

**Final Report: December, 1991**

**Project:** Distribution and Prevalence of the Kandiyohi Frog in Minnesota

**Investigators:** David M. Hoppe and Robert G. McKinnell

**Abstract**

Leopard frogs were captured and released at 20 different sites in 10 Minnesota counties, including 8 counties where the kandiyohi morph had been previously reported and 2 other counties within the general range of this mutant frog. Surveys of 8 sites in 4 counties where frogs had been previously abundant revealed no frogs in 1990. A total of 2008 frogs were captured and examined, among them being 8 kandiyohi frogs from 4 different counties (freq. = 0.4%) and 129 burnsi frogs (freq. = 6.4%). These data include 3 new county records for these leopard frog mutations.

The overall incidence of kandiyohi frogs found in these surveys compares favorably with 0.6% kandiyohi reported in 1965, but much larger sample sizes and more county surveys are needed to assess changes in the range or prevalence of this mutation. The burnsi morph appears to be relatively unaltered in distribution or abundance in the limited counties surveyed within the burnsi range. Collections are still needed in 8 Minnesota counties within the previously-known range of the kandiyohi morph, at least 2 Minnesota counties of interest outside the known range, and several South Dakota counties, in order to complete an update of the distribution and abundance of the kandiyohi leopard frog.

Leopard frogs in general appear to have been "regionally abundant" in 1990-91, but were absent or at decreased levels in some sites where they were abundant in the late 1970's.

The results of this study, along with some of the investigators' previous research and a general discussion of leopard frogs in Minnesota were published in the Nov-Dec, 1991, issue of *The Minnesota Volunteer*.

## Introduction

The leopard frog pigment pattern variants, kandiyohi and burnsi, were described as new species by Weed (1922). Both were later shown to be variants of *R. pipiens*, each caused by a dominant gene (Moore, 1942; Volpe, 1955). The kandiyohi and burnsi variants (pictured in Appendix 1) are both peculiarly Minnesotan, a fact emphasized by scrutiny of the map of North American leopard frogs of Wright and Wright (1949) (Appendix 1). Note that of the two forms, burnsi has the greater distribution in Minnesota while kandiyohi is the more westerly form. Kandiyohi has been noted rarely in eastern South Dakota (McKinnell and McKinnell, 1967). The most recent map was published by McKinnell and Dapkus (1973) (Appendix 2).

Unspotted leopard frogs were illustrated in a book by Dickerson (1906). It was noted that they were collected at "White Bear Lake, Minnesota." Later collections of Minnesota leopard frogs had not only the spotless (burnsi) frogs but mottled (kandiyohi) frogs as well (Weed, 1922). Both are illustrated and discussed with maps in *Reptiles and Amphibians of Minnesota* (Breckenridge, 1944). Burnsi and Kandiyohi distributions were reported by Merrell (1965) and his maps were updated in the study of McKinnell and Dapkus (1973).

Populations of leopard frogs in Minnesota plummeted in the 1970s for reasons not fully understood. There has not been a full recovery since that time. While it is true that substantial numbers of frogs can be collected from many sites, the abundance of frogs in the 1960s has never been restored. Kandiyohi frogs were formerly so common that the form appeared in biological supply catalogs of the 1960s. Only 3 kandiyohi frogs were captured in a sample of 1138 frogs examined by Hoppe and McKinnell from 1987-89 (unpublished data).

The present study seeks to (1) establish current distribution and relative frequency of the kandiyohi pigment pattern variant of the northern leopard frog, *Rana pipiens*, in western Minnesota, and (2) update the distribution and relative frequency of the burnsi pigment pattern variant of *R. pipiens*, with special reference to counties within its range where the mutant has not been recorded.

## Materials and Methods

Collection sites were selected on the basis of frog availability and access - most being roadside ditches, public access areas, or public wildlife areas near bodies of water. Frogs were individually captured in their feeding meadows by use of insect sweep nets. Data consisting of sex, color, pigment pattern, and snout/vent length were recorded on the site, and the frogs were released at the capture site. All kandiyohi frogs and any new county records of burnsi frogs were photographed before release.

## Results and Discussion

Most of this project's leopard frog collections were made and data recorded during August, September, and October of 1990. Successful collections (those in which substantial numbers of frogs were obtained) were made that year at 19 different sites in 10 Minnesota counties. The kandihohi leopard frog morph had been previously reported (McKinnell and Dapkus, 1973) in 8 of the counties, while the other 2 counties were in the general kandiyohi range but had not yielded kandiyohi frogs in the past. Additionally, collecting was unsuccessfully attempted at 8 sites in 4 counties, where leopard frogs were previously abundant but were rare or absent in 1990. The mileage involved in the 1990 collecting ended up being more than the expense allotment of this grant.

A total of 1690 frogs were captured and examined in the above surveys. These included 8 kandiyohi frogs (freq. = 0.5%) and 105 burnsi frogs (freq = 6.2%). Data on sex, body size, and dorsal color were also recorded for future analyses. The kandiyohi frogs came from 4 different counties: Lincoln, Stevens, Swift, and Traverse. Three of the pattern variant frogs are new county records for these mutations, and extend the known ranges of kandiyohi and burnsi frogs: kandiyohi into Lincoln county, and burnsi into Lincoln and Lyon counties. All of the frogs captured in this survey were released at the site of capture. Photographic records were made of all kandiyohi frogs and of the new county record burnsi frogs.

While sample sizes are not high enough for meaningful county-by-county comparisons, the overall incidence of kandiyohi (0.5%) in these surveys compares favorably with 0.6% kandihohi reported by Merrell (1965) among 1351 frogs captured in this same set of counties. Higher sample sizes are needed in some counties, and more counties need to be surveyed in order to make any conclusions on changes in the distribution and/or abundance of the kandiyohi leopard frog.

Limited collecting was also done in July and August of 1991, at the investigators' own expense and using the remaining DNR funds for student assistance. The 1991 surveys were in Douglas, Ottertail, and Stevens counties. A total of 318 frogs were examined, containing 24 burnsi and no kandiyohi frogs. The most interesting aspect of the 1991 data is confirmation of the abnormally high (ca. 20%) frequency of burnsi frogs in the Block Lake population in Ottertail county. Results of all 1990 and 1991 surveys are summarized in Table 1.

Our general impression on the population densities of leopard frogs in these western Minnesota counties is that they are "regionally abundant," but are at decreased levels or even absent in some sites where we have found them at high numbers in the past. Much of the decrease may be attributed to recent drought conditions, as the most dense populations appear to be near specific permanent lakes and rivers - sites affording both breeding and hibernating habitat even in dry years. Some declines at seemingly favorable sites remain puzzling.

Collections are still needed in 8 MN counties within the previously-known range of the kandiyohi morph, at least 2 MN counties of interest outside the known range, and several South Dakota counties. We are currently assessing anticipated expenses and possible sources of funding to complete these surveys.

The results of our leopard frog surveys prior to and during this grant period have been published in a general interest format in the most recent *Minnesota Volunteer* (Hoppe and McKinnell, 1991) (Appendix 3). We want to complete surveys in the aforementioned counties in 1992 and then publish the findings of the entire study, with updated burnsi and kandiyohi range maps in a scientific journal. Further, feedback from the *Volunteer* article has resulted in unconfirmed reports of mutant frogs outside of their known ranges that we want to examine.

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## Appendixes

- Appendix 1: Illustration of burnsi and kandiyohi forms from National Academy of Sciences publication, 1974
- Appendix 2: Map of the United States showing the peculiarly Minnesotan distribution of burnsi and kandiyohi leopard frogs (from Wright and Wright, 1949)
- Appendix 3: 1973 distribution map of the kandiyohi leopard frog (from McKinnell and Dapkus, 1973)
- Appendix 4: Copy of Hoppe and McKinnell paper from *The Minnesota Volunteer*

**TABLE 1. Leopard Frog Surveys, 1990-91**

I. MN counties where kandiyohi morph had been previously recorded

<u>county</u>	<u>site, date</u>	<u>total frogs sampled</u>	<u>#K</u>	<u>#B</u>	<u>%K</u>	<u>%B</u>
Big Stone	1. Jacobson farm, 9/90 2.	112	0	0	0	0
Chippewa	1. 2.					
Douglas	1. Lake Latoka, 9/90 2. Lake Mary, 7/91	28 112	0 0	0 2	0 0	0 1.7
Grant	1. 2.					
Kandiyohi	1. Lake George, 9/90 2.	36	0	0	0	0
Lac Qui Parle	1. 2.					
Meeker	1. 2.					
Ottertail	1. Block Lake, 8/90 2. Eagle Lake, 8/90 3. Block Lake, 10/90 4. Block Lake, 8/91	221 88 305 95	0 0 0 0	41 4 53 20	0 0 0 0	18.5 4.5 17.4 21.0
Pipestone	1. 2.					
Pope	1. Starbuck marina, 9/90 2. Westport Lake, 9/90 3. Lakes Ann & John, 9/90	17 101 124	0 0 0	1 0 0	0 0 0	5.9 0 0
Stearns	1. 2.					

(MN counties, cont.)		<u>N</u>	<u>#K</u>	<u>#B</u>	<u>%K</u>	<u>%B</u>
Stevens	1. Straw's farmsite, 9/90	100	1	0	1.0	0
	2. Wintermute Lake, 9/90	73	0	0	0	0
	3. Straw's farmsite, 8/91	101	0	2	0	2
Swift	1. Lake Moore, 9/90	70	1	0	1.4	0
	2. Lake Oliver, 10/90	65	1	1	1.5	1.5
Traverse	1. Mustinka river, 9/90	95	2	0	2.1	0
	2.					
Wilken	1.					
	2.					
Yellow Medicine	1.					
	2.					

## II. MN counties where kandiyohi had not been previously reported

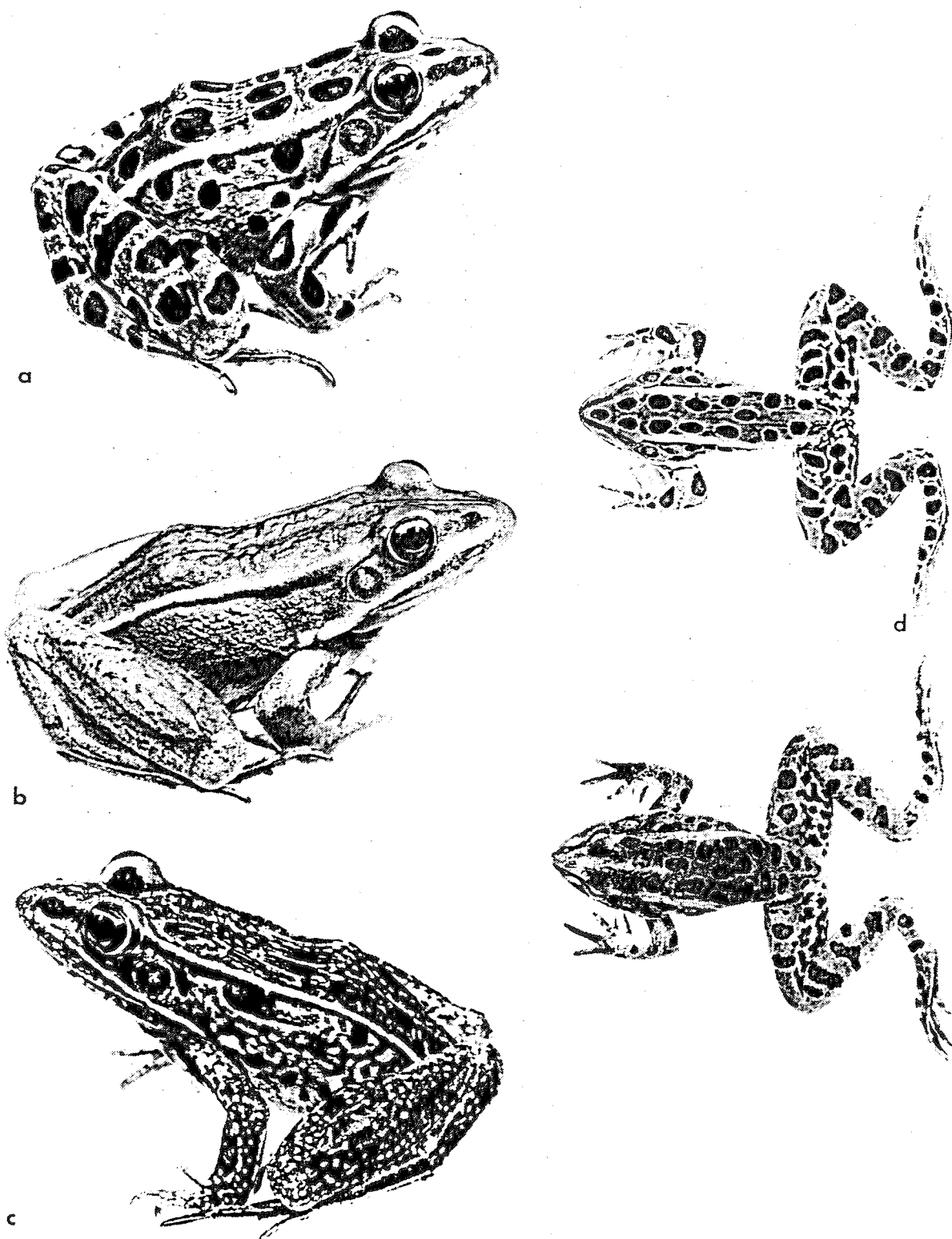
Lincoln	1. Steep Bank Lake, 9/90	148	3	4	2.0	2.7
	2. Lake Shaoratan, 9/90	50	0	0	0	0
	3. Lake Hendricks, 9/90	11	0	0	0	0
Lyon	1. Cottonwood Lake, 9/90	46	0	1	0	2.2
	2.					

## III. South Dakota counties

Roberts	1. Big Stone landing, 9/90	23	1	2	4.3	8.7
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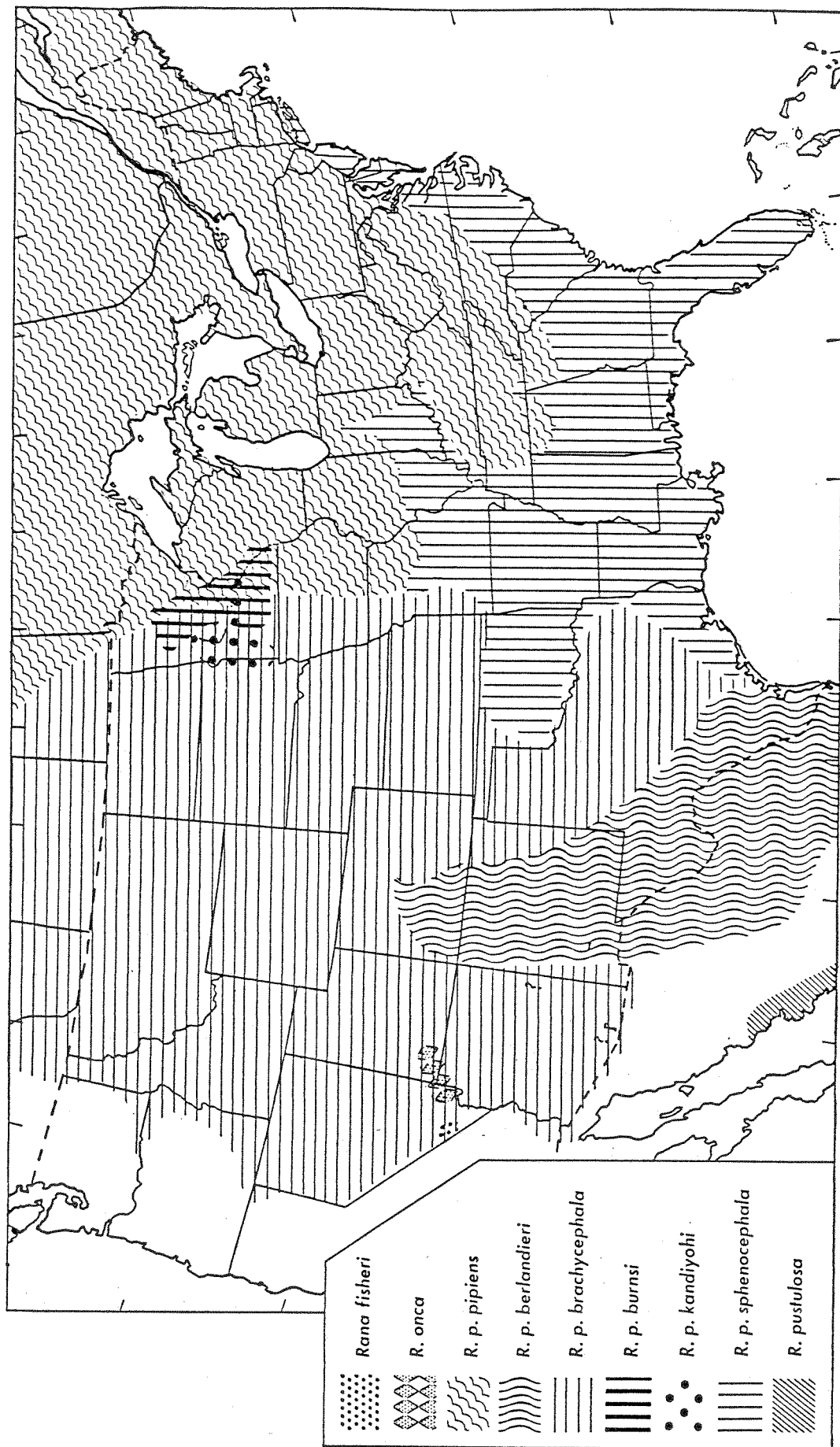
Hoppe and McKinnell: Leopard frog collection locations (4/20/93)

<u>Location</u>	<u>County</u>	<u>Coordinates</u>
Cormorant Lake	Becker	SW1/4 S1 T138N R43W
Jacobson farm	Big Stone	NW1/4 S7 T122N R45W
Lake Latoka	Douglas (Alexandria limits, shoreline SW of I94)	
Lake Mary	Douglas	NW1/4 S18 T127N R38W
Quick farm	Grant	SE1/4 S31 T128N R41W
Lake George	Kandiyohi	SE1/4 S31 T121N R34W
Steep Bank Lake	Lincoln	NE1/4 S1 T112N R 46W
Lake Shaokatan	Lincoln	S1/2 S23 T111N R46W
Lake Hendricks	Lincoln	S1/2 S19 T112N R 46W
Cottonwood Lake	Lyon	SE1/4 S4 T113N R46W
Star Lake	Meeker	E1/2 S5 T118N R31W
Block Lake	Otter Tail	S1/2 S8 T131N R38W
Eagle Lake	Otter Tail	NE1/4 S15 T131N R40W
Nelson Lake	Otter Tail	N1/2 S18 T131N R37W
Lakes Ann&John	Pope	SE1/4 S21 T126N R38W
Starbuck Marina	Pope	(Starbuck city limits)
Westport Lake	Pope	SW1/4 S22 T126N R36W
Koronis Boat Landing	Stearns	S1/2 S35 T127N R32W
Koronis Rest Area	Stearns	SE1/4 S35 T127N R32W
Gausman farmsite	Stevens	NW1/4 S19 T125N R41W
J.W.Edwards WPA	Stevens	NE1/4 S5 T124N R41W
Pomme de Terre Park	Stevens	NE1/4 S1 T124N R42W
Wintermute Lake	Stevens	SE1/4 S12 T125N R42W
Straw farmsite	Stevens	NW1/4 S22 T125N R42W
Lake Moore	Swift	NW1/4 S15 T122N R39W
Lake Oliver	Swift	SW 1/4 S26 T122N R43W
Mustinka river	Traverse	NE1/4 S31 T127N R47W



**FIGURE 8** Leopard frogs, *Rana pipiens*. (a) typical member obtained from northern United States; (b) Burnsii mutant of the leopard frog, obtained from Minnesota; (c) Kandiyohi variant of the leopard frog, obtained from Minnesota; (d) *top*: a "northern frog"; *bottom*: the more pallid "Mexican frog." Note that the spots between the dorsolateral ridges of the northern frog tend to be circular in contrast to the transverse posterior spots in the corresponding area of the Mexican frog.





Map 34

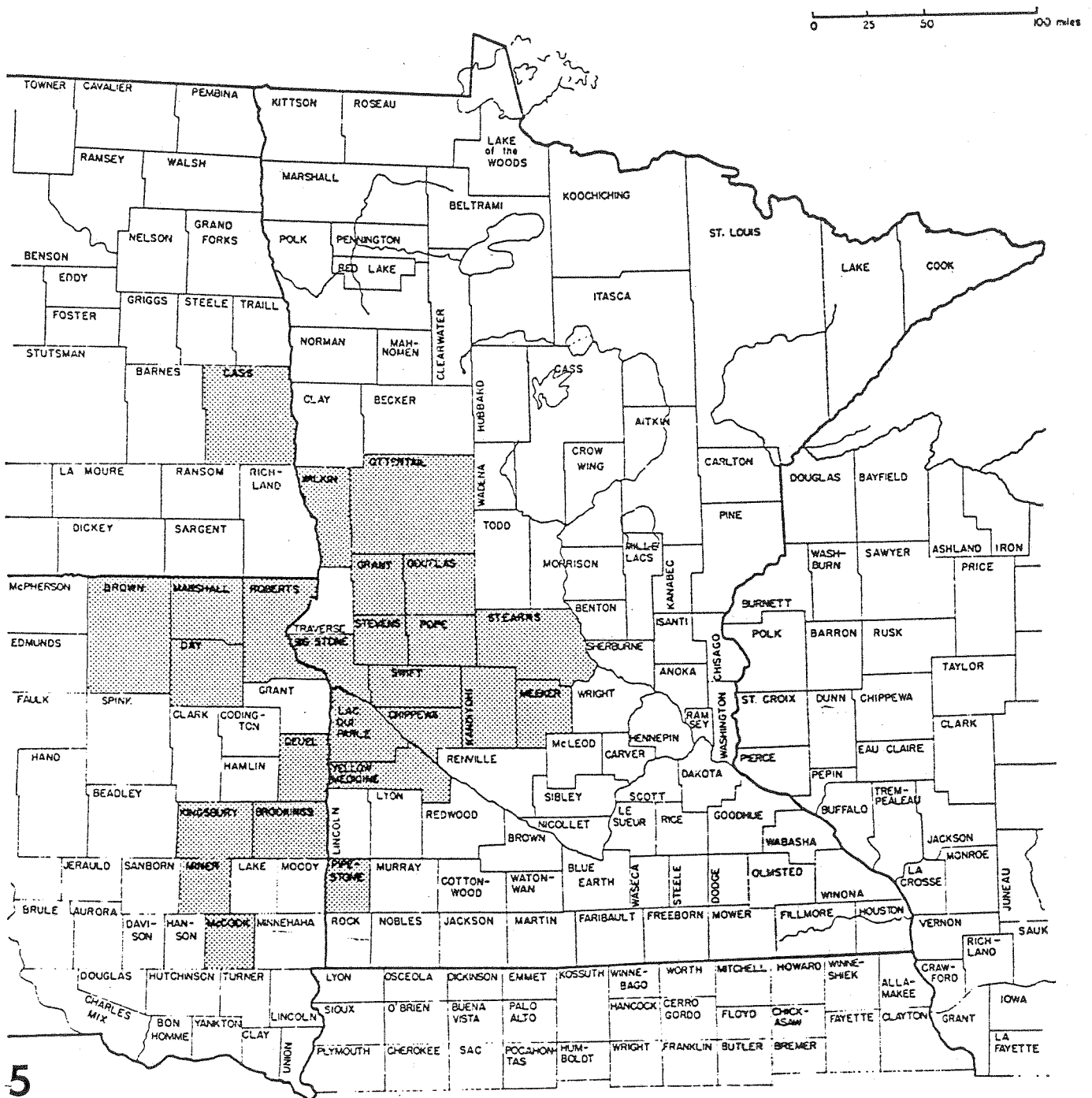
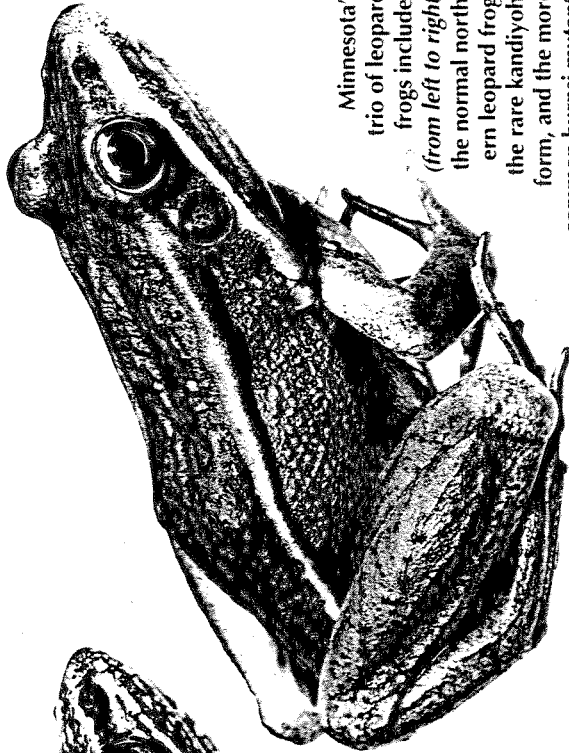
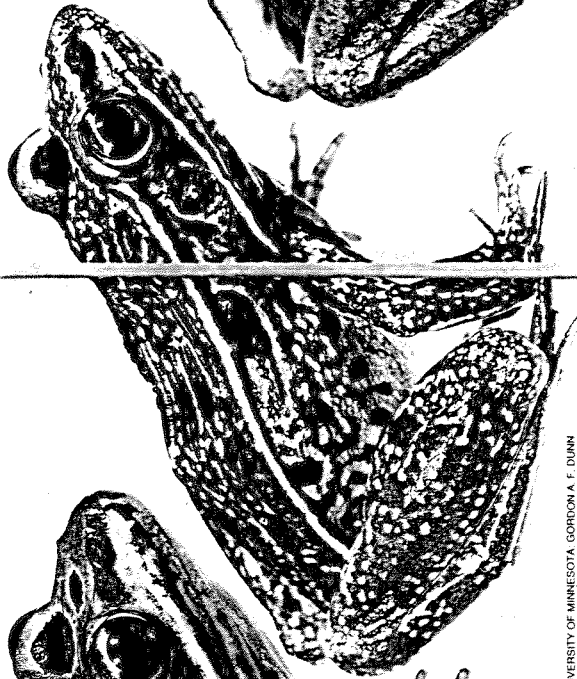


FIG. 5. County map of Minnesota and adjacent area showing distribution of kandiyohi frogs.

# Minnesota's Mutant

# Leopard Frogs



Minnesota's trio of leopard frogs includes (from left to right) the normal northern leopard frog, the rare kandiyohi form, and the more common burnsi mutant.

PHOTOS BY UNIVERSITY OF MINNESOTA GORDON A. F. DUNN

Two strange variations of Minnesota's common leopard frog pose a fascinating genetic riddle.

By David M. Hoppe and Robert G. McKinnell

**T**EEENAGE MUTANT leopard frogs in Minnesota? Does Hollywood know about this?

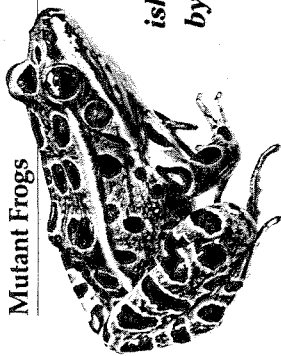
Minnesota does, in fact, have two unusual types of frogs that fit this description. Both are northern leopard frogs (*Rana pipiens*), the only species of leopard frog in our state. There are six species of leopard frogs in North

America, among the 3,494 living species of frogs and toads worldwide.

Leopard frogs, also called grass frogs, are the creatures most people associate with the term *frog*. They are the spotted green or brown frogs familiar to bass anglers, introductory biology students, and just about anyone who has driven near a wetland on a

rainy summer night. They've been found in every county of the state.

Are the mutant frogs really teenagers? It is unlikely that any leopard frog would ever live 13 years. But if you calculate "frog-years" based on maturity and life span, the way pet owners figure "dog years," a high percentage of the frogs seen in late



**“We aren’t looking for two-headed, six-legged, or otherwise freakish offspring born in ponds contaminated by radioactive fallout or toxic waste.”**

summer and fall are indeed teenagers. The 2- to 3-inch-long leopard frogs so abundant in September just went through metamorphosis from tadpole to frog in July. These young frogs are still growing and maturing (as we hope our own teenagers are) but won’t reach maturity until the following year. The less common, more plump 3- to 5-inch frogs are the 2- to 4-year-olds responsible for most reproduction.

As researchers funded by the Department of Natural Resources nongame wildlife research program, we do most of our surveys in the fall when frogs are more easily found because they are gathering near lakes and rivers where they will hibernate. So any frog captured at this time, mutant or otherwise, could be a “teenager.” But, of course, we also encounter adult northern leopard frogs.

*David M. Hoppe is a professor of biology at the University of Minnesota, Morris. His research deals primarily with amphibian color variation. Robert G. McKinnell is a professor of genetics and cell biology at the University of Minnesota, St. Paul. He has worked with cancer cells of frogs for 35 years.*

When we say we are looking for mutants, we are not talking about the rare occurrence of an albino frog, blue frog, or melanistic black frog. And we are not looking for two-headed, six-legged, or otherwise freakish offspring born in ponds contaminated by radioactive fallout or toxic waste. We are talking about two forms of leopard frogs that originated as mutations at some time in their history. But unlike most genetic mistakes, these mutant frogs are now relatively common—at least much more common than “one-in-a-million” mutations like albino frogs. And they persist.

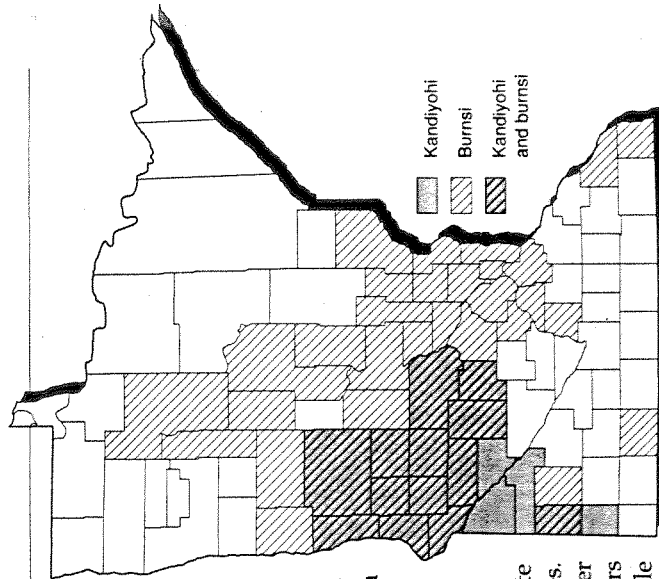
**One-Gene Difference.** These two variants are the *burnsi* and *kandiyohi* mutants. Each differs genetically from a typical leopard frog by just one gene and differs physically only in the pattern of spotting. Surprisingly, they are almost unique to Minnesota.

No one knows whether all Minnesota *burnsi* and *kandiyohi* frogs are descendants of a single mutant *burnsi* and a single mutant *kandiyohi* or if the *burnsi* and *kandiyohi* genes have frequently mutated over the years.

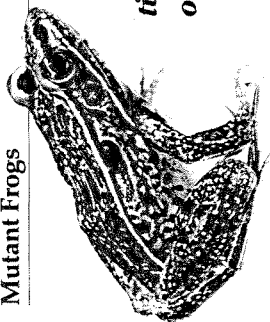
The presence of the mutant frogs may have resulted from the survival of the original mutants and their progeny, with the mutated gene passing from each generation to the next. If so, mere survival would suggest that these mutant genes do not hinder the frogs. In fact, to have become prevalent at even a one-in-a-hundred frequency, the mutants are likely superior to normal leopard frogs under some conditions.

Our leopard frogs hibernate mostly at the bottoms of lakes. Are spotless *burnsi* frogs better hidden from aquatic predators on sandy lake bottoms, while normal spotted frogs are better camouflaged while feeding in grassy meadows? Do *kandiyohi* frogs develop through the tadpole stages more rapidly, giving them an advantage in temporary prairie pothole breeding ponds? Such questions have been posed in the scientific literature, but good data to answer these questions is not yet available. But the mutants would certainly disappear quickly if the frogs were unsuited for survival in our rigorous climate.

**Recurrent Mutations.** A different explanation for the mutants’ continued presence is the possibility of mutations recurring in several generations. Re-



The *burnsi* frog is the more common and more widely distributed of Minnesota’s two leopard frog mutants. The *kandiyohi* form is found only in west-central Minnesota and parts of the Dakotas.



**“We have no idea whether the frogs ensued from one mutation or many, and if many, what the rate of mutation might be.”**

current mutations would result in burnsi or kandiyohi frogs indistinguishable from the original mutants. Supporting the hypothesis of recurrent mutations is the fact that while frog population numbers have fluctuated dramatically, neither burnsi nor kandiyohi frogs have disappeared. Consider a population that has a low prevalence of these mutant frogs. Subject that population to an ecological disaster such as one or more years of severe drought. You might expect that burnsi or kandiyohi frogs would disappear as populations plummet, if for no other reason than their initial scarcity. Yet they haven't. Perhaps the persistence of these frogs in Minnesota is due partly to recurrent mutations.

As is the case with many aspects of frog biology, we have no idea whether the frogs ensued from one mutation or many, and if many, what the rate of mutation might be. Whichever is true, burnsi and kandiyohi mutants have persisted. We are not dealing with overnight ninja sensations here!

The burnsi form appears very different from a typical leopard frog. It has no spots on its back. Bars or spots

may be present or absent on the legs, but the back is usually a uniform brown or green, although some frogs are partly speckled and may have one or two spots. In fact, the burnsi looked so different that when first discovered it was mistakenly considered to be a new species. It was temporarily dubbed *Rana burnsi* by Alfred Weed Burns in 1922 to commemorate F. J. and J. J. Burns of F. J. Burns & Co., Chicago produce dealers who helped obtain Minnesota frogs to study.

Burnsi leopard frogs are most common in the area north of the Twin Cities known as the Anoka Sand Plain. As many as 10 percent of the leopard frogs of these populations may be of the burnsi form. The frequency in most of the burnsi range is usually 1 to 5 percent burnsi. Burnsi frogs become less common in any direction from Anoka County, disappearing completely in the northeastern Arrowhead region and the upper Red River Valley. They occur in 42 Minnesota counties, seven counties in eastern South Dakota, three counties in western Wisconsin, and one county in northwestern Iowa.

However, within this range may be isolated populations with larger proportions of burnsi frogs. For example, in the fall of 1990, about 18 percent of the frogs in one locality in Otter Tail County were burnsi frogs. Why are burnsi mutants so common at one site in Otter Tail County, yet not found 75 to 100 miles away in Norman, Mahanomen, or Polk counties? It remains a mystery. And the scarcity of burnsi both north and south of the Anoka Sand Plain is also puzzling.

**Prairie Creatures.** The kandiyohi form differs less obviously from normal leopard frogs than does the burnsi, but it's still distinctive. This form too was once considered a separate species, *Rana kandiyohi*. Both burnsi and kandiyohi frogs were later reduced in status to subspecies, then ultimately came to be considered simply mutant variants of the northern leopard frog, since all freely interbreed. *Kandiyohi* was used as a name because the first study specimens showing this mutation were collected in Kandiyohi County near New London.

Kandiyohi leopard frogs have a mottled appearance on both the back and legs, due to an irregular pattern of markings between the major dark



Rachel Hoppe, daughter of the co-author, grasps a northern leopard frog, the common spotted amphibian familiar to bass anglers and quick-handed kids.



**“Our studies have caused us concern about leopard frogs in general. Something appears to be preventing eggs from developing into tadpoles.”**

spots. The extra markings make them much darker than other leopard frogs.

Kandiyohei leopard frogs appear to be creatures of the prairie, found in only 17 counties in west-central Minnesota, nine in eastern South Dakota, and one in extreme eastern North Dakota. Even less abundant than burnsi frogs, kandiyohei frogs are usually found at a frequency of only 0 to 2 percent, even in the heart of their range. It's a mystery why they are never found in other parts of our state.

We have been surveying Minnesota leopard frog populations extensively in recent years to update the distribution maps of these mutants and to check on their abundance. We were concerned that the kandiyohei form had become extinct, because there had been no official reports of its presence in about 10 years. And frog populations in the prairie regions of the state had been seriously depleted by the recent drought and perhaps other problems. However, we're happy to report that the kandiyohei has not disappeared; it's just quite rare. We found only 11 kandiyohei frogs in examining 2,828 leopard frogs within the known

range of kandiyohei during the past three years. The burnsi form appears to be maintaining both its distribution and relative abundance, with 109 mutant frogs recorded in the three-year sample.

Our studies of mutant frogs have caused us a new concern about Minnesota leopard frogs in general. We have noticed decreased reproductive success. Something appears to be preventing fertilized eggs from developing into tadpoles. Soon we plan to investigate the nature of this reproductive problem and its impact on declining frog populations.

**Global Decline.** Now is an especially important time to try to better understand frog biology. Amphibians, especially frogs, are declining in abundance—not just in Minnesota, but in the Pacific Northwest, the Rocky Mountains, the mid-continental prairies, the tropics, Europe, Australia, and many other areas worldwide. We are experiencing what scientists have dubbed a “global amphibian decline.”

The importance of understanding and halting this decline is stressed by

David Wake, a noted herpetologist and professor of zoology at the University of California: “[Amphibians] were here when the dinosaurs were here and [they] survived the age of mammals. They are tough survivors. If they're checking out now, I think it is significant.” Consider the variety of habitats

and habitat changes that amphibians have survived during their roughly 250 million years of existence. Why are they suddenly declining so drastically now? That question is of serious concern to biologists, enough so that the International Union for the Conservation of Nature has recently established a “Task Force on Declining Amphibian Populations,” centered in Corvallis, Ore. We hope to add to that task force's database with our leopard frog studies.

Tracking the less common forms of these frogs may help us understand why leopard frogs in general have declined over the past 15 years. Environmental problems causing the decline or disappearance of rare forms of wildlife are likely to affect, in turn, more common forms. That these mutants are unique to our area makes them especially interesting. Leopard frogs from South Carolina, Illinois, Colorado, or Oregon, for example, do not show the burnsi or kandiyohei mutations. Similar mutant frogs have been found only sporadically outside the upper Midwest. Why have these mutants survived? Why have they become reasonably common in Minne-

sota but nowhere else in the country? We do not have good answers to these questions yet.

As a more practical consideration, both burnsi and kandiyohei leopard frogs have been used in biological research, including experiments significant to human genetics and cancer research.

Minnesota's mutants have become well-known in scientific circles. A burnsi frog from White Bear Lake is pictured in *The Frog Book*, a 1906 publication by Mary C. Dickerson. Both mutants are pictured in Walter Breckenridge's 1944 *Reptiles and Amphibians of Minnesota* and in a 1975 college genetics textbook by David Merrell, who did much of the early research on these mutants. Photographs of burnsi and kandiyohei mutants are included in a 1974 National Academy of Sciences publication on laboratory amphibians. And as recently as 1989 a picture of a Minnesota kandiyohei frog graced the cover of *Cancer Research*, the internationally distributed journal of the American Association for Cancer Research. To assess the possible roles of these mutant leopard frogs in future research, we need to know more about their distribution and abundance.

And finally, even mutant frogs are natural members of Minnesota's diverse wildlife, worthy of interest and study for that reason alone. And darned handsome wildlife at that! Someone tell Hollywood! □