution because market demand and harvest activity confound interpretation of statistics. Nevertheless, the harvest data provided a means of documenting the species' declines of the mid-1970s when supply and demand remained constant and harvest was greatly reduced. Following an apparent recovery in the 1980s, local populations have increased in areas that were formerly decimated and harvest levels have increased reflecting recovery to some degree (COSEWIC, 2009).

Historical observations were reexamined, and observations and monitoring of the Northern Leopard Frog was reinitiated in the Northwest Territories following the listing of the species on Schedule 1 of the federal SARA in 2005 (Schock, 2009). After 1994, the next confirmed observation was in 2007 (Rob Gau pers. comm., 2011). There are ongoing monitoring efforts for Northern Leopard Frogs through environmental monitoring due to hydroelectric projects within the range of Northern Leopard Frogs in the Northwest Territories. There are also active government studies collecting information about the location and numbers of all amphibians in the Northwest Territories as well as providing information on the potential presence of disease and infections (Rob Gau pers. comm., 2011). However, local population abundance and trends are not yet available for this region.

## 3.3 Needs of the Northern Leopard Frog

### 3.3.1 Habitat and biological needs

The Northern Leopard Frog is a semi-aquatic species, utilizing both aquatic and terrestrial environments. Three habitat types are required by the species for breeding, foraging and overwintering (ANLFRT, 2005). Since there is a limited dispersal capability for this species,

these habitats must be available within close proximity to each other (Pope et al., 2000) and there must be some connectivity between habitats.

During the winter, Northern Leopard Frogs hibernate in water bodies which do not completely freeze solid, are cold (ca. <4 °C) and are well oxygenated (7-10 ppm) (Hine et al., 1981; Nace et al., 1996). These water bodies are typically associated with deeper, permanent water bodies including ponds and lakes, rivers and streams, and springs. Different water bodies are usually used for breeding and overwintering activities (Souder, 2000).

From winter sites, adult frogs travel up to 1.6 km to breed from April to June (Eddy, 1976; Hine et al., 1981; Kendall 2002a; Souder, 2000) in the shallow, warm waters of a variety of wetlands including marshes, springs, flooded ditches, dugouts, borrow pits, beaver ponds, margins of lakes, and slow-moving waters of streams and rivers (Cook, 1984; Hine et al., 1981; Merrell, 1977; Seburn and Seburn, 1998). Optimal wetlands have some degree of permanence, are generally non-acidic (pH of 6.5-8.5; Nace et al., 1996) and contain no predatory fish (Merrell and Rodell, 1968). Emergent vegetation is important for protective cover and is used as a substrate to attach egg masses (Hine et al., 1981; Merrill, 1977). Water temperature may be important in affecting hatching success and developments of tadpoles (Wershler, 1991).

After breeding, adults and sub-adults may disperse up to 8 km from breeding ponds (Dole, 1971; Seburn et al., 1997) to forage in the summer in riparian or upland habitats. These areas are moist habitats including meadows, pastures, scrublands, riparian corridors, and drainage or irrigation ditches (Hine et al., 1981; Merrell, 1977; Wershler, 1991). Northern Leopard Frogs usually do not utilize areas that are heavily wooded (Merrell, 1977) but in some regions they may utilize forest cover (e.g. Seburn, 1994). The species also avoids area of very sparse vegetation such as heavily grazed pastures or cultivated fields (Dole, 1971; Hine et al., 1981; Merrell, 1977). The return to overwintering sites begins in late summer or early fall (COSEWIC, 2009).

### 3.3.2 Limiting factors

The Northern Leopard Frog requires three distinct habitat types for its seasonal activities: shallow marshes for reproduction, moist uplands for summer foraging and dispersal and permanent water bodies for overwintering. All three of these habitat types must co-exist and be in close proximity to allow use and seasonal access.

Prolonged periods of drought may occur in portions of the Northern Leopoard Frog’s range, and can result in greatly reduced recruitment and possibly, local extirpations. This would exacerbate current vulnerability of this species to habitat fragmentation and isolation arising from past declines and reduction in distribution.

The Northern Leopard Frog completes its reproductive phase in wetlands where, like other amphibians, it is particularly vulnerable to pathogens which may be present, or be introduced by natural means (e.g. other wildlife or current) or human activity (e.g. fish stocking, aquatic recreation, etc).

# 4. THREATS

## 4.1 Threat Assessment

Table 1: Threat assessment table

| Threat | Level of Concern[1] | Extent | Occurrence | Frequency | Severity[2] | Causal Certainty[3] |
|---|---|---|---|---|---|---|
| **Habitat Loss or Degradation** | | | | | | |
| Drainage and filling of water bodies | High | Widespread | Current | Continuous | High | High |
| Conversion of upland habitat | High | Widespread | Current | Continuous | High | High |
| Urbanization/ Industrialization | Medium | Local | Current | Continuous | Medium | Medium |
| Livestock operations | Medium | Local | Current | Frequent | Medium | Medium |
| Alteration of water regimes | Medium | Local | Current | Frequent | Medium | Medium |
| **Changes in Ecological Dynamics and Natural Processes** | | | | | | |
| Introduction or increased incidence of disease and parasites | Medium | Widespread | Current | Unknown | Medium/High | High |
| **Climate and Natural Disasters** | | | | | | |
| Increased frequency of drought periods | Medium | Widespread | Current/Anticipated | Recurrent | Medium/High | Medium/Low |
| **Pollution** | | | | | | |
| Environmental Contaminants | Medium | Widespread | Current/Anticipated | Seasonal | Medium | Medium |
| **Exotic, Invasive or Introduced Species** | | | | | | |
| Fish stocking | Low | Local | Current | Seasonal | Low/Medium | Medium |
| **Accidental Mortality** | | | | | | |
| Mortality from road traffic | Low | Local | Current | Recurrent | Low | Low |
| **Biological Resource Use** | | | | | | |
| Commercial Harvesting and Collecting | Low | Local | Current | Recurrent | Low | Low |

[1] *Level of Concern: signifies that managing the threat is of (high, medium or low) concern for the management of the species, consistent with the management objectives. This criterion considers the assessment of all the information in the table.*

[2] *Severity: reflects the population-level effect (High: very large population-level effect, Medium, Low, Unknown).*

[3] *Causal certainty: reflects the degree of evidence that is known for the threat (High: available evidence strongly links the threat to stresses on population viability; Medium: there is a correlation between the threat and population viability e.g. expert opinion; Low: the threat is assumed or plausible).*

## 4.2 Description of Threats

Threats are listed in order of decreasing level of concern.

### *Drainage and Filling of Water Bodies*

Among other causes of decline, it is suspected that Northern Leopard Frog populations may have disappeared or been reduced from many regions of North America due to habitat loss, degradation, and fragmentation (Koch et al., 1996; Lannoo et al., 1994). Because this species requires the presence of three distinct habitat types in close proximity to one another for breeding, summer foraging, and wintering, Northern Leopard Frogs are particularly vulnerable to habitat loss and degradation (Pope et al., 2000). In southern Alberta, drainage of wetlands for agricultural use has been extensive. An estimated 60% of wetland basins and 80% of wetland margins, in the prairies and parkland regions of Alberta were impacted by agricultural activities in the 1980s (Turner et al., 1987). A similar situation has been observed in Manitoba where as little as 30 percent of the original wetlands remain in many regions as a result of drainage and in-filling for agriculture (Manitoba Eco-Network, 2009). Manitoba has lost 4305 acres of wetland habitat within the last year (CPAWS, 2011). In Saskatchewan, there is continual wetland drainage, and pipeline and highway construction which reduce suitable habitat for Northern Leopard Frogs (J. Pepper, pers. comm., in COSEWIC 2009). The filling and drainage of water bodies is not as common in the Northwest Territories as in the Prairies. (D. Schock, pers. comm., 2011).

### *Conversion of Upland Habitat*

Various human land-use activities (e.g. cultivation, highways) fragment Northern Leopard Frog habitat and result in fewer and smaller areas of suitable habitat separated by increasingly large areas of unsuitable habitat. Modification of upland habitat to benefit other wildlife may also be detrimental to Northern Leopard Frogs depending upon the nature of modification. Since the species migrates among a variety of habitats during their seasonal activities (Pope et al., 2000), conversion of upland habitat can act as a barrier to migration resulting in local population extinctions. Dispersal of individuals among local populations is interrupted (Pope et al., 2000), which compromises the species' persistence in fragmented locations. The growth of many amphibians after metamorphosis is lower in degraded habitats (Adama and Beaucher, 2006; Gray and Smith, 2005), which can affect subsequent survival and reproductive performance. Populations can be subject to local extirpations from environmental or natural factors, but can be re-colonized through dispersal of individuals among local populations (Hanski and Gilpin, 1991; Hanski, 1998). Increasing habitat loss and fragmentation as a result of conversion of upland habitat increases the isolation among local populations, which may reduce or prevent individuals from dispersing and re-colonizing habitats. Extensive tracts of unsuitable habitat (e.g. cropland) currently separate many existing local populations. In the long term, this may also result in extirpations of local populations due to reduced dispersal and gene flow.

### *Urbanization/Industrialization*

Habitat loss and alterations as a result of urbanization or industrial development reduce availability and suitability of summer foraging, breeding and overwintering habitats for Northern Leopard Frog Western Boreal/Prairie Populations.

In southern portions of the Prairies, the expansion of urban centers due to the agglomeration of the human population has resulted in the loss and degradation of adjacent lands. For instance, Okotoks and Strathmore in southern Alberta have had a population growth rate of approximately 40% between 1996 and 2001 (Canadian Prairie Partners in Flight, 2004). Johnson et al. (2011) have found that occupancy of wetlands by Northern Leopard Frogs in Colorado was negatively associated with urbanization. Similarly, frog species richness in aquatic habitats located in areas of high human population densities was found to be lower than in less disturbed areas with higher vegetation cover (Hamer and Parris, 2011). Wetlands in urbanized areas are more isolated and have less vegetation cover (Smallbone et al., 2011), thus reducing the habitat suitability and connectivity between the species' required habitats and local populations.

Resource exploration and extraction may also affect aquifers through degradation of the species'habitat such as the removal of surface and ground water (ANLFRT, 2005) which may accelerate the drying of breeding habitats and lower water levels in wintering habitats to the point where winterkill is more likely to occur, especially when exacerbated by drought conditions.

### *Livestock Operations*

Excessive numbers of grazing cattle and other livestock can damage Northern Leopard Frog breeding, foraging and overwintering habitats on the prairies (e.g. Wershler, 1991). Of particular concern is the concentration of grazing in riparian areas where livestock may trample and reduce moist upland vegetation cover, reduce shoreline emergent vegetation cover, disturb egg masses and affect water quality from stream bank erosion resulting in increased nutrients into the water bodies. Habitat in the form of dugouts, stock ponds, natural permanent wetland basins and river and streams can also be affected by excessive stocking rates. Shmutzer et al. (2008) found that water quality, amphibian diversity and tadpole abundance were lower in wetlands used by cattle compared to wetlands not accessed by cattle. Conversely, appropriate levels of livestock grazing can improve riparian habitat by reducing density of vegetation that may impact dispersal and foraging abilities of the Northern Leopard Frog (e.g. Waye and Cooper, 2001).

### *Alteration of Water Regimes*

Water projects that either alter or stabilize water levels to enhance industrial, agricultural, residential or recreational features of the landscape, or that alter habitat to accommodate the needs of other species (e.g. fish and waterfowl management) can negatively affect the Northern Leopard Frog (e.g. Wershler, 1991).

Increasing water levels (flooding) during the breeding season can create strong currents which are not conducive to successful breeding or egg-laying, or dislodge egg masses attached to emergent shoreline vegetation. Lowering of water levels can reduce the time period of surface water retention which can result in mortality of tadpoles. Altering water regimes can also result in negative changes in water temperature and oxygen levels. Water extraction for oil and gas production, for crop irrigation, and other land-use activities, may affect aquifers and reduce water levels, leading to unsuitable water levels in breeding ponds or freezing of water in overwintering ponds used by Northern Leopard Frogs.

Creation of new water bodies through damming of streams (e.g. for cattle watering or flood protection) can produce new overwintering and breeding habitat and can provide new habitats in some regions (e.g. some irrigation canals and associated reservoirs). However, subsequent water regime management may eliminate use for overwintering and breeding (e.g. winter draw-down for flood protection) and land use activities adjacent to water projects may not be conducive to summer foraging by Northern Leopard Frogs (e.g. maintenance of extremely low vegetation cover). Appropriate stewardship of aquatic and terrestrial habitats associated with water projects can produce and maintain seasonal habitat for Northern Leopard Frogs.

### *Introduction or Increased Incidence of Disease and Parasites*

Many factors are suspected to have contributed to the die-offs of Northern Leopard Frogs in prairie Canada in the mid-1970s, and disease(s) is thought to be one of them (ANLFRT 2005). Disease outbreaks have historically occurred in amphibian populations and it can be expected that they will continue to occur locally, and may over time, occur at a broader scale.

Die-offs of Northern Leopard Frogs have occurred due to *Ranavirus* in southern Ontario (Greer et al., 2005) and in southeastern Saskatchewan (Schock and Bollinger, 2005). *Ranavirus* has been found in Northern Leopard Frogs at a few sites in Alberta but it is considered to be uncommon (D. Prescott, pers. comm., 2009). The presence of *Ranavirus* in other amphibians has been confirmed in the Northwest Territories (Schock 2009; Schock et al. 2009) which suggests that this pathogen could also affect Northern Leopard Frogs. Chytrid Fungus is commonly found in all species of amphibians, including Northern Leopard Frogs, through most areas of Alberta. However, no evidence of Northern Leopard Frog mortality caused by Chytrid Fungus has been observed (D. Prescott, pers. comm. 2011). Chytrid Fungus has also been found in Northern Leopard Frogs collected from Manitoba for research purposes. Monitoring of the Chytrid Fungus and its incidence in the Northwest Territories is currently being assessed (R. Gau, pers. comm. 2011). Red leg syndrome has been suggested as a potential cause of the Northern Leopard Frogs die-offs that occurred during the late 1970s in Alberta (Roberts, 1992) and Manitoba (Koonz, 1992). Red leg syndrome also known as red leg disease or bacterial dermatosepticemia is a bacterial infection of amphibians' bloodstream associated with skin redness and can be caused by a number of bacteria. Reports of red leg disease predating the mid-1990s should be viewed with caution as this disease was overdiagnosed and often misdiagnosed prior to this date. For example, red leg disease was often systematically attributed to the bacteria *Aeromonas hydrophila* but may be caused by other bacteria (Densmore and Green 2007). Therefore, red leg disease reports of Roberts (1992) in Alberta and Koonz (1992) in Manitoba are uncertain. Common water mould disease, caused by the fungi *Saprolegnia ferax* and *S. parasitica,* is not

known to occur in Alberta, but *S. ferax* is a common fish pathogen and the introduction of fish may result in its establishment if it is not already present (Kiesecher et al. 2001; Alberta Sustainable Resource Development, 2003). *Saprolegnia* can infect egg masses and tadpoles of amphibians, and reduce productivity (Densmore and Green 2007). Although, *Saprolegnia* is widespread in aquatic environments (Densmore and Green 2007), much research is needed on this fungi (R. Gau, pers. comm., 2011). Infection by the Trematode Cyst *Ribeiroia ondatrae* is suspected in Alberta's Northern Leopard Frogs (K. Kendell, pers. comm., in COSEWIC 2009).

Transmission of bacterial, fungal and viral diseases among local populations of Northern Leopard Frog can arise from the use of bait fish, transport of vessels among water bodies, and introduction of fish populations to new water bodies.

Increasing ultraviolet (UV) radiation from a thinning ozone layer has also been associated with declines of amphibians, partly due to a reduction of resistance to diseases and pathogens (Blaustein et al., 1994). Northern Leopard Frogs lay eggs near the water surface which may increase their susceptibility to UV radiation as UV radiation is greatly attenuated with water depth.

### *Increased Frequency of Drought Periods*

Drought can affect Northern Leopard Frogs (Corn and Fogleman, 1984; Koch et al., 1996; Merrell, 1977) when suitable habitats are lost which may result in extirpation of local populations. Drying of breeding habitat, and reduced depth of water bodies used for overwintering leading to freezing or low oxygen levels, can reduce or eliminate local populations during successive years of drought. Drought conditions were believed to be associated with a decline in amphibians in southern Alberta in the 1930s (Fowler, 1935). Thus, climate has likely contributed to declines in the size of the Northern Leopard Frog, Western Boreal/Prairie Populations, but it is unlikely to be the only factor. Increased irrigation due to drought in some areas of the prairies may result in a low water table (Seburn, 1992a).

The impacts of predicted future climate conditions upon Northern Leopard Frogs and other amphibians have not been adequately assessed to understand how changes (increases and decreases) of seasonal average temperatures and average precipitation will affect different life history stages.

### *Environmental Contaminants*

Amphibians, including the Northern Leopard Frog, are sensitive to environmental contaminants (e.g. Bishop, 1992) resulting from anthropogenic activities such agricultural and industrial operations. The presence of gills in early life stages and skin permeability of amphibians makes them particularly sensitive to environmental contaminants (Henry 2000) which can impact their survival, metamorphosis and behaviour (Leconfort et al. 1998).

Surface water run-off from agricultural lands can increase the extent and concentration of algal blooms and reduce water oxygen concentration, which in turn can decrease survival and growth of Northern Leopard Frog tadpoles (Kiesecker, 2002; Ouellet et al., 1997). Nitrate concentrations

in surface water run-off, arising from fertilizers applied to crops in southern Ontario, were reported to be high enough to cause deformities and mortality in amphibians (Hecnar 1995; Rouse et al. 1999). Wastes from livestock affect water quality by increasing nutrient levels and lowering oxygen levels (ASRD, 2003). Pesticides introduced to breeding wetlands may reduce invertebrates and algae used for food, may decrease hatching success and tadpole growth rates, and cause mortality in tadpoles. Hatching success of amphibian eggs was negatively related to concentrations of several pesticides, particularly atrazine, endosulfan and chlorpyrifos, in wetlands located in orchards sprayed with pesticides and in nearby reference site wetlands in British Columbia (Bishop et al., 2010). However, the relevance of these results to the Northern Leopard Frog, Western Boreal/Prairie Populations is uncertain because the types of pesticides found in wetlands in the range of these populations differ from those reported in the above study. Moreover, concentrations of most pesticides reported in prairie wetlands that may serve as habitat for Northern Leopard Frogs are comparatively low and often below detection limits (Donald et al., 1999; 2001, Messing et al., in press). Nevertheless, even at low concentrations, certain pesticides and other environmental pollutants may disrupt the immune system (Albert et al., 2007; Brodkin et al., 2007; Vatnick et al., 1999) and endocrine system (McDaniel et al., 2008) of larval and adult Northern Leopard Frogs. Exposure to estrogenic compounds such as synthetic estrogen, ethinylestradiol, and other estrogenic compounds may delay development of Northern Leopard Frog tadpoles and affect gender (Hogan et al., 2008).

Industrial operations also have the potential to negatively impact Northern Leopard Frogs. Disappearances of Northern Leopard Frog local populations over the past 30 years in western, central, and northern New York State were associated with elevated levels of acid deposition (Gibbs et al., 2005). Acidification of aquatic habitats can decrease fertilization in amphibians by reducing sperm motility, and can increase mortality in amphibian embryos (Pierce 1987). Acidification can increase UV-B levels in water, and very low increases in UV-B radiation can delay and even prevent metamorphosis in the Northern Leopard Frog and other species of amphibians (Trudeau et al., 2010). Concern has been raised that the projected increase in heavy oil development in northeastern Alberta may cause lake acidification and thus pose a risk to Northern Leopard Frogs in the region (Gosselin et al., 2010), though there is no evidence that lakes are acidifying at present (Regional Aquatics Monitoring Program [RAMP], 2012). Naphthenic acids, which are contaminants associated with oil sands process waters, were harmful to Northern Leopard Frogs in toxicity tests (Melvin and Trudeau, 2012) although it has proven difficult to accurately quantify the concentrations of naphthenic acids in aquatic ecosystems in the oil sands area (RAMP, 2012), making it difficult to assess the risk that these compounds pose to Northern Leopard Frogs in the region.

The energy sector of oil and gas extraction, which is growing rapidly in Alberta and Saskatchewan (COSEWIC 2010), has the potential of releasing polycyclic aromatic hydrocarbons (PAHs) into the environment. PAHs have been shown to increase egg mortality (Marquis et al. 2006), disrupt gas exchanges within pulmonary tissues (Stabeneau et al. 2006) and interfere with the muscular system translating into a reduced mobility in frogs (Stabeneau et al. 2008). However, it should be noted that some of these studies have been conducted in a laboratory setting and may have exposed amphibians to higher concentrations of contaminants than what would normally be found in the environment.

Anurans[1] exposed to contaminants may also be more susceptible to pathogens (Kiesecker 2002; Taylor et al., 1999). Immunosuppression which may occur in Northern Leopard Frog tadpoles exposed to certain pesticides (Gilbertson et al., 2003), may cause them to be more susceptible to infection by parasites such as trematode worms (Rohr et al., 2008) and the Lungworm *Rhabdias ranae* (Gendron et al., 2003).

### *Fish Stocking*

The Northern Leopard Frog normally breeds in water bodies without fish (Merrell, 1968) and the species likely has not evolved any natural defense against predation by introduced fish (Smith and Keinath, 2007). The Northern Leopard Frog can co-exist in habitats with predatory fish although there is likely considerable local population depression.

The practice of introducing game fish to water bodies is a threat to the Northern Leopard Frog and other amphibians in prairie Canada (ANLFRT, 2005; Emery et al., 1972; Pearson, 2004; Saskatchewan Conservation Centre, 2006). Introduced fish can cause local extirpation by predating on all life stages of the Northern Leopard Frog during both the breeding and overwintering periods (Emery et al., 1972), and may also indirectly impact Northern Leopard Frog local populations through introduction of pathogens into the aquatic environment (Blaustein et al., 1994; Keisecker et al. 2001). For example, introduced Common Carp (*Cyprinus carpio*) can negatively affect Northern Leopard Frogs by destroying emergent and submersed vegetation and increasing turbidity and by reducing or eliminating algae and invertebrate populations necessary for survival and successful reproduction (Leonard and McAllister, 1996; McAllister et al.1999).

### *Mortality from Road Traffic*

In local situations where roads with significant traffic are in close proximity to breeding, summer foraging and wintering habitat, Northern Leopard Frogs can experience considerable mortality from vehicle traffic (Merrell, 1977). This mortality can contribute or lead to local population declines (Carr and Fahrig, 2001; Eigenbrod et al., 2008; Mazerolle et al., 2005). Mortality from vehicle traffic is not considered to be a serious threat for the species in Alberta (ANLFRT, 2005). Mortalities of Northern Leopard Frogs from vehicle traffic are frequently reported near Estevan, Saskatchewan (A. Didiuk, upubl. data) but this threat is likely uncommon throughout the remainder of the range.

### *Commercial Harvesting and Collecting*

Commercial harvest of the Northern Leopard Frog in Alberta for research and teaching materials has occurred in the past. However, this has been restricted for many years in that province (ASRD 2003). Some individuals have been harvested for use as bait and there is some recreational collection by children and others in Alberta. Given the low numbers of the Northern Leopard Frog in Alberta, even these small removals from local populations may have some effect (ANLFRT, 2005).

[1] Amphibians from the order Anura, comprising the frogs, toads, and tree frogs, all of which lack a tail in the adult stage and have long hind limbs often suited to leaping and swimming.

There is no history of commercial collection of the Northern Leopard Frog in Saskatchewan (Seburn, 1992a) and the Northwest Territories, and its use for bait has been banned in Saskatchewan. Recreational collection likely occurs at very low levels in this province and the Northwest Territories.

There have been commercial harvests of the Northern Leopard Frog in Manitoba since at least the 1920s (COSEWIC, 2009). In the early 1970s, prior to the die-offs, annual harvest approached 50,000 kg annually, which may have represented over one million individuals (Koonz, 1992). Following die-offs in the mid-1970s the harvest declined to approximately 6,000 kg despite a continued market demand, reflecting the drastic declines of the Northern Leopard Frog. By the mid 1990s, the harvest increased but has not reached previous levels (J. Duncan, pers. comm., in COSEWIC 2009). Commercial and recreational harvest continues to be permitted but no new commercial permits are being issued.

# 5. MANAGEMENT OBJECTIVE

At this time, it is not possible to develop a quantitative management objective for the Northern Leopard Frog, Western Boreal/Prairie Populations because 1) its abundance is currently not available, and 2) its trends are poorly documented or missing for large portions of its distribution (see section 3.2).

The objective of this management plan is to maintain and, where feasible, increase the distribution of the Northern Leopard Frog, Western Boreal/Prairie Populations, by identifying and reducing or eliminating threats to the species and its habitat where possible.

# 6. BROAD STRATEGIES AND CONSERVATION MEASURES

## 6.1 Actions Already Completed or Underway

### *Protection and Management*

The Northern Leopard Frog is considered to be a species of interest for conservation programs throughout its range. However, most of this activity occurs as components of broader grassland and wetland conservation initiatives, including; fencing and off-site watering (Hofman 1992; K. Kendell, pers. comm., 2009), beneficial management practices for amphibians (Quinlan et al., 2004), guidelines to avoid disturbance and impact of industrial development, reintroduction (Kendell, 2001; 2004; Kendell and Prescott, 2007; Romanchuk, 2003; Wendlandt and Takats, 1999), understanding land ownership and formation of a provincial recovery team in Alberta and preparation and implementation for the Alberta Northern Leopard Frog Recovery Plan (ANLFRT, 2005).

### *Research*

Several Alberta research projects have focused on the biology and conservation of Northern Leopard Frogs (Butterworth, 1999; Dalgleish, 2001; Fraser, 2008; Kendell, 2000a; Kendell, 2000b; Seburn et al., 1997; Stevens et al., 2010; Wendlandt and Taktats, 1999; Wilson et al., 2008; Wilson et al. 2009). In Saskatchewan, research projects have focused upon the Northern Leopard Frog's wintering ecology, disease and dispersal (Schock and Bollinger 2005; T.K. Bollinger, pers. comm. 2009; G. McMaster and C. White, pers. comm. 2009).

### *Monitoring and Assessment*

The national FrogWatch program has been implemented and is being promoted (M. Doyle, pers. comm. 2009). The Northwest Territories also have a reporting program encouraging the public and monitoring agencies to report their amphibian and reptile observations. Various other activities have been implemented to monitor the occurrence, abundance and distribution of the Northern Leopard Frog, Western Boreal/Prairie Populations (Kendell, 2002a; 2002b; Kendel et. al. 2007; Parks Canada, 2008; G. McMaster, pers. comm., 2009; R. Gau pers. comm., 2011; W. Watkins, pers. comm., 2009; C. White, pers. comm. 2009) as well; amphibian population and pathogen surveys have been conducted (Schock 2009; Schock et al. 2009).

### *Outreach and Communication*

The Northern Leopard Frog has received attention in many conservation publications of government and non-government organizations. The Alberta Volunteer Amphibian Monitoring Program (AVAMP) focuses upon increasing public awareness of amphibians and collecting information on their occurrence. The RANA project coordinated by Alberta Sustainable Resource Development includes a public education component on the conservation of amphibians. Waterton Lakes National Park has delivered numerous amphibian programs for public and school groups, as well as frequent media products (print, TV, radio).

## 6.2 Broad Strategies and Conservation Measures

The current distribution of the Western Boreal/Prairie Population of the Northern Leopard Frog appears to consist of a small number of localized breeding locations in southern Alberta, isolated local populations in northern Alberta, a more dispersed local population associated with major drainages in southern Saskatchewan, a wide distribution in southern Manitoba, and a very small and restricted local population in the southern Northwest Territories. Local populations in the forest fringe and boreal forest regions are poorly understood and targeting of stewardship will evolve as more information becomes available. Targeting of conservation measures will consequently vary in extent and focus among these areas and distribution information from territorial/provincial-wide surveys will be an important guide for this targeting. Jurisdictions and stakeholders involved in the management of the Northern Leopard Frog in western Manitoba, Saskatchewan, Alberta and the Northwest Territories will refine conservation measures where appropriate to address regional differences and opportunities depending on the budgetary restraints and priorities of local jurisdictions. Progress towards the objective for this management

plan will be achieved over the next five years through the following broad strategies and conservation measures:

1. Monitoring and Assessment of Local Populations and Habitat: Conduct targeted surveys to determine area of occupancy and to serve as a basis for monitoring of local populations, habitat trends and pathogens.
2. Habitat Conservation: Identify and conserve key habitats.
3. Stewardship: Develop and deliver stewardship activities that reverse causes of degradation of habitat, or maintain habitat to meet seasonal requirements.
4. Information and Outreach: Inform the public, with a particular focus upon landowners and stakeholders, about Northern Leopard Frogs and the need to maintain their seasonal habitats, and encourage involvement in stewardship activities.
5. Research: Address key knowledge gaps to improve the conservation and management of Northern Leopard Frogs.
6. Reintroduction: Implement reintroduction programs if deemed both necessary and feasible following appropriate research and monitoring programs.

Table 2: Conservation measures and implementation schedule

| Conservation Measure* | Priority | Threat addressed | Timeline |
|---|---|---|---|
| **Broad Strategy: Monitoring and Assessment of Local Populations and Habitat** | | | |
| 1. Conduct surveys to monitor local population trends and abundance, and habitat | High | Information gap that must be addressed in order to measure progress in meeting Management Objective | 2013-2018 |
| 2. Develop and deliver program to monitor pathogens | Medium | Introduction or increased incidence of disease and parasites | 2013-2018 |
| **Broad Strategy: Habitat Conservation** | | | |
| 3. Identify key habitats and for these areas, determine ownership, status and threats | High | Drainage and filling of water bodies, Conversion of upland habitat, Urbanization/Industrialization, Livestock operations, Alteration of water regimes, Environmental Contaminants, Fish stocking, Mortality from road traffic | 2013-2018 |
| 4. Implement best management practices in key habitats | High | Drainage and filling of water bodies, Conversion of upland habitat, Urbanization/Industrialization, Livestock operations, Alteration of water regimes, Environmental Contaminants, Fish stocking, Mortality from road traffic | 2013-2018 |
| **Broad Strategy: Stewardship** | | | |
| 5. Implement key habitat-based stewardship programs with landowners / lessees and land managers | High | Drainage and filling of water bodies, Conversion of upland habitat, Urbanization/Industrialization, Livestock operations, Alteration of water regimes, Environmental Contaminants, Fish stocking, Mortality from road traffic | 2013-2018 |

| | | | |
|---|---|---|---|
| 6. Collaborate with provincial fisheries departments to assess and reduce fish stocking threat | Low | Fish stocking | 2013-2018 |
| **Broad Strategy: Information and Outreach** | | | |
| 7. Promote conservation of Northern Leopard Frogs and best management practices for conserving the species and their habitat | High | Drainage and filling of water bodies, Conversion of upland habitat, Urbanization/Industrialization, Livestock operations, Alteration of water regimes, Environmental Contaminants, Fish stocking, Mortality from road traffic | 2013-2018 |
| **Broad Strategy: Research** | | | |
| 8. Develop spatially-explicit habitat models to support conservation measures | High | Drainage and filling of water bodies, Conversion of upland habitat, Urbanization/Industrialization, Livestock operations, Alteration of water regimes, Environmental Contaminants | 2013-2018 |
| 9. Identify habitat attributes and characteristics of habitat use | Medium | Information gap that must be addressed in order to measure progress in meeting Management Objective | 2013-2018 |
| 10. Assess the effects of diseases and parasites on local populations | Medium | Introduction or increased incidence of disease and parasites | 2013-2018 |
| 11. Investigate long-term implications of drought and climate change | Medium | Increased frequency of drought periods | 2013-2018 |
| **Broad Strategy: Reintroduction** | | | |
| 12. Implement reintroduction programs if deemed necessary and feasible | Low | Drainage and filling of water bodies, Conversion of upland habitat, Urbanization/Industrialization, Livestock operations, Alteration of water regimes, Introduction or increased incidence of disease and parasites, Environmental Contaminants, Fish stocking, Mortality from road traffic, Commercial harvesting and collecting, Increased frequency of drought periods | 2013-2018 |

[*] Measures are dependent on the budgetary restraints and priorities of the managing jurisdiction.

# 7. MEASURING PROGRESS

Success of this management plan implementation will be measured against the following performance indicator:

By 2018, the distribution of the Northern Leopard Frog, Western Boreal/Prairie populations will have been maintained or increased, by identifying and reducing or eliminating threats to the species and its habitat where possible.

# 8. REFERENCES

Adama, D.B., and M.A. Beaucher. 2006. Population monitoring and recovery of the Northern Leopard Frog (*Rana pipiens*) in southeast British Columbia. Report to the Columbia Basin Fish and Wildlife Compensation Program, Nelson, B.C. DRAFT. 41 pp.

Albert, A., K. Drouillard, G.D. Haffner, and B. Dixon. 2007. Dietary exposure to low pesticide doses causes long-term immunosuppression in the leopard frog (*Rana pipiens*). Environmental Toxicology and Chemistry 26:1179-1185.

Alberta Northern Leopard Frog Recovery Team. 2005. Alberta Northern Leopard Frog Recovery Plan, 2005-2010. Alberta Species at Risk Recovery Plan No. 7. 26 pp.

Alberta Sustainable Resource Development. 2003. Status of the Northern Leopard Frog (*Rana pipiens*) in Alberta: Update 2003. Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association, Wildlife Status Report No. 9 (Update 2003), Edmonton, AB. 61 pp.

Bishop, C. A. 1992. The effects of pesticides on amphibians and the implications for determining causes of declines in amphibian populations. In Declines in Canadian Amphibian Populations: Designing a National Monitoring Strategy. C.A. Bishop and K.E. Pettit (eds.). Canadian Wildlife Service, Occasional Paper No.76. Pp. 67-70.

Bishop, C.A., S.L. Ashpole, A.M. Edwards, G. Van Aggelen, J.E. Elliott. 2010. Hatching success and pesticide exposures in amphibians living in agricultural habitats of the South Okanagan Valley, British Columbia, Canada. Environmental Toxicology and Chemistry 29: 1593-1603.

Blaustein, A.L., P.D. Hoffman, D.G. Hokit, J.M. Kiesecker, S.C. Walls, and J.B. Hays. 1994. UV Repair and resistance to solar UV-B in amphibian eggs: a link to population declines? Proceedings of the National Academy of Sciences, USA 91:1791-1795.

Boutin, D. and C.M. Smith. 2008. Northern leopard frog reintroduction project: Waterton Lakes National Parks – 2007-08 summary. Unpublished technical report. Parks Canada, Waterton Lakes National Park, AB. 11pp.

Brodkin, M.A., H. Madhoun, M. Rameswaran, and I. Vatnick. 2007. Atrazine is an immune disruptor in adult Northern Leopard Frogs (*Rana pipiens*). Environmental Toxicology and Chemistry 26:80-84.

Butterworth, E.W. 1999. A review of the diseases important in decline of amphibian populations with special reference to the necessary protocols required to ameliorate their effects with regards to repatriation of amphibian species. Butterworth E.W. Consulting Ltd. Unpublished Report for Alberta Environmental Protection, Wildlife Management Division, Edmonton, AB. 33 pp.

Canadian Prairie Partners in Flight. 2004. Landbird Conservation Plan for Prairie Pothole Bird Conservation 11 in Canada. Canadian Wildlife Service, Edmonton, AB.

Carr, L.W., and L. Fahrig. 2001. Effect of road traffic on two amphibian species of differing vagility. Biological Conservation 15:1071-1078.

Cook, F. R. 1984. Introduction to Canadian amphibians and reptiles. National Museum of Natural Sciences, National Museum of Canada, Ottawa, ON. 200 pp.

Corn, P.S., and J.C. Fogleman. 1984. Extinction of montane populations of the Northern Leopard Frog *Rana pipiens* in Colorado. Journal of Herpetology 18:147-152.

Corn, P. S., and L. J. Livo. 1989. Leopard frog and wood frog reproduction in Colorado and Wyoming. Northwest Naturalist 70:1-9.

COSEWIC. 2000. COSEWIC assessment and update status report on the northern leopard Frog *Rana pipiens* (Southern Mountain and Prairie population) in Canada. Ottawa. vi+40 pp.

COSEWIC. 2009. COSEWIC assessment and update status report on the Northern Leopard Frog *Lithobates pipiens*, Rocky Mountain population, Western Boreal/Prairie populations, and Eastern populations, in Canada. Ottawa. vii + 69 pp.

COSEWIC 2010. COSEWIC assessment and status report on the Sprague's Pipit *Anthus spragueii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 34 pp.

CPAWS (Canadian Parks and Wilderness Society, Manitoba Chapter). 2011. Website: cpawsmb.org/1538/tag/wetlands. [accessed September 29, 2011]

Dalgleish, T. 2001. Preliminary considerations for the development of a northern leopard frog (*Rana pipiens*) research and captive breeding program at the Calgary Zoo. For the Calgary Zoo, Alberta Conservation Association and Alberta Sustainable Resource Development. Calgary, AB. 22+ pp.

Densmore, C.L., and Green, D.E., 2007. Diseases of amphibians. ILAR Journal 48: 235–254.

Didiuk, A. 1997. Status of amphibians in Saskatchewan. In Amphibians in Decline: Canadian Studies of a Global Problem, D.M. Green (Ed.). Herpetological Conservation. Society of the Study of Amphibians and Reptiles, St. Louis 1:110-116.

Dole, J. W. 1971. Dispersal of recently metamorphosed leopard frogs, *Rana pipiens*. Copeia 1971:221-228.

Donald, D., J. Syrgiannis, F. Hunter and G. Weiss. 1999. Agricultural pesticides threaten the integrity of northern prairie wetlands. Science of the Total Environment 231:173-181.

Donald, D., N. Gurprasad, L. Quinett-Abbott and K. Cash. 2001. Diffuse geographic distribution of herbicides in northern prairie wetlands. Environmental Toxicology and Chemistry 20:273-279.

Eddy, S.B. 1976. Population ecology of the leopard frog *Rana pipiens* Schreber at Delta Marsh, Manitoba. Master of Science Thesis. University of Manitoba, Winnipeg, Manitoba.

Eigenbrod, F., S.J. Hecnar, and L. Fahrig 2008. The relative effects of road traffic and forest cover on anuran populations. Biological Conservation 141:35-46.

Emery, A.L., A.H. Berst, and K. Kodaira. 1972. Under-ice observations of wintering sites of leopard frogs. Copeia 1972 (1):123-126.

Endangered Species Conservation Council (CESCC). 2011. Wild Species 2010: The General Status of Species in Canada. National General Status Working Group: 302 pp.

Fournier, M.A. 1997. Amphibians in the Northwest Territories. In Amphibians in Decline: Canadian Studies of a Global Problem, D.M. Green (Ed.). Herpetological Conservation. Society of the Study of Amphibians and Reptiles, St. Louis 1:100-106.

Fowler, R. L. 1935. Some amphibians and reptiles of the district around High River, Alberta, 1933. Canadian Field Naturalist 48:139-140.

Fraser, L.D. 2008. Distribution Characteristics of the eggs, tadpoles, and metamorphs of the Northern Leopard Frog (*Rana pipiens*) and their relation to conservation strategies. Masters of Science Thesis. University of Calgary and the Calgary Zoo Centre for Conservation Research. Calgary, Alberta, Canada.

Fulton, T.L. G.A. Wilson, C.A. Paszkowski, K. Kendell, and D.W. Coltman. 2007. Evolutionary history and population genetics of Northern Leopard Frogs (*Rana pipiens*) in western Canada reveal ideal source populations for Alberta reintroductions. (poster). Annual General Meeting of the Canadian Society for Ecology and Evolution, Toronto, Ontario.

Gendron, A.D., D.J. Marcogliese, S. Barbeau, M.-S. Christin, P. Brousseau, S. Ruby, D. Cyr, and M. Fournier. 2003. Exposure of leopard frogs to a pesticide mixture affects life history characteristics of the lungworm *Rhabdias ranae*. Oecologia 135:469-476.

Gibbs, J.P., K.K. Whiteleather, and F.W. Schueler. 2005. Changes in frog and, toad populations over 30 years in New York State. Ecological Applications 15:1148-1157.

Gilbertson, M.K., G.D. Haffner, K.G. Drouillard, A. Alberta, and B. Dixon. 2003. Immunosuppression in the Northern Leopard Frog (*Rana pipiens*) induced by pesticide exposure. Environmental Toxicology and Chemistry 22:101-110.

Gosselin,P., S.E. Hrudey, A. Naeth, A. Plourde, R. Therrien, G. Van der Kraak, Z. Xu. 2010. The Royal Society of Canada expert panel: environmental and health impacts of Canada's oil sands industry. The Royal Society of Canada.

Gray, M.J., and L.M. Smith. 2005. Influence of land use on postmetamorphic body size of playa lake amphibians. Journal of Wildlife Management 29:515-524.

Greer, A.L., M. Berrill, and P.J. Wilson. 2005. Five amphibian mortality events associated with ranavirus infection in south central Ontario, Canada. Diseases of Aquatic Organisms 67:9-14.

Hamer, A.J., and Parris, K.M. 2011. Local and landscape determinants of amphibian communities in urban ponds. Ecological Applications 21: 378-390.

Hanski, I. 1998. Metapopulation dynamics. Nature 396:41–49.

Hanski I., and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society 42:3–16.

Heard, S. 1985. Leopard frog at Bompas Lake. Blue Jay 43:17.

Hecnar, S.J. 1995. Acute and chronic toxicity of ammonium nitrate fertilizer to amphibians from southern Ontario. Environmental Toxicology and Chemistry 14:2131-2137.

Henry PFP. Aspects of amphibian anatomy and physiology. In: Sparling DW, Linder G, Bishop CA, editors. Ecotoxicology of amphibians and reptiles. SETAC technical publication series. Columbia, USA: SETAC Press; 2000. p. 71–109.

Hine, R. L., B. L. Les, and B. F. Hellmich. 1981. Leopard frog populations and mortality in Wisconsin, 1974-76. Technical Bulletin No. 122, Department of Natural Resources, Madison, WI. 39 pp.

Hoffman, E.A., and M.S. Blouin. 2004a. Evolutionary history of the Northern Leopard Frog: reconstruction of phylogeny, phylogeography, and historical changes in population demography from mitochondrial DNA. Evolution 58:145-159.

Hoffman, E.A., and M.S. Blouin. 2004b. Historical data refute recent range contraction as cause of low genetic diversity in isolated frog populations. Molecular Ecology 13:271–276.

Hofman, D. E. 1992. 1992 Leopard frog monitoring project Prince’s Spring, Alberta. Unpubl. rept., Alberta Fish and Wildlife Division, Red Deer, AB. 12 pp.

Hogan, N.S., P. Duarte, M.G. Wade, D.R.S. Lean, and V.L. Trudeau. 2008. Estrogenic exposure affects metamorphosis and alters sex ratios in the Northern Leopard Frog (*Rana pipiens*): Identifying critically vulnerable periods of development. General and Comparative Endocrinology 156: 515-523.

IUCN, Conservation International, and NatureServe. 2004. Global Amphibian Assessment. IUCN, Conservation International, and NatureServe, Washington, DC and Arlington, Virginia, USA.

Johnson, P.T.J., McKenzie, V.J., Peterson, A.C., Kerby, J.L., Brown, J., Blaustein, A.R., and Jackson, T. 2011. Regional decline of an iconic amphibian associated with elevation, land-use change, and invasive species. Conservation Biology 25(3): 556-566.

Kendell, K. 2001. Northern Leopard Frog reintroduction: Raven River – year 2 (2000). Alberta Sustainable Resource Development, Fish and Wildlife Service, Alberta Species at Risk Report No. 13, Edmonton, AB. 43 pp.

Kendell, K. 2002a. Survey protocol for the Northern Leopard Frog. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 43, Edmonton, AB. 30 pp.

Kendell, K. 2002b. Alberta inventory for the Northern Leopard Frog (2000/2001). Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 44, Edmonton, AB. 29 pp.

Kendell, K. 2004. Northern Leopard Frog recovery program: Year 5 (2003). Unpubl. rept., Alberta Conservation Association, Edmonton, AB. 14 pp.

Kendell, K., and D. Prescott. 2007. Northern Leopard Frog reintroduction strategy for Alberta. Technical Report, T-2007-002, produced by Alberta Conservation Association, Edmonton, Alberta, Canada. 31 pp + App.

Kendell, K., S. Stevens, and D. Prescott. 2007. Alberta Northern Leopard Frog survey, 2005. Technical Report, T-2007-001, produced by Alberta Conservation Association, Edmonton, Alberta, Canada. 18 pp + app

Kiesecker, J.M. 2002. Synergism between trematode infection and pesticide exposure: a link to amphibian limb deformities in nature? Proceedings of Natural Academy of Sciences 99:9900-9904.

Keisecker, J. M., A. R. Blaustein, and C. L. Miller. 2001. Transfer of a pathogen from fish to amphibians. Conservation Biology 15:1064-1070.

Koch, E.D. and C.R. Peterson. 1995. Amphibians and Reptiles of Yellowstone and Grand Teton National Parks. University of Utah Press, Salt Lake City, UT. 188 pp.

Koch, E. G., G. Williams, C. R. Peterson, and P. S. Corn. 1996. A summary of the Conference on Declining and Sensitive Amphibians in the Rocky Mountains and Pacific Northwest. Idaho Herpetological Society and U.S. Fish and Wildlife Service, Snake River Basin Office Report, Boise, ID.

Koonz, W. 1992. Amphibians in Manitoba. In Declines in Canadian Amphibian Populations: Designing a national monitoring strategy. C.A. Bishop and K.E. Pettit (eds.). Canadian Wildlife Service, Occasional Paper No. 76:19-20.

Lannoo, M. J., K. Lang, T. Waltz, and G. S. Philips. 1994. An altered amphibian assemblage: Dickson County, Iowa, 70 years after Frank Blanchard's survey. American Midland Naturalist 131:311-319.

Leconfort, H., Meguire, R.A., Wilson, L.H., and Ettinger, W.F., 1998. Heavy metals alter the survival, growth, metamorphosis, and antipredatory behaviour of Columbia Spotted Frog (*Rana luteiventris*) tadpoles. Achives of Environmental Contamination and Toxicology 35:447-456.

Leonard, W.P., and K.L. McAllister. 1996. Past Distribution and Current Status of the Northern Leopard Frog *Rana pipiens* in Washington. Washington Dept of Fish and Wildlife, Wildlife Management Program.

Manitoba Exo-Network. 2009. Wetlands in Manitoba. Website: mbeconetwork.org/index.php/download_file/-/view/111/ [accessed on September 16, 2011]

Marquis, O., Millery, A., Guittonneau, S., and Miaud, C. 2006. Toxicity of PAHs and jelly protection of eggs in the common frog *Rana* temporaria. Amphibia-Reptilia 27 :472-475.

Mazerolle, M.J., M. Huot, and M. Grave. 2005. Behavior of amphibians on the road in response to car traffic. Herpetologica 61:380-388.

McAllister, K.L., W.P. Leonard, D.W. Hays and L.C. Friesz. 1999. Washington State status report for the Nothern Leopard Frog. Washington Department of Fish and Wildlife, Olympia, Washington. 36 pp.

McDaniel T.V., P.A. Martin, J. Struger, J. Sherry, C.H. Marvin, M.E. McMaster, S. Clarence, and G. Tetreault. 2008. Potential endocrine disruption of sexual development in free ranging male Northern Leopard Frogs (*Rana pipiens*) and green frogs (*Rana clamitans*) from areas of intensive row crop agriculture. Aquatic Toxicology 88: 230-242.

Melvin, S.D., and V.L.Trudeau. 2012. Growth, development and incidence of deformities in amphibian larvae exposed as embryos to naphthenic acid concentrations detected in the Canadian oil sands region. Environmental Pollution167:178-83.

Merrell, D. J., and C. F. Rodell. 1968. Seasonal selection in the leopard frog, Rana pipiens. Evolution 22:284-288.

Merrell, D.J. 1968. A comparison of the estimated size and the "effective size" of breeding populations of the leopard frog, *Rana pipiens*. Evolution 22:274-283.

Merrell, D. J. 1977. Life history of the Leopard Frog, Rana pipiens, in Minnesota. Bell Museum of Natural History, University of Minnesota, Minneapolis, MN.

Messing, P.G., A. Farenhorst, D.T. Waite, D.A. Ross McQueen, J.F. Sproull, D.A. Humphries, L.L. Thompson. In press. Predicting wetland contamination from atmospheric deposition measurements of pesticides in the Canadian prairie provinces. Atmospheric Environment.

Moriarty, J.J. 1998. Status of Amphibians in Minnesota. Pages 166-168 *in* Lannoo, M. J., ed. Status and Conservation of Midwestern Amphibians. University of Iowa Press, Iowa City, IA. 507 pp.

Nace, G. W., D. D. Culley, M. B. Emmons, E. L. Gibbs, V. H. Hutchison, and R. G. McKinnell. 1996. Amphibians: guidelines for the breeding, care and management of laboratory animals. A report of the Subcommittee on Amphibian Standards, Committee on Standards, Institute of Laboratory Animal Resources and National Research Council National Academy of Sciences, Washington, DC.

NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, VA. U.SA. Website: http://www.natureserve.org/explorer. [accessed: September 16, 2011].

Ouellet, M.J., J. Bonin, J. Rodrigue, J. Desgranges, and S. Lair. 1997. Hindlimb deformities (ectromelia, ectrodactyly) in free-living anurans from agricultural habitats. Journal of Wildlife Diseases 33:95-104.

Parks Canada. 2008. Amphibian monitoring in Waterton Lakes National Park, 1007-2008. Unpublished technical report. Parks Canada, Waterton Lakes National Park, AB.

Pearson, K.J. 2004. The effects on introduced fish on the long-toed salamander (*Ambystoma macrodactylum*) in southwestern Alberta, Canada. M.Sc. Thesis, University of Lethbridge, Lethbridge, Alberta.

Pierce, B.A. 1987. The effects of acid rain on amphibians. The American Biology Teacher 49(6):342-347.

Pope, S. E., L. Fahrig, and H. G. Merriam. 2000. Landscape complementation and metapopulation effects on leopard frog populations. Ecology 81:2498-2508.

Preston, W.B. 1982. The Amphibians and Reptiles of Manitoba. Manitoba Museum of Man and Nature, Winnipeg, Manitoba.

Quinlan, R. W., B. A. Downey, B. L. Downey, and P. F. Jones. 2004. MULTISAR: The Milk River basin, a multispecies strategy for species at risk: Year 2 progress report. Alberta Sustainable Resource Management, Fish and Wildlife Division, Species at Risk Report No. 87, Edmonton, AB. 111 pp.

Regional Aquatics Monitoring Program [RAMP] 2011 Implementation Team. 2012. Regional Aquatics Monitoring Program 2011 technical report - final. Regional Aquatics Monitoring Program. Available at: http://www.ramp-alberta.org/ramp/results/report.aspx (Accessed Sept. 7, 2012).

Reichel, J.D. 1996. Status of amphibians and reptiles in eastern Montana. Intermountain Journal of Sciences 2:57.

Roberts, W.E. 1992. Declines in amphibian populations in Alberta. In Declines in Canadian Amphibian Populations: Designing a national monitoring strategy. C.A. Bishop and K.E. Pettit (eds.). Canadian Wildlife Service, Occasional Paper No.76:14-16.

Rohr, J.R., A.M. Schotthoefer, T.R. Raffel, H.J. Carrick, N. Halstead, J.T. Hoverman, C.M. Johnson, L.B. Johnson, C. Lieske, M.D. Piwoni, P.K. Schoff, and V.R. Beasley. 2008. Agrochemicals increase trematode infections in a declining amphibian species. Nature 455: 1235-1239

Romanchuk, K. A. 2003. Magrath Northern Leopard Frog reintroduction project – year 1 progress report. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta. Species at Risk Report No. 79, Edmonton, AB. 20 pp

Rouse, J.D., C.A. Bishop, and J. Struger. 1999. Nitrogen Pollution: An Assessment of its Threats to Amphibian Survival. Environmental Health Perspectives 107(10):799-803.

Russell, A. P., and A. M. Bauer. 2000. The amphibians and reptiles of Alberta. A field guide and Primer of boreal herpetology, 2nd edn. University of Calgary Press and University of Alberta Press, Calgary and Edmonton, AB. 279 pp.

Schmutzer, A.C., Gray, M.J., Burton, E.C., and Miller, D.L. 2008. Impacts of cattle on amphibian larvae and the aquatic environment. Freshwater Biology 53:2613-2625.

Schock, D.M. 2009. Amphibian population and pathogen surveys in the Dehcho and Sahtu, Nothwest Territories, 2007 and 2008. Department of Environmental and Natural Resources, Government of the Northwest Territories. Manuscript Report No. 206 122 pp.

Schock, D.M, and T.K. Bollinger. 2005. An apparent decline of Northern Leopard Frogs *Rana pipiens* on the Rafferty Dam mitigation lands near Estevan, SK. Blue Jay 63(3):145-153.

Schock, D. M., Ruthig, G. R., Collins, J.P., Kutz, S. J., Carriere, S., Gau, R. J., Veitch, A.M., Larter, N.C., Tate, D.P., Guthrie, G., Allaire, D.G. and Popko, R.A. 2009. Amphibian chytrid fungus and ranaviruses in the Northwest Territories, Canada. Diseases of Aquatic Organisms Special 4:1-10.

Seburn, C.N.L. 1992a. The status of amphibian populations in Saskatchewan. In Declines in Canadian Amphibian Populations: Designing a national monitoring strategy. C.A. Bishop and K.E. Pettit (eds.). Canadian Wildlife Service, Occasional Paper No.76:17-18.

Seburn, C.N.L. 1992b. Management Plan for the Northern Leopard Frog in Alberta. Unpublished report to Alberta Fish and Wildlife. Edmonton, Alberta.

Seburn, C. N. L. 1994. Leopard frog project – progress report 1993. Unpubl. rept. for Alberta Forestry, Lands and Wildlife. Edmonton, AB. 15 pp.

Seburn, C. N. L., D. C. Seburn, and C. A. Paszkowski. 1997. Northern Leopard Frog (*Rana pipiens*) dispersal in relation to habitat. In Amphibians in decline: Canadian studies of a global problem (D. M. Green, ed.). Herpetological Conservation. Society of the Study of Amphibians and Reptiles, St. Louis 1:64-72

Seburn, C. N. L., and D. C. Seburn. 1998. Status report on the Northern Leopard Frog (*Rana pipiens*) in Canada (western populations). Prepared for the Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. 43 pp.

Secoy, D.M. 1987. Status report on the reptiles and amphibians of Saskatchewan. Proceedings of the Workshop on Endangered Species in the Prairie Provinces. G.L. Holroyd, W.B. McGillivray, P.H.L. Stepney, D.M. Ealey, G.C. Trottier and K.E. Eberhart (Eds.) Natural History Occasional Paper No. 9. Provincial Museum of Alberta, Edmonton, Alberta.

Smallbone, L.T., Luck, G.W., and Wassens, S. 2011. Anuran species in urban landscapes: relationships with biophysical, built environment and socio-economic factors. Landscape and Urban Planning 101:43-51.

Smith, B.E. and D.A. Keinath. 2007. Northern Leopard Frog (*Rana pipiens*): A Technical Conservation Assessment. Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project. 66pp.

Smith, C.M. and T. Hewitt. 2007. Management Plan for northern leopard frog (Rana pipiens) in Waterton Lakes National Park, 2007-2011. Unpublished technical report. Parks Canada. Waterton Lakes National Park, AB. 36pp.

Souder, W. 2000. A plague of frogs: the horrifying true story. Library of Congress Cataloguing-in-Publication Data, New York, NY. 299 pp.

Stabeneau, E.K., Giczewski, D.T., and Maillacheruvu, K.Y. 2006. Uptake and elimination of naphthalene from liver, lung, and muscle tissue in the Leopard Frog (*Rana pipiens*). Journal of Environmental Science and Health Part A 41:1449-1461.

Stabeneau, E.K., Sasser, A., and Schulte, C. 2008. The effects of pyrene exposure on exercise performance, muscle contraction, and mitochondrial $O_2$ consumption in the Leopard frog (*Rana pipiens*). Journal of Environmental Science and Health Part A 43:576-583.

Stevens, S.D, D. Page, and D.R.C. Prescott. 2010. Habitat suitability index for the northern leopard frog in Alberta: model derivation and validation. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 132, Edmonton, AB. 16 pp.

Taylor, S.K., E.S. Williams and K.W. Mills. 1999. Effects of malathion on disease susceptibility in Woudhouse's toads. Journal of Wildlife Disease 35:635-641.

Trudeau, V,L, G.M. Somoza, G.S. Natale, B. Pauli, J. Wignall, P. Jackman, K. Doe and F.W. Schueler. 2010. Hormonal induction of spawning in 4 species of frogs by coinjection with a gonadotropin-releasing hormone agonist and a dopamine antagonist. Reproductive Biology and Endocrinology: 8:36.

Turner, B. C., G. S. Hochbaum, F. D. Caswell, and D. J. Nieman. 1987. Agricultural impacts on wetland habitats on the Canadian prairies, 1981-85. Trans. N.A. Wildl. Nat. Res. Conf. 52: 206-215.

Vatnick, I., M.A. Brodkin, M.P. Brodkin, M.P. Simon, B.W. Grant, C.L. Conte, M. Gleave, L. Myers, and M.M. Sadoff. 1999. The effects of exposure to mild acidic condition on adult frogs (*Rana pipiens* and *Rana clamitans*): mortality rates and pH preferences. Journal of Herpetology 33: 370-374.

Wagner, G. 1997. Status of the Northern Leopard Frog (*Rana pipiens*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, Wildlife Status Report No 9. Edmonton. 46 pp.

Waye, H. L., and J. M. Cooper. 2001. Status of the Northern Leopard Frog (Rana pipiens) in the Creston Valley Wildlife Management Area 1999 for the Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC. 51+ pp.

Weller, W.F., M.J. Oldham, F.W. Schueler, and M. E. Obbard. 1994. Report of the Historical Database Committee: Report of the Historical Populations Trends Subgroup, Canadian Working Group - Declines in Canadian amphibians identified using historical distributional data. In, Fourth Annual Meeting of the Task Force on Declining Amphibian Populations in Canada. Proceedings of a workshop, Manitoba Museum of Man & Nature, Winnipeg, Manitoba.

Wendlandt, M., and L. Takats. 1999. Northern Leopard Frog reintroduction: Raven River-pilot year (1999). Alberta Environment, Fisheries and Wildlife Management Division, Edmonton, AB. 22 pp.

Werner, J.K., B.A. Maxell, P. Hendricks, and D.L. Flath. 2004. Amphibians and Reptiles of Montana. Mountain Press Publishing Company, Missoula, MT. 262 pp.

Wershler, C. R. 1991. Status of the Northern Leopard Frog in Alberta – 1990. Unpublished report by Sweetgrass Consultants Ltd. for World Wildlife Fund Canada (Prairie for Tomorrow) and Alberta Forestry, Lands and Wildlife, Edmonton, AB. 47+ pp.

Wilson, G.A., T.L. Fulton, K. Kendell, G. Scrimgeour, C.A. Paszkowski, and D.W. Coltman. 2008. Genetic diversity and structure in Canadian Northern Leopard Frog (*Rana pipiens*) populations: implications for reintroduction programs. Canadian Journal of Zoology 86: 863–874.

Wilson, G.A., T.L. Fulton, K. Kendell, G. Scrimgeour, C.A. Paszkowski, and D.W. Coltman. 2009. Genetic assessment of potential source populations for the reintroduction of northern leopard frogs (*Rana pipiens*) to sites in Alberta. Technical report, T-2009-001, produced by the Alberta Conservation Association, Sherwood Park, Alberta, Canada. 32 pp.

# 9. PERSONAL COMMUNICATIONS

Bollinger, T.K.- Western College of Veterinary Medicine, SK

Doyle, M.- Environment Canada, ON

Gau, R. – Government of the Northwest Territories

Kendell, K.- Alberta Conservation Association, AB

McMaster, G.- Saskatchewan Watershed Authority, SK

Prescott, D.- Alberta Fish and Wildlife Division, AB

Schock, D.- Keyano College, AB

Watkins, W.- Manitoba Conservation, MB

White, C.- Saskatchewan Watershed Authority, SK

# APPENDIX A: NORTHERN LEOPARD FROG CONSERVATION STATUS AND POPULATION TRENDS

Table 3. Conservation status of Northern Leopard Frogs in Canada and northern United States adjacent to prairie Canada

| **State / Province** | **Status*** |
|---|---|
| Idaho | S2 (NatureServe 2011) |
| Montana | S1, S4 (Montana Natural heritage Program and Montana Fish, Wildlife and Parks 2011) |
| North Dakota | SNR (NatureServe 2011) |
| Minnesota | S4 (NatureServe 2011) |
| Manitoba | S4 (NatureServe 2011) |
| Saskatchewan | S3 (NatureServe 2011) |
| Alberta | S2 (NatureServe 2011) |
| Northwest Territories | SNR (NatureServe 2011) |

*NatureServe ranks: S = subnational rank; 1= critically imperilled; 2 = imperilled; 3 = vulnerable to extirpation; 4 = apparently secure; SNR not ranked

Table 4. Current abundance and population trends for the Northern Leopard Frog in northern United States adjacent to prairie Canada (from Smith and Keinath 2007 in COSEWIC 2009).

| **State** | **Present Abundance** | **Population Trend** | **References** |
|---|---|---|---|
| Idaho | Uncommon | Declining | Koch and Peterson (1995) |
| Montana | Uncommon | Declining | Reichel (1996), Werner et al. (2004) |
| North Dakota | Unknown | Unknown - | |
| Minnesota | Common | Declining | Moriarty (1998) |

# APPENDIX B. EFFECTS ON THE ENVIRONMENT AND OTHER SPECIES

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that plans may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the plan itself, but are also summarized below.

This management plan is anticipated to have an overall positive effect on other species because of its focus upon the conservation of wetlands and a variety of natural upland habitats. The plan focuses upon discouragement of conversion of wetlands to habitats of lower biodiversity, such as intensive agriculture. Water level manipulation for anthropogenic and wildlife management purposes may be able in many cases to accommodate habitat requirements of the Northern Leopard Frog. Stewardship practices to maintain and improve summer foraging habitat, notably riparian habitats, will benefit many other species of wildlife and native vegetation.