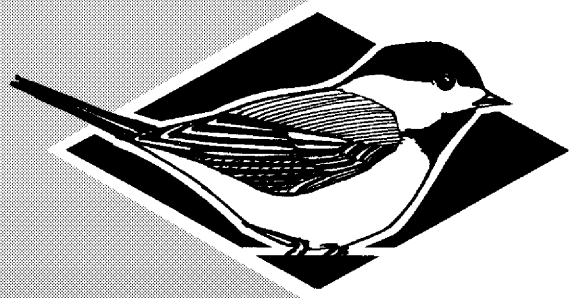
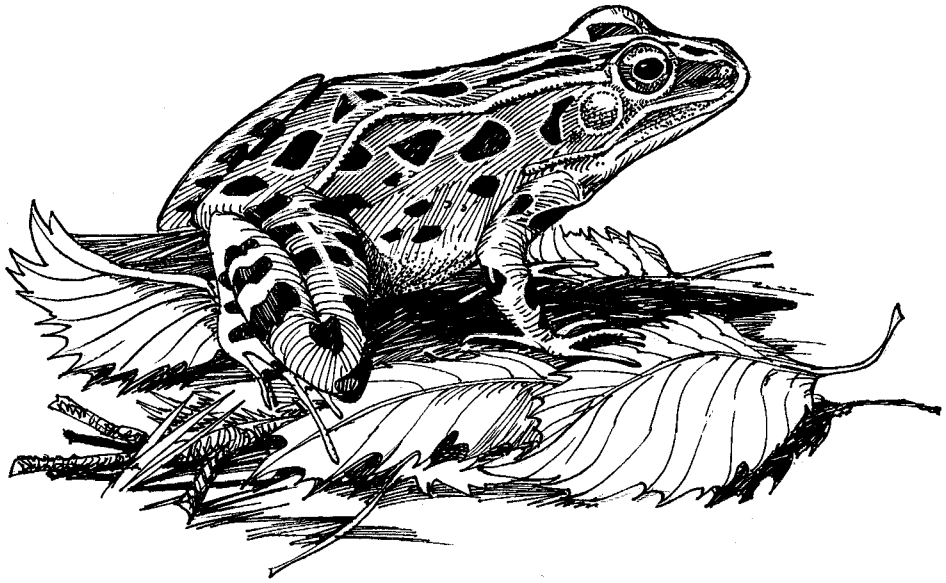


Wildlife Management Division

STATUS AND SURVEYS BRANCH

Status of the Northern Leopard Frog (*Rana pipiens*) in Alberta

Greg Wagner



Alberta Wildlife Status Report No. 9

Alberta ENVIRONMENTAL PROTECTION

Alberta Conservation Association

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PREFACE

Every five years, the Wildlife Management Division of Alberta Natural Resources Service reviews the status of wildlife species in Alberta. These overviews, which have been conducted in 1991 and 1996, assign individual species to "color" lists which reflect the perceived level of risk to populations which occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily-available sources of population data. A primary objective of these reviews is to identify species which may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the 1996 *Status of Alberta Wildlife* review process, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are potentially at risk in the province (Red or Blue listed), that are of uncertain status (Status Undetermined), or which are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Wildlife Management Division of Alberta Environmental Protection, and are intended to provide detailed and up-to-date information which will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information which will assist the proposed Alberta Endangered Species Conservation Committee to identify species that may be formally designated as endangered or threatened under the Alberta Wildlife Act. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

The Northern Leopard Frog has been designated as a "Red List" species in Alberta since 1991. In January 1997 it was afforded with legal designation and protection as an "endangered" species under the provincial Wildlife Act.

The species was formerly widely distributed and locally abundant in the prairies, foothills and central parkland in the southern half of the province, but abrupt and dramatic population declines were noted in the late 1970s and early 1980s. Populations have remained at a low level since that time. The species now appears to be extirpated over most of central Alberta, and with the exception of one repatriated population, is apparently now absent from the entire North Saskatchewan River drainage. In southern Alberta, populations are absent or greatly reduced. Since 1981, the Northern Leopard Frog has been reported from 84 locations in the province, although evidence of breeding has only been reported from 27 sites, and only seven sites in southeastern Alberta are considered to support major breeding populations. The vast majority of these records have occurred since 1990. Monitoring data suggests that at least three of the major breeding populations are stable and reproducing successfully on an annual basis.

The cause(s) of population declines in Alberta is unknown. Although little studied, the decline in Alberta does not appear to be part of a regular cycle. Instead, it appears to be related to a singular, widespread factor affecting the survivorship of the species. The abrupt declines observed in Alberta appear to follow a similar pattern of sudden and massive declines witnessed in the upper mid-western states and prairie provinces during the 1970s.

Small population recoveries have been noted recently in Saskatchewan and Manitoba, providing promise that recoveries may also occur in Alberta. Re-establishment of populations in formerly occupied areas with suitable habitat may occur as a result of dispersal from the remaining populations in southern Alberta. However, our understanding of dispersal in the Northern Leopard Frog is limited and it is difficult to predict the extent to which recolonization will occur. In some instances frogs may have to be transplanted from existing populations in order to establish populations elsewhere. This may be particularly true for central Alberta, which is separated from the remaining populations in southern Alberta by vast stretches of arid land.

ACKNOWLEDGEMENTS

This report was prepared with the cooperation, input and assistance of a number of individuals and I would like to extend my appreciation to the following: Wayne Roberts (Museum of Zoology, University of Alberta, Edmonton) for fruitful discussion and for making available museum records; Andy Didiuk (Environment Canada, Saskatoon) for making available survey data from the Suffield National Wildlife Area; Carolyn and David Seburn (Seburn Ecological Services, Kemptville, ON) for providing references; Francis Cook (Canadian Museum of Nature, Ottawa) for reviewing museum records from northern Alberta; Cleve Wershler (Sweetgrass Consultants Ltd., Calgary) for providing background information and historic Leopard Frog observations; Tony Russell (University of Calgary), Mark Steinhilber (Provincial Museum of Alberta, Edmonton), and the Field Museum of Natural History (Chicago, IL) for making available museum records; Larry Powell (University of Calgary) for providing references and recent Leopard Frog observations; Stephen Corn (Aldo Leopold Research Institute, Missoula, MT) for providing references; Richard Lauzon (Axys Environmental Consulting Ltd., Calgary) and Mike Houser (Express Pipelines, Calgary) for provided recent Leopard Frog observations; Dave Elphinstone (Parks and Recreation, City of Calgary) for providing historic observation records; I. A. (Penny) Ohanjanian (Independent consultant, Kimberley, BC) for providing recent distributional information from British Columbia; Archie Balaski (Ducks Unlimited, Brooks) and Don Watson (Ducks Unlimited, Lethbridge) for providing information on management of Leopard Frogs at the Circle E project; and Kevin Wingert (Alberta Environmental Protection, Red Deer) for providing observational records from Bocquene Lake.

This report also benefited from review comments provided by Dave Prescott and Steve Brechtel (Alberta Environmental Protection, Edmonton), Cynthia Paszkowski (University of Alberta), Larry Powell and Andy Didiuk. I would like to thank Steve Brechtel and Dave Prescott for giving me the opportunity to work on this project, and Jane Horb for producing the maps.

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INTRODUCTION

Over the last 35 years, Northern Leopard Frog (Rana pipiens) populations have declined dramatically over much of the species' range in North America. Abrupt population declines were first noted in Alberta in 1979. Since then, populations appear to have been extirpated over much of central Alberta and are absent or greatly reduced in southern Alberta. Only a handful of viable breeding populations currently remain in south-eastern Alberta. Because of its virtual disappearance from the province, the Northern Leopard Frog has been designated as an "endangered species*" under the Alberta Wildlife Act.

Since 1990, considerable effort has been expended trying to locate Northern Leopard Frogs in Alberta. Known breeding populations have also been routinely monitored and studies have been carried out on two of the breeding populations to provide more information on dispersal and the general ecology of the species in the province. This information, as well as information from other jurisdictions, is reviewed in this report to provide an update on the status of the Northern Leopard Frog in Alberta.

HABITAT

The Northern Leopard Frog requires a mosaic of habitat types to meet the annual requirements of all life history stages. Generally, separate sites are used for breeding and overwintering. However, in some cases breeding and overwintering may occur in the same pond. This is particularly true in spring-fed wetlands. In Alberta, Northern Leopard Frogs are typically associated with clear water that is relatively fresh to moderately saline (Wershler 1992a). Other parameters of water quality, however, vary widely between sites (Seburn 1992a).

Breeding occurs in shallow and warm standing water associated with permanent and semi-permanent wetlands, springs, dugouts, borrow pits, lakes, beaverponds, and the backwaters and oxbows of rivers (Cook 1966, 1984, Cottonwood Consultants 1986, Hine et al. 1981, Merrell 1977, Roberts 1981, Wershler 1992a). Temporary ponds and shallow lakes that are unsuitable for fish, and that contain water until late July or August are considered to be the most favourable spawning sites for Northern Leopard Frogs (Hine et al. 1981, Merrell 1977, Roberts 1981). Most breeding ponds contain a mixture of open water and emergent vegetation. Although at some sites in Alberta, breeding ponds are totally encompassed by emergent vegetation (Wershler 1992a). Leopard Frog tadpoles are generally poorly adapted to cope with currents and thus can develop successfully only in slow reaches of streams or backwaters (Roberts 1981). In Minnesota, Leopard Frog densities were lower in stream habitats relative to ponds (Merrell 1977).

Following breeding and transformation, adult, juvenile and young-of-the-year frogs move to summer feeding areas. Most often, these areas are located along the margins of waterbodies (Hine et al. 1981, Merrell 1977, Wershler 1991a). Smaller, immature frogs appear to be more closely tied to water; adults will occasionally venture some distance from water in the summer (Dole 1965b, Merrell 1977, C. Seburn 1994, Wershler 1991a). This difference may be related to the greater surface-area-to-volume ratio of smaller frogs,

* See Appendix 1 for definitions of selected status designations

which makes them more prone to desiccation (C. Seburn 1994).

Preferred summer feeding habitat generally consists of open and semi-open areas with shorter vegetation (Cottonwood Consultants 1986, Dole 1965a,b, Merrell 1977, Wershler 1992a). Areas lacking vegetation or with closely-clipped vegetation, such as found on heavily-grazed pasture, are avoided by frogs. Areas with tall, dense marsh vegetation, grasses or extensive shrub cover are also avoided, particularly by smaller frogs. Merrell (1977) notes that "in tall grass the frogs are less able to capture insects which tend to be out of their reach". Merrell (1977) also noted that Northern Leopard Frogs were seldom found in heavily-wooded areas away from water. Seburn (1994), however, found no difference in the density of frogs occupying wooded versus non-wooded habitats in the Cypress Hills of southeastern Alberta.

Unlike most of Alberta's other species of amphibians, Northern Leopard Frogs overwinter in water (Russell and Bauer 1993). Overwintering frogs require well-oxygenated water that does not freeze to the bottom during the winter. Hibernacula are most often located in springs, streams, spillways below dams, or in deeper lakes and ponds (Cunjak 1986, Emery et al. 1972, Merrell 1977, Roberts 1981). Frogs have been found hibernating under rocks, logs, leaf litter or vegetation, or in depressions in sand or mud. Shallow breeding ponds and lakes are unsuitable for overwintering because of the depletion of oxygen in the water column, which can lead to winterkill (see Babin and Prepas 1985). In southern Alberta, springs appear to provide critical overwintering habitat during periods of drought when deeper permanent water sources become limited (Wershler 1991a).

CONSERVATION BIOLOGY

Northern Leopard Frogs emerge from overwintering sites shortly after the ice begins to melt and narrow strips of open, warmer water form along the shoreline. Increasing temperature probably acts as a stimulus, causing hibernating frogs to become more active and to move from deeper overwintering areas to shallow water areas along the shore (Merrell 1977). Pace (1974) noted that migration from overwintering sites begins when water temperatures reach 9 to 12^{o}C. Merrell (1977) observed that frogs did not leave the hibernacula until the air temperature exceeded 13^{o}C, or rose above the temperature of the water. Short overland migrations may be made between overwintering sites and breeding ponds. In some instances, breeding may also occur in overwintering habitats.

The timing and duration of breeding also appears to be temperature dependent. In Alberta, breeding occurs from late April to late June and breeding behaviour may occur while ice is still on ponds (Wershler 1992a). Yaremko (1994) observed males calling in early May in southern Alberta when the air temperature was 17.3^{o}C and the water temperature was 14.8^{o}C. Cooler air temperatures can suppress breeding activity, resulting in two or more mating periods and several size classes of larvae (Hine et al. 1981, Merrell 1977).

Sexually-mature males arrive at the breeding pond first and call while floating on the surface of the water. Males typically congregate in small groups in the warmest parts of the breeding ponds. Sexually-mature females are attracted to the calling of the males and arrive within a few days to a few weeks after the males (Hine et al. 1981). Egg laying occurs shortly thereafter. Egg masses are typically laid in shallow water on

vegetation, branches, and, rarely, on the pond bottom (Corn and Vivo 1989, Hine et al. 1981, Merrell 1977, Seburn 1992a, 1993, Yaremko 1994).

Females are believed to produce only one clutch per year (Corn and Livo 1989) and it is thought that all eggs are laid in one mass (Noble and Aronson 1942). Egg masses may contain between 600 and 7,000 eggs (see Corn and Livo 1989). Female body size has been positively correlated with clutch size in most anurans (Slathe and Duellman 1973 cited in Corn and Livo 1989) and Corn and Livo (1989) suggest that the frequency distribution of the number of eggs in clutches could be used as a method to determine age structure of breeding females in Northern Leopard Frog populations.

The time of hatching is variable and is also dependent on water temperature (Russell and Bauer 1993). Hine et al. (1981) observed hatching five to nine days after egg laying. Cool weather, however can extend hatching to 14 days or more after egg laying (Hine et al. 1981). Merrell (1977) found that hatching success was greater in egg masses located below the surface of the water relative to egg masses laid on the surface. In Wisconsin, about five percent of the eggs in each egg mass were lost to parasites, disease or other factors (Hine et al. 1981). Within a pond, Corn and Livo (1989) reported hatching success of between 70 and 99 %, although hatching success of individual egg masses was as low as 30 %. They also note that factors such as flooding, droughts or periods of cold temperatures can produce high mortality of eggs, including failure of entire clutches.

Tadpoles remain close to egg masses after hatching but disperse after a few days (Eddy 1976). Time to metamorphosis is temperature, and, perhaps, density dependent (Seburn 1993), ranging from 60 to 90 days and may occur over several weeks at a single site. Survivorship, from total egg to metamorphosed young, averaged three percent in Minnesota (Merrell 1977) and from one to six percent in Wisconsin (Hine et al. 1981). Mortality, however, can be complete if breeding ponds dry up before tadpoles become fully transformed (Hine et al. 1981, Merrell 1977). Seburn (1993) also observed that cool weather delayed the development of tadpoles well into September in the Cypress Hills of Alberta. She felt that these frogs would not survive because of the lack of time for them to gain nutrient reserves before the onset of winter. In Alberta, tranformation generally occurs in July and early August (Seburn 1992a, 1993, Wershler 1991a, Yaremko 1994).

Tadpoles feed on floating vegetation and detritus. At metamorphosis, frogs become carnivorous, taking only moving prey. Their diet includes insects, arachnids and other small invertebrates as well as small birds, garter snakes, frogs and fish (Hine et al. 1981, Moore and Strickland 1954, Rittschof 1975, Russell and Bauer 1993). Adults will also cannibilize newly-transformed young (Russell and Bauer 1993, Wershler 1992a).

Individuals take two or more years to become sexually mature. However, in Minnesota it was shown that in less dense populations young frogs grew rapidly and sexual maturity was reached in one year (Merrell 1977). In denser populations, growth during the first summer was minimal and young frogs may have taken three years to reach sexual maturity (Merrell 1977).

Annual adult mortality has been estimated to be approximately 60 % (Merrell and Rodell 1968). In Manitoba, frogs decreased in relative abundance in the population toward

the end of their fourth summer (Eddy 1976). Mortality rates of immature frogs are relatively high. The ratio of young-of-the-year (YOY) frogs to sexually mature frogs ranged from about 15:1 to 20:1 in Minnesota (Merrell 1977). Similar values were reported in Wisconsin (Hine et al. 1981). In Alberta, C. Seburn (1994) observed ratios of approximately 120:1 in a breeding population in the Cypress Hills. In 1994, overwintering mortality of YOY frogs in this same population was estimated at 93 % (Yaremko 1994). This estimate may, however be high because it was based on the assumption that there was little dispersal from natal areas (C. Paszkowski, pers. comm.).

Following breeding, adults may remain in the vicinity of breeding ponds or disperse to summer feeding ranges (Eddy 1975, Hine et al. 1981, Merrell 1977, Seburn 1993). Usually these feeding ranges are located near water. Adults appear to establish home ranges in the summer (Dole 1965a,b, Hine et al. 1981). In Michigan, home ranges tended to be smaller in areas where habitat was localized and limited relative to areas where habitat was more readily available (Dole 1965b). In late summer or early fall, adults begin to migrate from summer feeding areas to overwintering sites (Eddy 1975, Merrell 1977). Roberts (1981) reports that Northern Leopard Frogs are active in Alberta until October, and exceptionally into November. Little is known about the overwintering ecology of Northern Leopard Frogs.

Following transformation, young-of-the-year frogs disperse away from natal ponds. In Michigan, Dole (1971) found that YOY frogs disperse up to 800 m per night, and recaptured two as adults five kilometers from their natal pond. Dole noted that this distance could have only been travelled overland. In the Cypress Hills, YOY frogs dispersed up to 2.1 km from natal ponds along aquatic corridors (Seburn et al., in press). However, the greatest distance travelled over land was 0.4 km. One of the frogs marked as a YOY in the Cypress Hills in 1993 was recaptured in 1994 at a distance of 8 km from the natal pond.

DISTRIBUTION

1. Alberta. - Northern Leopard Frog populations experienced drastic declines in Alberta near the end of the 1970s (see "Population Size and Trends"). Such declines in population were accompanied by changes in distribution in the province. Accordingly, descriptions of the distribution of Northern Leopard Frogs in Alberta are divided into "historic" and "current", based on whether observations were collected before and during, or after, 1980.

Many authors (Cook 1984, Schueler 1982, Stebbins 1951, Wright and Wright 1949) have shown the historic distribution of the Northern Leopard Frog to be continuous in Alberta, with the range including most of southern Alberta and a band running along the eastern border of the province north to the Northwest Territories. However, a review of museum collections (Appendix 2), and naturalists' records and published sources of information (Appendix 3) suggests that the species' range was largely restricted to two discontinuous parts of the province (Figure 1). These two areas include the Slave River valley and Kazan Uplands in extreme northeastern Alberta and the prairies, parkland and foothills of southern Alberta.

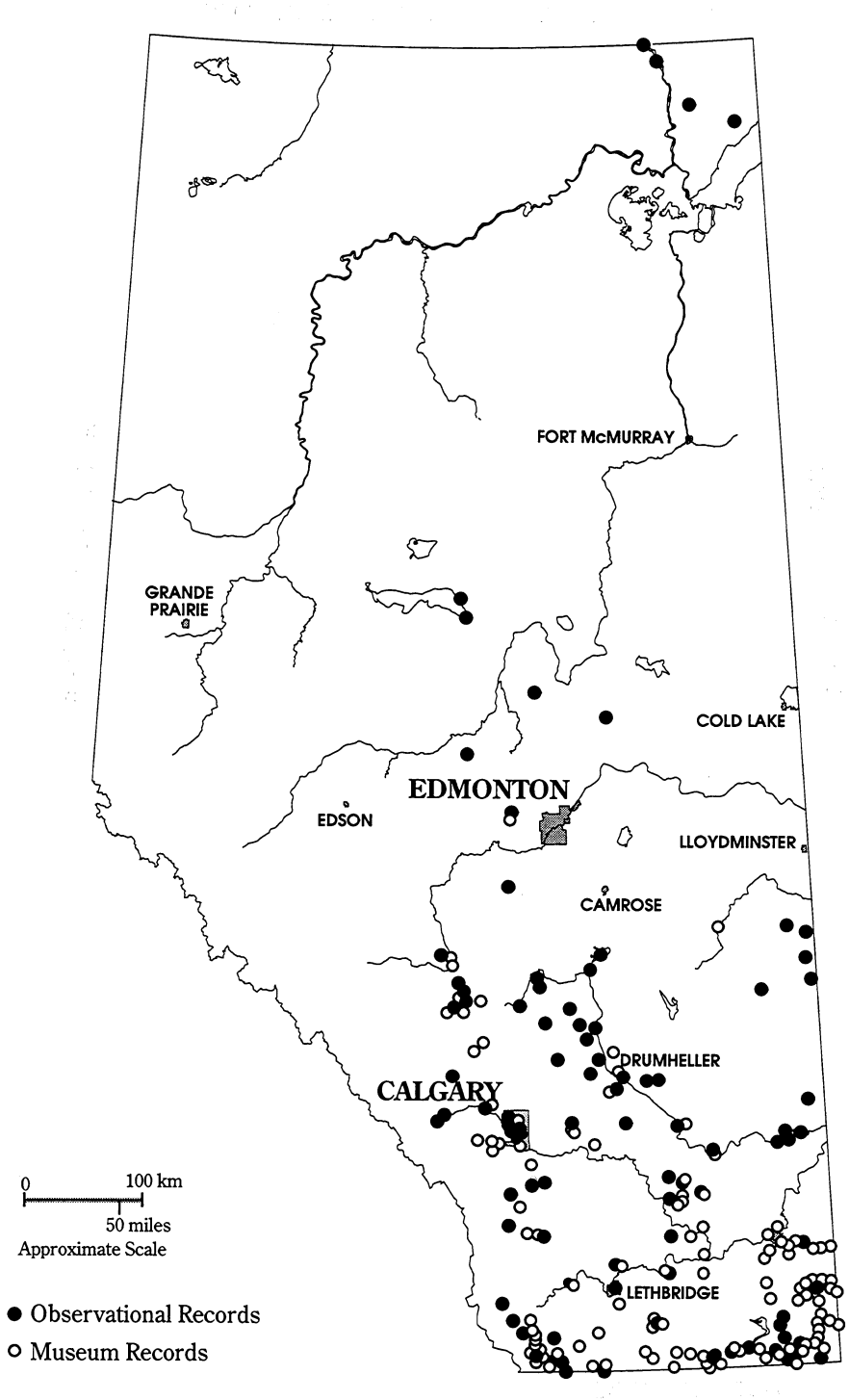

Figure 1. Known observation and collection sites for Northern Leopard Frogs in Alberta prior to 1981. See Appendices 2 and 3 for descriptions of sites.

The occurrence of the species in northeastern Alberta is based on published accounts from the Slave River at Fitzgerald Settlement (Smith Landing) and Fort Smith near the turn of century (Preble 1908). Other records also exist from nearby sites in Saskatchewan and the Northwest Territories (Harper 1931a, Hodge 1976, Logier and Toner 1961, Museum of Zoology, University of Alberta, unpubl. data). There is also a museum specimen from the Rocher River at the western end of Lake Athabasca (Appendix 2 - specimen NMC593), but it is likely that catalogue information for the specimen is in error. This specimen was collected by F. Harper, but he does not mention the specimen in subsequent reports about his trips in the area (Harper 1931a,b). The collection date for the specimen, 5 August 1914, also corresponds to the date that Northern Leopard Frogs were collected at the Natla Rapids on the Talston River, Northwest Territories (Harper 1931a). Considering these factors, it is likely that the specimen was actually collected at the Talston River and not at the Rocher River (F. Cook pers. comm.).

In the southern half of the province, the species' range extended across the prairies, foothills and parkland from the U.S. border north to Edmonton. Within this region, the Northern Leopard Frog was continuously distributed along major rivers and tributaries with scattered populations associated with lakes, springs and irrigation reservoirs. Although the species appears to have been widely distributed in the western half of the central parkland, there are only a handful of records from the eastern portion of the parkland north of the Battle River (Figure 1).

In southern Alberta, the western extent of the range was the foothills and the eastern periphery of the Rockies at lower elevations. There are records from the northeastern and eastern edges of Waterton Lakes National Park and from the Bow Valley corridor near Bow Valley Provincial Park and the Yamnuska Centre (Appendix 2 and 3, Salt 1977). Historic records from the mountains are lacking (Bow Valley Naturalists 1978, Holroyd and Van Tighem 1983, McIvor 1994, McIvor and McIvor 1995, 1996 - Banff National Park and Bow Valley Corridor; Holroyd and Van Tighem 1983 - Jasper National Park; C. Wershler pers. comm. - Waterton Lakes National Park; Salt 1977 - Kananaskis Country) and Salt (1979) considered the species to be of "hypothetical" occurrence in Alberta's Rockies. It should be noted, however, that many of the amphibian surveys from the Rocky Mountains were conducted after abrupt population declines were observed elsewhere in the province. Salt (1979) also mentions a museum specimen collected near Jasper, but that record could not be located during research conducted for this paper.

Outside of the extreme northeastern corner of Alberta, there are few historical records from north of Edmonton and Russell and Bauer (1993) indicate that "the true distribution north of 55^{o}N is poorly known". It should be noted, however, that the National Museum of Canada and the University of Alberta (in 1976, W. Roberts, pers. comm.) have both made extensive amphibian collections in northern Alberta, but have not encountered Northern Leopard Frogs. In some areas, extensive biophysical surveys have also failed to locate the species (e.g. Roberts and Lewin 1979). Although information on the historic distribution of herpetofauna in northern Alberta is largely lacking, the data that does exist suggests that the Northern Leopard was only locally and sparsely distributed in the boreal forest.

North of Edmonton, museum specimens have been collected at Valleyview, Whitecourt and at sites along the Smoky River that were initially identified as Northern Leopard Frogs (Appendix 2). These specimens are of tadpoles, which can be difficult to identify. A recent preliminary examination of the specimens indicates that they may have been misidentified (F. Cook, pers. comm.). Until further confirmation, these records must be considered dubious. There is also a specimen record (USNM 9343) from the late 1880s with the site locality of "Athabaska River, British America R." (Yarrow 1882, pg. 179; Cope 1889, pg. 403). The exact location of this record is, however, difficult to pinpoint. Northern Leopard Frogs have also been observed along the Lesser Slave River (Wershler 1991a), at Lesser Slave Lake Provincial Park (Griffiths 1976 cited in Bradley 1980), and at Thunder Lake, Long Lake and Cross Lake Provincial Parks (Spalding 1980, Wershler 1991a). It should be noted, however that Griffiths does not mention Northern Leopard Frogs in her account of the wildlife of Lesser Slave Lake Provincial Park presented in Spalding (1980). The Fort Smith site location shown in Cottonwood Consultants Ltd. (1986), Alberta Fish and Wildlife (1991) and Wershler (1991a) is based on an unconfirmed sightings reported to Roberts and Lewin (1977).

Since 1980, there has been a southern contraction of the provincial range of the Northern Leopard Frog, and the species now appears to be largely extirpated from the central parkland, and is apparently absent from the entire North Saskatchewan River drainage (Figure 2). With the exception of the Kazan Uplands in northeastern Alberta, where there were observational records from Bocquene Lake in 1991 (K. Wingert, pers. comm.) and from Wylie Lake in 1983 (Wallis and Wershler 1983), there have been no observations of Northern Leopard Frogs north of the Red Deer region since 1979.

In 1990 and 1991, extensive presence/absence surveys were conducted at sites in southern Alberta where Northern Leopard Frogs were known to occur historically, or where there had been recent unconfirmed sightings of the species (Hofman 1991, Seburn 1992a, Wershler 1991a, 1992a). These surveys revealed that Leopard Frog populations were locally abundant at three sites in the Cypress Hills, along the Milk and South Saskatchewan rivers, along the lower reaches of the Bow and Red Deer rivers, and at sites along the Little Bow River, and Canal and Manyberries creeks (Figure 2). Leopard Frogs were also found to be present at a few sites in the central parkland near Red Deer (Figure 2). Population surveys conducted at the proposed Suffield National Wildlife Area from 1994 to 1996 located additional populations along the South Saskatchewan River (A. Didiuk, pers. comm.). Since 1990, additional populations have also been discovered along Willow Creek (D. A. Westworth and Associates 1993), along the Red Deer (R. Lauzon, pers. comm.), Milk (L. Powell, pers. comm., Wershler and Smith 1996) and Sheep (Alberta Amphibian Monitoring Program, unpubl. data) rivers, and along an irrigation drainage near Bow City (pers. obs.).

In total, Northern Leopard Frogs have been observed at 84 locations since 1981 (with the vast majority occurring since 1990; Figure 2, Appendix 4), but direct (tadpoles or developing or recently transformed young) or indirect (calling males) evidence of breeding has been reported from only 27 sites in the province (Figure 2, Appendix 4). Only seven of these sites appear to be of major breeding populations (>100 young-of-the-year

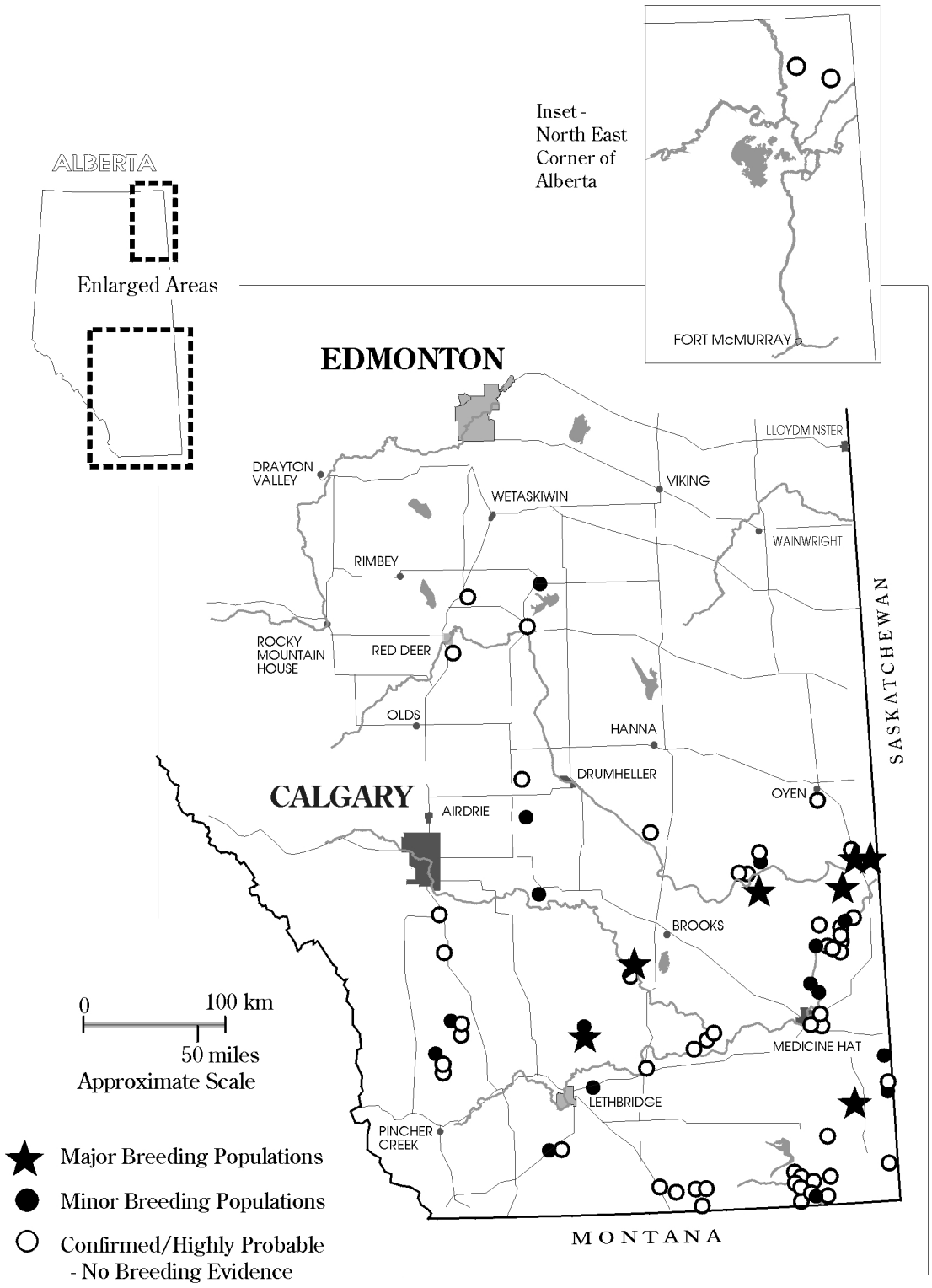

Figure 2. Known site records for Northern Leopard Frogs in Alberta since 1981. Detailed descriptions of observations are given in Appendix 4.

observed; Figure 2, Appendix 4). These populations are located at Bow City, Empress Creek, Jenner Pond, Kennedy's Coulee, Little Bow River, Prince's Spring (near Bindloss), and Sexton Creek (Cypress Hills).

2. Continental Range. **-** The Northern Leopard Frog is widely distributed over much of central North America (Figure 3), and with the exception of range contractions resulting from local extirpations of breeding populations (particularly in western North America), the current and historical ranges are generally similar. The species is broadly distributed across the southern half of Canada east of the Rockies. The range extends as far north as south-central Northwest Territories, and a disjunct population occurs in southern Labrador (Cook 1984). In eastern British Columbia, the Northern Leopard Frog occurs in the Kootenay and Columbia river valleys and in the vicinity of Creston at the southern end of Kootenay Lake (Orchard 1992). The species has also been successfully introduced on Vancouver Island and Newfoundland (Cook 1984, Green 1978).

In the United States, the species' range extends from the Canadian border south along eastern Washington and Oregon to California, Arizona and extreme southern New Mexico and then north into the northern plains states, and east through the Ohio Valley to New England (Baxter and Stone 1980, Russell and Bauer 1993, Stebbins 1951).

POPULATION SIZE AND TRENDS

1. Alberta. - Until recently, the herpetofauna of Alberta has received little attention from either scientists or naturalists (Russell and Bauer 1993, Wershler 1991a). The Northern Leopard Frog is no exception. Population surveys were not conducted before the 1980s, and there is little formal documentation of historic population levels in the province. Much of our understanding of the historic distribution and abundance of the species is based on biophysical inventories in specific areas of the province, museum collections, and the records and recollections of naturalists. These sources indicate, however, that Northern Leopard Frogs were historically common and widely distributed south of Edmonton, south and west of the Battle River (Cottonwood Consultants 1986, Roberts 1981, 1987, 1992, Russell and Bauer 1993, Wershler 1991a). Documented reports indicate that the species was common in southeastern Alberta (Lewin 1963), along the Milk River valley (Wallis 1976), in the Cypress Hills (Halladay 1965), at several natural areas in Calgary (Bird 1973, 1974, Pinel 1980), south and west of Red Deer along the Raven and Red Deer rivers and Kneehill Creek (Roberts 1981), and along Kilini Creek west of Edmonton (W. Roberts pers. comm., Spalding 1980). Specimen records of the National Museum of Canada and Museum of Zoology, University of Alberta, also reveal that Leopard Frogs could readily be collected at a number of locations in small geographical areas in the prairies and foothills of southern Alberta during the 1950s and 1960s. Extensive field surveys conducted in southern Alberta in the 1970s indicate, however, that relative to the Striped Chorus Frog (Pseudacris triseriata), Leopard Frogs were only locally abundant (Wershler 1991a). This is no doubt related to the species' need for well-oxygenated overwintering sites (Lewin 1963). In summary, although quantitative survey data are lacking, the information that does exist indicates that Northern Leopard Frogs were historically widely distributed but locally abundant south of Edmonton, and south and west of the Battle River.

Figure 3. North American range of the Northern Leopard Frog (adapted from Stebbins 1985).

In Alberta, abrupt population declines were first noted south and west of Red Deer in 1979 (Roberts 1981). Between 1976 and 1978, Northern Leopard Frogs were abundant at sites along Kneehill Creek, along the Raven and Clearwater rivers, and along the upper and middle reaches of the Red Deer River, and populations were reproducing successfully (Roberts 1981). However, extensive searching in the area in 1979 and 1980 failed to locate any Leopard Frogs (Roberts 1981), and ongoing annual surveys have not yielded subsequent records in these areas (Roberts 1987, 1992, 1995, pers. comm.). A similar pattern has been noted in Calgary, where annual monitoring of natural areas within the city by the Calgary Field Naturalists Society has not produced records of Northern Leopard Frogs since the late 1970s (M. Babey, pers. comm.). In 1979, extensive searches were also conducted at other sites where Leopard Frogs had been known to occur but only one individual was found overwintering in the Milk River (Wershler 1991a). At the same time, naturalists, scientists, fishermen and farmers in southern Alberta were queried as to whether they had seen any Leopard Frogs. These enquiries yielded no recent records, although many of the people recalled that the species was previously abundant in many areas (Roberts 1987).

It is unknown when population declines first occurred in other parts of southern Alberta, but declines appear to have been complete in many areas by at least the early- to mid-1980s (Cottonwood Consultants 1986, Roberts 1981, 1987, Wershler 1991a). Between 1979 and 1989 there were few reports of Northern Leopard Frogs from anywhere in the province. In the early 1980s, naturalists were asked to increase their surveillance of reptile and amphibian populations in Alberta (Roberts 1981, 1982), but few reports of Leopard Frogs resulted. Many of the reports that did come in turned out to be other species (Wershler 1991a). Field surveys conducted in southern Alberta in the early and mid-1980s revealed that Leopard Frogs were absent from many historically-occupied sites and, where they did exist, populations were greatly reduced from historic levels (Cottonwood Consultants 1986, Roberts 1987, Wershler 1991a). These surveys located a few individuals along the St. Mary's River and Pinepound Creek, and locally-abundant populations at Prince's Spring (near Bindloss), along the Milk River and along the lower Bow River (Cottonwood Consultants 1986, Roberts 1987, Wershler 1991a).

Populations at Prince's Spring, Sexton Creek and Empress Creek have been monitored since 1990 (Table 1). Censusing amphibian populations can be problematic and populations can fluctuate widely between years (Pechmann et al. 1991), so caution must be exercised when comparing population trends between sites and between years. Nonetheless, the available data indicates that the breeding populations at these three sites are stable and reproducing successfully on an annual basis.

It should be cautioned that data limitations make it somewhat difficult to identify long-term population trends in the province. At some locations there are long-term, qualitative data that indicate dramatic population declines have occurred over the last 20 years. However, elsewhere in southern Alberta population trends have largely been determined from presence/absence surveys conducted in 1990 and 1991 at locations where historic occurrence was recorded from museum specimens, naturalists' records or published accounts in the literature (Hofman 1991, Seburn 1992a, Wershler 1991a, 1992a).

Table 1. Northern Leopard Frog census results from Prince's Spring, Empress, and Sexton Creek populations. Numbers for Prince's Spring are maximum individuals observed; values for other populations are maximum linear density per 100 m (unless otherwise noted).

	Prince's Spring		Empress		Sexton Creek (Upper Marsh)		Sexton Creek (Lower Marsh)	
Year	Adults	YOY	Adults	YOY	Adults	YOY	Adults	YOY
1990	5	>272	-	-	2	62	16	594
1991	0	>388	9	397(a)	6	9	21	629
1992	3	213-245	8	62	28	162	28	276
1993	12	>300	12	191	7	676(a)	11	28
1994	>12	>119	8	109	9	441	12	496
1995	17	>74	-	-	-		-	-

Sources: Prince's Spring - Hofman 1992, 1994a, b, 1995, Wershler 1991b, 1992b; Empress - Seburn 1992a, 1993, 1994, Yaremko 1994; Sexton Creek - Seburn 1992a, 1993, 1994, Wershler 1991a, Yaremko 1994.
(a) Minimum estimate based on mark-recapture census

Because of time constraints and the large geographic area surveyed, many of the locations surveyed were visited on only one occasion and many of the sites were visited outside of the breeding season. Repeat visits were generally only made to sites where evidence of breeding was found on the initial site visit or from other earlier surveys of the site. Corn (1994) notes that there can be some problems with using such surveys to determine long-term population trends. First, single site visits may fail to detect individuals that are actually present, which would result in an overestimation of population declines (Corn 1994). For example, during the breeding season Northern Leopard Frogs may not call on certain day or at certain times of the day (Cook 1994) and breeding populations may go undetected during brief, single call surveys at a site. After the breeding season, adults may also be difficult to find because of dispersal away from breeding ponds (Corn 1994). Second, the use of museum, naturalists' and published records may not provide an accurate baseline of historic population levels, and may ignore population trends resulting from the natural processes of local extinction and recolonization (Corn 1994). This is particularly true if records are combined over several decades. Furthermore, museum records and anecdotal accounts do not always represent breeding populations, or they may represent records from marginal habitats where breeding may occur but is rarely successful (Corn 1994).

Giving due consideration to data limitations, it is still apparent that Northern Leopard Frog populations have declined dramatically in southern and central Alberta over the last twenty years. Within the central parkland, declines occurred abruptly in 1979 (Roberts

1981).

2. Other Areas. - Northern Leopard Frogs have long been used as laboratory and research animals in North America and wild frogs have traditionally supplied this market. Beginning in the early 1960s, harvesters for biological supply houses noted sudden and dramatic declines in leopard frog numbers in many localities in the midwestern U. S. and California (Gibbs et al. 1971, Hine et al. 1975). Biological supply houses also observed a general decline in the health of the animals (Gibbs et al. 1971, Hine et al. 1975). Frogs often died in holding tanks before they could be shipped to customers, and it was not uncommon for 50 to 90 % of the frogs to die from a septicemia resulting from overwhelming infection with the bacteria Aeromona hydrophila. This was not surprising as most frogs were placed under a great deal of stress between the time of capture and delivery to end users, and were probably very susceptible to disease (Gibbs et al. 1971). Approximately five to 10 % of the frogs caught in the northeastern and north-central United States also had kidney tumours (Gibbs et al 1971). Based on the difficulty of obtaining frogs for laboratory use and reports of frog declines from harvesters, Gibbs et al. (1971) estimated that Northern Leopard Frog populations declined by 50 % in the U. S. during the 1960s. They blamed the decline on overzealous harvesting and habitat loss.

The abrupt and widespread population declines previously described for Alberta appear to have been parallelled over much of the species' range in the upper midwestern states and prairie provinces during the 1970s. The initial declines were noted in centres of high frog densities in the upper midwest states, most notably in Michigan, Minnesota, Wisconsin and South Dakota in the late 1960s and early 1970s (Hine et al. 1975, 1981, Rittschof 1975) The die-off spread rapidly and, within a year or two, declines of Northern Leopard Frogs and other related species of Leopard Frog were noted as far south as Mexico (Koonz 1992).

Abrupt population declines occurred shortly afterward in Manitoba (Hine et al. 1981, Koonz 1992, Wershler 1991a). Traditionally, the Northern Leopard Frog harvest in Manitoba has made up a large portion of the North American market, with as much as 50,000 kg of frogs being shipped annually to biological supply houses in the U.S. (Koonz 1992). By 1976, however, no exports were made, as Northern Leopard Frogs had virtually disappeared from the province, particularly from areas such as Lake Manitoba, that formerly supported the greatest densities of frogs (Koonz 1992). Windrows of dead frogs were observed on shorelines along Lake Manitoba and piles nearly a metre high were noted in artesian wells ("frog holes") used as hibernacula. Small, isolated populations (e.g., on golf courses, stock ponds and islands) survived through to 1983, when some recovery was noted and exports resumed at much reduced levels (Koonz 1992). Since then, Northern Leopard Frog populations have increased in some areas while remaining extremely low in others (Koonz 1992). The species has not reoccupied frog holes, and appears to be only slowly occupying what were once major centres of population. Although Northern Leopard Frogs have moved back into much of their traditional range, they have not approached historic population densities. Habitats once supporting the highest frog densities continue to show considerable population fluctuations (Koonz 1992).

From Manitoba, the die-offs apparently spread westward. As in Alberta, there is little data on

the historic distribution and abundance of Northern Leopard Frogs in Saskatchewan. However, available data suggest that population levels reached a low in the early to mid-1970s (Seburn 1992b). Over the last five years there has been an increased number of reports in the province, which suggests that the species may be increasing locally (A. Didiuk, pers. comm.). In many areas, however, population densities are still low relative to historic levels (W. Harris, pers. comm.). It should also be noted that increased reporting in recent years may also be related to increased interest in the species brought about by the establishment of the Saskatchewan Amphibian Monitoring Project and Saskatchewan Herpetology Atlas Project. Major populations increases have been noted recently in some areas of the province. In the late 1980s, for example, Northern Leopard Frogs were difficult to find in Grasslands National Park (W. Harris, pers. comm.). However, in 1991 the species was found to be common in many areas of the park (W. Roberts, pers. comm.) and in 1995 and 1996, it was observed to be common along both the Frenchman River valley and along Rock Creek (L. Powell, pers. comm.). Various age classes, including a large number of adults were recorded during the 1995 and 1996 surveys.

Recent population surveys have been conducted over much of the historic range of the Northern Leopard Frog in the Kootenay and Columbia river valleys of southeastern British Columbia (Ohanjanian and Teske 1996, I. Ohanjanian, pers. comm., Orchard 1992). Frogs, however, have only been found near Creston (I. Ohanjanian, pers. comm., Orchard 1992). The exact timing of the declines in British Columbia is unknown, but they appear to have occurred over the last 10 to 15 years (Orchard 1992). The cause of the decline is unknown, but in some areas it may be related to habitat loss (Orchard 1992).

Population declines have been reported from a variety of other jurisdictions in the western U.S. As was the case in Alberta, most populations have been poorly studied and there is lack of historical data. Most declines have also been noted after the fact, so attributed causes for the declines have been based more on correlative rather than experimental evidence (Corn 1994). To date, researchers have not linked the declines observed in the western U.S. with the abrupt and widespread population die-offs observed in the upper midwestern states and prairie provinces during the 1970s.

The Northern Leopard Frog was formerly widely distributed across Montana, but is now apparently absent over much of the western half of the state (Reichel and Flath 1995). The species is still common in the southeastern corner of the state, but its status is uncertain in central and northeastern Montana (Reichel and Flath 1995). Population declines appear to have occurred over the last 10 to 15 years. Elsewhere in the western U. S., declines have been noted in eastern Washington (Andelman and McAllister 1994, Koch et al. 1996, Leonard and McAllister 1996), eastern Oregon and southern Idaho (Koch et al. 1996), Colorado and Wyoming (Baxter and Stone 1980, Corn and Fogleman 1984, Corn et al. 1989, Hammerson 1982, Weise 1990), Nevada (Panik and Barrett 1994), and Arizona and California (Clarkson and Rorabough 1989, Fernandez and Bagnara 1995, Hayes and Jennings 1986, Schwalbe and Rosen 1988, Sredl and Waters 1995).

Recent major populations declines have not been noted in eastern Canada (Bishop and Petit 1992), but Gilbert et al. (1994) note that local population declines have occurred in Quebec because of habitat loss.

LIMITING FACTORS

Over the last 30 to 50 years, amphibian populations have declined dramatically and around the globe, a relatively large number of species are in jeopardy (Barinaga 1990, Blaustein and Wake 1990, Wyman 1990). This is true of many species found in Canada (Bishop and Petit 1992, Cook 1970, Quinn 1991), including the Northern Leopard Frog. In this, and other, species, declines can often be explained in relation to natural population fluctuations (Pechmann et al. 1991), extremes in climatic conditions (Barinaga 1990) or anthropogenic factors such as habitat loss, acidification, contaminant releases and the introduction of non-native species (Baringa 1990). However, in many other cases the declines cannot be explained and have occurred in relatively pristine environments or in areas where there has been no recent obvious disturbance. Such declines are often characterized by abrupt, massive and widespread population declines of one or more species. At the same time, populations of other amphibian species occupying the same area and similar habitats show no signs of decline.

In the past few years, comprehensive research and monitoring programs have been initiated world-wide to determine the extent and cause(s) of amphibian declines. Among the factors being examined are disease, the reduction in the ozone layer and accompanying increase in ultraviolet radiation, changing weather patterns and climatic extremes, acid rain and chemical contaminants, the introduction of exotic species, and habitat loss or fragmentation. The following sections outline factors which may be applicable to declines in Northern Leopard Frog populations in Alberta. Although the focus of this section is on human-induced factors, a number of naturally-occurring factors are also included because of their possible synergistic impacts with other factors.

1. Climate. - Climatic conditions have a major influence on Northern Leopard Frog populations (Merrell 1977). In general, during wet years there will be increase in the amount of breeding and overwintering habitat allowing populations to expand and providing opportunities for dispersal and colonization of unoccupied areas of suitable habitat. In drier years, available habitat will diminish causing a reduction in population levels. Some local populations will also become extinct because of a lack of habitat. For example, drought in the 1930s caused a general decline in amphibian populations in southern Alberta (Fowler 1935). Drought has been suggested as a possible reason for the decline and disappearance of Northern Leopard Frog populations in Washington, Oregon, Idaho, Montana and Colorado (Corn and Fogelman 1984, Koch et al. 1996).

During the late 1970s and 1980s, drought conditions prevailed over much of southern Alberta. The accompanying loss of wetland habitat probably caused general population declines and the extinction of some local populations in that area during this period (Wershler 1991a). Drought, however, has been dismissed as the cause of the abrupt and widespread population declines observed in southern Alberta since 1979 (Roberts 1981, 1987, 1992, Wershler 1991a). These authors argue that while reduction in wetland habitat and reduced winter stream flows might explain the disappearance of frogs in some areas, it would not explain the simultaneous disappearance of frogs in spring-rich areas such as along Kilini Creek and the Clearwater River or at deep-water overwintering sites at major lakes and reservoirs. These assertions, however are based on limited data and there is

the need for further research to determine the extent to which Northern Leopard Frog populations are affected by climatic conditions in southern Alberta.

2. Disease. - Mass mortality of amphibians from disease is not uncommon and may be a natural feature of the biology of a species, or it may be induced by environmental stressors (Corn 1994, Crawshaw 1992). Amphibians are known to be susceptible to a variety of diseases including many diseases of fish (Crawshaw 1992). Mortality in Northern Leopard Frogs has often been associated with the condition of "red leg" (Gibbs et al. 1971, Hine et al. 1981, Koonz 1992), which is not a disease itself but rather a condition of kidney failure (Koonz 1992). It is often associated with infection by Aeromona hydrophila, a naturally-occurring and widespread bacterium. Ordinarily, this pathogen only affects individuals whose immune systems have been weakened by stress, and not entire populations. Overwintering mortality in Northern Leopard Frogs has also been attributed to a herpesvirus (Lucke tumour virus) that causes renal carcinomas (Hunter et al. 1989, McKinnel 1973, 1980).

Roberts (1995) suggests that the pattern of decline observed in the upper midwestern states and the prairie provinces "was like that expected if a plague started in the east and spread across the continent". However, there is little conclusive evidence that disease was responsible for the abrupt and dramatic population declines observed in Alberta and elsewhere (Hine et al. 1981). The lack of calling males in the Red Deer area during the spring of 1979 suggests that mortality occurred in the fall or winter (Roberts 1981). This is similar to the pattern of mortality observed in Wisconsin (Hine et al. 1981). Incidences of overwintering mortality were noted in the Clearwater River in 1976 (Roberts 1992). Similar to other locations, mortality in the Clearwater River was associated with the condition of "red leg". In this case, however, only individuals were affected and healthy populations persisted in the area for the next two years.

3. Habitat Loss and Fragmentation. - Habitat loss and fragmentation can impact Leopard Frog populations at two levels. Locally, populations are dependent on a variety of habitat types to meet the annual requirements of various life history stages (Merrell 1977). The loss of any one of these habitats or the impairment of movement between habitat types could result in the demise of the entire population. Relative to many other amphibians, this requirement for a seasonal mosaic of habitat types makes Northern Leopard Frogs particularly vulnerable to habitat loss or alteration. On a regional basis, many amphibian populations exist as metapopulations, represented by a set of linked but geographically discrete local populations occupying suitable habitats (see Blaustein et al. 1994). Local populations will fluctuate because of environmental factors and natural stochastic mechanisms and local extinctions may occur. But regionally, populations will be maintained through dispersal of individuals between populations and recolonization of vacant habitat. However, habitat loss can result in populations becoming isolated or separated by greater distances. This can limit immigration from neighbouring populations, which can lead to a decrease in the fitness of individuals in the isolated population because of reduced gene flow and increase the likelihood that the isolated population will become extinct because of random population fluctuations (Blaustein et al. 1994, Corn 1994).

Habitat loss is believed to be one of the causes of Northern Leopard Frog declines in

Washington, Oregon, Idaho and Montana (Koch et al. 1996) and in Dickson County, Iowa, habitat loss has caused populations to decline by two to three orders of magnitude over the last 70 years (Lannoo et al. 1994). Over the last half of this century, wetland drainage has been extensive in southern Alberta. For example, it is estimated that 60 % of the wetlands have been lost in the aspen parkland (Alberta Water Resources Commission 1990), and over 90 % of wetland margins in the prairie and parkland have been impacted by agricultural activities (Turner et al. 1987). The extent to which wetland loss and alteration have impacted Northern Leopard Frog population in the province is unknown, but in some areas population declines have no doubt been substantial.

4. Livestock Activity. - In California, Jennings (1988) considered alterations to riparian vegetation by livestock grazing to be an important factor in the decline of ranid frog species. Livestock have been present at a number of sites in southern Alberta where Leopard Frogs have been found (Seburn 1992), and livestock disturbance is considered a threat to frog populations at Prince's Spring, Empress Creek and Sexton Creek (Seburn 1992a, 1993, Wershler 1991b, 1992b, Yaremko 1994). Livestock activity has resulted, or could result, in the following disturbances: 1) grazing and trampling have reduced vegetation cover and created drier soil conditions in riparian areas, reducing the quality of summer habitats; 2) cattle trampling along the shores and in the water have caused an increase in water turbidity, which could have negative effects on tadpole and egg development; and 3) cattle movements along the shoreline and wetlands could potentially dislodge or trample egg masses. Livestock defecation in or around overwintering ponds could result in increased nutrient loading in the pond and increase the likelihood of winterkill.

5. Road Kills. - In Minnesota and Ontario, road kills account for the death of a large number of Northern Leopard Frogs, particularly in the spring and fall when frogs are moving between overwintering and breeding sites (Ashley and Robinson 1996, Merrell 1977). Until recently, road kills were not thought to be a major concern in Alberta. In 1994, Yaremko (1994) reported the death of a small number of frogs along a frequently-travelled trail in a meadow adjacent to the upper marsh at Sexton Creek. This area was used as summer habitat by the frogs and large numbers of YOY that disperse through the area.

6. Water Management. - Wershler (1991a) noted that a number of water-management practices could negatively impact Northern Leopard Frogs in Alberta. The raising and stabilization of water levels to enhance recreational activities or to improve habitat for other species, such as fish or waterfowl, can lower the habitat potential for frogs by reducing the amount of wetland vegetation. Drawdowns of wetlands for vegetation management can impact tadpoles if the drawdown occurs before transformation. Similarly, flooding of artificial wetlands in the spring could dislodge eggs. Wershler (1991a) also indicated that onstream dams alter physical processes along rivers. This could limit the creation of side channels and oxbows, which are important habitats for frogs. Onstream dams can also reduce winter streamflow levels, which could increase overwintering mortality.

Seburn (1993) raised concerns that the destruction of beaver dams could reduce available Leopard Frog habitat in the Cypress Hills.

7. Harvest. - Throughout its range, the Northern Leopard Frog has been collected for teaching and research needs, bait and even food (Gibbs et al. 1971, Koonz 1992, Wershler 1991a). In Alberta, commercial harvest has long been illegal, so the extent of collecting has probably been limited to the capture of frogs for fish bait and to the collecting and raising of tadpoles and frogs by children. In the past, these were probably relatively benign activities, but with the recent population declines, any loss must be considered unacceptable. The collecting of frogs by children has been noted recently in Medicine Hat and at Writing-on-Stone Provincial Park (Wershler 1991a).

With the recent designation of the Northern Leopard Frog as an "endangered species" (see "Status Designations", below) it is now illegal to collect frogs for any purposes. With the recent designation, ongoing efforts will have to be made to inform the public, particularly children, that collecting could be detrimental to frog populations.

8. Introduction of Game Fish and Exotic Species. - In many parts of western North America, declines of amphibian populations have been linked to the introduction of game and other species of fish (Corn 1994, Corn and Peterson 1996). Fish introductions are also thought to pose a threat to Northern Leopard Frogs. The species is believed to select against fish-bearing waterbodies for spawning as many fish species are known to prey on tadpoles. Game fish are also known to prey on overwintering frogs (Emery et al. 1972). In the White Mountains of Arizona, population declines have also been linked to the introduction of crayfish (Orconectes virilis, Fernandez and Bagnara 1995).

The extent to which sport fish introductions have impacted Leopard Frog populations in the province is unknown, but the matter is a cause for concern. Seburn (1992a) noted that an individual had wanted to introduce sport fish into a beaver pond at Sexton Creek. This could potentially have had dire consequences for the important Leopard Frog population occupying the site.

The introduction of Bullfrogs (Rana catesbeiana) has also been implicated in the decline of Northern Leopard Frog populations (Hammerson 1992, Koch et al. 1996, Lannoo et al. 1994, Panik and Barrett 1994, Schwalbe and Rosen 1988, Weise 1990). Bullfrogs have not been introduced into Alberta. However, Bullfrogs have recently been introduced into western Montana, which coincidentally is where the greatest Leopard Frog declines have been noted (Reichel and Flath 1995). Whether Bullfrogs have played a role in the decline is unknown. It is also unknown whether the species will expand its range into this province, but the potential impacts on amphibian populations, and on biodiversity in general, is cause for concern.

9. Contaminants and Wetland Acidification. - Because of their use of subcutaneous respiration, use of water for egg laying, reliance on both terrestrial and aquatic environments, and the different positions of larvae and adults in the food chain, amphibians are particularly vulnerable to a variety of contaminants, including pesticides (Bishop 1992, Harfenist et al. 1989). There is, however, no evidence linking Northern Leopard Frog declines in Alberta to use of pesticides or other toxic compounds. Research in Wisconsin also failed to establish a link between pesticide use and population declines, although research has pointed out the need for further study into the possible role of herbicides in the decline (Hine et al. 1981).

The distribution of many amphibian species is related to the acidity of wetland habitats, and concerns have been raised that acid rain could lower the pH of wetlands causing population declines in many species (Clark 1992). Laboratory studies have shown that wetland acidification can lead to increased mortality in embryos and disrupt sodium and chloride balances and increase the rate of heavy metal uptake in larvae (Clark 1992, Freda and MacDonald 1990, Freda et al. 1990). Decreased pH levels can also have indirect effects by altering food chain dynamics and habitat characteristics in wetlands (Clark 1992).

Acid deposition is of greatest concern in the Canadian Shield in eastern Canada. To date, however there has been no data linking population declines relative to increased habitat acidity (Clark 1992, Corn 1994). Acid deposition is of less concern in western North America, and episodic acidification has been dismissed as a cause of Northern Leopard Frog declines in montane areas in Colorado (Corn et al. 1989).

10. Summary. - The cause of Northern Leopard Frog population declines in Alberta is unknown. Initial population declines went largely unnoticed and in many areas were so complete that there was little or no opportunity to examine the reason(s) for the decline. Although little studied, population declines in Alberta do not appear to be part of a regular cycle. Instead, the declines appear to be related to a singular, widespread factor affecting the survival of the species (Cottonwood Consultants 1986, Koonz 1992, Powell and Russell 1996, Roberts 1981, 1987, 1992, 1994, Vial and Saylor 1993).

The abrupt population declines observed in Alberta appear to follow a similar pattern of abrupt and massive population die-offs witnessed over much of the species' range in the upper midwestern states and prairie provinces during the 1970s. Despite investigations into the cause(s) of these declines, the underlying causes remain a mystery. Hine et al. (1975, 1981) conducted a three-year study to determine the cause of the massive population die-off observed in Wisconsin in the early 1970s. The study revealed that there had been a dramatic reduction in Northern Leopard Frog populations across the state and that only a small percentage of suitable ponds showed evidence of breeding activity. Despite diminished population densities, breeding phenology, sex and age ratios, size and condition of adults and young, egg production, metamorphosis and movements appeared to be normal relative to other published studies. There was also no evidence of mortality at the breeding ponds. Widespread mortality was, however, noted with the onset of colder weather in the fall. Low-levels of mortality were noted soon after frogs began to gather at overwintering sites, and increased to a peak just before freeze-up when the frogs were entering the water for hibernation. There were also some indications that mortality continued through the winter. Winterkill, resulting from oxygen depletion in the water column, was dismissed as a cause of the mortality because high incidences of mortality were observed at deep (non-winterkill) lakes, along trout streams and at spring fed ponds. Extensive pathological studies were conducted on sick and dying frogs. Laboratory observations revealed a variety of internal and external abnormalities including ventral skin discoloration ("red leg"), hard muscles, eroded appendages, subcutaneous haemorrhages, eye haemorrhages, body emaciation and various liver abnormalities. Histological examination of liver sections revealed necrotic tissue similar to that produced by toxic

accumulation. Many adult female frogs also had normally-developed, but unpigmented eggs, suggesting a diversion from normal oogenesis patterns or pathological oogenesis. Incidents of egg resorbtion were also noted, as were incidents of unusual behaviour. Specifically, frogs were observed crawling out of the water onto ice, and dead frogs were found on the ice of partially frozen lakes in November and December. These observations lead Hine et al. (1981) to suggest that frogs were possibly unable "to enter and remain in the water at hibernation time, which in turn may be related to abnormal water metabolism beneath the skin and the change from lung to skin respiration".

The study failed to identify a specific cause for the mortality observed in Wisconsin Based on the technology available at the time, viral and bacterial infection were ruled out as major causes of mortality. Hine et al. (1981) noted that there was a need for additional studies to determine if pesticides, particularly the herbicide Atrazine, played a role in the declines. Population monitoring and laboratory studies also failed to determine the cause of similar die-offs in Manitoba (Koonz 1992). As in Wisconsin, mortality was generally associated with conditions of "red leg".

STATUS DESIGNATIONS

1. Alberta. - In 1984, the Northern Leopard Frog was listed as a "declining" species in Alberta, and the goals of monitoring population status and ensuring viable populations were established (Alberta Fish and Wildlife 1984). In the following year, the species was categorized as "status undetermined" in *A Draft Policy for the Management of Threatened Wildlife in Alberta* (Alberta Fish and Wildlife 1985). Cottonwood Consultants (1986) recommended that the species be regarded as "threatened" in Alberta. Roberts (1987, 1991) suggested that Northern Leopard Frog was endangered, requiring management to prevent further declines and to aid in recovery. Because of concerns over widespread population declines in southern Alberta, the official status was upgraded in 1991 and the Northern Leopard Frog was designated as a "Red List" species (Alberta Fish and Wildlife 1991a). This status was reaffirmed in 1996 (Alberta Wildlife Management Division 1996).

In 1991, a provincial status report was prepared (Wershler 1991a). It recommended that the Northern Leopard Frog be designated as a "threatened" species and that its legal status under the Alberta Wildlife Act be changed from an "unlicensed [non-liscence] species", which allowed for the collection or harvesting of the species but prohibited exportation, buying or selling, to a "licensed [nongame] species" to afford the species protection from collecting. A draft provincial management plan was prepared in 1992 (Seburn 1992c). The management plan established the goal of maintaining or restoring "a minimum of 30 viable subpopulations in six drainage systems across the historic range in Alberta". It also recommended that the Northern Leopard Frog be designated as an "endangered" species under the Alberta Wildlife Act. In January 1997, the species was designated as an "endangered species" under the Alberta Wildlife Act.

2. Other Areas. - In British Columbia, the Northern Leopard Frog was regarded as a "Blue List" species in 1991 (Seburn 1992c). Since then, the Leopard Frog has been upgraded to the "Red List" of species which are currently being considered for designation as "threatened" or "endangered" under the

provincial Wildlife Act (L. Fries, pers. comm.). No formal ranking system exists in Saskatchewan, but restrictions are in place to prevent human development in breeding areas (W. Harris, pers. comm.). In Manitoba, a permit is required for commercial collecting of Leopard Frogs (Preston 1987). The Northern Leopard Frog was identified as a "species of concern" in the *Prairie Conservation Action Plan* (World Wildlife Fund Canada 1988).

The Northern Leopard Frog has currently not been assigned a designation by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). A draft status report has recently been prepared for populations in western Canada (Seburn and Seburn 1996), and a status designation will be assigned in the near future (C. Seburn, pers. comm.).

The Northern Leopard Frog has been placed on a candidate list of species of special concern by the State of Colorado (Livo 1986).

RECENT MANAGEMENT IN ALBERTA

1. Planning. - The planning of management activities for Northern Leopard Frogs has been guided by the preparation of a provincial status report and draft management plan. The status report (Wershler 1991a) presented information on the general ecology of the species, and current and historic distribution and abundance data, and outlined potential threats to Leopard Frogs in the province. The draft provincial management plan (Seburn 1992b) outlined objectives for population and habitat management and for informing and educating the public about the plight and conservation of the Leopard Frog in Alberta. The report also discussed the possible need to re-establish populations by transplanting individuals from existing populations to areas containing suitable habitat.

The species was also considered as part of planning exercises conducted by the North American Waterfowl Management Plan (NAWMP) in Alberta. It was ranked as a priority vertebrate species in relation to NAWMP program delivery in the prairie and aspen parkland biomes (Patriquin 1993).

2. Population Monitoring. - The Alberta Fish and Wildlife Division launched a poster campaign in 1989, which asked the general public to report all sightings of Northern Leopard Frogs. Over 150 reports were received in response to the campaign (Seburn 1991, D. Seburn 1994, Wershler 1991a). Many of these reports turned out to be other species, or were thought to be unreliable observations (Wershler 1991a). Nevertheless, many of the reports led to the discovery of new population centres, proving the value of the program.

During 1991 and 1992, field surveys were conducted to update and expand the information base on Leopard Frog habitats, populations and distribution in southern Alberta. Sightings reported during the poster campaign were also checked during the field program. In 1994, the Alberta Amphibian Monitoring Program was initiated (Alberta Fish and Wildlife 1994, Powell and Russell 1996, Yaremko 1996). This program was implemented under the auspices of the Declining Amphibian Population Task Force established by the Species Survival Commission of the World Conservation Union. The monitoring program was designed to gather basic presence/absence data on amphibians using volunteers. Volunteers are provided with a handbook (Alberta Wildlife Management Division, no date) and a tape of calls to assist with

identification. To date, over 300 individuals have become involved with the program. Data obtained by the volunteers have been, or will be, entered into the Biodiversity/Species Observation Database developed by Alberta Natural Resources Service. Confirmed observations from the 1990 poster campaign as well as observations from surveys sponsored by the Alberta government have also been entered into the database.

3. Habitat Securement, Protection and Enhancement. - In 1991, a management plan was developed for the Prince's Spring area, which contains a major breeding population of Northern Leopard Frogs (Wershler 1991b). The plan outlined the need for fencing around spring-fed streams to protect fragile riparian habitats from cattle damage. The springs themselves were fenced sometime before 1980 (Hofman 1992). Revisions to the fencing plan were made in 1992 (Wershler 1992b) and fences were established around the streams in 1992 (Hofman 1992).

The significant Leopard Frog habitat at Sexton Creek in the Cypress Hills is located within the proposed Eagle's Nest Ranch Natural Area (Biota Consultants 1992). Management considerations for the proposed natural area include restricting livestock activity around wetlands to protect Northern Leopard Frog habitat (Biota Consultants 1992).

In the fall of 1994, a population of Northern Leopard Frogs was discovered along a small creek (Drain K) extending from Lonesome Lake to the Bow River about 8 km south of Bow City (D. Watson, pers. comm.). Portions of the creek are dominated by small spring-fed wetlands, which may provide important breeding or overwintering habitat. Level portions of the creek are also dominated by large cattail marsh complexes. Most of the creek flows across the Circle E project, which is being developed for waterfowl production under the NAWMP. Project development began in 1995 and management plans for the project recognised the importance of the creek as Leopard Frog habitat. In 1996, cross fencing was erected across pastures bordering portions of the creek to prevent disturbance of the wetlands by cattle during the breeding season (A. Balaski, pers. comm.).

4. Research. - In addition to the previously-discussed survey and monitoring programs, three research projects with applications for Leopard Frog management have been conducted in recent years. Seburn (1993) examined the feasibility of using pond enclosures to assess growth rates of transplant and control populations of tadpoles. The methodology was found, however to be inadequate because of high predation rates and low growth rates within the enclosures. In 1993, habitat use and YOY dispersal studies were conducted at Sexton Creek (Seburn 1994, Seburn et al., in press). The results of these studies were discussed previously. YOY dispersal and overwintering survivorship were also studied at Sexton Creek in 1994 (Yaremko 1994).

5. Repatriation of Northern Leopard Frog Populations. - The recovery and re-establishment of Northern Leopard Frog populations over much of their former range in southern Alberta will be dependent on the dispersal of individuals from existing populations. However, we know very little about dispersal in Northern Leopard Frogs and it is therefore difficult to predict the extent to which dispersal may lead to recolonization of unoccupied areas of suitable habitat. It may well be that the relative isolation of some populations may limit opportunities for population expansion because of the inability of individuals to

disperse to other areas (Roberts 1994). Furthermore, some areas of suitable habitat may now be unavailable for recolonization because of habitat alterations that have eliminated dispersal corridors. This may be particularly true of large areas in the parkland, which are separated from the remaining breeding populations in the south by large expanses of dry upland habitat (Roberts 1994). Re-establishment of Northern Leopard Frogs in many parts of their former range may therefore be dependent on transplanting individuals from major breeding populations in southern Alberta (Cottonwood Consultants 1986; Roberts 1987, 1991, 1992, 1994, Seburn 1992c, Wershler 1991a). Major review papers about the pros and cons of using transplants to re-establish amphibian populations are presented in Burke (1991), Dodd and Seigel (1991) and Reinert (1991).

Under a pilot reintroduction program, Northern Leopard Frogs were released at two sites in central Alberta (Roberts 1991, 1992). At both sites, frogs survived and reproduced for several years following release (W. Roberts, pers. comm.). However, at one of the sites a winterkill event eliminated the population. At the other site, in the upper North Saskatchewan River basin, the population continues to flourish and is monitored annually (W. Roberts, pers. comm.). The success of this initial release indicates that Northern Leopard Frogs can perhaps be re-established using frogs from population centres in the southern part of the province.

6. Public Information and Education. - Several authors (Cottonwood Consultants 1986, Quinn 1991, Roberts 1991, Seburn 1992, Wershler 1991a) have outlined the need to inform and educate the public about the plight of the Northern Leopard Frog. Public information programs are felt important for building awareness about the plight of the species, for soliciting sighting and other information from the public, for requesting assistance in protecting and maintaining habitat, and for reducing activities such as collecting which may be detrimental to frog populations.

In Alberta, the dissemination of public information has included the poster campaign initiated in 1989, the publication of a Leopard Frog brochure in 1991 (Alberta Fish and Wildlife 1991b) and the establishment of the Alberta Amphibian Monitoring Program in 1984 (Alberta Fish and Wildlife 1994, Powell and Russell 1996, D. Seburn 1994, Yaremko 1994). In addition, an elementary school teachers' guide about the Northern Leopard Frog was prepared in 1995.

SYNTHESIS

Prior to 1980, the Northern Leopard Frog was widely distributed and locally abundant over much of Alberta south of Edmonton. However, populations are now greatly reduced in number, and the range is limited mainly to the lower reaches of the South Saskatchewan and Milk River drainage basins.

In Alberta, the cause(s) of the abrupt and widespread population declines that occurred in the late 1970s and early 1980s remains a mystery. Our lack of understanding about causes of the declines is reason for concern. Even if populations were to recover, either naturally or through conservation initiatives, the species would have to be considered at risk until such time as the cause(s) of the decline is determined and addressed. Hine et al. (1981) aptly sum up the situation as follows: "The drama of the leopard frog decline that has been unfolding over the past decade may provide a vital insight into

ecosystem health - it must not go on unnoticed or unattended."

Recent general population increases in Saskatchewan (W. Harris, pers. comm., Seburn 1992b) and Manitoba (Koonz 1992) provide some promise that Northern Leopard Frog populations will recover in Alberta. Natural recovery and re-establishment of populations in formerly occupied area will be dependent on dispersal of individuals from the remaining breeding populations. We know very little, however about dispersal in Northern Leopard Frogs and it is therefore difficult to predict the extent to which dispersal may lead to recolonization of suitable habitat areas. Re-establishment in some areas, particularly the central parkland, may therefore be dependent on transplanting individuals from the major breeding populations in southern Alberta (Cottonwood Consultants 1986, Roberts 1987,1991, 1992, 1994, Seburn 1992c, Wershler 1991a). Until such time as broad-scale transplantation is feasible, continued surveys and monitoring of provincial populations will be necessary to ensure that current population distribution and trends in the province are well understood.

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APPENDIX 1. Definitions of selected legal and protective designations.

A. Status of Alberta Wildlife color lists (after Alberta Wildlife Management Division 1996)

Red	Current knowledge suggests that these species are at risk. These species have declined, or are in immediate danger of declining, to nonviable population size
Blue	Current knowledge suggests that these species may be at risk. These species have undergone non-cyclical declines in population or habitat, or reductions in provincial distribution
Yellow	Species that are not currently at risk, but may require special management to address concerns related to naturally low populations, limited provincial distributions, or demographic/life history features that make them vulnerable to human-related changes in the environment
Green	Species not considered to be at risk. Populations are stable and key habitats are generally secure
Undetermined	Species not known to be at risk, but insufficient information is available to determine status

B. Alberta Wildlife Act

Species designated as Aendangered≅ under the Alberta Wildlife Act include those defined as Aendangered≅ or Athreatened≅ by *A Policy for the Management of Threatened Wildlife in Alberta* (Alberta Fish and Wildlife 1985):

Endangered	A species whose present existence in Alberta is in danger of extinction within the next decade
Threatened	A species that is likely to become endangered if the factors causing its vulnerability are not reversed

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 1996)

Extirpated	A species no longer existing in the wild in Canada, but occurring elsewhere
Endangered	A species facing imminent extirpation or extinction
Threatened	A species likely to become endangered if limiting factors are not reversed
Vulnerable	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events
Not at Risk	A species that has been evaluated and found to be not at risk
Indeterminate	A species for which there is insufficient scientific information to support status designation

D. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species which is in danger of extinction throughout all or a significant portion of its range
Threatened	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range

APPENDIX 2. Known museum specimens of Northern Leopard Frogs collected in Alberta.

Catalogue #	Collection Location	# Collected	Date
National Museum of Canada, Ottawa, ON			
NMC593(a)	Hilly Island Rapid, Rocher River, W end of Lake Athabasca	1	5 Aug 1914
NMC1111	Morin	1	8 Aug 1924
NMC2086	Cypress Hills	6	Not given
NMC3363	2.4 miles N of Waterton Lakes National Park	1	12 Jun 1957
NMC3364	9.6 miles S of Lethbridge	3	14 Jun 1957
NMC3366	2.3 miles NE of Cardston	2	14 Jun 1957
NMC3370	1.4 miles E of Mountain View	2	14 Jun 1957
NMC3380	Indian Creek at Highway #6, Waterton Lakes National Park	4	17 Jun 1957
NMC3383	Beaver ponds 7.9 miles S of junctions of Highways #5&#6, Waterton Lakes National Park	1	17 Jun 1957
NMC3418	4 miles N of Taber	13	26 Jun 1957
NMC3431	SW corner of Cypress Hills Prov. Park	6	2 Jul 1957
NMC5278	Kin Coulee, Medicine Hat	127	23 May 1961
NMC5488	1.7 miles N of Graburn	19	5 Jul 1961
NMC5502	Elkwater Lake	3	9 Jul 1961
NMC5503	31.6 miles N on Highway #48 of Wildhorse	?	9 Jul 1961
NMC5504, 5505	18.6 miles N on Highway #48 of Wildhorse	1+	9 Jul 1961
NMC5507	10.6 miles W on Highway #1 of Elkwater Lake turnoff	22	10 Jul 1961
NMC5508	6.1 miles W on Highway #1 of Walsh turnoff	1	10 Jul 1961
NMC5509	4.3 miles W on Highway #1 of Walsh turnoff	6	10 Jul 1961
NMC5512	1.4 miles W on Highway #1 of Walsh turnoff	1	10 Jul 1961
NMC5526	4.3 miles W on Highway #1 of Walsh turnoff	1	12 Jul 1961
NMC5537	9 miles E on Highway #3 of Seven Persons	25	15 Jul 1961
NMC5539	3.5 miles E on Highway #3 of Seven Persons	14	15 Jul 1961
NMC5540	8.6 miles N of Orion	3	15 Jul 1961
NMC5542	17 miles NE of Manyberries	1	15 Jul 1961
NMC5544	24 miles NE of Manyberries	7	15 Jul 1961
NMC5545,5546	4.6 miles S of Highway #1 on Manyberries road, E side of Medicine Hat	31+	15 Jul 1961
NMC5548	4.3 miles W on Highway #1 of Walsh	4	15 Jul 1961
NMC5552	4.3 miles W on Highway #1 of Walsh	6	18 Jul 1961
NMC6024	0.5 miles NW on Highway #1 of Brooks turnoff	1	20 May 1962
NMC7138	1.5 miles N of Rocky Mountain House	1	9 Jun 1963
NMC7145	2.5 miles N of Rocky Mountain House	1	9 Jun 1963
NMC7151	5.8 miles N of Rocky Mountain House on Crimson Lake Rd.	3	10 Jun 1963
NMC7175	Fish Creek, near Priddis	2	13 Jun 1963
NMC7177	5 miles NW of Priddis	7	13 Jun 1963
NMC7236	4.3 miles N of Highway #6 of Twin Butte	2	3 Jul 1963

NMC7238	1.1 miles N on Highway #6 of Twin Butte	3	3 Jul 1963
NMC7246	1 mile W of junctions of Highways #5&#6, Waterton Lakes National Park		4 Jul 1963
NMC7328	2.9 miles S on Highway #1 of Strathmore		26 Jul 1963
NMC7336	4.2 miles W on Highway #1 of Walsh		30 Jul 1963
NMC8642	16 miles E and 8 miles S of Milk River	1	21 Jul 1965
NMC9555	8 miles S of Pincher Creek, along Highway #6	1	13 Sep 1966
NMC9556	17 miles S of Calgary in Sheep River at Highway #2	1	13 Sep 1966
NMC9557	Knights Lake, Waterton Lakes National Park	1	17 Sep 1966
NMC9558	8 miles N of Big Chief Mountain Customs Station	1	17 Sep 1966
NMC9585	Milk River, 0.25 miles south	1	24 May 1966
NMC9586	17 miles W of Wildhorse (SE1/4-1-1-5-W4)	2	28 May 1996
NMC9588	Milk River, 8 miles E and 2.5 miles S	2	28 May 1966
NMC9590	Milk River, 15.5 miles W & 4.5 miles S of south fork of Milk River	2	29 May 1966
NMC9591	Milk River, 18 miles E, 4 miles S (SW33-1-25-W4) (Von Cleeve Coulee)	1	29 May 1966
NMC9592	Milk River, 8.0 miles E and 3.0 miles S (NW1-2-15-W4)		?
NMC9600	Milk River, 4 miles E and 3.5 miles S, Gold Springs Park	2	25 Jul 1966
NMC9603	18 miles S and 1 mile E of Elkwater (NE30-5-2-W4)	6 tadpoles	28 Jul 1966
NMC9604	Milk River, Lodge Creek, 18 miles S,1 mile E of Elkwater (NE30-5-2-W4)	2	28 Jul 1966
NMC9607	Red Creek 1.5 miles W, 10.5 miles S of Milk River town (SW5-1-16-W4)	1	10 Aug 1966
NMC9609	Halfbreed Creek, Aden, 8 miles due N and 1 mile due E	5	4 Sep 1966
NMC9892	Writing-on-Stone Prov. Park	1	26 Jun 1967
NMC10320	Calgary, SW bypass at rifle range and power transformer	3	15 May 1966
NMC10397	6.1 miles W of Stavely on Willow Creek Park road	1	18 June 1966
NMC10400	18.4 miles W of Stavely on Willow Creek Park road	1	18 June 1966
NMC10665	0.5 miles W of Whiskey Creek near junction with Fish Creek on Fish Creek road, SW of Priddis	tadpoles	21 Jul 1966
NMC10670	coulee, 15 miles S of Seven Persons	1	23 Jul 1966
NMC10754	1.9 miles S of Bragg Creek	1	17 Sep 1966
NMC10772(b)	17.1 miles S of Smoky River bridge on Highway #34	tadpoles	22 Jun 1965
NMC10773(b)	5.1 miles N of Valleyview on Highway #34	tadpoles	22 Jun 1965
NMC10777(b)	2.8 miles S of Little Smoky on Highway #34	tadpoles	23 Jun 1965
NMC10780(b)	10.7 miles S of Little Smoky	tadpoles	23 Jun 1965
NMC10784(b)	18.2 miles S of Whitecourt on Highway #34	tadpoles	24 June 1965
NMC10794	14.7 miles S of Muirhead		16 Jun 1966
NMC14234	18 miles E and 4 miles S of Milk River (3-1-13-W4)	1	3 Jun 1967
NMC14244	18 miles E and 4 miles S of Milk River (SW33-1-13-W4)	1	10 Aug 1967
NMC14246	18 miles E and 4 miles S of Milk River (SW33-1-13-W4)	3	28 Aug 1967
NMC14652	Milk River, 1 mile E of Writing-on-Stone Prov. Park	1	31 May 1970
NMC16083	2 miles S of Grassy Lake	7	9 Jun 1973
Provincial Museum of Alberta, Edmonton, AB			
Z71.62.1	Hardisty Campsite, Battle River	1	10 Aug 1971

Z70.49.59	South Pinhorn Grazing Reserve	1	31 May 1970
Z68.80.13	Aden bridge over Milk River	1	10 Sep 1968
Z68.47.2	Lake Newell	1	11 Jun 1968
Z68.47.1	Lake Newell	1	11 Jun 1968
Royal Ontario Museum, Toronto, ON			
ROM7779	Lethbridge in irrigation ditch		1946
ROM7865,7866	Elkwater Lake		5 Jul 1948
ROM9320	Waterton Lakes National Park at park entrance		16 Jul 1955
ROM9397	Medicine Hat, Saskatchewan River and Creek NE of town		11 Jun 1920
Museum of Comparative Zoology, Harvard University, Cambridge, MA			
17550	Medicine Hat	1	?
Field Museum of Natural History, Chicago, IL			
39471	Medicine Hat		Jul 1929
56424-25	Elkwater Lake		5 Jul 1948
56426	Boschee Creek		4 Jul 1948
56427-28	Mitchell Creek		14 Jul 1948
56429-30	Willow Creek		6 Jul 1948
56426-32	Battle Creek and Vicinity		18 Jul 1948
Tongrass Historical Society Museum, Anchorage, AK (see Hodge 1976)			
55	Grand Forks		?
57,59	Milk River		?
University of Calgary Museum of Zoology, Calgary, AB			
1975.114	7.8 miles from Sundre		?
1975.115	Midnapore		?
1975.116-117	4-5 miles S of Elkwater, Cypress Hills Prov. Park		?
1975.118-120	Wildhorse		?
1975.290-292	Hays		?
1977.66	Nose Creek		?
	Wildhorse	3	16 May 1963
	4.5 miles S of Elkwater, Cypress Hills Prov. Park	2	22 May 1962
	Nose Creek (Calgary), just W of Edmonton Trail	1	7 Jul 1962
	Nose Creek, N of Airport Road, Calgary	1	28 Jul 1962
	Big Hill Creek, 2.2 miles NE of Cochrane	1	28 Jul 1962
	7.8 miles S of Sundre, Fallen Timber Creek		24 Jun 1964
University of Alberta Museum of Zoology, Edmonton, AB			
2,5, 6-11,13	Elkwater Lake, Cypress Hills		5 Jul 1948
14,15	Cardston		15 Aug 1949
16	Eagle Lake, near Strathmore		15 Jun 1949
126	Drumheller		11 May 1950
127	Drumheller		18 May 1950
135	Drumheller		5 Jun 1950

141,142	Beynon		5 Jul 1950
222	Milk River		9 Jul 1950
262	Milk River		1 Aug 1950
266	Spring Creek R.S. Cypress Hills		1 May 1950
270-272	Tilley		16 Aug 1950
305,306	Gros Ventre Creek, Cypress Hills		20 Aug 1950
319	Cardston		29 Aug 1950
355-357	Eagle Butte		5 Aug 1951
358	St. Kilda		14 Aug 1951
359	Medicine Hat		14 July 1951
361	Brooks		8 Jul 1951
362-364	High River		25 Aug 1951
365,366	Calgary		18 Aug 1951
367	Gleichen		3 Aug 1951
368	Edmonton		5 Oct 1951
369,370	Lethbridge		23 Jul 1951
371	Crammond		25 May 1951
372	Burmis Lake		24 Jun 1951
391	Macleod		18 Aug 1951
404	Vauxhall		Aug 1951
408	Whiskey Gap		21 Jul 1951
475	Cardston		21 Jul 1951
476	Taber		19 Jul 1951
477	Vauxhall		19 Jul 1951
478	Taylorville		21 Jul 1951
585-588	Onefour		1951
719	Raven River Fish Ponds		11 Aug 1951
721	Onefour		Fall 1953
767	Redcliff		5 Aug 1955
768,769	Picture Butte		19 May 1956
1238-1241	Hussar		16 Dec 1953
1242-1253	Calgary		18 Aug 1951
1254-1257	6 miles S of Caroline		15 Aug 1954
1258	High River		8 Aug 1952
1382	Raven Fish Pond	5	11 Aug 1955
1383	Milk River near Milk River town	13	23 Aug 1950
1428,1430,1431	Milk River 19 miles W of Wildhorse		3 Jun 1962
1429	Milk River 19 miles W of Wildhorse		5 Jun 1962
1432	Milk River 19 miles W of Wildhorse		18 May 1961
1433-1437	Milk River 19 miles W of Wildhorse		19 May 1961

1547	Ross Creek		3 Aug 1966
1664-1680	Middle Coulee, 5 miles S of New Dayton	1*	6 Jun 1968
1740-1742	Road to Eagle Butte, Cypress Hills	1*	2 Jun 1968
1743-1744	Highway 48 approximately 25 miles S of Cypress Hills	1*	9 Jun 1968
1745-1752	Highway 48 approximately 26 miles S of Cypress Hills	1*	9 Jun 1968
1753	Eagle Butte, Cypress Hills	1	12 Jun 1968
1754-1755	Stream connected with Little Fish Lake	1*	5 Jul 1968
1756	Highway 36 just S of Crossford Junction	1	6 Jul 1968
1757-1766	Dinosaur Park	1*	7 Jul 1968
1767-1771	Road to Thelma, Cypress Hills	1*	10 Jul 1968
1772-1774	Graburn Gap Road, past campsite, Cypress Hills	1*	11 Jul 1968
1775,1776	Road to Graburn Gap, just in evergreens, Cypress Hills	1*	11 Jul 1968
1777	Lost River by One-Four	1	13 Jul 1968
1861	Highway 48, second bridge, 25 miles S of Cypress Hills	5 tadpoles	9 Jun 1968
1862	Stream east end of Little Fish Lake	36 tadpoles	5 Jul 1968
1863-1865	Highway 48, second bridge, 25 miles S of Cypress Hills	1*	9 Jun 1968
1926-1938	Pond near Tyrell Lake	1*	1 Sep 1969
1983, 1984	Lake Newell, 12 miles S and 3 miles W of Brooks		22 Jun 1970
2017, 2018	Cottonwood Creek, 9 miles N of Waterton, Waterton Lakes National Park	1*	30 Jul 1971
2028	Lake Newell	1	8 Jun 1972
2076-2078	Lake Newell	1*	14 Jun 1972
2122-2124	Pinhorn Grazing Reserve 49°04'N; 110°57'W	1*	28 Aug 1972
2191	Lodge Creek below Saskatchewan Reservoir (in Alberta)	1	15 May 1973
2217	Sage Creek, 7 miles S of Cressday	2	17 July 1975
2268-2271	1/2 mile E of Heatherdown	1*	16 May 1976
2439	Spruce Coulee, Cypress Hills Prov. Park	1	3 Aug 1976
2449	Spring tributary of Clearwater River 1/4 mile N of Ricinus	1	12 Dec 1976
2450	Spring tributary of Clearwater River 1/4 mile N of Ricinus	1	7 Nov 1976
2472	1/2 mile E of Heatherdown	1	26 Apr 1977
2482-2484	1/2 mile S of Heatherdown		7 May 1977
2557	Red Deer River		16 Jul 1975
2562	S end of Lake Newell		4 Jun 1979
2563	North Milk River tributary, 18 miles E of Del Bonito	3	5 Jun 1979
2651	Pinepound Creek, 1 mile W of Spring Coulee	1*	3 May 1980
2654	8 miles SE of Rolling Hills	1	29 Jun 1980
2882	Lodge Creek	1	Jun 1976

(a) The wrong site location is probably given for this specimen (NMC593). The specimen probably refers to a collection at the Natla Rapids on the Talston River, Northwest Territories on 5 August 1914 (Harper 1931a)

(b) Tadpoles can be difficult to identify to species. Until further confirmation, these records must be considered suspect (F. Cook, pers. comm.).

*one specimen per collection number

APPENDIX 3. Pre-1981 observational records of Northern Leopard Frogs in Alberta. Natural Regions are after Achuff and Wallis (1977).

Location	Source	Comments
Foothills Grassland Natural Region		
Hillspring	Wershler (1991a)	S of Hillspring in the vicinity of the Belly River
Whiskey Gap	Wershler (1991a)	N fork of the Milk River near Whiskey Gap
Fort McLeod	C. Wallis (pers. obs.)	Observed in 1978
Willow Creek	Crack and Danielson (1974a)	Willow Creek at Willow Creek Prov. Park
Foothills Parkland Natural Region		
Outpost Lake	Wershler (1991a)	Police Outpost Prov. Park
Paine Lake-Beaverdam Lake	C. Wallis (pers. obs.)	Beaverdam Lake, creek SE of Paine Lake, and wetlands along Lee Creek SE of Paine Lake. Observed 20 June 1978.
Waterton Lakes National Park	C. Wershler and C. Wallis (pers. obs.)	One calling at pond at N gate of Waterton Lakes National Park on 28 April 1977
Foothills Creek	C. Wallis (pers. obs.)	Foothills Creek, E of Pecten, observed in 1977
Foothills Parkland and Northern Fescue Grassland Natural Regions		
Beaverdam Flats	Bird (1974), Pinel (1980)	"Present in the lagoon and some old gravel pits"
Beddington Creek, Calgary	Bird (1974)	"This frog is quite abundant in the beaver ponds, and was seen from May through August"
Bowmont Flats	Pinel (1980)	"Occasional in the gravel pit area≅
Cominco, Calgary	Bird (1974), Pinel (1980)	"Abundant in the lagoon area"
Edworthy Park, Calgary	Pinel (1980)	"Occasional in the ponds and sloughs≅
Fish Creek Prov. Park, Calgary	Bird (1974), Pinel (1980), Wershler (1991a)	"Frequent along the creek banks"
Glenmore Park, Calgary	Bird (1973), Pinel (1980)	"The most abundant frog in the beaver and oxbow ponds." Breeding noted
Inglewood Bird Sanctuary, Calgary	Pinel (1980), Wershler (1991a)	"Fairly common in the pond and extreme north end of the water channel in the early 1960s. Now it is almost non-existent for unknown reasons"
Sandy Beach, Calgary	Pinel (1980)	"Occasional sightings in the pond below the dam. It is heard in late April"
Cochrane	Bird (1975b)	
Rocky Mountain - Montane Natural Region		
Beauvais Lake Prov. Park	Crack and Danielson (1974b), Spalding (1980, pg.70)	"Observed along the lakeshore and in the ponds and streams during the summer"
Burmis	Wershler (1991a)	"In the vicinity of Burmis"
Chain Lakes Prov. Park	Crack and Danielson (1974c)	"Seen along the lakeshore and marsh below dam"
Bow Valley Prov. Park	Salt (1977, 1979)	
Yamnuska Centre	Salt (1977, 1979)	
Shepard Creek	C. Wallis (pers. obs.)	Seen in 1977 in bullrush pond on the upland
Foothills Grassland and Rocky Mountain - Montane Natural Regions (Disjunct)		
Cypress Hills	Wershler (1991a), Halladay (1965), Lewin (1963)	Reservoirs, creeks and ponds in the Cypress Hills

Mixed Grassland Natural Region		
Milk River - Writing-on-Stone	Wershler (1980)	Milk River and associated coulee streams in the vicinity of Writing-on-Stone Prov. Park. "Breeds locally along deep, calm stretches of Police and Van Cleeve Creeks, especially in beaver ponds"
Lower Milk River	Wallis (1976)	Milk River Canyon, associated coulee streams, and upland ponds in the vicinity of the lower Milk River. "Common along creeks and river valley, where water is permanent"
Lost River - Canal Creek	C. Wershler (pers obs.)	Observed along the Lost River, Canal Creek and adjacent upland ponds in the 1970s
Wildhorse	Wershler (1991a)	Wildhorse Lake area
Manyberries	C. Wershler (pers. obs.)	Manyberries Creek drainage near Manyberries and S of Manyberries in the early 1970s. Also in ponds N of the Onefour Experimental Station
McNab	Wershler (1991a)	NE of McNab in Tyrrell Lake area
Lethbridge	Lethbridge Naturalists' Society (1978), Moore and Strickland (1954)	Within the city of Lethbridge
Picture Butte	Wershler (1991a)	Just W of Picture Butte
Taber	Wershler (1991a)	In the vicinity of Taber
Vauxhall	Wershler (1991a)	In the vicinity of Vauxhall
Ross Creek	C. Wallis (pers. obs.)	Along Ross Creek, W of Irvine, 23 August 1977
Rainier	Woolford (1966)	Noted as prey of Black-crowned Night Heron
Tilley	Wershler (1981a), Woolford (1966)	Noted as prey of the Black-crowned Night Heron. Wershler (1981a) also reports observations in the vicinity of Tilley
Cassils	Woolford (1966)	Noted as prey of Black-crowned Night Heron
Brooks	Wershler (1991a)	In the vicinity of Brooks
Douglas Creek	C. Wallis (pers. obs.)	At Douglas Creek and Hutton Springs, along the Red Deer River in the mid 1970s
Dinosaur Prov. Park	C. Wallis and C. Wershler (pers. obs.)	Along the N side of Red Deer River in Dinosaur Prov. Park. At least one calling on 12 May 1977 and two calling on 17 June 1977
Lower Red Deer River	Wershler (1991a)	Red Deer River or a tributary creek, NE of Buffalo
Alkali Creek	W. Smith (pers. obs)	Near its junction with the Red Deer River
Alkali Creek	W. Smith (pers. obs.)	N of the previous site, perhaps along Alkali Creek. Records from 1974 and 17 June 1977
Minor Spring	Wershler (1991a)	Downstream from Dune Point on the N side of the Red Deer River
Acadia Valley	C. Wallis (pers. obs.)	Observed in mid-1970s north of Acadia valley; possibly along Empress Creek
Northern Fescue Grassland Natural Region		
Strathmore	Wershler (1991a)	E of Strathmore
Frank Lake	Bird (1975a)	
High River	Moore and Strickland (1954)	
Hussar	Wershler (1991a)	E of Hussar
Beynon	Wershler (1991a)	Beynon area, probably along Rosebud Creek
Drumheller	Spalding (1980, pg. 131), C. Wallis (pers.	Drumheller area, probably along Red Deer River.

	obs.)	Observed at the Midland Mine in the mid-1970s
Little Fish Lake	W. Smith and C. Wallis (pers. obs.)	Two sites: Handhills Ecological Reserve and Fish Creek. Observed 6 July 1974 and 1 May 1976
Rumsey	C. Wallis (pers. obs.)	Observed in the mid-1970s W of Rumsey in the vicinity of the Red Deer River
Gooseberry Lake Prov. Park	Ebel et al. (1973)	"Occasionally seen around marsh area (W of Lake)"
Central Parkland Natural Region		
Bodo	C. Wallis (pers. obs.)	Observed in the mid-1970s near Bodo, probably along Eyehill Creek
Hayter	C. Wallis (pers. obs.)	Observed in the mid-1970s at a pond N of Hayter
Tail Creek	C. Wallis (pers. obs.)	Observed in the mid-1970s along Tail Creek near its junction with the Red Deer River
Red Deer	K. Wood (pers. comm. to C. Wershler)	Gaetz Lakes
Innisfail	W. Roberts (pers. obs.)	In the vicinity of Innisfail and the Red Deer River
Kneehill Creek	W. Roberts (pers. obs.)	Common along the creek in the mid- to late 1970s
Buffalo Lake	Anderson (1981)	Listed on a species checklist for the area prepared by C. D. Bird
Killarney Lake	C. Wershler & C. Wallis (pers. obs.)	One heard calling upland pond N of Killarney Lake in spring 1982
Black Creek	C. Wallis (pers. obs.)	One heard calling along Black Creek SE of Ribstone on 2 May 1976
Pigeon Lake Prov. Park	Spalding 1980 (pg. 203)	
Foothills - Northern Outliers Natural Region		
Slave Lake	Wershler (1991a)	Near the town of Slave Lake, possibly along the Lesser Slave River
Lesser Slave Lake	Griffiths (1976, in Bradley 1980)	Lesser Slave Lake Prov. Park
Main Foothills Natural Region		
Harold Creek	Wershler (1991a)	In the vicinity of Harold Creek
Clearwater River	Wershler (1991a), W. Roberts (pers. obs.)	Clearwater River near Ricinus and Dovercourt
Crimson Lake Prov. Park	Spalding (1980, pg. 170), C. Wershler (pers. obs.)	One seen in large fen S of Crimson Lake by C. Wershler in July 1973
Boreal Forest - Mixed Wood Natural Region		
Raven River-Caroline	W. Roberts (pers. obs.)	Along the Raven River S and E of Caroline
Glory Hills - Kilini Creek	Spalding 1980 (pg. 206), W. Roberts (pers. obs.)	NW of Red Deer
Thunder Lake Prov. Park	Friesen and Schaafsma (1973)	
Long Lake Prov. Park	(Spalding 1980, pg. 234), Friesen and Schaafsma (1973)	"Seen in shoreline community"
Steele Lake	Report probably in provincial parks' ecological report from 1973 (C. Wershler pers. comm.)	Cross Lake Prov. Park
Boreal Forest - Hay River Natural Region		
Fitzgerald Settlement	Preble (1908)	Location listed as Smith Landing which is now known as Fitzgerald Settlement.

APPENDIX 4. Sightings of Northern Leopard Frogs recorded in Alberta since 1981.

Location	Georeference(a)	Date	Comments	Source (b)
Major Breeding Populations (>100 young-of-the-year observed)				
Bow City	17-17-W4M(*)	1991, 1992, 1996		(Seburn 1992a, 1993), BSOD 1033-1035
Empress Creek	23-1-W4M(*), 23-1-W4M(*), 23-1-W4M(*)	1990-1994	see Table 1	Seburn (1992a, 1993, 1994), Yaremko (1994)
Jenner Pond	21-8-W4M(*)	1990, 1991		Wershler (1991a, 1992a)
Kennedy's Coulee, N of Red Deer River	23-2-W4M	1990, 1991	15 ad., 6 juv.	Wershler (1991a, 1992a)
Little Bow River	12-20-W4M(*)	1990, 1991		Wershler (1992a)
Prince's Spring	21-3-W4M(*)	1990-1995	see Table 1	Wershler (1991b, 1992b), Hofman (1992, 1994a&b, 1995)
Sexton Creek	7-3-W4M(*)	1990-94	see Table 1	Wershler (1991a), Seburn (1992a, 1993, 1994), Yaremko (1994)
Minor Breeding Populations with Direct or Indirect Evidence of Breeding (see text)				
Bashaw	42-20-W4M	17-May-90	males calling in spring	Wershler (1991a)
Blood Indian Creek	23-8-W4M	16-Aug-91	breeding location	Seburn (1992a), BSOD 660, 661
Bow River S of Gleichen	21-23-W4M(*)	28-Aug-90	1 yoy observed,	Wershler (1991a),BSOD 601
Coaldale	9-20-W4M(*)	12-Aug-91	several transforming tadpoles	Seburn (1992a)
Claresholm	11-30-W4M(*)	15-Jul-91	one in creek	Seburn (1992a)
Kennedy Creek	1-6-W4M	1990s		Seburn (1992c), Wershler and Smith (1996)
Little Bow River	13-20-W4M(*)	2-Aug-91	1 ad., 5 yoy	Wershler (1992a)
McKay Creek	36-10-1-W4M	26-Jun-91	breeding site; 3 small ad. and 7 tadpoles seen	Seburn (1992c), C. Wershler (unpubl. data)
Milk River Natural Area	542/521	1990s		Seburn (1992c), Wershler and Smith (1996)
North Saskatchewan River Drainage, Upper Reach (c)	location kept secret at request of landowner	1990s	transplanted frogs doing well in area	W. Roberts (pers. comm.)
Old Channel Lake	14-5-W4M(*), 15-5-W4M	1990, 1991, 1995		Seburn (1992a), Wershler (1991a), A. Didiuk (unpubl. data)
Reesor Lake, Cypress Hills Prov. Park	8-1-W4M	1990 & May1991	males calling in spring, ad. and juv. observed	Seburn (1992a)
Rockyford St. Mary's River, E of St. Mary Reservoir	26-23-W4M(*) 5-23-W4M(*)	Jun-91 8-Jul-90	3+ calling 20 juv., 1 tadpole. Record might be suspect (Wershler 1992a)	Seburn (1992a) Seburn (1992a)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	560/542 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	559/531 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Willow Creek	13-29-W4M (*)	Jun-92	4 ad., 75 yoy	D. A. Westworth & Associates (1993)

Confirmed or Highly Probable Site Records With No Confirmed Evidence of Breeding				
Battle Creek	8-1-W4M	8-Jul-91	7 ad.	Seburn (1992a)
Beaver Creek	10-30-W4M (*)	1990, 1991		Seburn (1992a)
Boquene Lake	121-7-W4M (*)	5-Jun-91	10 observed	Seburn (1992a)
Bow River	12-12-W4M (*)	29-Aug-90	11 ad.	Wershler (1991a)
Bow River at Grand Forks	12-12-W4M (*)	17-Aug-89	2 ad.	Seburn (1992a)
Bow River at Grand Forks	11-13-W4M	11-Aug-91	2 ad.	Seburn (1992a)
Canal Creek	2-5-W4M (*) 2-5-W4M (*)	1990	ad. and juv. observed	Seburn (1992a)
Circle E Project (south and east of Lonesome Lake)	16-17-W4M	1994,1995	several ad. observed, possibly major breeding site	G. Wagner, G. Erickson, S. Brechtel, B. Triechel (1995, pers. obs.), D. Watson (1994, pers. obs.)
Connaught Golf Course	12-5-W4M (*)	1990, 1991	ad. and juv. observed	Seburn (1992a)
Dugout and irrigation canal on N side of the Red Deer River	563/482 (NAD 27)(*)	Aug-93	15 ad. observed	R. Lauzon, unpubl. data
Dugout on N side of the Red Deer River	563/484 (NAD 27)(*)	1993, 1995	ad. observed	R. Lauzon and E. Hofman, unpubl. data
Finnegan Ferry	25-15-W4M (*) 26-16-W4M (*)	1990, 1991	possibly a major breeding location	Wershler (1991a), Seburn (1992a)
Gold Spring Park, along Milk River	2-15-W4M	30-Jun-91	2 ad. observed	Seburn (1992a)
Horse Creek	27-4-W5M, 27-5-W5M (*)	1990, 1996	possible, but unconfirmed breeding	Seburn (1992a), BSOD 460, 572, 1037
J. J. Collett Natural Area, S of Morningside	41-26-W4M	1990	no frogs found in 1991 (Seburn 1992a)	Wershler (1991a)
Kennedy's Coulee, N of the Red Deer River	23-2-W4M	8-Aug-90	15 ad., 6 juv.	Wershler (1991a)
Kneehills Creek near Carbon	29-23-W4M (*)	10-Sep-96	1 ad.	BSOD 1038
Little Bow River	18-29-W4M (*)	20-Sep-96	4 ad. observed	BSOD 463
Lodge Creek	3-1-W4M (*)	29-Aug-90	1 ad.	Wershler (1991a)
Mannyberries Creek	5-5-W4M (*)	1990	7 ad.	Seburn (1992a)
Milk River Canyon	1-6-W4M (*)	1-Jul-90	1 observed	Seburn (1992a)
Milk River Canyon	1-6-W4M (*)	1-Jul-90	1 observed	Seburn (1992a)
Milk River Canyon	2-6-W4M (*)	30-Jun-90	1 observed	Seburn (1992a)
Milk River Canyon	2-7-W4M (*)	30-Jun-90	1 observed	Seburn (1992a)
Milk River Canyon	2-7-W4M (*)	30-Jun-90	1 observed	Seburn (1992a)
Milk River Canyon	2-7-W4M (*)	30-Jun-90	1 observed	Seburn (1992a)
Milk River (Pinhorn Ranch)	2-7-W4M	23-Aug-91	200, mostly yoy seen, unconfirmed but highly probable report	Seburn (1992a)
Milk River (town)	2-16-W4M (*)	4-Jul-91	1 ad.	Seburn (1992a)
Pinhorn Grazing Reserve along Milk River	2-7-W4M	1995		L. Powell (pers. obs.)
Police Point Park, Medicine Hat	13-5-W4M (*)	20-Aug-95		BSOD 462
Porcupine Hills	10-30-W4M	10-Aug-91	3 ad.	Seburn (1992a)
Riverbend Campground along Sheep River near Okotoks	20-29-W4M (*)	28-Aug-96	1 ad., 3 juv.	BSOD 1031
Slack Slough, Red Deer	37-27-W4M (*)	23-Jun-90	2 observed	Seburn (1992a)
S of Lost River Ranch	2-13-W4M (*)	1990	1 observed	Seburn (1992a)
St. Mary's River and Pinepound Creek near Spring Coulee	5-22-W4M	early 1990s	population now believed eradicated	W. Roberts (unpubl. data)
Strathcona Island Park, Medicine	12-5-W4M	1989,1990		Wershler (1991a)

Hat				
Suffield National Wildlife Area	560/530 (NAD 83)(*)	1-May-96		BSOD 359
Suffield National Wildlife Area	559/536 (NAD 83)(*)	1994		A.Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	558-558/532-542 (NAD 83) (*)	1994	along rivers edge between these points	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	558/540 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	560/543 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	559-560/542-542 (NAD 83)(*)	1994	along rivers edge between these points	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	558/542 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	559/542 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	558/541 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1995		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1995		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1995		A. Didiuk (unpubl. data)
Sunwater Slough	23-8-W4M (*)	1990,1991	2 observed	Seburn (1992a)
Taber Prov. Park	10-16-W4M	1994	8 observations	B. Sundberg, unpubl. data
Tail Creek near its junction with the Red Deer River	39-22-W4M	?	no frogs found in 1991 (Seburn 1992a)	Wershler (1991a)
Weir Bridge, Milk River, 8 miles upstream from Writing-on-Stone Prov. Park	2-13-W4M (*)	23-Jun-90	1 observed	Seburn (1992a)
Willow Creek	13-28-W4M (*)	Jun-92	52 ad. seen during the month	D. A. Westworth & Associates (1993)
Willow Creek	12-28-W4M (*)	Jun-92	19 ad., 1 juv.	D. A. Westworth & Associates (1993)
Writing-on-Stone Prov. Park	1-13-W4M (*)	1990	several records	Seburn (1992a), Wershler (1991a)
Wylie Lake	119-3-W4M	1983		Wallis and Wershler (1983)

(a) Georeferences are given as Township-Range, or as UTM (northing/easting). Accuracy of georeference points indicated with an asterisk (*) has been reduced to protect sites from disturbance. Precise locations may be provided to agencies/individuals with a demonstrated need to know

(b) ABSOD≅ refers to record numbers in the Biodiversity/Species Observation Database, maintained by the Wildlife Management Division of Alberta Natural Resources Service

(c) Not mapped

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