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SURVEY AND ASSESSMENT OF AMPHIBIAN POPULATIONS IN ROCKY MOUNTAIN NATIONAL PARK

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ABSTRACT—We conducted surveys in Rocky Mountain National Park, Colorado for amphibians in 1987–1994. Four species, *Ambystoma tigrinum, Bufo boreas, Pseudacris maculata,* and *Rana sylvatica,* were recorded. *Pseudacris maculata* was the most widely distributed and abundant species in the Park. Two populations of *P. maculata* were estimated to contain 161 and 136 breeding males in 1988. There was no evidence of a decline of *A. tigrinum* or *R. sylvatica,* but these species were found at relatively few locations. We did not detect *Rana pipiens,* which had been known previously from 3 locations in the Park. We found 7 breeding populations of *B. boreas,* which has declined recently elsewhere in the southern Rocky Mountains, but all but 2 of these populations were small and may not reproduce annually. At least one of these small populations is thought to have been extirpated. Estimated numbers of males in the 2 large populations, which are 6.4 km apart in the same drainage, were stable or increasing slightly from 1992 to 1995, averaging 189 and 239 individuals. Current and known locations of amphibians did not differ in elevation, size, lake type, presence of shallow water or emergent vegetation on the north shore, or presence of trout. Water chemistry at amphibian breeding sites was variable, but pH decreased significantly with increasing elevation. Causes of declines of *B. boreas* and *R. pipiens* are not known. Populations of *B. boreas* in the North Fork of the Big Thompson River are critically important to the conservation of this species in the Rocky Mountains.

Declines and extinctions of amphibian populations throughout the world are receiving considerable attention (Richards and others 1993; Blaustein 1994; Pechmann and Wilbur 1994; Pounds and Crump 1994; Pyke and Osborne 1996; Green 1997). In the western United States, recent declines in abundance and distribution of several pond-breeding amphibians have been identified (Corn and Fogleman 1984; Bradford 1989; Carey 1993; Corn 1994; Drost and Fellers 1996; Fisher and Shaffer 1996). Declining amphibian populations in the southern Rocky Mountains are particularly alarming, because they occurred within the past 20 yr and in areas still considered pristine. However, except where habitat destruction has been observed, reasons for declines in amphibian populations are not well understood. The rapidity and magnitude of declines of some species emphasizes the need for baseline data on distribution and abundance of amphibians. Unfortunately, historical data on montane amphibians is often fragmentary or anecdotal, and life history information is also lacking or poorly understood. This lack of information confounds interpretation of data on trends in population size or distribution, and it makes it difficult to identify the factors causing declines.

Corn and others (1989) determined that 2

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species of amphibians had declined from historic distributions in north-central Colorado and southern Wyoming, including Rocky Mountain National Park (RMNP). This report and other evidence of declining amphibians in the southern Rocky Mountains stimulated interest in the National Park Service to assess amphibian populations within RMNP. As a result, we expanded ongoing investigations of amphibian status in Colorado and Wyoming to include a more comprehensive evaluation of RMNP from 1988 to 1990 and 1994. The objective of this study was to determine the status of amphibian populations in RMNP by comparing the historic occurrence (RMNP and museum records, other data) to current distributions of amphibians.

The mountains of western North America have a depauperate amphibian fauna, but species occurring there have generated a disproportionate share of the concern about unexplained declines (Blaustein 1994; Corn 1994; Drost and Fellers 1996). These patterns also occur in RMNP. Just 5 species, 1 salamander and 4 anurans, have been recorded in the Park, but the status of several of these is questionable.

Ambystoma tigrinum (tiger salamander) is the only salamander that occurs in the State of Colorado. Declines in population sizes have been observed in the Elk Mountains in central Colorado (Harte and Hoffman 1989; but see Wissinger and Whiteman 1992). *Bufo boreas* (boreal toad) formerly was widespread and abundant in the southern Rocky Mountains but has declined to the point where the U.S. Fish and Wildlife Service has been petitioned to list it as endangered (USFWS 1994), and Colorado listed *B. boreas* as an endangered species in 1993 (Goettl 1997). *Pseudacris maculata* (boreal chorus frog) is common in central and western North America, including Colorado. Except for some populations located a few km northwest of RMNP that have declined (Corn and others 1989), this species is not thought to be in trouble. *Rana pipiens* (northern leopard frog) is another widely distributed frog, but one that has declined in several areas, including the southern Rocky Mountains (Corn and Fogleman 1984; Corn and others 1989; Koch and Peterson 1995). *Rana sylvatica* (wood frog) is common in North American forests from Georgia to Alaska, but it is restricted to small relict populations in the southern Rocky Mountains. This species is classified as threatened in Colorado because of its limited distribution and the lack of knowledge of its status. Recent surveys have not suggested that *R. sylvatica* is declining (Corn and others 1989; K. Kehmeir, Colorado Division of Wildlife, Ft. Collins, pers. comm.).

This paper details the historical and current distribution of amphibians in RMNP, including some population estimates for *P. maculata* and *B. boreas*. These data should be used for baseline information, indicating where future research effort be directed. To enhance the long-term usefulness of our data, we include an appendix of locality data collected from 1988 to 1996.

METHODS

Amphibian Surveys

We conducted searches at locations where presence of ≥1 species of amphibian was indicated by historical records and at other accessible locations within RMNP boundaries. Known localities were compiled using museum records, published accounts, a file of visual observations maintained by RMNP, and field notes from local herpetologists. Additional locations were identified based on physical habitat characteristics that would support amphibians and evaluated for comparative purposes. We also attempted to survey most reasonably accessible bodies of water in the Park. Many locations contained >1 body of water, for example a complex of beaver ponds or ponds in close proximity connected by surface water.

Park-wide surveys were conducted from 1988 to 1990 and in 1994, beginning at snow melt (May and June) and continuing through early August of each year. Both daytime and nighttime searches were conducted during the breeding season. Searches later in the summer were conducted during the day. Daytime visits involved visual searches of shorelines and adjacent wetlands for adult amphibians, and shallow water for eggs or larvae. We used a dip net to search for larvae in water with dense emergent vegetation. We also recorded the life stages of each species encountered. These included transformed juveniles and adults, breeding adults (including breeding choruses), tadpoles and larvae, and eggs.

For each lake or pond surveyed, origin was recorded as either geologic or man-made. Location type was recorded as drainage (having a permanent outlet), semidrainage (judged to have an outlet only in years of high water), or as a beaver pond. Dimensions of each site were estimated by eye, measured with a range finder, or measured on topographic maps for larger lakes. Water depth was recorded as <1 m, 1 to 2 m, or >2 m. The substrate was characterized as predominantly organic matter, silt, sand, gravel, or boulders. The area covered by emergent vegetation was estimated, the presence or absence of emergent vegetation and shallow water on the north shoreline was noted, and the nearest distance to a forest edge was measured. We used Student's *t*-tests (for continuous variables) or log-likelihood Chi-square tests (for categorical variables) to compare environmental characteristics of sites with and without amphibians.

Population Estimates

Numbers of male *P. maculata* were estimated at 2 ponds in Horseshoe Park during 1988. Frogs were collected by hand at night, uniquely marked by toe-clipping, and immediately released. Frogs were released the same night or early the next day. We marked frogs on 3 occasions at 1 pond and 5 occasions at the other.

We estimated numbers of *B. boreas* at 3 locations in the North Fork of the Big Thompson River: Lost Lake and Kettle Tarn in 1991 to 1996, and Halfway in 1994 to 1996. Toads were collected from the breeding aggregation in May and June each year and from the surrounding habitat during the rest of the summer. We measured snout-vent length to the nearest 0.1 mm with dial calipers, and marked each toad by injecting a uniquely numbered passive integrated transponder (PIT tag; Camper and Dixon 1986; Sinsch and Seidel 1995; Christy 1996) subcutaneously, initially on the ventral surface but then dorsally parallel to the urostyle beginning in 1995. PIT tags were inserted using a sterile 12-gauge needle and applicator provided by the manufacturer. Transponder function was tested before the toad was released.

Lost Lake was visited 5 to 8 times and Kettle Tarn 5 to 10 times each year. Halfway was visited 2 to 4 times each year from 1994 to 1996. After the initial samples of the breeding aggregation, suitable habitat within 100 to 200 m of each lake was searched thoroughly during each visit. Captured toads were measured and scanned with a hand-held PIT tag reader. Previously marked toads were measured and released at the capture site, while unmarked toads received a PIT tag.

Population sizes of *P. maculata* were estimated using CAPTURE (Rexstad and Burnham 1991). This program estimates numbers of animals using closed population (no births, deaths, immigration, or emigration) capture-recapture models (Otis and others 1978). We estimated population sizes of *B. boreas* with JOLLY (Pollock and others 1990) for the years 1992 to 1996. Each sample comprised all toads captured in a given year. JOLLY uses the Jolly-Seber model for open populations, which allows for estimates of survival rate and recruitment between years.

Water Chemistry

We measured pH in the field using a temperature-compensated portable pH meter and glass electrode. A sample was collected in a 125-ml high-density polyethylene (HDPE) bottle in shallow water (<0.5-m deep) from the littoral zone of a pond. If amphibian eggs or breeding activity was observed, the sample was taken from that spot. We divided the sample and read pH from three successive aliquots; only the value from the final aliquot was recorded. We used linear regression to examine changes in pH across the elevation gradient.

More complete water chemistry was recorded from 28 localities. We collected water in a 250- or 500-ml HDPE bottle and delivered samples to the Water Analysis Laboratory at the U.S. Forest Service Rocky Mountain Research Station in Fort Collins. One to 7 samples were collected at each location from 3 May to 11 July, 1988 to 1991 (mean day = 7 June). Unfiltered samples were refrigerated and held 1 to 3 days before they were delivered for analysis. pH was measured electrometrically with a glass electrode, and acid neutralizing capacity (ANC) was determined by Gran titration. Major anions and cations were measured following standard methods (USEPA 1987). Variables were averaged at locations with multiple samples.

RESULTS

Surveys and Population Estimates

We found historical records of amphibians at 21 localities: 10 with 1 species, 7 with 2 species, and 4 with 3 species. There were 6 known localities for *A. tigrinum*, 13 known localities for *B. boreas*, 11 known localities for *P. maculata*, 3 known localities for *R. pipiens*, and 4 known localities for *R. sylvatica*. We searched 193 bodies of water at 116 locations (Fig. 1, Appendix). Forty-eight locations were surveyed once, 34 locations were surveyed twice, 13 locations were surveyed 3 times, and the remaining 21 locations were surveyed 4 to 49 times (total surveys = 376). Reliability of visual searches increases with the number of times a location is surveyed, but logistic constraints prevented us from searching many of the back-country locations more than once. Locations with either historical or current amphibian sightings received a disproportionate number of repeat visits (Table 1), but back-country locations with no amphibians were rarely surveyed more than once.

We observed amphibians at 48 locations, including 40 locations with 1 species, 6 locations with 2 species, and 2 locations with 3 species. We found *A. tigrinum* in 2 of 6 known localities (Fig. 2). They were also found in 4 locations that did not have previous records. Reproductive

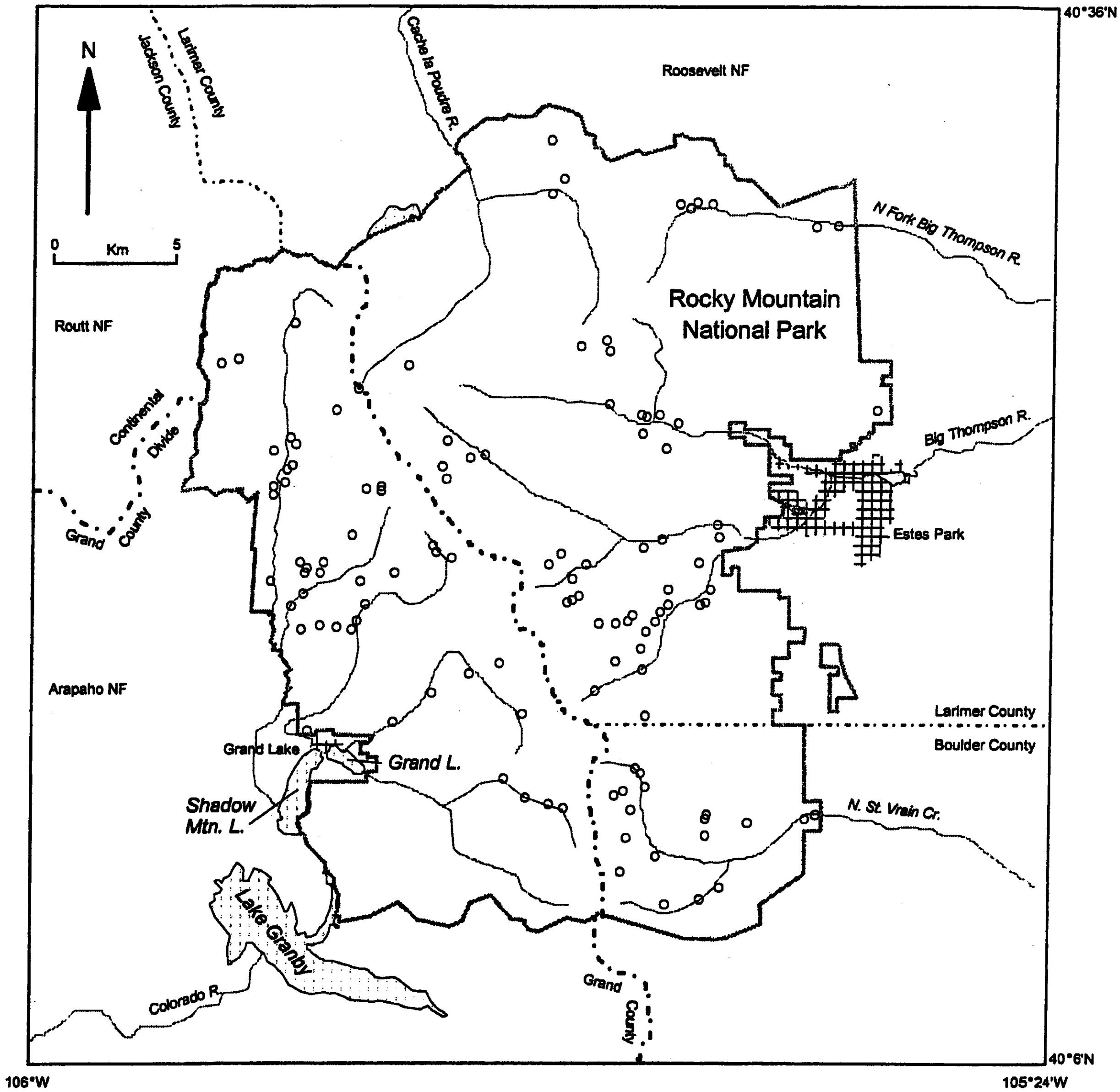

FIGURE 1. Locations in Rocky Mountain National Park searched for amphibians 1988 to 1996.

activity was apparent at all 6 sites that contained tiger salamanders. The most widespread species encountered in RMNP was *P. maculata*. We found this species at 9 of 11 localities where they had been previously reported

TABLE 1. Numbers of surveys at locations with historical, new, or no records of amphibians.

Locations	Number of surveys 1	2	3	≥4
Historical records	2	6	1	12
New records	14	7	3	7
No records	32	21	9	2

and at 23 new locations (Fig. 2). Because *P. maculata* are conspicuous only during the breeding season, we located most populations by listening for breeding choruses. During 1988, we captured 72 and 77 male *P. maculata* from 2 ponds in Horseshoe Park, respectively. Estimated numbers of breeding males in these 2 populations were 161 (SE = 38.9) and 136 (SE = 20.3), respectively. Previous accounts of *R. pipiens* in RMNP are limited to Sheep Lakes, Horseshoe Park, and Shadow Mountain Lake. No *R. pipiens* were found at Sheep Lakes and Horseshoe Park despite 20 visits in 1988 to 1990. Shadow Mountain Reservoir was

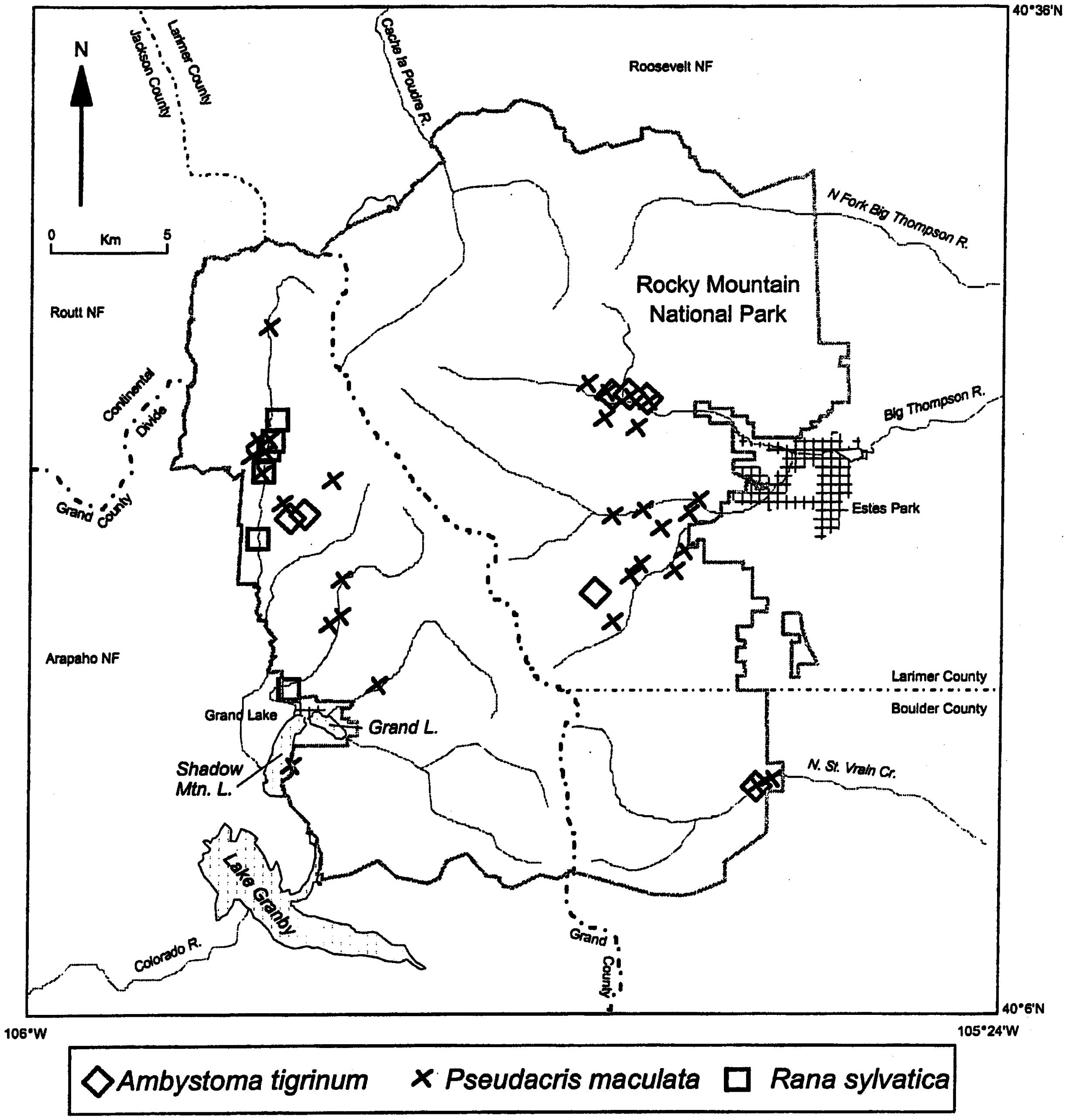

FIGURE 2. Current locations for 3 species of amphibians in Rocky Mountain National Park.

searched twice in 1988 and no *R. pipiens* were observed. Although restricted in range in Colorado and to the Colorado River drainage in RMNP, *R. sylvatica* appears to be doing well in RMNP. It was found in 3 of the 4 localities with previous records. We also found *R. sylvatica* at 3 new sites (Fig. 2). Reproductive populations were documented at all 6 sites where *R. sylvatica* was found.

We found *B. boreas* at 6 of 13 known localities and at 8 sites with no previous records (Fig. 3). Breeding was observed at 7 sites, all east of the Continental Divide: 3 of the known locations (Glacier Basin, Lost Lake, and Spruce Lake) and 4 of the "new" localities (Alluvial Fan, Halfway, Kettle Tarn, and Lake Husted). However, only Kettle Tarn and Lost Lake, in the North Fork Drainage of the Big Thompson River, and possibly Spruce Lake support significant populations of *B. boreas*. At Kettle Tarn, the numbers of egg masses observed annually from 1990 to 1996 were 13, 23, 18, 25, 21, 24, and 8.

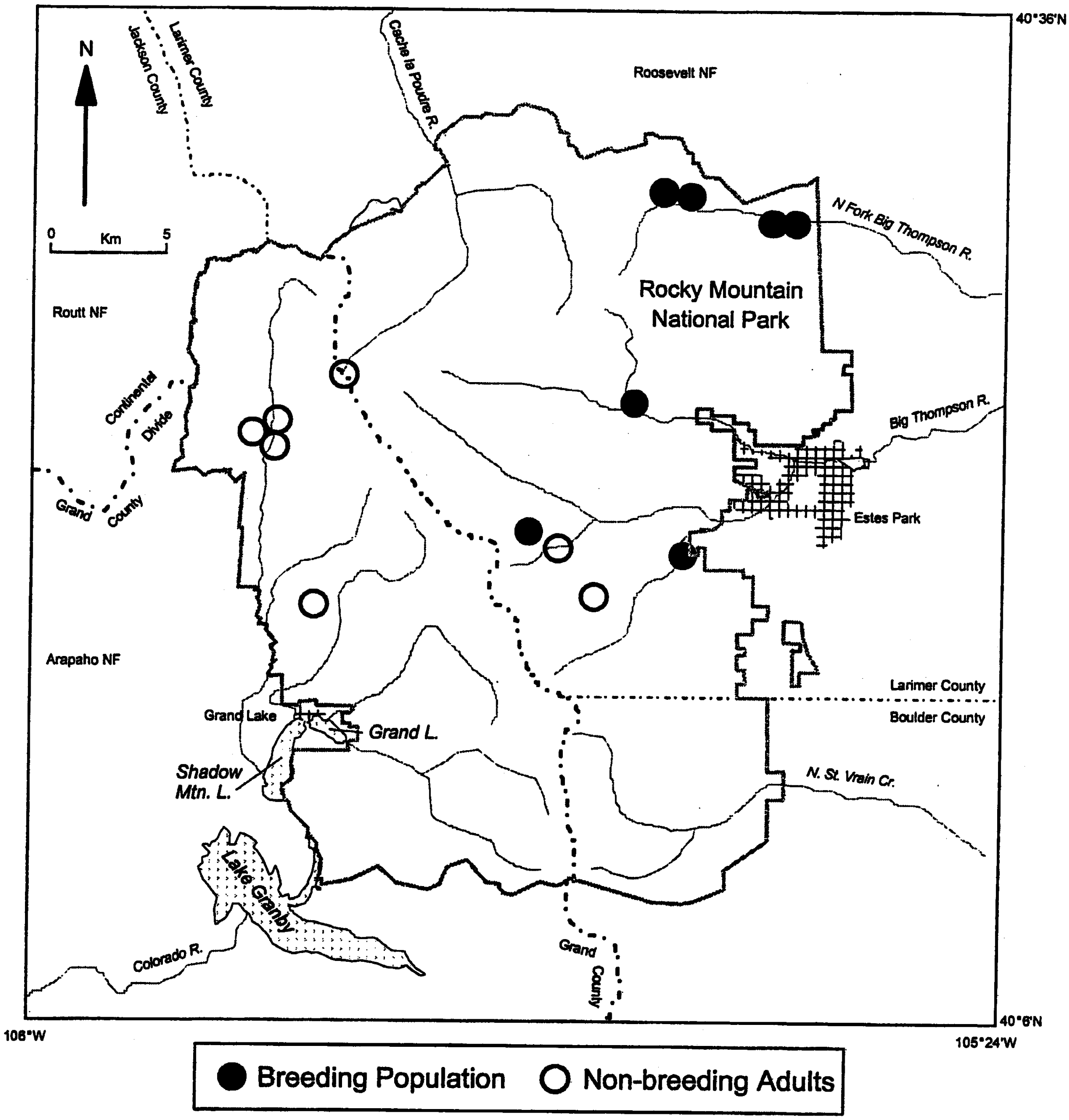

FIGURE 3. Current locations for *Bufo boreas* in Rocky Mountain Park.

We located 22, 15, and 23 egg masses at Lost Lake from 1990 to 1992 and 35, 32, and 15 egg masses from 1994 to 1996. Bad weather and reduced effort resulted in no observations during the breeding season at Lost Lake in 1993, although large numbers of tadpoles were seen later that year. We discovered *B. boreas* breeding at Halfway in 1994 and counted 3 egg masses that yr, 5 egg masses in 1995 and none in 1996. We did not observe egg masses at Spruce Lake, but David Stevens (Rocky Mountain National Park, personal communication) reported tadpoles there in August, 1990. Reproduction took place at Glacier Basin in 1988, 1989, 1990, and 1996, but we never observed >1 egg mass in any year and no toads were observed during single visits in 1992 and 1994. Tadpoles were seen in Lake Husted only in 1990, but we doubt that any of these were able to metamorphose before winter. We found a pair of toads in amplexus at the Alluvial Fan in 1988, but never observed eggs or tadpoles at this location.

From 1991 to 1996 we captured, measured, marked, and released 401 male and 87 female

TABLE 2. Captures, recaptures, and population estimates ($\hat{N}$) of *Bufo boreas* at 3 locations in Rocky Mountain National Park. Population estimates were made using JOLLY except as noted.

Location	Sex	Year	Captures	Recaptures[a]	$\hat{N}$	Standard error	95% confidence interval
Lost Lake	♂	1991	204				
	♂	1992	144	92	249	17.22	213–286
	♂	1993	78	56	225	24.32	177–273
	♂	1994	110	66	266	31.27	205–328
	♂	1995	121	77	215	35.41	146–285
	♂	1996	43	32			
	♀	1991	29				
	♀	1992	22	1			
	♀	1993	10	3			
	♀	1994	20	2			
	♀	1995	12	0			
	♀	1996	3	0			
Kettle Tarn	♂	1991	22				
	♂	1992	63	5	121	38.97	45–198
	♂	1993	54	23	192	36.6	120–264
	♂	1994	118	39	204	23.18	159–250
	♂	1995	210	93	238	31.43	176–300
	♂	1996	29	16			
	♀	1991	2				
	♀	1992	8	0			
	♀	1993	12	0			
	♀	1994	9	1			
	♀	1995	25	0			
	♀	1996	13	3			
Halfway	♂	1994	18		24[b]	5.16	19–42
	♂	1995	19	3	16[b]	1.43	15–22
	♂	1996	7	6			
	♀	1994	2				
	♀	1995	6	0			
	♀	1996	0	0			

[a] Toads marked in previous years.
[b] Estimate made from within-year capture history using CAPTURE.

B. boreas at Lost Lake; 316 males, 62 females, and 5 juveniles (small toads without secondary sexual characters) at Kettle Tarn; 20 males and 7 females at Lake Husted; and 32 males and 6 females at Halfway (1994 to 1996). An additional 7 males, 19 females, and 8 juveniles were marked away from any breeding site, bringing the total number of *B. boreas* marked in the North Fork drainage to 970 in 6 yr. The capture data at Lost Lake and Kettle Tarn were best fit by the full Jolly-Seber model, allowing for variation in survival and capture probability. This model does not provide population estimates for the 1st or last yr of data. The estimated numbers ($\hat{N}$) of male toads (Table 2) indicate that both Lost Lake and Kettle Tarn had stable or increasing populations from 1992 through 1995. However, the smaller numbers of captures and egg masses deposited in 1996 may indicate a decline in these populations. Too few toads were marked at Halfway for accurate estimates using JOLLY, so population size was estimated using CAPTURE and the data within each year. As in the larger populations, fewer toads were observed at Halfway in 1996, and no egg masses were seen.

The apparent large imbalance in the sex ratio of *B. boreas* in the North Fork populations (776 males [81%] and 181 females [19%] marked overall) probably does not reflect the true population structure. Female toads had lower capture rates. The mean probabilities of capture for males from 1991 to 1996 were 0.47 at Lost Lake and 0.54 at Kettle Tarn. Recapture data were too sparse to estimate capture probability of females accurately, but preliminary analysis suggests that it was ≤0.10. This disparity was probably because females do not breed annually, skipping ≥1 yr because of energy constraints (Olson, 1992). Female *B. boreas* also may

TABLE 3. Elevation and frequency of occurrence in habitat variable categories of all locations searched, and known and current locations of amphibians Rocky Mountain National Park.

			Current locations for				
Habitat parameter	All sites	Known locations	Any amphibian	*A. tigrinum*	*B. boreas*	*P. maculata*	*R. sylvatica*
N	116	21	48	6	14	32	6
Elevation (m)							
Minimum	2449	2557	2449	2545	2606	2449	2606
Mean	2991	2824	2760	2734	2889	2699	2704
Maximum	3511	3487	3383	2975	3383	3115	2780
Area (number in category)							
<0.05 ha	23	3	13	0	4	9	4
0.05–0.5 ha	42	9	21	6	5	14	2
0.5–5.0 ha	35	5	7	0	4	3	0
>5.0 ha	10	4	5	0	1	4	0
Site type (number in category)							
Drainage lake	57	8	14	3	5	7	0
Semidrainage lake	25	4	8	2	3	5	0
Beaver pond	33	9	26	1	6	20	6
North shoreline (number in category)							
Shallows present	94	19	44	5	12	30	5
Shallows absent	16	2	2	1	2	0	0
Vegetation present	75	17	41	5	13	28	5
Vegetation absent	33	4	5	1	1	2	0
Trout (number in category)							
Present	67	14	27	1	8	19	5
Absent	49	7	21	5	6	13	1

disperse farther from breeding sites than males (Campbell 1976), and so would have been less likely to have been captured during searches after the breeding season.

Habitat

Locations searched for amphibians in RMNP occurred at 2449 to 3511 m elevation, and the majority were small (<0.5 ha), drainage lakes or beaver ponds, with shallows and emergent vegetation present on the north shore (Table 3). More than one-half of the locations (58%) had native or introduced species of trout present. *Bubo boreas* was distributed across the broadest range of elevations (777 m) and *R. sylvatica* across the narrowest (174 m). Compared to locations without *P. maculata,* locations were *P. maculata* were present were smaller (log-likelihood ratio, $G = 10.72$, 3 df, $p = 0.013$), more often in beaver ponds ($G = 23.88$, 2 df, $p < 0.001$), contained shallow water along the north shore ($G = 11.18$, 1 df, $p = 0.001$), and more often had emergent vegetation along the north shore ($G = 13.43$, 1 df, $p = 0.001$). Presence of *P. maculata* was unrelated to presence of trout ($G = 0.10$, 1 df, $p = 0.75$). Locations with *B. boreas* did not differ from locations without *B. boreas* in any environmental parameter. There were too few locations with *A. tigrinum* or *R. sylvatica* for formal comparisons, although we located *R. sylvatica* only in small beaver ponds.

The 21 known locations did not differ significantly from the 48 current locations we observed with amphibians in elevation ($t = 1.08$, $p = 0.29$), area ($G = 3.81$, 3 df, $p = 0.15$), site type ($G = 0.78$, 2 df, $p = 0.68$), presence of north shore shallows ($G = 0.64$, 1 df, $p = 0.42$), presence of north shore emergent vegetation ($G = 0.79$, 1 df, $p = 0.37$), or presence of trout ($G = 0.67$, 1 df, $p = 0.41$).

Water Chemistry

We measured pH of 115 water bodies at 63 locations in the field. Hydrogen ion concentrations were averaged for multiple observations at single locations. Although pH declined with elevation (Fig. 4; $pH = 9.44 - 0.00098 \times$ (meters elevation); $F = 11.99$, $p < 0.001$), we recorded only 7 instances of pH below 6.0. Most other variables had large ranges with standard

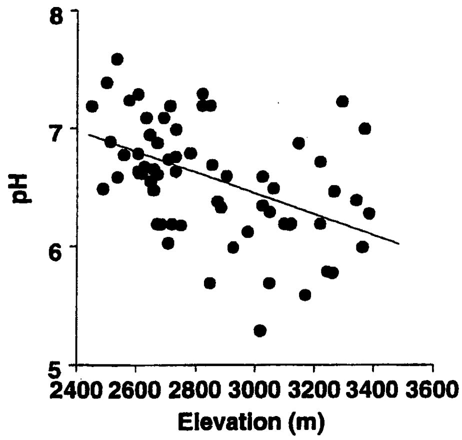

FIGURE 4. pH at 63 locations in Rocky Mountain National Park, measured in 1988.

deviations greater than the mean, but mean values indicated that surface waters of amphibian habitats were relatively dilute (Table 4). The mean alkalinity (194.6 μeq/l) is at the threshold for susceptibility to damage from acidic precipitation (Schindler 1988).

Discussion

Amphibians are not especially diverse or abundant in RMNP. Although all 5 species that inhabit the northern mountains of Colorado have been recorded previously from the park, we found only 4 of them in this study. The absent species, *R. pipiens*, had been recorded previously from only 3 locations in RMNP, but this species has suffered recent severe declines in the Front Range (Corn and Fogleman 1984, Corn and others 1989). The current absence of *R. pipiens* from RMNP may be part of the general decline of the species in Colorado, but suitable habitat for *R. pipiens* is not abundant in RMNP. Many of the locations we searched were at higher elevations than where *R. pipiens* occur in northern Colorado (Corn and others 1989), and semidrainage lakes, a favored habitat of *R. pipiens* (Pennak 1969) were the least common type of water body searched.

The most abundant species in the Park, *P. maculata*, is common in the large glacial valleys both east and west of the Continental Divide. These habitats are characterized by meandering streams with beaver ponds. *Rana sylvatica* occurs in similar habitats in the Colorado River valley. Temporary ponds are the preferred habitats of *A. tigrinum*, but few of the bodies of water we searched were of this habitat type. *Bufo boreas* occurs in a variety of habitats in RMNP; from large lakes with trout (Lost and Spruce Lakes), to small glacial ponds (Kettle Tarn), and beaver ponds (Glacier Basin).

The populations of *B. boreas* in RMNP are interesting because this species has undergone a severe decline in the southern Rocky Mountains (southeastern Wyoming, Colorado, and northern New Mexico) in the last 20 years (Carey 1993, Corn and others 1989, Stuart and Painter 1994). Lost Lake and Kettle Tarn harbor the largest populations of *B. boreas* now known to exist in the southern Rocky Mountains, so they are an important resource in future management plans. Despite these populations, toads in RMNP have probably also declined in the last few years. No evidence of breeding was

TABLE 4. Mean water chemistry from 28 locations in Rocky Mountain National Park. Units are mg/liter except alkalinity (μeq/liter) and conductivity (μS/cm).

Variable	N	$\bar{x}$	SD	Range
Alkalinity	28	194.64	301.56	38.5–1595
Conductivity	15	16.83	11.4	8.2–48.4
Ca^{++}	28	2.64	3.34	0.39–18.0
Mg^{++}	28	0.71	1.19	0.06–6.31
Na^{+}	27	1.53	1.47	0.16–6.46
K^{+}	28	0.83	0.97	0.00–3.14
$NH4^{+}$	28	0.05	0.03	0.001–0.125
Cl^{-}	28	0.43	0.73	0.08–3.79
$SO4^{=}$	27	1.80	3.07	0.12–16.42
$NO3^{-}$	28	0.22	0.35	0.00–1.16
SiO2	15	4.55	4.93	0.60–19.13
P	28	0.02	0.02	0.00–0.09
Al	28	0.08	0.12	0.00–0.49
Dissolved inorganic carbon	13	1.80	1.30	0.00–4.41
Dissolved organic carbon	13	10.10	8.91	0.57–27.17

seen at one-half of the 14 locations where we observed *B. boreas,* and breeding apparently ceased at 1 location, Horseshoe Park, during this study. Loss of this population is alarming, because in 1986, toads had recolonized beaver ponds that were damaged by the 1982 Lawn Lake flood (Zimmerman and Tracy 1993). Breeding at Lake Husted is infrequent and probably unsuccessful because of the high elevation of this location. The size and status of the population of *B. boreas* at Spruce Lake is not well known, so the only "good" populations occur in the North Fork of the Big Thompson River at Kettle Tarn and Lost Lake.

The causes of declines of *R. pipiens* and *B. boreas* are probably different. Corn and Fogleman (1984) observed extinction of several populations of *R. pipiens* and attributed these events to a severe winter drought that caused semipermanent ponds to dry. The decline of *B. boreas* is not likely to have been caused by drought, because this species has disappeared from several large permanent lakes and wetlands associated with streams (Corn and others 1989, Stuart and Painter 1994). Carey (1993) observed the disappearance of several populations of *B. boreas* in the West Elk Mountains of central Colorado between 1974 and 1982, and she observed toads with symptoms of red-leg disease, a common bacterial infection in amphibians and fish. Carey hypothesized that an unidentified environmental factor had caused sublethal stress of adult *B. boreas,* which caused suppression of the immune system, which allowed the infection and death of the toads. This is an attractive hypothesis, because a regional stress is one of the few mechanisms we can envision that would cause the nearly simultaneous decline of *B. boreas* throughout the southern Rocky Mountains. A stressor has not been identified, although Maniero and Carey (1997) observed immunosuppression in *R. pipiens* exposed to low temperature in the laboratory.

Harte and Hoffman (1989) hypothesized that acidic precipitation, in the form of an acidic pulse during snowmelt, had killed salamander embryos and caused a decline of a population of *A. tigrinum* in central Colorado from 1982 to 1987. This population has since recovered (Wissinger and Whiteman 1992), and there is little evidence that either chronic or episodic acidification occurs widely in the Rocky Mountains at levels sufficient to kill embryos (Corn and Vertucci 1992; Vertucci and Corn, 1996). However, sublethal effects of acid precipitation, such as possible negative effects on immune response (Carey and others 1996) have not been evaluated.

Blaustein and others (1994a) found that *B. boreas* embryos shaded from ambient UV-B radiation had higher hatching success than embryos exposed to ambient radiation in the Cascade Mountains in Oregon, and that *B. boreas* oocytes had low rates of enzyme activity related to repair of UV-damaged DNA. Mortality related to increased UV-B radiation could explain the relatively synchronous decline of *B. boreas* in the southern Rocky Mountains in the last 20 yr. Direct observations of mortality, however, have been of adult toads rather than embryos (Carey 1993), and experiments in 1994 at Kettle Tarn and Lost Lake failed to demonstrate a relationship between UV-B exposure and hatching success of toad embryos (Corn, in press).

Blaustein and others (1994b) documented fungal (*Saprolegnia*) infections resulting in large scale embryo mortality at several locations in the Pacific Northwest, but this has not been observed in the Rocky Mountains. Effects of other potential pollutants are even more difficult to evaluate. Pesticide, herbicide, and heavy metal contamination have negative effects on adult and larval amphibians. Baron and others (1986) studied sediments of high-elevation lakes in RMNP and found an increase in deposition of lead beginning around 1850, but concentrations at 2 of 4 sites had declined since 1960.

The bullfrog (*Rana catesbeiana*) is a large frog from the eastern U.S. that has been introduced throughout the West and is suggested to have caused the decline of many western ranid species (Moyle 1973, Hammerson 1982, Bury and Whelan 1984). *Rana catesbeiana* does not occur above about 1550 m in Colorado (Hammerson 1986), so it cannot have contributed to declines of montane species.

Other introduced predators may have influenced the historical distribution and abundance of amphibians in RMNP, if not recent changes. Introduced fish, especially trout in the Sierra Nevada, have been implicated in declines of ranid frogs in California (Hayes and Jennings 1986; Bradford 1989; Knapp 1996). Three species of introduced trout occur in RMNP (Rosenlund and Stevens 1986): rainbow (*Oncorhyncus mykiss*), brown (*Salmo trutta*) and brook (*Salvelinus fontinalis*). There is also an active program for reintroducing the endangered greenback cutthroat trout (*O. clarki*). Occurrence of *B. boreas* and *P. maculata* were unrelated to presence or absence of introduced or native trout. However, *A. tigrinum* was found at only 1 location that also had trout present (Table 3). Salamanders are especially vulnerable to predation by fish. After Bear Lake was treated with antimycin in 1975 to remove *S. fontinalis*, *A. tigrinum* flourished because of poor reproduction by reintroduced *O. clarki* (Rosenlund and Stevens 1986). Spawning habitat was improved and *O. clarki* restocked in 1981 and 1984, and we found no salamanders in our surveys of Bear Lake. Geraghty (1992) surveyed *A. tigrinum* populations above 3000 m in central Colorado, and only 2 of 31 ponds with salamanders also contained fish.

Difference among species in vulnerability to predation relate to behavior and morphology (Wassersug 1997). The herbivorous, filter-feeding tadpoles of *P. maculata* inhabit heavily vegetated shallow water and are less likely to be exposed to predation than are larval *A. tigrinum*, which are active predators on zooplankton. *Bufo boreas* tadpoles also tend to aggregate in extremely shallow water that may offer a refuge from predation, but toad eggs and tadpoles are unpalatable to fish and most other potential predators (Licht 1969).

Adult *Bufo* supposedly have some protection from predation because of their toxic skin secretions. However, Olson (1989) documented high levels of predation on adult *B. boreas* at breeding aggregations in the Cascade Mountains by common ravens (*Corvus corax*) and Brothers (1994) observed predation on *B. boreas* in Idaho by American crows (*C. brachyrhynchos*). Corvids do not eat the entire toad, but leave characteristic remains on the banks of ponds that include the head with dorsal skin attached, the limbs, and the ovaries of gravid females. On 13 May 1992, 5 toad carcasses (4 were female) were observed at Kettle Tarn that appeared to have been killed and eaten by *C. corax* (Corn 1993).

Populations of pond-breeding amphibians are characterized by "boom or bust" dynamics that lead to large fluctuations without human interference (Bragg 1960, Pechmann and others 1991, Pechmann and Wilbur 1994). Late freezes during the breeding season, early drying of temporary ponds, and predation can cause catastrophic mortality. Populations of amphibians in the Rocky Mountains are often small and females do not breed annually. These factors lead to demographic stochasticity, which may lead to extinction. Montane populations of *R. pipiens* may have succumbed to the effects of just such a stochastic event when breeding ponds dried in the late 1970s (Corn and Fogleman 1984), but the apparently synchronous disappearance of *B. boreas* in much of the southern Rocky Mountains does not support the hypothesis of a random fluctuation.

A paradox that we have no ready explanation for is that Lost Lake, which harbors the largest population of *B. boreas* known in RMNP (and perhaps Colorado), has undergone a great amount of habitat alteration recently. An earthen dam on Lost Lake was removed in 1986, lowering the water level and exposing 10 to 20 m of rocky shoreline. However, this may have benefitted *B. boreas* by creating the shallow pools now favored for reproduction (see Fig. 3 in Vertucci and Corn 1996). Also in 1986, Lost Lake was treated with antimycin in preparation for introduction of *O. clarkii* in 1987 to 1989 (Rosenlund and Stevens 1986). These observations support our conviction that the general decline of *B. boreas* has not been caused by habitat alteration.

Management Recommendations

Management of amphibians in RMNP should focus on protection of existing populations of *B. boreas*, because of the severe decline this species has undergone in the southern Rocky Mountains. Because we do not know the reasons for the decline, however, management prescriptions are difficult to devise. Consideration might be given to protecting breeding toads from predation by *C. corax*, but the severity of this threat is questionable. No carcasses of toads attributable to predation have been observed since 1992.

There is a need for continued monitoring of populations of *B. boreas* in RMNP, and data already collected at Lost Lake and Kettle Tarn can form the basis for a long-term study of population dynamics. Such data are critical to evaluating the role of stochastic variation in declines of amphibian populations. Knowledge of other aspects of the ecology of these toads, including habitat use, is needed for future management of *B. boreas* in RMNP and elsewhere in the southern Rocky Mountains.

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APPENDIX

Location and results of amphibian surveys conducted in Rocky Mountain National Park, Colorado, 1988–1994. Species codes are AMTI (*Ambystoma tigrinum*), BUBO (*Bufo boreas*), PSMA (*Pseudacris maculata*), RAPI (*Rana pipiens*), and RASY (*R. sylvatica*). Species observed indicate evidence of breeding unless noted otherwise in parentheses. Number in parentheses after year observed indicates the number of times the site was searched that year.

Name	County	Township, range, section	UTM (Zone 13)	Elev (m)	7.5′ USGS topo map	Known species	Species observed	Year(s) surveyed
Alberta Falls	Larimer	T4N R74W S14	4461718N 445778E	2926	McHenrys Peak			88 (2), 89 (1)
Arrowhead Lake	Larimer	T5N R75W S23	4470500N 435500E	3448	Fall River Pass			94 (1)
Bear Lake	Larimer	T4N R74W S14	4462586N 445100E	2902	McHenrys Peak	AMTI 1979[a]		88 (3), 89 (2)
Beaver Creek (2 ponds)	Grand	T5N R75W S18	4471733N 428121E	2731	Fall River Pass		RASY 89	89 (2)
Beaver Mill Campsite Pond	Boulder	T3N R73W S21	4451570N 450906E	2950	Allens Park			90 (1)
Bench Lake	Grand	T4N R74W S19	4460110N 438376E	3097	McHenrys Peak			90 (1)
Bierstadt Lake (2 ponds)	Larimer	T4N R74W S12	4463930N 446903E	2847	Longs Peak		PSMA 88, 89	88 (2), 89 (2)
Big Meadows Lily Pond	Grand	T4N R75W S8	4463252N 431604E	2871	Grand Lake	PSMA 1980[b]	PSMA 89	89 (1), 90 (1)
Big Meadows (3 ponds)	Grand	T4N R75W S17	4462393N 431171E	2871	Grand Lake	PSMA 1980[b]	PSMA 89	88 (1), 89 (3), 90 (1)
Black Lake	Larimer	T4N R74W S35	4457278N 445746E	3243	McHenrys Peak	BUBO 1957[c,d]		88 (1), 90 (1)
Bluebird Lake	Boulder	T3N R74W S26, 27	4449000N 444500E	3341	Isolation Peak			94 (1)
Boulder Brook (10 ponds)	Larimer	T4N R73W S7	4463117N 448503E	2655	Longs Peak	BUBO 1941[c]	PSMA 88	88 (2), 89 (1), 90 (1), 94 (2)
Cascade Falls Pond	Grand	T4N R75W S26	4458566N 434962E	2719	Grand Lake			90 (1)
Chickaree Lake	Grand	T4N R75W S6	4464945N 428552E	2835	Grand Lake		AMTI 89 (not breeding)	89 (1)
Chickaree Pond number 1	Grand	T4N R75W S6	4465191N 428648E	2847	Grand Lake		AMTI 89	89 (1)
Chickaree Pond number 2	Grand	T4N R76W S1	4465503N 428321E	2819	Grand Lake		PSMA 89	89 (1)
Chickaree Pond number 3	Grand	T4N R75W S6	4464938N 429330E	2920	Grand Lake			89 (1)

APPENDIX. Continued.

Name	County	Township, range, section	UTM (Zone 13)	Elev (m)	7.5′ USGS topo map	Known species	Species observed	Year(s) surveyed
Chickaree Pond number 4	Grand	T4N R75W S6	4465492N 429501E	2926	Grand Lake			89 (1)
Chipmunk Lake (2 ponds)	Larimer	T6N R74W S35	4476470N 443929E	3261	Trail Ridge			89 (1), 90 (1)
Chiquita Lake	Larimer	T6N R74W S34	4476728N 442494E	3463	Trail Ridge			90 (1)
Cony Creek (2 ponds)	Boulder	T3N R73W S31	4447500N 433500E	3109	Allens Park			94 (1)
Copeland Lake	Boulder	T3N R73W S14	4451980N 454312E	2533	Allens Park		PSMA 89, 92	89 (1), 90 (1), 92 (1)
Cub Creek (5 ponds)	Larimer	T4N R74W S1	4466584N 446592E	2499	McHenrys Peak		PSMA 88, 89	88 (1), 89 (1)
Cub Lake	Larimer	T4N R74W S2	4466159N 445645E	2627	McHenrys Peak	AMTI 1972[d]; BUBO 1953[c]	PSMA 88, 89	88 (1), 89 (1)
Doughnut Lake	Larimer	T5N R75W S23	4469850N 435700E	3426	Fall River Pass			94 (1)
Dream Lake	Larimer	T4N R74W S15	4462161N 444247E	3024	McHenrys Peak			88 (3)
Dutchtown Campsite Pond	Grand	T5N R76W S2	4476202N 425266E	3246	Mt. Richthofen			90 (1), 94 (1)
Eagle/Box Lakes (3 ponds)	Boulder	T3N R74W S23	4450800N 444800E	3292	Isolation Peak			94 (1)
Emerald Lake	Larimer	T4N R74W S15	4462167N 443397E	3097	McHenrys Peak			88 (3)
Endovalley Pond	Larimer	T5N R74W S11	4473695N 443908E	2633	Trail Ridge			89 (1)
Falcon Lake	Boulder	T3N R74W S15	4453066N 444180E	3414	Isolation Peak			90 (1)
Fan Falls (3 ponds)	Boulder	T3N R74W S14	4453300N 444650E	3414	Isolation Peak			94 (1)
Fan Lake	Larimer	T5N R74W S12	4473128N 445530E	2606	Trail Ridge		PSMA 88–90	88 (4), 89 (1), 90 (1)
Fern Lake	Larimer	T4N R74W S3	4465286N 442760E	2658	McHenrys Peak		BUBO 94 (not breeding)	88 (2), 89 (1), 90 (1), 94 (1)
Finch Lake	Boulder	T3N R73W S32	4448126N 449512E	3024	Allens Park			89 (1), 94 (1)

APPENDIX. Continued.

Name	County	Township, range, section	UTM (Zone 13)	Elev (m)	7.5′ USGS topo map	Known species	Species observed	Year(s) surveyed
Forest Canyon Pass (2 ponds)	Larimer	T5N R75W S3	4475800N 433800E	3511	Fall River Pass			94 (1)
Forest Canyon Pond	Larimer	T5N R75W S14	4471850N 435750E	3353	Fall River Pass			94 (1)
Forest Lake	Larimer	T5N R74W S19	4471100N 437650E	3146	Trail Ridge			94 (1)
Fourth Lake	Grand	T3N R74W S16	4452407N 441622E	3139	Isolation Peak			90 (1), 94 (1)
Gaskil	Grand	T4N R76W S1	4464530N 426849E	2670	Grand Lake		RASY 89	89 (1)
Gem Lake	Larimer	T5N R72W S7	4473299N 457317E	2691	Estes Park			89 (1)
Glacier Basin (3 ponds)	Larimer	T4N R73W S8	4463915N 449027E	2618	Longs Peak	BUBO 1951[d]; PSMA 1972[c]	BUBO 88–90, 96 PSMA 89, 90	88 (4), 89 (4), 90 (2), 92 (1), 94 (1), 95 (2), 96 (2)
Glacier Creek (2 ponds)	Larimer	T4N R74W S12	4463129N 446898E	2707	Longs Peak		PSMA 89	89 (1), 94 (1)
Glacier Knobs	Larimer	T4N R74W S23	4460826N 445512E	2987	McHenrys Peak		PSMA 88	88 (1)
Green Mountain Trail (2 ponds, below U.S. highway 34)	Grand	T4N R76W S13	4461956N 428358E	2670	Grand Lake		PSMA 88	88 (3)
Green Mtn. Trail pond number 1	Grand	T4N R75W S18	4462163N 429304E	2835	Grand Lake			88 (1), 89 (1)
Green Mtn. Trail pond number 2	Grand	T4N R75W S17	4462063N 430153E	2829	Grand Lake		BUBO 88 (not breeding)	88 (1), 89 (1), 90 (1)
Green Mtn. Trail pond number 3	Grand	T4N R75W S17	4461932N 430907E	2883	Grand Lake		PSMA 88, 89	88 (1), 89 (2), 90 (1)
Hague Creek	Larimer	T6N R74W S4,5,6	4485750N 441000E	3097	Comanche Peak			94 (1)
Halfway	Larimer	T6N R73W S11	4482900N 454275E	2840	Estes Park		BUBO 94–96	94 (4), 95 (3), 96 (2)
Hallowell Park (2 ponds)	Larimer	T4N R73W S6	4465338N 448447E	2557	Longs Peak	AMTI 1955[c]; BUBO 1955[c]; PSMA 1956[c]	PSMA 88	88 (2)

APPENDIX. Continued.

Name	County	Township, range, section	UTM (Zone 13)	Elev (m)	7.5′ USGS topo map	Known species	Species observed	Year(s) surveyed
Harbison Ditch (2 ponds)	Grand	T4N R75W S31	4456619N 428662E	2606	Grand Lake	PSMA 1980[b]; RASY 1959[c], 1980[b]	RASY 88, 92	88 (2), 92 (1)
Haynach Lake	Grand	T4N R75W S2	4466336N 435030E	3368	Grand Lake			90 (1)
Haynach Lakes number 2–4 (3 ponds)	Grand	T4N R75W S2	4465995N 435192E	3365	Grand Lake			90 (1)
Haynach Lake number 5	Grand	T4N R75W S2	4465680N 435968E	3267	Grand Lake			90 (1)
Hidden Valley (lower, 2 ponds)	Larimer	T5N R74W S24	4471362N 446791E	2749	Estes Park		PSMA 88	88 (1)
Hidden Valley (upper, 4 ponds)	Larimer	T5N R74W S13	4472141N 445594E	2733	Trail Ridge		PSMA 89	88 (1), 89 (1)
Horseshoe Park (3 ponds)	Larimer	T5N R74W S13	4473034N 445789E	2606	Trail Ridge	RAPI 1974[e]	AMTI 88–90; BUBO 88, 89 (not breeding); PSMA 88–90	88 (8), 89 (4), 90 (1)
Jewel-Mills Lakes (2 ponds)	Larimer	T4N R74W S26	4459715N 445598E	3048	McHenrys Peak			88 (1), 90 (1)
Kettle Tarn	Larimer	T6N R73W S12	4482950N 455347E	2810	Estes Park		BUBO 89–96	89 (1), 90 (6), 91 (9), 92 (10), 93 (6), 94 (5), 95 (6), 96 (6)
Lake Helene	Larimer	T4N R74W S9	4463290N 441801E	3231	McHenrys Peak			90 (1)
Lake Husted	Larimer	T6N R73W S8	4484209N 448318E	3383	Pingree Park		BUBO 88 (not breeding), 89 (not breeding), 90, 94, 95 (not breeding)	88 (1), 89 (1), 90 (2), 91 (1), 94 (3), 95 (3), 96 (1)
Lake Irene	Grand	T5N R75W S8	4473503N 430165E	3219	McHenrys Peak			88 (2), 92 (1)
Lake Louise	Larimer	T6N R73W S7	4484123N 447470E	3368	Pingree Park			88 (1), 89 (1), 90 (1)

APPENDIX. Continued.

Name	County	Township, range, section	UTM (Zone 13)	Elev (m)	7.5' USGS topo map	Known species	Species observed	Year(s) surveyed
Lake of the Clouds	Grand	T5N R76W S3	4475994N 424415E	3487	Mt. Richthofen	BUBO 1971[c]		90 (1), 94 (1)
Lake Solitude	Grand	T4N R74W S32	4457418N 439535E	2966	McHenrys Peak			90 (1), 94 (1)
Lake Verna (2 ponds)	Grand	T3N R74W S17	4452977N 439688E	3109	Isolation Peak			90 (1), 94 (1)
Lion Lake number 1 (4 ponds)	Boulder	T3N R74W S11	4453500N 445750E	3365	Isolation Peak			94 (2)
Lion Lake number 2 (2 ponds)	Boulder	T3N R74W S11	4454250N 445500E	3463	Isolation Peak			94 (2)
Lone Pine Lake	Grand	T3N R75W S12	4454003N 438586E	3024	Isolation Peak			90 (1), 94 (1)
Long Meadows (2 ponds)	Grand	T5N R75W S32	4466927N 430953E	3115	Grand Lake		PSMA 89	89 (1)
Loomis Lake (2 ponds)	Larimer	T4N R74W S5	4465301N 440872E	3121	McHenrys Peak			90 (1), 94 (1)
Lost Lake	Larimer	T6N R73W S8	4484111N 449070E	3266	Pingree Park	BUBO 1975[f]	BUBO 89–96	88 (1), 89 (1), 90 (5), 91 (7), 92 (8), 93 (5), 94 (5), 95 (5), 96 (6)
Lulu City (North)	Grand	T6N R75W S31	4478055N 428087E	2853	Fall River Pass		PSMA 89	89 (1)
Marigold Pond	Larimer	T4N R74W S9	4463624N 442393E	3231	McHenrys Peak			90 (1), 94 (1)
Mirror Lake (2 ponds)	Larimer	T7N R74W S28,33	4487500N 441000E	3353	Comanche Peak			94 (1)
Moraine Park (7 ponds)	Larimer	T4-5N R73W S5,6, 32	4466687N 449471E	2451	Longs Peak		PSMA 88, 89	88 (1), 89 (1)
Moraine Park Campground (2 ponds)	Larimer	T5N R73W S32	4467336N 449381E	2449	Longs Peak		PSMA 88, 89	88 (1), 89 (1)
Mummy Pass Creek	Larimer	T6N R74W S2,3,4	448500N 443750E	3438	Comanche Peak			94 (1)
Never Summer North (2 ponds)	Grand	T5N R76W S24	4470412N 427684E	2731	Fall River Pass		PSMA 89; RASY 89	89 (1)

APPENDIX. Continued.

Name	County	Township, range, section	UTM (Zone 13)	Elev (m)	7.5' USGS topo map	Known species	Species observed	Year(s) surveyed
Never Summer Ranch (2 ponds)	Grand	T5N R76W S25	4469092N 426987E	2707	Fall River Pass, Grand Lake	PSMA 1980[b]; RASY 1980[b]	PSMA 89, 90; RASY 88 (not breeding), 89	88 (1), 89 (2), 90 (1)
Never Summer South (3 ponds)	Grand	T5N R76W S24	4469524N 426991E	2731	Grand Lake		PSMA 90	90 (1)
North Fork Ponds (3 ponds)	Larimer	T6N R73W S7	4483903N 447986E	3362	Pingree Park			88 (1), 89 (1)
Nymph Lake	Larimer	T4N R74W S14	4462280N 444862E	2975	McHenrys Peak	AMTI 1979[a]; BUBO 1933[d], 1954[c]	AMTI 88; BUBO 88 (not breeding)	88 (4), 89 (2)
Odessa Lake	Larimer	T4N R74W S9	4464521N 442070E	2819	McHenrys Peak			88 (1), 90 (1), 94 (1)
Onahu Creek (above Hwy 34)	Grand	T4N R76W S12	4463836N 428470E	2707	Grand Lake	PSMA 1980[b]; RASY 1960[c]		88 (1)
Onahu Creek (below Hwy 34)	Grand	T4N R76W S12	4463194N 427874E	2670	Grand Lake	AMTI 1980[b]; PSMA 1980[b]	PSMA 88	88 (1)
Ouzel Lake	Boulder	T3N R74W S25	4449813N 446284E	3072	Isolation Peak			90 (1), 94 (1)
Pear Lake	Boulder	T3N R74W S36	4447250N 446750E	3243	Isolation Peak			94 (1)
Poudre Lake	Larimer	T5N R75W S4	4474602N 431283E	3292	Fall River Pass	BUBO[d]	BUBO 88 (not breeding)	88 (3), 89 (2), 90 (1), 92 (1)
Ptarmigan Beaver Ponds (2 ponds)	Grand	T4N R75W S25	4459568N 436837E	2816	McHenrys Peak			90 (1)
Red Mountain Trail	Grand	T5N R76W S13	4471405N 427010E	2957	Fall River Pass		BUBO 90 (not breeding)	90 (1)
Rock Lake (2 ponds)	Larimer	T5N R75W S13,24	4470950N 436900E	3146	Trail Ridge			94 (1)
Sandbeach Lake	Boulder	T3N R73W S18	4452015N 448852E	3146	Allens Park			89 (2), 90 (1), 94 (1)
Sandbeach Meadow	Boulder	T3N R73W S19	4451800N 448780E	3060	Allens Park			89 (1), 90 (1), 94 (1)
Shadow Mtn. Reservoir (south end)	Grand	T3N R75W S7	4453289N 428630E	2572	Shadow Mountain	BUBO 1961[g]; PSMA 1961[g]; RAPI 1961[g]	PSMA 88	88 (2)

APPENDIX. Continued.

Name	County	Township, range, section	UTM (Zone 13)	Elev (m)	7.5′ USGS topo map	Known species	Species observed	Year(s) surveyed
Sheep Lakes (4 ponds)	Larimer	T5N R74W S18	4472684N 447389E	2597	Estes Park	AMTI 1955[c]; BUBO 1955[c]; PSMA[d]; RA-PI[h]	AMTI 88, 89; PSMA 88, 89	88 (6), 89 (1)
Sky Pond (2 ponds)	Larimer	T4N R74W S27	4458623N 443205E	3341	McHenrys Peak			88 (1)
Snowbank Lake	Boulder	T3N R74W S11	4454500N 445250E	3511	Isolation Peak			94 (2)
Spirit Lake	Grand	T3N R74W S17	4452628N 440867E	3124	Isolation Peak			90 (1), 94 (1)
Sprague Lake (2 ponds)	Larimer	T4N R73W S7	4463239N 448763E	2646	Longs Peak			88 (2), 90 (1), 94 (1)
Spruce Lake	Larimer	T4N R74W S4	4465851N 441490E	2707	McHenrys Peak	BUBO 1979[c]	BUBO 88 (not breeding), 89 (not breeding), 90, 92 (not breeding), 94 (not breeding)	88 (2), 90 (1), 94 (1), 88 (2), 89 (1), 90 (1), 92 (2), 94 (1)
Squeak Creek	Grand	T5N R75W S13	4472075N 427865E	2731	Fall River Pass		BUBO 89 (not breeding)	89 (1)
Summerland Park	Grand	T4N R75W S33	4457042N 432989E	2609	Grand Lake		PSMA 90	89 (1), 90 (1)
The Loch	Larimer	T4N R74W S22	4460157N 444232E	3121	McHenrys Peak			88 (1)
Thunder Lake	Boulder	T3N R74W S14	4452289N 445025E	3243	Isolation Peak			90 (1), 94 (2)
Timber Creek (9 ponds)	Grand	T5N R75W S19	4470625N 427945E	2780	Fall River Pass	BUBO 1980[b]; PSMA 1980[b]; RASY 1980[b]	BUBO 89 (not breeding); PSMA 89; RASY 89	88 (2), 89 (2)
Timber Creek Campground	Grand	T5N R76W S24	4469734N 427583E	2731	Fall River Pass		PSMA 89	89 (1)
Timber Lake	Grand	T5N R75W S21,28	4469473N 432415E	3365	Grand Lake			90 (1), 94 (1)
Timber Lake ponds 2 and 3 (2 ponds)	Grand	T5N R75W S28	4469258N 432413E	3371	Grand Lake			90 (1), 94 (1)

APPENDIX. Continued.

Name	County	Township, range, section	UTM (Zone 13)	Elev (m)	7.5' USGS topo map	Known species	Species observed	Year(s) surveyed
Timber Lake pond number 4	Grand	T5N R75W S21	4469357N 431660E	3328	Grand Lake			90 (1)
Twin Bogs (2 ponds)	Grand	T4N R75W S5	4464488N 431356E	3018	Grand Lake			89 (1)
Twin Lakes (2 ponds)	Boulder	T3N R73W S19	4450906N 448774E	2999	Allens Park			89 (1), 90 (1), 94 (1)
Two Rivers Lake	Larimer	T4N R74W S9	4463411N 442061E	3231	McHenrys Peak			90 (1)
Wild Basin Road	Boulder	T3N R73W S22	4451767N 453791E	2545	Allens Park		AMTI 90; PSMA 90	90 (1)
Ypsilon Lake	Larimer	T6N R74W S35	4477027N 443768E	3219	Trail Ridge			89 (1), 90 (1)

[a] Roselund and Stevens 1986.
[b] Haynes and Aird 1981.
[c] Rocky Mountain National Park, wildlife observation file.
[d] University of Colorado Museum.
[e] P.S. Corn, personal observation.
[f] David Stevens, Biologist, Rocky Mountain National Park, Estes Park, CO 80517.
[g] Biological Survey collection, USGS Midcontinent Ecological Science Center, Fort Collins, CO 80525.
[h] Brattstrom 1963.