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Wyoming Toad (Bufo baxteri)

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Bufo baxteri Porter, 1968
WYOMING TOAD

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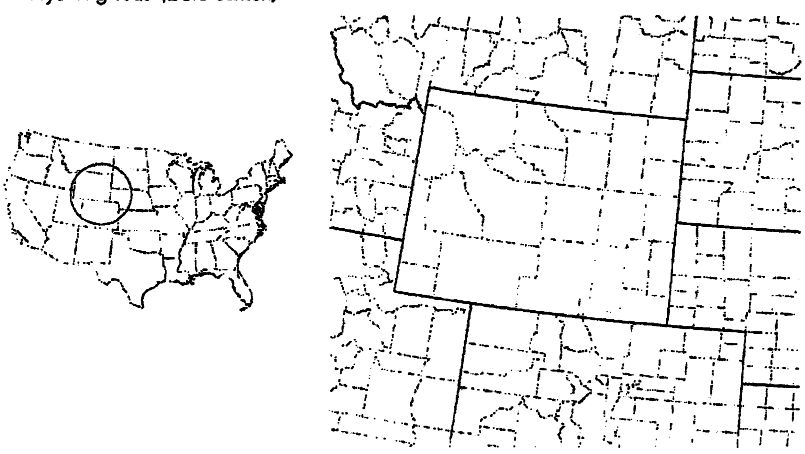
1. Historical versus Current Distribution. Historically, Wyoming toads *(Bufo baxteri)* were abundant in the vicinity of Laramie, Albany County, Wyoming (Baxter, 1952; Corn, 1991), where they were found in the flood plains of the Big and Little Laramie rivers (Stebbins, 1985), an area of only 2,330 km^2 (Lewis et al., 1985). A rapid decline was observed in the mid-1970s (Lewis et al., 1985) when they disappeared from most of their range. Surveys in the early 1980s yielded few animals, and Lewis et al. (1985) reported their possible extinction in 1983. Wyoming toads were listed as Endangered under the Endangered Species Act in February 1984.

Wyoming Toad *(Bufo baxteri)*



Currently, Wyoming toads have been reintroduced under a U.S. Fish and Wildlife Service recovery plan (Stone, 1991) to Mortenson Lake, ~23 km southwest of Laramie and the site of the last known population of toads. This population has yet to return to its 1988 levels and may not be sustainable (see "Historical versus Current Abundance" below). Attempts were also made to reintroduce Wyoming toads at two locations on the Hutton Lake National Wildlife Refuge, 10 km southeast of Mortenson Lake. These animals did not establish breeding populations and all released toads disappeared. The Mortenson Lake population is considered the only known current distribution in nature for Wyoming toads (Jennings et al., 2001).

Captive populations are being maintained at seven American Zoo and Aquarium Association (AZA) institutions (Central Park Zoo, New York; Cheyenne Mountain Zoo, Colorado Springs, Colorado; Detroit Zoo, Detroit, Michigan; Houston Zoo, Houston, Texas; Sedgwick County Zoo, Wichita, Kansas; St. Louis Zoo, St. Louis, Missouri; and Toledo Zoo, Toledo, Ohio); at the Saratoga National Fish Hatchery, Saratoga, Wyoming, and the Wyoming Game and Fish Sybille Wildlife Research Unit, Sybille, Wyoming. These animals are managed cooperatively in an AZA Species Survival Plan (SSP®) to maximize genetic diversity in captivity and produce offspring for reintroduction (Spencer, 1999).

Wyoming toads reflect relict populations of Canadian toads *(B. hemiophrys)* isolated at higher altitudes (2,164 m) of the Laramie Basin at the end of the Pleistocene when glaciers receded and climatic conditions warmed (Blair, 1972a). Currently, the closest population of Canadian toads is ~750 km from the Laramie Basin. Canadian toads are more aquatic than most toads and are frequently found on the shores of small lakes (Conant and Collins, 1991; see the Canadian toad account). This aquatic tendency is shared by Wyoming toads.

The presence of Canadian toads in the Laramie Basin was first recorded by Baxter (1947, 1952) and included on the map accompanying the species account in Stebbins (1954a, p. 145). The Laramie population, with its long-term isolation and distinctive characteristics, was later elevated to subspecies status (*B. hemiophrys baxteri*; Porter, 1968) and then to full species status (*B. baxteri*; Smith, 1998). Debate continues about whether Wyoming toads deserve separate species status (Packard, 1971; Smith et al., 1998). We follow Crother et al. (2000) in designating Wyoming toads as a valid species.

2. Historical versus Current Abundance. The occurrence of natural populations has dropped precipitously in the past 30 yr. Lewis et al. (1985), Parker (1998), and others (see "Historical versus Current Distribution" above) report that Wyoming toads were abundant in the 1950s and 1960s, but by the mid-1970s experienced a drastic decline (Baxter and Stone, 1985). A 1980 survey revealed Wyoming toads in a 5 km^2 area (Van Kirk, 1980). In 1981, only one male and one female were observed during the breeding season (Baxter and Meyer, 1982). No toads were observed in 1982; the discovery of two juveniles in 1983 represented the first evidence that reproduction had occurred since 1975 (Lewis et al., 1985). An intensive survey in 1984 located ~30 males, but similar surveys in 1985 and 1986 found no animals (Stone, 1991). In 1987, a single population of Wyoming toads was located at Mortenson Lake (Anonymous, 1987). This is the last natural population of toads that has been located.

There is no evidence for what the size was of a "typical" population before the decline of this species, but the size of the Mortenson Lake population has been monitored with varying degrees of rigor since it was discovered. Based on single surveys conducted each year about 1 September, this population was thought to include about 100–150 adults in 1987–89 (Withers, 1992; Corn, 1993a; Parker, 2000). Beginning in 1990, a capture-recapture study was conducted using photography to identify individual toads. In 1990, there were 120 (s.e. = 22) adult-sized toads (Corn, 1991). The population estimate in 1991 was 415 (s.e. = 99), but the majority of these were subadult toads that had metamorphosed the previous summer (Corn, 1992). The population estimate in 1992 was 155 (s.e. = 21), and a size-frequency analysis estimated that 36% of the population was composed of toads that were 2 yr old (Corn, 1993a). Few toads emerged in 1993, and only two adults were located during the annual September survey; these were taken into captivity in an effort to salvage the species (Parker, 2000).

Reproduction was recorded at Mortenson Lake beginning in 1988 when at least nine egg masses were found (Freda et al., 1988). Numbers of egg masses declined in subsequent years, with two found in 1989 (McLeary, 1989), three in 1990 (Chamberlin, 1990), and three in 1991 (Withers, 1992). No reproduction was observed in 1992 or 1993 (Corn, 1993a; Parker, 2000).

Corn (1993a) observed that with a mortality rate of about 80% for adults, the population was unsustainable. This was supported by population modeling, which resulted in a negative population growth rate and certain extinction within 10 yr (Jennings et al., 2001). When the last naturally bred wild toad was collected in 1994 at Mortenson Lake, Wyoming toads probably became extinct in the wild (M. Jennings, unpublished data).

Efforts to establish a second population were initiated in 1992 at Lake George, Albany County, Wyoming. Four "managed breedings" in protective enclosures were successful. The breeding stock came from animals collected at Mortenson Lake in 1990 and 1991 and held in captivity until the spring of 1992. These breedings resulted in large numbers of newly metamorphosed animals in July (Withers, 1992), but a survey performed the following spring found only 22 individuals. This number decreased to two in the fall of 1993. Subsequent efforts to release animals at Lake George have not been successful (total releases = 3,963 larvae or metamorphosed animals, 56 juveniles [1 yr olds]; M. Jennings, unpublished data).

In 1994, 77 Wyoming toads were produced in the first captive breeding of this species at the Sybille Wildlife Research Unit, Sybille, Wyoming. These animals were held in captivity for further breeding stock. In 1995, a concentrated effort to reintroduce toads back to Mortenson Lake commenced from captive produced offspring. In 1995, 1,300 Wyoming toad young (< 4 mo) were released. This was followed by 2,638 young in 1996 and 213 in 1997 (M. Jennings, unpublished data). In 1998, free-ranging toads from the 1995 releases at Mortenson Lake produced four egg masses, the first known wild breedings since 1991 (Parker, 2000). The same year, these breedings were augmented with the release of 3,428 captive-born young. Three wild breedings were observed at Mortenson Lake in 1999 and the population was estimated to be 159 adults. Two thousand captive bred toads were also released in 1999. It appeared that the population was on its way to recovery; however, the following year reproduction was limited to two egg masses (Parker, 2000). In 2000, no reproduction was observed, census numbers were very low, and sick and dead toads were observed. The outcome for this reintroduction effort is still guarded.

3. Life History Features.

A. Breeding. Reproduction is aquatic.

i. Breeding migrations. Adult toads first emerge from hibernation when air temperatures reach 21 °C (usually in early to mid-May; Stone, 1991; Withers, 1992; Parker, 2000). Males usually start calling a week later. The call of Wyoming toads is a harsh trill. Calling peaks when air and water temperatures are between 21.1–26.7 °C, decreases as temperatures fall, and ceases at 10 °C (Withers, 1992).

ii. Breeding habitat. Withers (1992) reported that vegetation at sites selected by calling males was a sedge/rush (*Carex* sp./*Scirpus americanus*) mix. These plants were also associated with egg masses.

B. Eggs.

i. Egg deposition sites. Wyoming toads deposit their eggs in shallow areas of ponds and small lakes (Baxter, 1952). Withers (1992) reported egg masses in water 3.5–6.3 cm deep where mean daytime water temperatures ranged from 20.6–21.8 °C.

ii. Clutch size. Egg masses may contain 1,000–6,000 individual 2–3 mm ova in strings (Freda et al., 1988, Withers, 1992). One captive produced egg mass was estimated at 8,000 eggs (M. Bock, personal communication). The female involved in this captive breeding was especially robust and this number may exceed the largest clutch of eggs produced in the wild. Eggs may hatch in 4–6 d (Freda et al., 1988; Withers, 1992) in the wild (2 d in a controlled captive situation; R. A. O., personal observations).

C. Larvae/Metamorphosis.

i. Length of larval stage. Wyoming toad tadpoles are darkly pigmented and 5–7 mm in length at hatching. Length of larval stage is approximately 1 mo, with metamorphosis in early July (Withers, 1992). Larval periods are reduced under more thermally homogeneous conditions in captivity (R. A. O., personal observations).

ii. Larval requirements.

a. Food. Although not well studied, Wyoming toad tadpoles are generalized suspension feeders, grazing on the organic and inorganic matter associated with rock, plant, and log surfaces.

b. Cover. Larvae select areas of higher temperature as high as 31 °C (Withers, 1992). Beiswenger (1978) collected tadpoles from shallow water at 30.5 °C and noted that Wyoming toad tadpoles seek out warm regions in thermally stratified environments. In one case, shallow depressions described as "water cow paths" were areas of congregation for tadpoles from three separate clutches (Withers, 1992). In the laboratory, Beiswenger (1978) observed that Wyoming toad tadpoles aggregate in temperatures between 28–34 °C (preferred temperature was ~31 °C) when placed in a stratified thermal environment.

iii. Larval polymorphisms. Do not occur.

iv. Features of metamorphosis. Metamorphosis usually takes place in early July, which corresponds to the annual bloom of small black flies (Diptera), possibly a food resource for young toads (Withers, 1992; A. Anderson, personal communication).

v. Post-metamorphic migrations. Following metamorphosis, young toads disperse along or near the shoreline. By late summer, many migrated from the north side of Mortenson Lake to the east and southeast sides (Withers, 1992).

D. Juvenile Habitat. Similar to those of adults.

E. Adult Habitat. Wyoming toads are found close to water in short grass prairie (Stebbins, 1985; Luce et al., 1997; see Withers, 1992 for a more detailed analysis of habitat). Adults almost always restrict their habitat use to the shoreline within 10 m of water (Withers, 1992; Parker, 2000). This may be due to the low humidity associated with the Laramie Basin uplands and the need for toads to have access to moisture for rehydration. Historically, Wyoming toads frequented a variety of habitats including lakes, ponds, streams, marshes, roadside ditches, and floodplains (Stebbins, 1985; Luce et al., 1997). At Mortenson Lake, toads use areas along the shoreline as well as adjacent marshes and ditches (Corn, 1991; Withers, 1992). When disturbed, Wyoming toads frequently seek escape by diving into open water and submerging (Parker, 2000). Adults tend to be nocturnal (Luce et al., 1997) or diurnal (Parker, 2000), with activity levels largely dependent on temperature (Parker, 2000).

F. Home Range Size. Has not been clearly delineated. At Mortenson Lake, Withers (1992) suggested a post-breeding migration from the north shore to the south shore. This migration would require the toads to move several hundred meters. Parker (2000) observed a maximum 1 d movement of 151.8 m and a mean daily movement of 5.05 m.

G. Territories. Unknown, but unlikely.

H. Aestivation/Avoiding Desiccation. Parker (2000) observed that adult toads active during the day often sought "night refuge" under dense grass on moist substrate. While in these nocturnal refugia, toads were observed in a state of torpor. Wyoming toads also use rodent burrows for refuge (Withers, 1992; Parker, 2000).

I. Seasonal Migrations. Seasonal migrations involve breeding (see "Breeding migrations" above), post-metamorphic (see "Post-metamorphic migrations" above), and overwintering (see "Torpor [Hibernation]" below) movements.

J. Torpor (Hibernation). Only anecdotal data exist on the hibernation sites of Wyoming toads. Withers (1992) observed toads near pocket gopher or ground squirrel burrows in the spring and fall and assumed these structures were used for hibernation. One captive born and released toad with an implanted radio transmitter was found in the fall burrowed in a badger excavation. The toad was at a depth of 35 cm and a temperature of 13 °C. The badger had broken through the hard soil crust, allowing the toad to dig into the softer substrata (Parker, 2000).

K. Interspecific Associations/Exclusions. Wyoming toads may hybridize with American toads (*B. americanus*; Henrich, 1968).

L. Age/Size at Reproductive Maturity. Wyoming toads are smaller than Canadian toads. Smith et al. (1998) recorded a maximum length of only 59.5 mm, with only 3 of 23 preserved specimens measuring over 56 mm. However, Corn (1993a) measured live toads and recorded a maximum length of 68 mm. Sexually mature males and females are dimorphic for size.

In 1992 at Mortenson Lake, the average size of 1-yr-old males was estimated to be 48 mm and the average size of 2-yr-old males was 52 mm. One-yr-old females were the same size (47 mm) as males of the same age, but the average size of 2-yr-old females was estimated to be 61 mm. Growth after metamorphosis is rapid, and males reach adult size by August of their second summer and breed the following spring (2 yr old, similar to Canadian toads; Breckenridge and Tester, 1961). Females most likely require an additional year to reach maturity (Baxter, 1952; Corn, 1991; Withers, 1992). In the artificial environment of captivity, 1-yr-old toads have produced offspring (D. Roberts, personal communication).

M. Longevity. No long-term studies have been performed to determine the maximum longevity of Wyoming toads in the wild. Corn (1993a) observed that few adult toads lived >2 yr at Mortenson Lake, but that was in a population afflicted with chytrid fungus. In captivity, one female toad with an estimated birth date in 1989 (studbook #5) lived in captivity from 1994 until its death in 1997 (Callaway, 1998). This animal produced large numbers of healthy young from 1994–96.

N. Feeding Behavior. Adults feed on ants, beetles, and other small insects and invertebrates (Luce et al., 1997). Stomach contents and fecal pellets of adult toads contained substantial numbers of ants, which appear to be the main component of the adult diet (G. Lipps, personal communication; R. A. O., personal observations).

O. Predators. Predation may be an important cause of mortality in Wyoming toads (Parker, 2000; see "Conservation" below).

P. Anti-Predator Mechanisms. Nocturnal activity patterns. Wyoming toads will swim out into the water away from shore when frightened (Parker, 2000).

Q. Diseases. An overview of diseases of Wyoming toads is presented in Taylor et al., 1999. A substantial number of deaths (71% in cases where cause was known) resulted from mycotic dermatitis with secondary bacterial infections. The authors misidentified the primary pathogen as *Basidiobolus ranarum*, which was later determined to be *Batrachochytrium dendrobatidis* (chytrid fungus; A. Pessier, personal communication; E. Williams, personal communication). The majority (90%) of these deaths in free-ranging toads occur in September–October when temperatures start to fall. Chytrid fungal infections are also the most frequent cause of mortality in captive populations and again are most prevalent in autumn. A treatment for this disease has been developed for captive animals (A. Pessier, personal communication).

R. Parasites. Unreported in wild populations. In captivity, a wide variety of protozoan and helminth parasites have been isolated (R. A. O., personal observations).

4. Conservation.

Wyoming toads were extirpated in the wild in 1994 and have been reintroduced. Chytrid fungus appears to have been the proximate cause of the decline of these toads (Taylor et al., 1999; A. Pessier, personal communication). Disease still remains important and impacts Wyoming toad recovery efforts (Jennings et al., 2001).

Other factors have been hypothesized as responsible for the precipitous Wyoming toad decline, including the aerial application of baytex (fenthion), an organophosphate pesticide used for mosquito control; predation by California gulls (*Larus californicus*), American white pelicans (*Pelecanus erythrorhynchos*), and raccoons (*Procyon lotor*), which have been increasing in numbers in this region; and habitat modification due to the irrigation regions of the native hay meadows (see Jennings and Anderson, 1997). However, there is little evidence that any of these factors are the primary cause of toad declines. Parker (2000) found radio-tagged toads preyed upon in his study and suggested additional predators include skunks, weasels, badgers, coyotes, mink, domestic cats, and herons.

Another factor impacting Wyoming toad recovery is the small amount of genetic diversity remaining in the species. The entire captive, and thus the reintroduced wild, population contains the equivalent genetic diversity of ~2.4 unrelated animals (Founder Genome Equivalents). This is equal to 79.4% of the expected gene diversity that should have been contained in the original wild population. The mean inbreeding coefficient (F) of the population is 0.155, which is greater than a first cousin cross. Inbreeding depression has not been conclusively documented in Wyoming toads, although there is some correlation between inbreeding and lower fecundity (Lipps and Odum, 2001).

Attempts have been made to manage the captive and reintroduced populations to maximize the retention of gene diversity. Using the studbook data, mean kinship is calculated to determine which pairs will maximize the amount of gene diversity retained in the next generation. Unfortunately due to husbandry difficulties, this method has not been entirely successful. Many scheduled priority breedings have not produced offspring and other less important pairings have. Analysis of the husbandry data (G. Lipps and R. A. O., unpublished 2000 data) show that there is a slightly less than significant negative correlation between the inbreeding coefficient of the offspring produced by a pairing and breeding success (as number of offspring produced from the breeding). These data are still preliminary, and results from 2001 appear to be contradictory.

Captive Wyoming toads currently are being managed as two separate populations. The first group (Group A toads) is composed of animals that have fully known pedigrees that can be traced back to the original collection of animals in the early 1990s. All other animals are derived from these earlier collections, and Group A represents all of the known diversity for the species. The second group (Group B) is composed of animals that were collected as wild-born offspring of reintroduced Wyoming toads from Group A. Although Group B represents less gene diversity than Group A, they are the offspring of successful survivors in nature, which may indicate increased fitness.

Wyoming toad recovery is still largely dependent upon an influx of individuals from the captive populations. Large numbers of animals have been released at Mortenson and two other sites (Lake George and Rush Lake at Hutton Lake NWR). Only the Mortenson Lake site has had any recent breeding activity and continues to have animals present. The recovery of Wyoming toads is still uncertain. Considering the limited numbers, low genetic diversity, reliance on captive breeding, and continuing problems with disease, Wyoming toads are the most endangered anuran in the United States, if not the world.