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Alberta Northern Leopard Frog Recovery Plan 2010-2015

Alberta Species at Risk Recovery Plan No. 20

Government of Alberta

Alberta Northern Leopard Frog Recovery Plan 2010-2015

Prepared by:

Alberta Environment and Sustainable Resource Development

October 2012

Alberta Government

ISBN: 978-4601-0542-9 (Printed Edition)
ISBN: 978-4601-0543-6 (On-line Edition)
ISSN: 1702-4897 (Printed Edition)
ISSN: 1702-4900 (On-line Edition)

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http://srd.alberta.ca/FishWildlife/SpeciesAtRisk/LegalDesignationOfSpeciesAtRisk/RecoveryProgram/RecoveryPlans.aspx

This publication may be cited as:

Alberta Environment and Sustainable Resource Development. 2012. Alberta Northern Leopard Frog Recovery Plan, 2010-2015. Alberta Environment and Sustainable Resource Development, Alberta Species at Risk Recovery Plan No. 20. Edmonton, AB. 34pp.

PREFACE

Albertans are fortunate to share their province with a diverse variety of wild species. Populations of most species of plants and animals are healthy and secure. However, a small number of species are either naturally rare or are now imperiled because of human activities. Recovery plans establish a basis for cooperation among government, industry, conservation groups, landowners and other stakeholders to ensure these species and populations are restored or maintained for future generations.

Alberta's commitment to the *Accord for the Protection of Species at Risk* and to the *National Framework for the Conservation of Species at Risk*, combined with requirements established under Alberta's *Wildlife Act* and the federal *Species at Risk Act*, has resulted in the development of a provincial recovery program. The overall goal of the recovery program is to restore species identified as *Threatened* or *Endangered* to viable, naturally self-sustaining populations within Alberta. The policy document: *Alberta's Strategy for the Management of Species at Risk (2009-2014)* provides broader program context for recovery activities.

Alberta species at risk recovery plans are prepared under the supervision of the Species at Risk Program, Alberta Environment and Sustainable Resource Development. This often includes involvement of a recovery team composed of a variety of stakeholders including conservation organizations, industry, landowners, resource users, universities, government agencies and others. Membership is by invitation from the Director of Wildlife Management, and may include representation from the diversity of interests unique to each species and circumstance. Conservation and management of these species continues during preparation of the recovery plan.

The Director of Wildlife Management provides these plans as advice to the Minister responsible for fish and wildlife management. Alberta's Endangered Species Conservation Committee reviews draft recovery plans, and provides recommendations to the Minister. Additional opportunities for review by the public may also be provided. Plans accepted and approved for implementation by the Minister are published as a government recovery plan. Approved plans are a summary of the Department's commitment to work with involved stakeholders to coordinate and implement conservation actions necessary to restore or maintain these species.

Recovery plans include three main sections: background information that highlights the species' biology, population trends, and threats; a recovery section that outlines goals, objectives, and strategies to address the threats; and an action plan that profiles priority actions required to maintain or restore the *Threatened* or *Endangered* species. Each approved recovery plan undergoes regular review, and progress of implementation is evaluated. Implementation of each recovery plan is subject to the availability of resources, from within and from outside government.

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ACKNOWLEDGEMENTS

This plan was prepared by the David Prescott (AESRD), Scott Stevens (AESRD), and Kris Kendell (ACA) with the advice, guidance, and review of the Alberta Northern Leopard Frog Advisory Group. This *ad hoc* advisory group of biologists and land managers with specific interest in, and knowledge of, the northern leopard frog in Alberta. This group attended the first Alberta Northern Leopard Frog Summit in March 2010, and formulated the core of the *Alberta Northern Leopard Frog Recovery Plan, 2010-2015*:

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We also thank Breana Jones (Calgary Zoo) for updating much of the background information in Sections 1-3, and Breana Jones, Barb Johnston, Cindy Paszkowski, Des Smith and Cindy Kemper for providing comments on an earlier draft.

Preparation of the plan was funded by the Species at Risk Program of Alberta Environment and Sustainable Resource Development. We also recognize the many landowners, funding partners, field staff, past recovery team members, and other individuals and agencies that contributed to implementation of the inaugural recovery plan. The contributions of these partners form the basis of the current recovery plan, and will be instrumental in the anticipated success of recovery actions described herein.

EXECUTIVE SUMMARY

Historically, northern leopard frogs were widely distributed and locally abundant in the Grassland, Foothills, and Parkland Natural Regions of central and southern Alberta and in the extreme northeastern region of the province. However, abrupt and dramatic population declines were noted in the late 1970s and early 1980s. Since that time, the abundance of northern leopard frogs in Alberta has been low and the species has been extirpated from many parts of its historical range. Similar declines have been reported in many parts of western North America.

In February 2004, the Minister of Environment and Sustainable Resource Development maintained the listing of the northern leopard frog as *Threatened* under Alberta's *Wildlife Act*. Formal recovery efforts began with the formation of the Alberta Northern Leopard Frog Recovery Team in 2004, and the preparation and approval of the *Alberta Northern Leopard Frog Recovery Plan, 2005-2010* (Alberta Northern Leopard Frog Recovery Team 2005). That Plan had a goal of achieving "well-distributed and self-sustaining populations of northern leopard frogs throughout their historical range in Alberta". Significant progress was made in several strategic areas. Key accomplishments included completion of a provincial survey in 2005 along with subsequent surveys that discovered at least 27 previously unknown populations, development of a reintroduction strategy, translocation of egg masses to 10 vacant sites within the current range, completion of cooperative stewardship projects at six sites, development and distribution of several information and education products, and completion or initiation of research projects into population genetics, diseases, and habitat occupancy modelling. These activities have provided a better understanding of the northern leopard frog and its management in the province. However, populations remain low in most areas, and populations on the periphery of the range are in danger of disappearing. Much more management must be implemented to achieve recovery targets for the northern leopard frog in Alberta.

The *Alberta Northern Leopard Frog Recovery Plan, 2010-2015* has been prepared under the guidance of the newly-formed Alberta Northern Leopard Frog Advisory Group. The Plan is a continuation of work begun in 2005, with an increased emphasis on monitoring the success of past reintroduction efforts, on cooperative stewardship to protect key habitats, and on research activities that will improve the management of northern leopard frogs in the future. These projects include a study of winter habitat selection and completion of habitat occupancy models. Efforts to clarify our understanding of population size, distribution and trends in the province will also continue through targeted field surveys and solicitation of public sightings.

The overall cost of the actions detailed in the recovery plan is $639,000 over five years, including both cash and essential "in-kind" support. A variety of agencies will be invited to participate in the funding and implementation of recovery initiatives.

The *Alberta Northern Leopard Frog Recovery Plan, 2010-2015* was reviewed by the Endangered Species Conservation Committee in December 2011. The committee subsequently recommended to the Minister that the plan be approved as written, and implemented. In August 2012 the Minister approved the recovery plan and directed the Department to implement the Plan to guide the recovery program for northern leopard frog in Alberta.

1.0 INTRODUCTION

1.1 Provincial and Federal Status

In February 2004, the Minister of Environment and Sustainable Resource Development approved the maintenance of the listing of northern leopard frog (*Lithobates pipiens*, formerly *Rana*) as *Threatened* in Schedule 6 of Alberta's *Wildlife Act*, based on the recommendation from the Endangered Species Conservation Committee (ESCC). This designation was based on a decline in the number of populations and in the area of occupancy, population fragmentation, and limited dispersal and exchange capabilities of this species. The action statement specified that a recovery plan would be prepared within 24 months of the species' listing and that sufficient new resources should be made available to support population monitoring and assessment, and recovery planning. Furthermore, the action statement advised that Alberta Environment and Sustainable Resource Development should enhance programs to collect data on population size, distribution, trends, and habitat availability in Alberta.

The national status of the western boreal/prairie population of the northern leopard frog was evaluated by the Committee on the Status of Endangered Wildlife in Canada in April 1998 as *Special Concern*, and this designation was re-assessed and subsequently confirmed in April 2009 (COSEWIC 2009). This designation reflects the widespread contraction of this species range on the western prairies for which the causes remain largely unknown, increasing isolation of the remaining populations, and the lack of recolonization of areas formerly occupied. As a species of *Special Concern*, a draft management plan for the northern leopard frog in Canada was submitted to the Species at Risk Act (SARA) office of the Canadian Wildlife Service in December 2010. The plan is expected to be posted for public review in mid-2011 (A. Didiuk, pers. comm.).

Significant declines in northern leopard frog populations have occurred across much of western Canada and the western United States. The British Columbia (Rocky Mountain) population is listed as *Endangered* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2009). The species is also on the provincial Red List and is listed as *Endangered* in British Columbia's *Wildlife Act*. In Washington, the northern leopard frog is listed as S1 ("critically imperilled"). The species is listed as S1S2 ("critically imperilled/imperilled") in Oregon, S1S3 ("critically imperilled/vulnerable") in Montana, and S3 ("vulnerable") in Saskatchewan, Idaho and Wyoming (NatureServe 2010).

1.2 Recovery Advisory Group

In 2004, the Minister of Environment and Sustainable Resource Development initiated the Alberta Northern Leopard Frog Recovery Team, which received operational guidance from the Director of Wildlife Management. Led by a species lead from AESRD, the team's primary responsibility was to provide recommendations for recovery of the northern leopard frog, by outlining recovery strategies and actions in the Alberta Northern Leopard Frog Recovery Plan (hereafter referred to as the Plan). AESRD oversaw implementation of the Plan by facilitating and encouraging involvement of appropriate and interested parties, including members of the Team. The team lead was responsible for updating the Plan and evaluating and reporting on the progress of recovery actions.

The inaugural recovery team had 10 stakeholders from nine organizations, with varying degrees of expertise in the management of northern leopard frogs and their habitat. Team membership was static. Over time, it became apparent that there was a larger body of participants that should be involved in leopard frog management, and that their participation may be more ephemeral (e.g., graduate students) or directed towards specific components of the recovery program (e.g., specific research topics, habitat management). Accordingly, the Team leader, in consultation with other Team members, elected to modify the structure of the Team to a more dynamic, informal, and inclusive Northern Leopard Frog Advisory Group. This new format has allowed the AESRD to draw on the expertise of several smaller groups of people that are most engaged in specific aspects of the recovery program. In so doing, the overall recovery program now collectively embodies a much broader range of people and expertise than the formal recovery team structure allowed. The new structure will better ensure that a key objective of northern leopard frog recovery program is met: "to encourage and facilitate the involvement of all interested parties in the recovery of northern leopard frogs in Alberta" (Alberta Northern Leopard Frog Recovery Team 2005).

2.0 SPECIES BIOLOGY

2.1 Life History

The northern leopard frog is a medium-sized frog (60 to 110 mm adult snout-vent length) with powerful hind legs and extensively webbed hind feet that are well adapted for jumping and swimming (Hine et al. 1981, Russell and Bauer 2000). Northern leopard frogs are identified by their smooth skin, by a pair of continuous white- or cream-coloured ridges extending from behind their eyes to their lower backs, and by the presence of numerous dark spots with light borders on their backs, legs, and sides (Russell and Bauer 2000). The background colour of the skin is typically green, often brown, and rarely golden. Females are typically larger than males (Hine et al. 1981, Russell and Bauer 2000).

Northern leopard frogs are amphibious, spending time in both aquatic and terrestrial environments. During the winter, leopard frogs hibernate in waterbodies that do not freeze solid (Hine et al. 1981, Russell and Bauer 2000). Emergence from hibernation occurs shortly after ice begins to melt (Merrell 1977). After emergence, adult frogs travel up to 2 km to different waterbodies to breed (Hine et al. 1981, Souder 2000). In Alberta, breeding typically occurs between April and late June (Wershler 1992a, Kendell 2002a) and may be limited to a few days or can occur over several weeks. Breeding is initiated by males that vocalize to attract females. Breeding females deposit 600-7000 eggs in masses that are attached to emergent vegetation (Corn and Livo 1989). Hatching is dependent on water temperature but may occur as soon as five to nine days after egg laying (Hine et al. 1981). Metamorphosis occurs 60 to 90 days after hatching (Wershler 1991a). At metamorphosis, frogs switch from being herbivorous to carnivorous, foraging primarily on small invertebrates (e.g., insects, spiders), and occasionally on small birds, snakes, frogs and fish (Moore and Strickland 1954, Rittschof 1975, Russell and Bauer 2000). Newly transformed frogs can disperse up to 8 km from natal ponds (Dole 1971, Seburn et al. 1997). After breeding, adults disperse to forage in riparian or upland habitats.

Life spans of wild northern leopard frogs rarely exceed four to five years, but captive frogs may live as long as nine years (Froom 1982, Leclair and Castanet 1987, Russell and Bauer 2000). Annual mortality rates of adult and immature frogs are high; mortality of adult frogs has been estimated at around 60% (Merrell and Rodell 1968), whereas overwinter mortality of newly transformed frogs may exceed 93% (Yaremko 1996).

2.2 Habitat

Three distinct habitat types (breeding, foraging and overwintering) are required by northern leopard frogs. Given the limited dispersal capabilities of this species, it is important that these habitats are available within close proximity, and well connected, to each other (Pope et al. 2000).

Breeding Habitat

Breeding occurs in the shallow, warm waters of a variety of waterbodies including marshes, sloughs, springs, ditches, dugouts, borrow pits, beaver ponds, lakes, and slow-moving sections of streams and rivers (Merrell 1977, Hine et al. 1981, Seburn and Seburn 1998). Preferred waterbodies also have some degree of permanence such that water is present until after transformation of tadpoles (Merrell and Rodell 1968), are non-acidic (pH: 6.5-8.5, Nace et al. 1996), and contain no predatory fish (Merrell and Rodell 1968). The presence of emergent vegetation is also important for protective cover and as a substrate on which to attach egg masses (Wershler 1991a, 1992a, Kendell 2002b).

Foraging Habitat

After breeding and transformation, adults, sub-adults and young-of-the-year can move considerable distances (up to 2 km) to summer foraging areas. These areas are usually moist habitats such as meadows, pastures, scrublands, or drainage or irrigation ditches (Merrell 1977, Hine et al. 1981, Wershler 1991a, Seburn 1994). Northern leopard frogs tend to avoid areas that are heavily wooded (Merrell 1977, but see Seburn 1994) or that have sparse cover (e.g., heavily grazed fields, lawns, cultivated fields; Dole 1971, Merrell 1977, Hine et al. 1981).

Overwintering Habitat

Waterbodies used for overwintering by northern leopard frogs are cold ($<4^{o}$C), well oxygenated (7-10 ppm) and do not freeze solid (Hine et al. 1981, Cunjak 1986, Nace et al. 1996). These characteristics are typically associated with deeper, permanent waterbodies including springs, streams, creeks, rivers, ponds and lakes. Normally, different waterbodies are used for breeding and overwintering (Souder 2000). Information on the characteristics and location of overwintering sites in Alberta is very limited.

2.3 Population Distribution and Trends in Alberta

Population surveys for northern leopard frogs in Alberta were not conducted before the 1980s, and there is little formal documentation of historic population levels in the province (Wagner 1997). However, sources such as biophysical inventories in specific areas of the province, museum collections, and the records and recollections of naturalists indicate that northern leopard frogs were widely distributed and locally abundant in the Grassland, Foothills, and

Parkland Natural Regions[1] of central and southern Alberta, and in extreme northeastern Alberta (Figure 1A; Wagner 1997, Kendell 2003). Abrupt and dramatic population declines were noted in the late 1970s and early 1980s (Roberts 1981, 1987). These declines were also reported in many areas of central and western North America (Hine et al. 1981, Corn and Fogleman 1984, Rorabough 2005).

In 1990, a province-wide survey was undertaken to determine the distribution of northern leopard frogs in Alberta. Of the 74 populations known at the time to have been occupied since 1983, only 24 sites were reported to be occupied (Wershler 1991a), including 13 populations verified from site visits (it is not clear how many sites were actually visited), and 21 additional sites submitted by the public that were considered to be reliable. More intensive local surveys, focussing on a small number of these sites were conducted in the early 1990s (e.g., Hofman 1991, 1992, 1994a,b, 1995, Wershler 1992b). Numerous historical records were compiled during preparation of a provincial status report (Wagner 1997), and many of these were included in a second province-wide survey conducted in 2000 and 2001 (Kendell 2002b). In total, 269 historical sites were surveyed; northern leopard frogs were found at only 54 of these sites. Several sites occupied in the previous survey (1990) appeared to be vacant, and there was no apparent recolonization of sites that were depopulated in the 1970s and 1980s.

A third province-wide survey in 2005 included 177 historical sites, with frogs being observed at 73 sites (Kendell et al. 2007). However, only 56% of sites known to be occupied in the 2000-2001 survey were found to be occupied. Since this last province-wide survey, many of the larger populations have been monitored on a regular basis, because of their use as source sites for the reintroduction program (see Section 5.4), or their inclusion in research projects such as disease monitoring (Whiteside et al., in prep.), population genetics (Wilson et al. 2008, 2009), habitat modelling (Stevens et al. 2010) or habitat occupancy modelling (Smith and Jones, in prep.). Data are also collected through the Alberta Volunteer Amphibian Monitoring Program (Alberta Conservation Association and Alberta Environment and Sustainable Resource Development 2010), consultants' reports, biophysical inventories, and records submitted to AESRD offices by the public. These surveys and opportunistic observations have led to the discovery of 40-50 new sites in the past 10 years, and have revealed that several sites found to be vacant on provincial surveys (e.g., Kendell 2002b, Kendell et al. 2007) are in fact still occupied.

It is important to note that most population surveys conducted in Alberta have covered a large geographic area, allowing sites to be checked (usually) only once during the survey. Recent research in Alberta has shown that single-site surveys are relatively ineffective at detecting the presence of leopard frogs (Smith and Jones, in prep.), and therefore provide poor indicators of occupancy and relative population size. Furthermore, amphibian populations can fluctuate widely among years (Pechmann et al. 1991) making annual differences in population size a factor in determining site occupancy. Habitat modelling (Stevens et al. 2010) has identified many areas of potential habitat in southern Alberta that have not been surveyed, which raises the possibility of new populations being discovered. Taken together, however, surveys show that the provincial population has contracted from the historical range (Figure 1A). The species has disappeared from most central and western areas of the province, and is now largely restricted to

[1] See Alberta Environmental Protection (1994) for description of Natural Regions of Alberta.

major river drainages in the Grassland Natural Region. This includes the lower reaches of the Red Deer, Oldman, South Saskatchewan, Bow, and Milk Rivers (see Figure 1B for locations of major river basins), where the species is occasionally abundant. Very small, and likely imperilled, populations persist in the Willow Creek and Sheep/Highwood Rivers south of Calgary, and on the lower Battle River near Wainwright. Populations reported to occur in the Red Deer area as recently as 1990 (Wershler 1991a) appear to have disappeared, but most other populations known to occur in southern Alberta since that time appear to be persisting. Northern leopard frogs are known to occur on several lakes on the Canadian Shield in extreme northeastern Alberta. There has been relatively little survey effort in this area, but the species appears to be patchily distributed and of low abundance (Kendell 2002b; D. Prescott, pers. obs.). Additional surveys are needed to clarify the status of the species on the Canadian Shield.

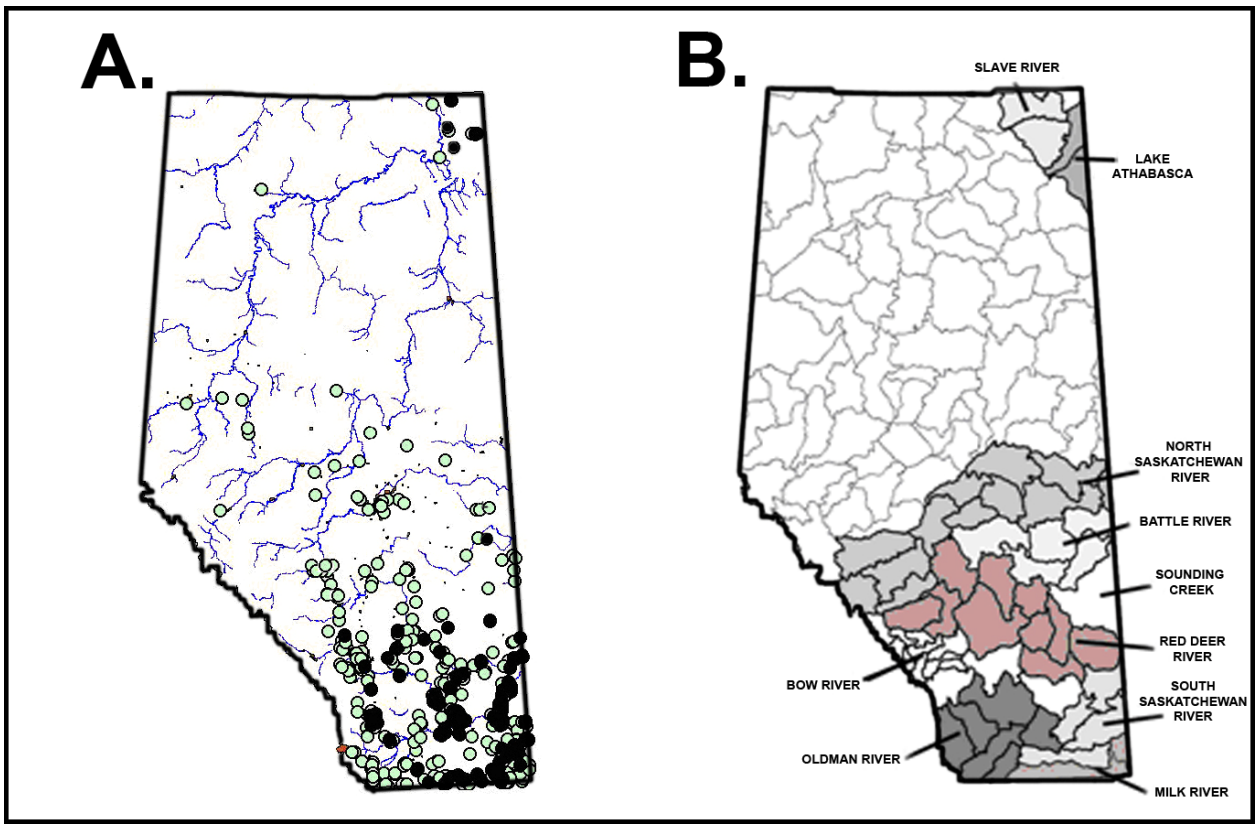

Figure 1. A: Historical distribution (light circles), and distribution since 2000 (dark circles) of northern leopard frogs in Alberta. B: Major river basins and sub-basins (following Alberta Environment) where management of northern leopard frogs will occur in Alberta.

3.0 THREATS AND LIMITING FACTORS

Dramatic declines in population size have been observed for numerous amphibian populations around the world. In many cases, the reasons for these declines are not clear (Blaustein and Wake 1990, Collins and Storfer 2003). This is also true of population declines of the northern leopard frog in Alberta and elsewhere in North America. However, a number of natural and human-caused factors have been implicated in Alberta (Kendell 2003), and are explained in more detail below. These factors may act independently, may interact, or may act simultaneously to threaten frog populations (Collins and Storfer 2003). Several of the natural limiting factors (e.g., climate) are unlikely to be mitigated by actions outlined in this recovery plan.

3.1 Climate

Climatic factors such as drought can have a major influence on northern leopard frog populations (Merrell 1977, Corn and Fogleman 1984, Koch et al. 1996). In drought years, habitat for frogs is lost and local populations may be extirpated. Drought conditions were associated with a decline in amphibian populations in southern Alberta in the 1930s (Fowler 1935). Drought conditions were also prevalent in southern Alberta in the late 1970s and 1980s, suggesting a possible link between climatic conditions and the abrupt provincial decline of this species beginning in the late 1970s. Some biologists have dismissed this possibility because populations have been lost from many permanent waterbodies in Alberta that would not have been affected by drought (Roberts 1981, 1987, 1992, Wershler 1991a). Thus, climate has likely contributed to declines in population size, but it is unlikely to be the only factor.

Increasing ultraviolet (UV) radiation from a thinning ozone layer has also been associated with declines of amphibian populations. In the genus *Rana*, UV radiation has been shown to cause mortality of embryos (Blaustein et al. 1994). In addition, northern leopard frog tadpoles exposed to environmentally relevant levels of UVB radiation in a laboratory exhibited spinal curvature that inhibited foraging behaviour and eventually caused death (Croteau et al. 2008b). Ultraviolet radiation may also reduce resistance to disease and pathogens (Kiesecker and Blaustein 1995). Northern leopard frogs lay their eggs close to the water surface, possibly increasing their susceptibility to UV radiation. However, egg masses are globular in form, and the outer eggs may shield the inner eggs from exposure to UV radiation, compared with amphibians that lay their eggs in strings or thin sheets (Croteau et al. 2008a).

3.2 Disease

Northern leopard frogs and other amphibians are susceptible to diseases that may cause large numbers of mortalities (Daszak et al. 1999). Mass mortalities from diseases may be a natural phenomenon and/or may be related to a variety of environmental stressors. Many diseases of amphibians appear to have increased in their incidence and/or virulence in recent years, and may have been spread to new areas by human activities such as the global pet and food trade, and fish stocking (Kiesecker et al. 2001, Daszak et al. 2003).

Infections by certain bacteria (most commonly *Aeromonas hydrophilia*) results in a condition referred to as “red-leg” that is nearly always fatal, and which has been linked to population declines in several areas of North America (Gibbs et al. 1971, Hine et al. 1981, Koonz 1992) This disease affects the kidneys and other organs of frogs and appears to be triggered by factors such as stress, injury, malnourishment or environmental conditions such as poor water quality (Nace et al. 1996, Kendell 2002b, 2003). The best-described viral pathogen in northern leopard frogs is Lucke’s tumour virus (a herpesvirus), which causes tumours of the kidneys. The virus can also infect eggs and young embryos, which may result in tumour development during the adult stage (McKinnell and Carson 1997). Ranavirus infections are also well described in northern leopard frogs, and may contribute to mortality of adults or embyros (McKinnell 1973,

Hunter et al. 1989, Kendell 2003). Two fungi in particular have been associated with large numbers of mortalities of amphibians. Chytridiomycosis caused by the "chytrid" fungus (*Batrachochytrium dendobatidis*) was first found on northern leopard frogs collected in Alberta in 1999 (Kendell 2003). More recent research has shown the disease to be widespread in this province (Whiteside et al., in prep.; see Section 5.3). Chytrids are ubiquitous fungi found in aquatic and moist habitats where they degrade cellulose, chitin and keratin. In amphibians, the parasitic chytrid degrades the keratin component of the skin, leading to excessive keratin production and sloughing of skin (Berger et al. 1999). Degradation of the skin impairs absorption of water and electrolytes to the point where cardiac arrest results in death of the animal (Voyles et al. 2009). Tadpoles infected with chytridiomycosis can display lower foraging rates and survivorship (Parris et al. 2006). Factors affecting chytrid abundance include seasonal temperature changes, water pH, light, nutrition and dissolved oxygen (Sparrow 1968). Saprolegniasis, associated with *Saprolegnia ferax and S. parasitica*, results from invasion of these fungi into wounds. *S. ferax* is a common pathogen of fish and their eggs. Although this species has not been found in Alberta, it has been associated with high mortality of northern leopard frog eggs in British Columbia (Kendell 2003).

3.3 Habitat Loss and Fragmentation

Habitat loss has been associated with declines of leopard frog populations in many areas of North America (Lannoo et al. 1994, Koch et al. 1996). In southern Alberta, the drainage of small wetlands for agricultural use has been extensive over the past century. Such losses have no doubt caused populations to disappear at a local level (Kendell 2003). However, the creation of a vast system of irrigation reservoirs and canals constructed since the late 1800s has certainly created a substantial amount of habitat in southern Alberta, where the arid environment (and periodic droughts) otherwise limits the availability of habitat for frogs. Today, the irrigation network comprises over 8000 km of conveyances and more than 50 storage reservoirs that irrigate 625 000 km of upland (Alberta Agriculture and Food 2000). Many of the larger leopard frog populations are now found within the irrigated areas (e.g., Kendell 2002b, Kendell et al. 2007). However, information on the historical distribution and abundance of leopard frogs is poor (Wagner 1997), and it is difficult to quantify the extent to which irrigation systems have influenced leopard frog distribution in this province.

Habitat degradation, rather than loss, is probably a larger concern for the conservation of northern leopard frogs in Alberta. Turner et al. (1987) estimated that almost 60% of basins and approximately 80% of wetland margins in the prairies and parkland regions of Alberta were impacted by agricultural activities in the 1980s. More recent estimates suggest that over 90% of wetlands in Alberta have margins that are impacted by agricultural activities (Bartzen et al. 2010). Some land-use activities certainly reduce suitability of habitat for northern leopard frogs. For example, livestock grazing and trampling in riparian habitat can reduce vegetative cover and diversity, destroy or disturb egg masses, increase water turbidity, and contaminate breeding and overwintering sites with livestock wastes (Wershler 1991b). The presence of livestock has been noted at a number of sites used by northern leopard frogs in Alberta (Seburn 1992, Kendell 2003,

Kendell et al. 2007). On the other hand, ungulates and livestock may benefit northern leopard frog populations by controlling non-native vegetation, and by reducing vegetation cover that would otherwise impede movement and foraging by frogs (Waye and Cooper 2001). Consequently, management of livestock activity may be used to improve riparian habitat for northern leopard frogs.

Habitat fragmentation may be a particular concern for frog populations because individuals migrate among habitat types to fulfill various aspects of their life histories (Pope et al. 2000). Thus, activities such as cultivation, urban development, and construction of transportation corridors can act as barriers to migration and dispersal, and cause local population extinctions (Pope et al. 2000). Prior to the recent population decline, northern leopard frog populations in Alberta likely operated as a metapopulation, characterized by a collection of local populations occupying geographically isolated patches of suitable habitat. These local populations are typically subject to high rates of local extinctions from environmental or natural factors, but are re-colonized through dispersal of individuals among populations (Hanski and Gilpin 1991, Hanski 1998). Escalating habitat loss or fragmentation that increases isolation among local populations may limit the ability of individuals to disperse and re-colonize habitats, or may result in extinctions of local populations from reduced gene flow. Northern leopard frog populations may be particularly affected by fragmentation because they appear to have limited ability to disperse across large areas of unsuitable habitat (Kendell 2002a, 2003). If amphibians occupy degraded habitat after the onset of metamorphosis, they can suffer lower growth rates (Gray and Smith 2005; Adama and Beaucher 2006) which could negatively impact their survival, reproduction, ability to compete and consequently their ability to repopulate a neighbouring area.

3.4 Water Quality

Northern leopard frogs carry out a number of activities in the water (including breeding, foraging, and overwintering), and have thin but well-vascularized skin that allows for cutaneous respiration. Consequently, northern leopard frogs are particularly sensitive to environmental contaminants or activities that impact water quality. The specific impact of aquatic contaminants on northern leopard frogs in Alberta have not been studied, but numerous deleterious effects on this species, and on other amphibians in North America, suggest that agricultural, industrial and urban pollution is of concern to populations in this province.

Studies have shown that exposure to pesticides such as atrazine, DDT, and dieldrin can reduce immune responses in larval and adult leopard frogs (Gilbertson et al. 2003, Albert et al. 2007, Brodkin et al. 2007, McDaniel et al. 2008), and increase their susceptibility to infections from trematode worms (Rohr et al. 2008) and lungworms (Gendron et al. 2003). Exposure to low concentrations of atrazine can cause demasculinization and feminization of amphibians (Hayes 2004). Shenoy et al. (2009) noted that continuous exposure of leopard frog tadpoles to levels of mancozeb and endosulfan, typically found in wetlands of agricultural areas, greatly reduced survival rates. Mancozeb also caused retarded growth rates in survivors (Shenoy et al. 2009). Reduced growth rate may result

in smaller individuals at metamorphosis, which can reduce immunocompetence (Carey et al. 1999), fecundity, survival (Goater 1994), and overall ability to avoid predation (John-Alder and Morin 1990). Synthetic estrogens have been demonstrated to delay northern leopard frog development (Hogan et al. 2008), and municipal wastewater effluent containing known endocrine disruptors caused slower metamorphosis and higher occurrence of testicular oocytes in leopard frog tadpoles (Sowers et al. 2009). In agricultural areas, runoff of fertilizers and livestock waste can increase nutrient levels and increase the intensity and duration of algal blooms. The resulting reduction in dissolved oxygen levels can impact the abundance of aquatic prey, and reduce the growth and survival of leopard frog tadpoles (Ouellet et al. 1997, Kiesecker 2002, Kendell 2003). Nitrate fertilizers have been shown to reduce activity levels, growth rates, and survivorship of northern leopard frogs and other amphibians (Hecnar 2009). The addition of road salt in Ontario has been linked to reduced tadpole activity and weight and may prompt physical deformities (Sanzo and Hecnar 2005).

3.5 Water Management Activities

Projects that stabilize or alter water levels to enhance agricultural, industrial or recreational opportunities or to improve habitat for other species (fish and birds) can impact northern leopard frog populations (Wershler 1991a). These activities can reduce habitat availability by reducing the amount of vegetation around wetlands. Furthermore, raising water levels (flooding) during spring can dislodge egg masses from emergent vegetation or alter the water current and levels such that the location is no longer favourable for breeding and development. Lowering water levels prior to metamorphosis can result in the mortality of tadpoles, and the desiccation of egg masses. These activities may also impact water quality, including temperature, nutrient quantity and oxygen levels.

Use of water for oil and gas and other land-use activities during the winter can also affect aquifers and reduce water levels, leading to freezing of overwintering ponds used by northern leopard frogs. Conversely, the development of new waterbodies from damming streams or the creation of dugouts for watering cattle, irrigation, or flood protection may provide new overwintering or breeding habitat, particularly in arid areas where little natural habitat exists (Environment Canada 2009).

3.6 Road Mortality

When large numbers of frogs migrate between breeding, foraging, and overwintering sites they may be at risk of road mortality (Fahrig et al. 1995). Road kills are not likely a limiting factor for the northern leopard frog in Alberta, but high road mortality has been noted in other parts of the species' range (Merrell 1977, Fahrig et al. 1995, Ashley and Robinson 1996, Carr and Fahrig 2001, Eigenbrod et al. 2008, 2009). As habitat becomes increasingly fragmented by roads, this factor may become more important in Alberta.

3.7 Harvest

Traditionally, northern leopard frogs were harvested commercially for research and teaching purposes (e.g., dissection), but this practice has been restricted for many years in Alberta (Kendell 2003). Leopard frogs have also been harvested as bait for recreational fishing and collected by children who enjoy raising frogs and tadpoles. These latter uses would not typically threaten the species, but the small, localized populations in some areas of Alberta could make them particularly sensitive to excessive collections. As a *Threatened* species in the *Wildlife Act*, collection of northern leopard frogs is prohibited without a permit. Efforts to inform the public on the status of this species and its formal protection may help ensure that recreational collection is minimized.

3.8 Introduction of Game Fish and Other Non-native Species

Northern leopard frogs may have evolved in the absence of fish in their breeding ponds and it is therefore unlikely the species has any natural defences against introduced fish (Smith and Keinath 2007). Consequently, the introduction of game fish to waterbodies could lead to increased predation of northern leopard frog adults or tadpoles (Emery et al. 1972, Hecnar and M'Closkey 1977) or may serve as vectors of parasites or pathogens (Kiesecker et al. 2001). The impact of fish introductions in Alberta is not known (Kendell 2003). Many waterbodies in southern and central Alberta that have moderate or high levels of dissolved oxygen (necessary for overwintering by leopard frogs) have introduced sportfish (normally rainbow trout [*Oncorhynchus mykiss*] or walleye [*Sander vitreus*]) which likely has some impact on frog populations. However, leopard frogs on the Canadian Shield of northeastern Alberta appear to be locally abundant (D. Prescott, pers. obs.), despite the abundance of predatory fish such as northern pike (*Esox lucius*).

In other areas of North America, introductions of bullfrogs (*Rana catesbeiana*) have been associated with declines in leopard frog populations (Lannoo et al. 1994, Reichel and Flath 1995, Koch et al. 1996). Bullfrogs do not occur in Alberta, but populations have been introduced into many areas of the northwestern Unites States, as well as in British Columbia (COSEWIC 2009). Further expansion of bullfrog range into Alberta may be an issue for northern leopard frog populations in the future.

4.0 RESEARCH NEEDS

Although the biology and ecology of northern leopard frogs have been relatively well studied, there are many areas where directed research could improve the management and recovery of this species. Recent research conducted in Alberta into the genetic composition of populations (Wilson et al. 2008, 2009), habitat modelling (Stevens et al. 2010), prevalence of disease (Whiteside et al., in prep), and habitat occupancy (Smith and Jones, in prep.) have filled many crucial information gaps. The successful completion and continuation of these projects, evaluation of past management activities, and commencement of new research initiatives will be desirable in the coming years. Specific research recommendations include:

1. Research into overwinter site selection of northern leopard frogs. This will improve knowledge of important habitats that should be conserved, and aid in the identification of possible reintroduction sites and development of captive rearing programs.
2. Continued validation of habitat suitability models, and refinement of models as new information (e.g. overwinter site characteristics) and GIS coverages (e.g., Grassland Vegetation Inventory) become available.
3. Continued evaluation of the success of the reintroduction program, with refinement to existing protocols to increase probability of success.
4. Continued research into the impact of diseases on leopard frog populations. Chytrid fungus, which has been implicated in numerous amphibian declines and extinctions (Berger et al. 1999), is now known to be widespread in Alberta. However, the relationship between the presence of this pathogen and population declines has not been investigated in this province.
5. Development of population viability models to assess the viability of northern leopard frog populations in Alberta under existing conditions and under different management and land-use scenarios.

5.0 RECENT RECOVERY AND CONSERVATION EFFORTS

A variety of initiatives aimed at conservation of northern leopard frogs and their habitat have been implemented in Alberta since province-wide declines of the species were recognized in the 1980s. Activities have intensified over the past six years, following establishment of a provincial recovery team in 2004, and approval of the inaugural recovery plan in 2005 (Alberta Northern Leopard Frog Recovery Team 2005). The major accomplishments of this recovery plan are summarized below. Initiatives undertaken prior to 2005 are summarized in Alberta Northern Leopard Frog Recovery Team (2005).

5.1 Information and Extension

Information and extension activities began with a review of existing materials and an evaluation of audiences and messages by a subcommittee of the Alberta Northern Leopard Frog Recovery Team in 2005. This led to the development of three main products: (1) the redesign of the "Have You Seen This Frog?" poster, which was first developed by Alberta Fish and Wildlife in 1989 to solicit records of northern leopard frogs by the public. The updated poster was distributed through many channels, including Tourism, Parks, and Recreation and AESRD offices, watershed groups, fishing lodges, and in municipal campgrounds; (2) update of a brochure in the provincial Species at Risk series. The brochure was widely distributed, and was the major informational tool for educating landowners about leopard frog management; and (3) creation of a northern leopard frog postcard as part of the provincial series. These cards were given out at numerous events, as well as from offices of the AESRD and partner agencies.

Other activities included popular articles in the Alberta Game Warden Magazine (Prescott 2006), Green Matters (Anonymous 2006), Croaks and Trills (Kendell and Prescott 2006, Kendell 2007a, Stevens et al. 2009), the Alberta Wildlifer (Kendell 2007b) and promotional articles distributed as part of Environment Week in 2008 to provincial watershed groups and to supporters of the Calgary Zoo. Several technical articles were published by the Alberta Conservation Association (Kendell and Prescott 2007, Kendell et al. 2007, Wilson et al. 2009) and in the AESRD Species at Risk Program report series (Stevens et al. 2010). There were several newspaper articles published on the management of leopard frogs, and radio and television coverage of the reintroduction at Beauvais Lake Provincial Park and research conducted by the Calgary Zoo. Several presentations to the public, naturalist groups, and other organizations were delivered by staff of Alberta Parks and Protected Areas, AESRD, Alberta Conservation Association, Alberta Agriculture, Food and Rural Development, Parks Canada and the Calgary Zoo. An interpretive sign was designed and installed at Kin Coulee in Medicine Hat to educate the public about leopard frogs and to discourage collections. Interpretive signs were also erected at the reintroduction site at Magrath, and a sign to recognize stewardship sites was developed by the Alberta Conservation Association. In addition, information on the management and conservation of northern leopard frogs has been maintained on the websites of the AESRD and partner agencies such as the Alberta Conservation Association and the Calgary Zoo.

5.2 Population Monitoring

Four primary actions related to population monitoring were implemented during the course of the 2005-2010 northern leopard frog recovery plan: (1) a population survey and habitat assessment in 2005 of 177 historical sites; 2) late summer surveys of occupied sites; 3) annual spring surveys to identify breeding sites; and 4) targeted surveys for previously unknown northern leopard frog populations or at historical sites.

The 2005 survey found northern leopard frogs at 73 of 177 sites (41%), with breeding confirmed at 13 locations (7%). Healthy populations were described in the Brooks, Cypress Hills, Medicine Hat, and Strathmore areas of the province (Kendell et al. 2007). The survey also showed that many sites occupied by leopard frogs were impacted by human activities, with cattle damage to shorelines being the most common impact. An additional component of the survey was to contact landowners and gauge their knowledge of leopard frogs, and their interest in participating in habitat conservation. Overall, 63% of respondents were aware of leopard frogs, but only 45% were aware the species occurred on their property. About two-thirds of landowners that had frogs on their land showed a positive attitude towards conservation, with only 4% being averse to stewardship activities (Kendell et al. 2007).

Other surveys (late summer, spring breeding and new/historical sites) were conducted on an opportunistic basis each year since 2005, with over 75 sites being visited (some a single time, some every year). Sites were visited for a variety of reasons, including to search for egg masses for the reintroduction program, to monitor the status of key populations, to verify observations submitted by the public, to validate a habitat model,

and as part of various research initiatives (see Section 5.3). These surveys have helped clarify the status of populations in Alberta and at least 27 previously unknown sites have been verified to support leopard frogs since 2005. Furthermore, the confirmation of egg masses, tadpoles or young-of-the year has identified 35 specific breeding sites at 25 locations in the province. Targeted surveys have also confirmed the general absence of leopard frogs in the lower Battle River and Willow Creek areas (K. Kendell, pers. obs.), the patchy distribution of frogs on the Canadian Shield (D. Prescott, pers. obs.), and the success of the recently completed habitat model in predicting the occurrence of leopard frogs where populations were previously unknown (Stevens et al. 2010, D. Smith, unpubl. data).

Results of all surveys were submitted to the Fish and Wildlife Management Information System (FWMIS) maintained by Alberta Environment and Sustainable Resource Development (AESRD). Of 2577 occurrence records currently held in the database (through October 2010), 1049 (40.7 %) were of records reported during the 2005-2010 plan implementation period.

5.3 Research

Four major research initiatives were initiated or completed between 2005 and 2010: (1) a study to characterize the genetics of leopard frog populations in Alberta and western Canada; (2) surveillance for chytrid fungus and iridoviruses in northern leopard frogs and other amphibians in Alberta; (3) development and validation of a habitat model to predict the occurrence of suitable leopard frog habitat in southern Alberta; and (4) development of site-occupancy models to improve survey efficiency of leopard frogs.

Genetics of Northern Leopard Frog Populations in Alberta

Genetics of source populations can affect reintroduction success (Reed and Frankham 2003) and should be considered in any such program. As a precaution, the *Alberta Northern Leopard Frog Recovery Plan 2005-2010* called for within-drainage basin transfer of egg masses (which occurred in 2007), until the genetics of Alberta populations were investigated. Biologists collected tissue samples from leopard frogs throughout Alberta, and also from a small number of sites in British Columbia, Saskatchewan, Manitoba and northwestern Ontario in 2004 and 2005. Subsequent analysis (Wilson et al. 2008, 2009) indicated a high degree of genetic differentiation between most populations sampled in Alberta. The apparent low levels of migration (and therefore gene flow) between sites suggested that inter-basin transfer of eggs would not be detrimental to frog populations, and would allow the possibility of introduction to watersheds from which northern leopard frogs had been extirpated. Furthermore, a decline in genetic diversity from east to west across the prairies suggested that there may be benefits to supplementing Alberta populations from larger (and more diverse) populations in Manitoba and Ontario.

Disease Surveillance

Emerging infectious diseases are implicated in the declines and extinctions of amphibians worldwide (Kiesecker et al. 2004). Although a number of important diseases have been

identified, two pathogens have received widespread attention in recent years because of their link to catastrophic impacts on amphibian populations: chytridomycosis (caused by the pathogenic chytrid fungus *Batracochytrium dendrobatidis*) and ranavirus (from the Iridoviridae family). Chytrid fungus was identified in Alberta in 1999 (Kendell 2003), but no further investigation of the distribution and prevalence of the disease had been conducted. Because the presence of diseases may have implications for planned translocations (in terms of both success of reintroductions, and the potential spread of disease from infected populations), it was considered prudent to investigate the distribution and incidence of key amphibian diseases in the province.

Between 2006 and 2009, we sampled 3276 individuals of eight species of amphibians at 87 sites throughout Alberta for the presence of chytrid fungus (Whiteside et al., in prep.). We also sampled for the presence of ranavirus in northern leopard frogs at 25 sites (896 individuals sampled). Chytrid fungus was found to be widespread in the province, with positive results occurring at 37 of 87 (42.5%) sites sampled, and at 6 of 39 (15.4%) leopard frog sites. Seven of eight species represented in the study tested positive for chytrid in at least one site. Ranavirus was found to be relatively rare in leopard frogs, with only three sites showing positive results. To date, there has been little evidence that these diseases are having an impact on leopard frog populations in Alberta. However, the severe impacts of chytridomycosis and ranavirus in other geographical areas suggests that there is significant potential for disease outbreaks to hamper future recovery efforts in the province.

Habitat Modelling

The *Alberta Northern Leopard Frog Recovery Plan 2005-2010* specified the development of a habitat suitability model for northern leopard frogs in Alberta as an action item. The intent of this model was to identify habitats that may support previously undocumented populations of leopard frogs, and to identify potential areas for the reintroduction of frogs (see Section 5.4). Using data collected during the 2005 provincial survey, Stevens et al. (2010) characterized occupied and unoccupied leopard frog sites in terms of numerous aquatic and terrestrial landscape features (GIS layers). Sites differed in terms of various hydrological variables, road density, moisture index, various vegetation characteristics, soil type and salinity. A model was developed that classified habitats across the range of occurrence of leopard frogs in southern Alberta, based on landscape features found to occur at occupied sites. The model appeared to have reasonable predictive power, as subsequent field investigations discovered leopard frogs at 11 of 23 sites that were predicted by the model to have a high probability of supporting the species (D. Smith and B. Jones, unpubl. data).

Site Occupancy Modelling

In 2009, researchers from the Centre for Conservation Research at the Calgary Zoo commenced a northern leopard frog area occupancy modelling project in southeastern Alberta (Smith and Jones, in prep.). The research involves conducting eight repeat surveys (per year) at 69 sites, and the collection of covariates that may be correlated with observer ability to detect frogs and whether or not a site is occupied by frogs. Results so far indicate that single surveys of sites will result in severe negative bias in the estimation

of frog occupancy. Furthermore, the ability to detect frogs is higher in late-summer than spring, with frog detection in spring being strongly related to temperature variables (e.g. wind chill, water temperature). This research has confirmed that northern leopard frogs in Alberta are operating as metapopulations, and that there is a series of site extinctions and colonization across the landscape that is more complex than first thought. This research will continue through 2011.

5.4 Reintroductions

The 2005-2010 recovery plan listed the following reintroduction actions to be implemented: 1) develop a detailed strategy and protocol for reintroduction of northern leopard frogs into vacant areas of their historical range in Alberta; 2) determine the feasibility of a captive-rearing facility to provide a source of eggs for the reintroduction program; 3) reintroduce egg masses to 10 unoccupied but suitable sites in at least two major river basins; 4) conduct annual surveys at release sites; and 5) develop a quantitative system for measuring the success of reintroductions. A detailed reintroduction strategy (Kendell and Prescott 2007) described a protocol and methodology for the transplant of northern leopard frog egg masses, identified priority watersheds, and developed a system for assessing success. Based on a successful reintroduction at Magrath prior to implementation of this recovery plan (Romanchuk and Quinlan 2006), and a population viability analysis prepared for Parks Canada (Tischendorf 2007), the strategy called for introduction of two to four egg mass for two consecutive years at each reintroduction site. During the 2005-2010 recovery plan implementation, seven sites (Wyndham-Carseland Provincial Park, Grainger Dam, Michichi Reservoir, Snake Lake, Rock Lake, and two sites in Waterton Lakes National Park,) received a minimum of two egg masses in two consecutive years, while three additional sites (Beauvais Lake, Big Knife, and Kinbrook Island Provincial Parks) received the first year of transplants (to be completed in 2010). All reintroduction sites achieved initial success (hatch to tadpole and metamorphosis to young-of-year). Overwinter survival of young-of-year frogs has been documented at all sites in at least one year with the exception of Grainger Dam, Snake Lake and Rock Lake, and successful breeding has been confirmed at Wyndham-Carseland Provincial Park. Intensive monitoring of all reintroduction sites will continue for the next several years to determine the success of the reintroduction program.

Based on recent success of a captive rearing project in Washington State (Sayler 2006, Sayler and Gomez 2008), the construction of a simple outdoor facility to house northern leopard frogs was completed at the Raven Brood Trout Station near Caroline in the summer of 2010. Success at maintaining a year-round population of frogs in captivity, including the production of eggs, will be assessed over the next few years.

5.5 Habitat Management and Stewardship

One objective of the provincial northern leopard frog survey in 2005 was to assess landholder attitudes toward stewardship and threats to northern leopard frogs (Kendell et al. 2007). It was found that landholders generally had positive attitudes towards species

at risk and northern leopard frogs and often expressed a willingness to improve stewardship of their wetlands. Since over-use of wetland habitat by cattle was identified as the most common threat from the 2005 survey, habitat management for northern leopard frogs often focussed on modifying cattle use at sensitive breeding sites. Six projects were completed by the Alberta Conservation Association during 2005-2010 recovery plan implementation: 1) fencing at Drain K (2006) to exclude cattle from a breeding pond; 2) fencing repairs at Prince Springs (2007) to exclude cattle from sensitive wetland areas; 3) fencing of breeding ponds and provision of off-site watering at Jenner Springs (2008); 4) provision of an alternate water source for cattle to improve water quality for leopard frogs in a beaver pond along Trout Creek (2008); 5) use of a portable off-site watering system at Red Creek (2008) to reduce cattle damage; and 6) mitigation of degraded habitat (removal of debris from waterways and reseeding of damaged soil areas) and the provision of advice on enhancement activities at a trout pond in Taber was initiated in 2009.

6.0 RECOVERY STRATEGY

6.1 Biological and Technical Feasibility of Recovery

In 2004, the Alberta Northern Leopard Frog Recovery Team concluded that the recovery of northern leopard frogs is biologically and technically feasible (Alberta Northern Leopard Frog Recovery Team 2005). This view was reiterated by the Alberta Northern Leopard Frog Advisory Group in 2010. Much of the biology and ecology of northern leopard frogs is well understood, which limits the amount of background work and information required to determine where conservation efforts should be focussed. Much of this work, including efforts to manage populations of northern leopard frogs, has been conducted in Alberta . The collective wisdom gained from this work provides a solid basis for the goals, strategies and actions contained in this recovery plan, and for optimism about the recovery of northern leopard frog populations in Alberta.

The possibility of recovery is augmented by the apparent stability of frog populations over the past decade (albeit at low levels), the discovery of new populations, and the preliminary success of the reintroduction program. Recent advances in captive rearing, and the conclusion that genetically diverse populations of frogs from the eastern prairies could be used as sources for the reintroduction program are additional developments that further enhance the probability of population recovery. Finally, public interest and support for conservation and stewardship of northern leopard frogs has been high, and management initiatives aimed at frogs can complement numerous other wetland and riparian conservation programs in the province. Thus, management conflicts or competing goals of various conservation initiatives should not be an issue, which should increase cooperation by landholders and users.

Optimism for recovery of northern leopard frogs must be tempered by the recent discovery, and widespread occurrence, of chytrid fungus in the province. The serious

impact of this disease on amphibian populations in many areas of the world has the potential to further devastate leopard frog populations in this province.

6.2 Guiding Principles

The recovery and management of northern leopard frogs in Alberta will be guided by the following principles:

- The recovery of the northern leopard frog is both desirable and achievable
- The loss of habitat and populations of the northern leopard frog is undesirable and preventable
- Members of the northern leopard frog advisory group, associated organizations, and conservation partners are committed to working together to achieve the goal of northern leopard frog recovery
- All land users and managers on northern leopard frog range, including all affected branches of government, will be strongly encouraged to share responsibility for, and support the goal of, northern leopard frog recovery
- Land managers, landowners, industry and other agencies will work cooperatively and collaboratively to ensure, to the extent possible, that recovery initiatives are compatible with sustainable land uses
- Recovery actions will embrace an ecosystem (holistic) approach to management, whenever possible
- Lack of information or scientific certainty should not impede implementation of actions believed to be necessary to achieve the goals of this recovery plan
- Whenever possible, the collection of data and scientific study of northern leopard frogs and their management are desirable
- The recovery process will be guided by the concept of adaptive management, whereby specific actions are implemented, evaluated, and improved upon on an iterative basis
- Landowners, lessees, and other cooperators in the management of northern leopard frogs should be recognized for their contributions towards achieving recovery goals
- Landowners will not be unduly affected by the costs associated with maintaining or enhancing northern leopard frog habitat, or other recovery measures.

6.3 Recovery Goal

The goal of the *Alberta Northern Leopard Frog Recovery Plan* is to achieve well-distributed and self-sustaining populations of northern leopard frogs throughout their historical range in Alberta.

6.4 Recovery Objectives

- Implement appropriate management to protect all known populations and habitats against anthropogenic threats (to the extent possible)
- Improve knowledge of population size, distribution, trends, reproductive status, threats and habitat availability in Alberta

- Monitor the progress of past and current reintroduction, stewardship, and other management efforts
- Increase public awareness of leopard frogs and their conservation in Alberta
- Conduct research that will improve the management of leopard frogs in Alberta
- Continue with the reintroduction of frogs to vacant areas of the range if ongoing evaluations suggest that past efforts have been effective.

6.5 Strategies for Recovery

The goal and objectives of the Alberta *Northern Leopard Frog Recovery Plan, 2010-2015* will be achieved through implementation of five distinct strategies, which will be pursued concurrently over a five-year period. Whenever possible, these strategies, and their associated actions, will be integrated with those of other species at risk recovery efforts in the province. In general, this Plan is a continuation of activities initiated during the *Alberta Northern Leopard Frog Recovery Plan, 2005-10* (Alberta Northern Leopard Frog Recovery Team 2005), with increased emphasis on the evaluation of past reintroduction efforts, and stewardship of key leopard frog habitats.

Population Conservation and Management – all actions related to the monitoring of northern leopard frog populations in Alberta, including regular monitoring of known sites, assessment of reintroduction sites, search for new populations, and reintroduction of frogs to vacant areas of their provincial range.

Habitat Conservation and Management – all actions related to assessing and improving the quality and security of breeding, summering and wintering habitat for northern leopard frogs in Alberta. Existing tools, policies and processes that are applicable to the protection of habitat in Alberta will be used whenever possible. Emphasis will be placed on voluntary stewardship with landholders.

Information and Education – all actions related to providing information and extension to landowners/lessees, industrial interests, recovery partners, and the general public about the conservation and management of the northern leopard frog in Alberta. The focus will be on preventing degradation or loss of habitat, gaining public assistance with finding new leopard frog populations, expanding awareness of conservation issues related to leopard frogs, and gaining support and participation in management initiatives.

Research – all activities that require the rigorous collection, analysis and reporting of scientific data that will yield information relevant to the management and recovery of northern leopard frog populations in Alberta.

Plan Management and Administration – all activities related to the operation of the Alberta Northern Leopard Frog Advisory Group and implementation of the Alberta Northern Leopard Frog Recovery Plan. Key elements of this strategy are to secure funding and other resources needed to support management actions, and to build linkages with other provincial, national and international initiatives that will benefit northern leopard frog conservation in Alberta.

7.0 ACTION PLAN

Actions designed to meet the objectives of the northern leopard frog recovery program are listed below for each strategy described in Section 6.0 (above). Specific timetable and costs for each action are detailed in Section 8.0.

7.1 Population Conservation and Management

1. Compile all information on population distribution, size, status, threats and habitat availability for all subwatersheds and watersheds where northern leopard frogs occur in Alberta. The resulting population status report will form the basis of future monitoring and inventory efforts in the province.

2. Conduct surveys of all currently occupied sites a minimum of once every five years, with a subset of sites being visited each year. Surveys will determine occupancy, specific breeding and wintering sites, potential sources of egg masses for reintroduction, and candidate sites for stewardship and other conservation actions.

3. Conduct targeted surveys each year to search for previously unknown frog populations in areas where new information indicates possible presence of northern leopard frogs.

4. Complete (2010) the second year of reintroductions at three sites (Kinbrook Island, Big Knife, and Beauvais Lake Provincial Parks) where introductions initiated under the previous Plan were not completed.

5. Conduct ongoing surveys to determine the success of reintroductions, following protocols outlined in the Alberta Northern Leopard Frog Reintroduction Strategy (Kendell and Prescott 2007). Site monitoring will be enhanced by use of audio recording equipment (Song Meter™) and analysis software (SongScope™).

6. Establish a pilot breeding facility at the Raven Brood Trout Station or an alternate site to house up to 30 adult leopard frogs year-round; these frogs will provide a source of egg masses to supplement or replace eggs removed from the wild for transplantation.

7. Conduct reintroductions of eggs to augment populations that are at risk of extirpation, or where there is indication of preliminary success at sites where past reintroductions have occurred and where additional translocations are deemed to be desirable. The occurrence of any reintroductions will be dependent on ongoing evaluation of the success of past reintroductions, and the availability of eggs from the captive rearing program.

7.2 Habitat Conservation and Management

1. Make application within AESRD or to the Special Areas Board for protective notations (PNTs, or notations in the Special Areas Management System [SAMS]) on all northern leopard frog habitats occurring on crown and other publicly owned land.

2. Make contact with landholders on private or leased land that supports northern leopard frog populations to make them aware of the presence of frogs, advise them of recommended land-management practices which enhance survival of northern leopard frogs, and seek opportunities for stewardship and cooperative management.

3. Implement direct management of sites to alleviate threats through cooperative agreements with landowners/lessees, or other initiatives.

4. Encourage and work with non-government conservation organizations to secure and protect sites with important northern leopard frog populations.

5. Maintain involvement in referrals (application of appropriate government land-use guidelines) related to industrial or other developments that could potentially impact, affect or degrade northern leopard frog habitat in Alberta.

7.3 Information and Education

1. Annually review existing extension information (brochures, web sites, posters, postcards, etc.) to assess which products require revision/updating or development.

2. Revise, produce and distribute new extension material as needed. An update to the current AESRD brochure is anticipated, as is the development of a "beneficial management practices" guide for industry and landholders with northern leopard frogs on their property.

3. Continue the "Have You Seen This Frog" poster campaign to solicit public assistance with determining the presence of frog populations in areas targeted for surveys (including reintroduction sites).

4. Provide information on leopard frog-related topics to technical and non-technical audiences through presentations, signage and other mechanisms.

7.4 Research

1. Support and assist research on habitat occupancy of northern leopard frogs currently underway at the Calgary Zoo. The development of an improved survey protocol that maximizes survey efficiency, and minimizes variation in survey effort between sites is a desired outcome of this research.

2. Conduct or support a research program to determine seasonal habitat use by northern leopard frogs, with emphasis on the use of over-wintering habitats.

3. Cooperate with all other provincial, national, and international research initiatives that will provide information to better manage northern leopard frogs in Alberta.

7.5 Plan Management and Administration

1. Convene the Alberta Northern Leopard Frog Advisory Group a minimum of once annually, and circulate results of these meetings to interested persons. Meetings will be to monitor and assess the progress of recovery plan actions, and develop new recovery strategies and actions when needed (adaptive management).

2. Liaise with other provincial, multi-provincial or international conservation agencies to ensure continuity and flow of information.

3. Enter accumulated population data into the Fisheries and Wildlife Management Information System and other centralized databases following each field season.

4. Prepare and distribute annual reports on recovery plan activities.

5. Approach government, non-government and industry partners to participate in or fund leopard frog recovery initiatives.

6. Hire and train seasonal staff to participate in annual field programs, and provide training/orientation to staff of cooperating agencies (government and non-government) when opportunities arise.

8.0 IMPLEMENTATION SCHEDULE AND COSTS

The following table provides a timeline and estimated cost (including direct and "in-kind') for implementation of action items detailed in Section 7.0. AESRD will be responsible for overseeing all activities, however it is anticipated that a variety of agencies will participate in the funding and implementation of these activities. (*) denotes that costs are included within other action items, or are part of the daily operations of the identified agencies.

Plan	Action	Cost (thousands/year)					Total
		2010-11	2011-12	2012-13	2013-14	2014-15	
7.1	**Population**						
1.	Population status report	**0**	**30**	**0**	**0**	**0**	**30**
2.	Annual surveys	**25**	**25**	**25**	**25**	**25**	**125**
3.	Search for new sites	**10**	**10**	**10**	**10**	**10**	**50**
4.	2010 reintroductions	**10**	**0**	**0**	**0**	**0**	**10**
5.	Reintroduction evaluation	**10**	**10**	**10**	**5**	**5**	**40**
6.	Establishment of captive facility	**5**	**5**	**5**	**5**	**5**	**25**
7.	Additional reintroductions	**6**	**2**	**2**	**2**	**2**	**14**
		66	**82**	**52**	**47**	**47**	**294**
7.2	**Habitat Conservation/Management**						
1.	Application for PNT/SAMS notations	**2**	**2**	**2**	**2**	**2**	**10**
2.	Landholder contact	**5**	**5**	**5**	**5**	**5**	**25**
3.	Site management and stewardship	**15**	**15**	**15**	**15**	**15**	**75**
4.	Work with conservation organizations	*	*	*	*	*	**0**
5.	Industrial referrals	*	*	*	*	*	**0**
		22	**22**	**22**	**22**	**22**	**110**
7.3	**Information and Outreach**						
1.	Review of materials	**1**	**1**	**1**	**1**	**1**	**5**
2.	Update, production and distribution	**2**	**2**	**2**	**2**	**2**	**10**
3.	Poster distribution	**1**	**1**	**1**	**1**	**1**	**5**
4.	Presentations	**2**	**2**	**2**	**2**	**2**	**10**
		6	**6**	**6**	**6**	**6**	**30**
7.4	**Research**						
1.	Site-occupancy research	**50**	**50**	**0**	**0**	**0**	**100**
2.	Winter habitat use research	**10**	**25**	**25**	**0**	**0**	**60**
3.	Cooperate in research	*	*	*	*	*	**0**
		60	**75**	**25**	**0**	**0**	**160**
7.5	**Management/Administration**						
1.	Advisory group meetings	**2**	**2**	**2**	**2**	**2**	**10**
2.	Liaison with other initiatives	*	*	*	*	*	**0**
3.	Database management	1	1	1	1	1	5
4.	Annual reporting	**1**	**1**	**1**	**1**	**1**	5
5.	Funding solicitation and application	**3**	**3**	**3**	**3**	**3**	**15**
6.	Staff training	**2**	**2**	**2**	**2**	**2**	**10**
		9	**9**	**9**	**9**	**9**	**45**
TOTAL		**163**	**194**	**114**	**84**	**84**	**639**

9.0 SOCIO-ECONOMIC CONSIDERATIONS

An important guiding principle of the Alberta northern leopard frog recovery program is that it will work in a collaborative and cooperative manner with stakeholders to ensure that recovery initiatives for this species are compatible, to the extent possible, with sustainable land uses that support economic activity. We will therefore strive to minimize the negative implications to Albertans that may result from efforts to recover northern leopard frog populations. On a local level, potential economic costs affecting landholders or land users (e.g., oil and gas developers) may include restrictions on land-use activities, or on timing of these activities. On the other hand, protection and improvements to northern leopard frog habitat may yield economic benefits for leaseholders and landowners through improved water quality and increased productivity of their lands. In addition, conservation and stewardship of habitat for leopard frogs will benefit a variety of other wildlife species and may increase biodiversity in these areas, to the benefit of all Albertans.

There is considerable public interest in northern leopard frogs making this an ideal species for increasing public awareness and support for the conservation of other "At Risk" wildlife and their habitats. Potential ecotourism opportunities may arise from recovery initiatives (e.g., tours of reintroduction facilities and sites).

10.0 PLAN REVIEW AND AMENDMENT

The life of this plan is five years. The Alberta Northern Leopard Frog Advisory Group will conduct an annual review of activities to monitor the implementation of the plan and to determine the effectiveness of recovery actions. A report on the results of these reviews will be submitted annually to the Director of Wildlife Management. Recovery plans are considered to be "living" documents and recovery actions can be amended during these reviews, as new information becomes available, as conditions change, or as circumstances warrant. At the end of five years, the Advisory Group will review the overall accomplishments of the plan, discuss amendments to management strategies and actions, and redraft a new plan for implementation over the next five-year period.

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