SPECIES ASSESSMENT FOR BOREAL TOAD (*BUFO BOREAS BOREAS*) IN WYOMING

prepared by

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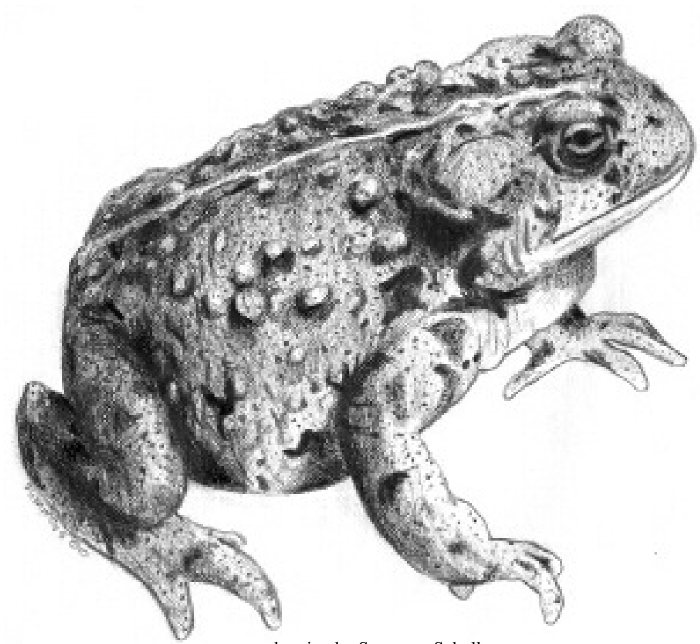

drawing by Summers Scholl

prepared for

United States Department of the Interior
Bureau of Land Management
Wyoming State Office
Cheyenne, Wyoming

March 2004

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Introduction

Boreal toads (*Bufo boreas boreas*) were once considered widely distributed and common amphibians in the western United States. The boreal toad shows signs of significant declines in population size and distribution across its range in western North America, and especially in the southern Rocky Mountains (Wyoming, Colorado, and New Mexico) (Corn et al 1989, Carey 1993, Corn 1994, Keinath and Bennet 2000, BTRT 2001). The Southern Rocky Mountain Population of boreal toads was petitioned for federal listing with the U.S. Fish and Wildlife Service in 1995 and was classified as warranted but precluded (USDI Fish and Wildlife Service 1995). The boreal toad has been listed as endangered by the state of New Mexico since 1976 (New Mexico Stat. Ann. §§ 17-2-37 et seq) (NMGFD 1988) and Colorado since 1993 (Colorado Rev. Stat. Ann. §§33-2-109 et seq) (CDOW 2000). The Wyoming Game and Fish Department ranks the southern Rocky Mountain population of the boreal toad as a native species of special concern 1 (NSS1), and the northern Rocky Mountain population as NSS2 (Oakleaf et al. 2002).

This assessment of the boreal toad is part of the Species Conservation Assessment Project for the Wyoming Office of the USDI Bureau of Land Management (BLM). It addresses the biology, ecology, and conservation status of the boreal toad throughout its current range in Wyoming and North America. Our goal is to provide a current summary of published information and expert interpretation of this information that can be used to develop management plans.

The boreal toad was selected for this assessment because it is classified as a sensitive species by the BLM in Wyoming due to recently observed declines in abundance and distribution across its range in the Rocky Mountains. The boreal toad was once considered widespread and common throughout its range but it has declined dramatically over the past 20 years (BTRT 2001)

Natural History

Morphological Description

Boreal toad coloration varies from dark brown or black to olive with a distinct white or pale yellow mid-dorsal stripe (Fig. 1 and 2). Their throat is pale relative to the rest of the body and their sides and belly and covered with many dark spots. The skin is typically dry and warty and large parotid glands are present behind the eye and tympanum. Immature boreal toads vary from adults in that they may lack a distinct dorsal stripe and they have yellow spots on the ventral surface of the feet and orange to red spots on their body. Males develop thickened dark areas on the upper surfaces of their thumbs during the breeding season; these pads may become less distinct after the breeding season. These nuptial pads help the male grip the female during amplexus. Adult females range from 3 to 4 in. (75-100 mm) in length from snout to vent while adult males are generally smaller ranging from 2.4 to 3.2 in. (60-80 mm) long. Eggs are black above and white below, the ovum average 1.5 to 1.8 mm in diameter and are encased in two jelly layers (Livezy and Wright 1947) which make each egg approximately 5 mm in diameter (Fig. 3). Eggs occur in one to three strands encased in gelatinous sheaths that are typically deposited in shallow water and contain on average 6,000 to 12,000 eggs (Samallow 1980, Olson 1988, Koch and Peterson 1995, Hammerson 1999). Boreal toad tadpoles are typically black or dark brown in color, (Fig. 4) and range in size from 6 mm when they are first transformed to 34 -38 mm long when fully developed. In contrast to other toad tadpoles, the boreal toad tadpole’s eyes are not on the lateral sides of the head; instead they are positioned about halfway between the midline and the lateral edge of the head (Stebbins 1985, Koch and Perterson 1995, Hammerson 1999).

The boreal toad differs from spadefoot toads by the presence of swollen parotid glands on each side of the nape. In the adult phase they differ from Woodhouse’s toad by the absence of conspicuous cranial crests on the inner side of the upper eyelids, however the eggs and larvae of boreal toads, and Woodhouses toads are very similar. Boreal toads differ from the black toad which is often solid black dorsally and heavily mottled ventrally with black spots (Baxter and Stone 1985, Stebbins 1985, Hammerson 1999).

Taxonomy and Distribution

The currently accepted scientific name for the western toad is *Bufo boreas*. There are currently three accepted subspecies in the *Bufo boreas* complex. *Bufo boreas boreas*, which is classified as the boreal toad, Bufo boreas halophilus is known as the California toad or alkali toad, and Bufo boreas nelsoni, is called the Amargosa toad (Stebbins 1985, Collins 1990). There is high confidence in the subspecies designations based on geographic separation and genetic differences. Additionally, there are at least four phylogentic groups of western toads that may eventually be recognized as separate species (Goebel 1996). The Southern Rocky Mountain Population (southern Wyoming, Colorado, and New Mexico) is geographically isolated from the Northern Rocky Mountain Population (northern Wyoming, Idaho, and Montana) by dry, non-forested intermountain valleys. These populations have proven to be genetically differentiated and probably represent independently evolving lineages or species (Goebel 1996). There is evidence that boreal toads in northern Utah, and Sublette County, Wyoming may be of the same lineage as those in the Southern Rocky Mountain Population, but additional data is needed to confirm that hypothesis. The southern Utah group and southwestern group (southern Nevada, southern California) are also recognized as geographically isolated and genetically distinct populations (Goebel 1996).

The range of *Bufo boreas* currently extends from western British Columbia and southern Alaska south through Washington, Oregon, and Idaho to northern Baja California and Mexico;

east to Montana, western and south-central Wyoming, Nevada, the mountains and higher plateaus of Utah, and western Colorado. It has not been recorded at lower elevations east of western Wyoming (Baxter and Stone 1985), western Montana and central Colorado (Stebbins 1985). There are reports of boreal toads from the Yukon Territory and Northwest Territories (Cook 1977).

The range of the boreal toad currently extends from western British Columbia and southern Alaska south to northern California (Washington, Oregon); western Montana, Idaho, western and south-central Wyoming, Nevada, the mountains and higher plateaus of Utah, and portions of the mountains of Colorado (Fig. 5). It has not been recorded at lower elevations east of western Wyoming (Baxter and Stone 1985), western Montana and central Colorado (Stebbins 1985). There are reports of boreal toads from the Yukon Territory and Northwest Territories (Cook 1977). There is some overlap with the California toad in northern California, and no overlap with the Amorgosa toad. The current distribution in North America is similar to the historic distribution, but there is evidence from recent research, especially in the southern Rocky Mountains, that indicates significant declines regionally in the mountains of New Mexico, Colorado and southeastern Wyoming. These reductions in distribution indicate that overall abundance of boreal toads is lower in the Southern Rocky Mountains as compared to the rest of their range.

Historically boreal toads from the Northern Rocky Mountain Population were considered common in areas where they were studied. Carpenter (1953) reported that the boreal toad was “the most wide-spread amphibian in the region”, and Turner (1955) reported observing large numbers of boreal toads near Fishing Bridge and Lake Lodge in Yellowstone National Park. The Northern Rocky Mountain Population of boreal toads has recently been reported to be less abundant but still present in areas where it was recorded historically, such as Grand Teton National Park (Peterson et al. 1992, Koch and Peterson 1995). Surveys in Montana during the

1990's indicated boreal toads were absent from a large number of historical sites and that although they were still widespread across the landscape they occupied a small proportion of suitable habitat (<10%) (Werner and Reichel 1994, 1996; Reichel 1995, 1996, 1997; Hendricks and Reichel 1996, Werner et al. 1998). Recent surveys by Maxell (2000) found boreal toads to be widespread but rare in watersheds across western Montana. Boreal toads were found in only 27% (11/40) of the watersheds surveyed, and breeding was observed in only 21% (7/33) of the watersheds with suitable breeding habitat. Additionally, boreal toads were found in only 3.7% (13/347) of the standing water bodies that were surveyed. Similar surveys conducted at 400 sites in Glacier National Park found boreal toads at less than 5 % of the sites surveyed in 1999-2000, and surveys on the Flathead Indian Reservation found boreal toads at only 4 of 9 sites where they were historically observed (Maxell 2000).

Boreal toads were historically present in the Medicine Bow, Sierra Madre, and Laramie ranges in Wyoming. Boreal toads were historically present throughout most of the mountain ranges of Colorado except the Sangre de Cristo Range, Wet Mountains, and Pikes Peak region. Currently, boreal toads are only found in a few isolated areas in Medicine Bow National Forest in Wyoming and it is reported as being virtually extirpated from its historical range in New Mexico (Degenhart et al. 1996). Further, in Region 2, numbers of boreal toads have been greatly reduced (in many cases to the point of extirpation) in large parts of the current range. The Boreal Toad Recovery Team reported that in the southern Rocky Mountains boreal toads are currently present in less than one percent of historic breeding areas (BTRT 2001). Thus, in addition to range contraction, much apparently suitable habitat within the current range is unoccupied.

For this assessment, the current and historical distribution of boreal toads (Fig. 6) was mapped using occurrence data to modify the predicted distribution from GAP data. Occurrence data included in developing the Wyoming distribution map for boreal toads was primarily drawn from the Wyoming Natural Diversity Database), with reference made to GAP distributions (Merrill et al. 1996).

Habitat Requirements

General

Boreal toads live in a wide range of habitats in western North America including wetlands, forests, woodlands, sagebrush, meadows, and floodplains in the mountains and valleys (Carpenter 1953, Campbell 1970, Black 1971, Stebbins 1985). They have been observed using habitat across a wide range of elevations from sea level to near or above tree line in some areas (Stebbins 1985, Hammerson 1999). In Rocky Mountain states, boreal toads generally occur between 2250 and 3600 meters (7500-12000 feet) (Hammerson 1999, Livo and Yackley 1997). They are typically less common in densely forested areas and are usually found in wetlands near ponds, lakes, reservoirs, rivers, and streams (Fig. 7) (Hammerson 1999). The wetland habitat classification system of Cowardin et al. (1979) defines the following wetland classes used by boreal toads: aquatic bed, streambed, rocky shore, unconsolidated shore, emergent wetland (persistent and non-persistent), scrub-shrub wetland, and forested wetland. Boreal toads are found within these classes within Riverine, Lacustrine, and Palustrine wetland systems. The terrestrial habitat classification system of Grossman et al. (1998) defines the following habitat classes used by boreal toads: Herbaceous, Forest, Woodland, and Shrubland. In Wyoming, boreal toads use wet habitats in foothills, montane and subalpine areas seldom far from water (Baxter and Stone 1985). They can potentially be found in all riparian habitat types (Gerhart and Olson 1982), including marshes, wet meadows, streams, beaver ponds, glacial kettle ponds, and lakes that are interspersed in subalpine forest of lodgepole pine, Engleman spruce, subalpine fir, and aspen (Campbell 1970, Hammerson

1999). Boreal toads occupy three distinct types of habitats during the course of a year: 1) breeding ponds, 2) summer range, and 3) over winter hibernacula (BTRT 2001).

<u>Spring-Summer</u>

In the late spring and early summer, during breeding, adult boreal toads are found in or near water and as the season progresses they may use more terrestrial habitats (Campbell 1970). Breeding habitats typically include shallow water (<20 cm) edges of ponds and lakes, stream and river edges where the water is pooled or very slow moving, oxbow ponds, thermal pools and streams, flooded meadows, ephemeral pools, abandoned and active beaver ponds, and man made impoundments including reservoirs and quarries (Patla 2001). Hawk (2000) observed that breeding sites for boreal toads in the Greater Yellowstone Ecosystem have waters with relatively high conductivity. Koch and Peterson (1995) also observed that the water chemistry of boreal toad breeding sites generally have a high pH (>8.0) and high acid neutralizing capacity. Hawk (2000) hypothesized that thermally influenced waters with high conductivity may provide some protection from bacterial infections.

During the larval stage boreal toads are limited to aquatic habitats until metamorphosis (approximately 75 days after hatching) (BTRT 1998), which usually occurs in Wyoming from July to August (BTRT 2001, Patla 2001). Relatively little is known about the habitat use patterns of metamorphs during this season other than that they occupy shallow waters and banks along the margins of ponds or in slow moving backwaters of streams.

<u>Summer-Fall</u>

Terrestrial habitats occupied by boreal toads after breeding during the summer and fall include a diversity of forested and non-forested wet and dry areas. Bartelt (2000) observed that radio-tagged boreal toads occupied underground burrows over 26% of the time. Bartelt also observed that willows, woody debris, and breaks in the shrub or tree canopy layers that allowed sunlight to reach the ground were also frequently used terrestrial habitat features. In general boreal toads occupy terrestrial micro-habitats during this season that allow for efficient thermal regulation and conservation of moisture. Bartelt (2000) observed that boreal toad movements and habitat use were characterized by extensive use of terrestrial habitats after breeding. He observed boreal toads moving through terrestrial habitats containing varied microhabitats, and that toads selected those microhabitats that provided protection from evaporative water loss and met their needs for behavioral thermoregulation (e.g., shrub habitats and warm sites for basking, with moist ground litter for cooling). Bartelt (2000) documented that boreal toads travel long distances after breeding and use terrestrial habitats extensively. The radio-tagged toads that Bartelt tracked selected protected microhabitats in terrestrial habitats that had greater amounts of shrub cover than would have been predicted by the available habitat composition.

Winter

In early fall, adults and young of the year migrate to hibernacula in terrestrial habitat, which are typically burrows from other animals, such as rodents and squirrels, where they over winter. Boreal toads also over winter commonly beneath debris piles, for instance from rockslides or deadfall timber. Patla (2000b) observed boreal toads on the National Elk Refuge using streamside cavities and old rodent burrows for hibernation sites. Bartelt and Peterson (1997) documented radio tagged boreal toads using underground burrows within 1 mile of a small flowing stream and under a slash pile on the Targhee National Forest. Boreal toads in Colorado have be observed using underground chambers near creeks, ground squirrel burrows, and beaver lodges/dams where flowing water keeps the air temperature above freezing (Loeffler 1998). Boreal toads are not able to hibernate in water like spotted frogs (*Rana luteiventris*) or leopard frogs (*Rana pipiens*), nor are they able to tolerate freezing as are boreal chorus frogs (*Pseudacris triseriata maculata*).

Area Requirements

In general boreal toad area requirements are restricted during breeding and hibernation seasons to relatively localized areas, and their area requirements are larger between breeding and hibernation. During this time period boreal toads use terrestrial habitats extensively and have been observed traveling long distances away from breeding sites (Bartelt 2000). Campbell (1970) documented home ranges of two boreal toad populations in Boulder County, Colorado and observed that the size of home ranges varied greatly in relation to the amount of available habitat, the number of toads in the population, and the sex of toads. In general, toads' home ranges were larger in areas with greater amounts of quality habitat, suggesting that high population densities in some areas may not be a direct indicator of high quality habitat, but could rather be due to a limited concentration of marginal habitat in otherwise poor areas. This observation could be the result of differences between the habitats of the surveyed toad populations, and not indicative of all boreal toad populations area requirements. Campbell (1970) also observed that home ranges were larger in a population with fewer boreal toads and hypothesized that the lower density in this population allowed toads to occupy larger home ranges. It is also apparent from the data collected on these two populations that the population that consisted of a larger proportion of males had larger average home ranges than the population that consisted of a larger proportion of females. It is important to note that all of these observations may be confounded by habitat variables such as water quality, vegetative cover, or prey availability. The population tracked at Albion consisted of 29 boreal toads (75% male: 25% female) and had a larger area of available habitat. The average home range size was 516 m^2. In comparison the other population tracked consisted of 50 boreal toads (14% male: 86% female) and had a smaller area of available habitat. The average home range size was 198 m^2.

Bartlet (2000) observed that boreal toads moved into terrestrial habitats surrounding wetland breeding sites up to 438 meters in 24 hours, mostly on warm, humid nights. Female toads moved as far as 2.4 km from breeding sites while male toads traveled only 0.9 km from breeding sites.

Landscape Pattern

There are three main habitat components required for boreal toads: 1) shallow wetlands for breeding, 2) terrestrial habitats for foraging that provide vegetative cover, and 3) burrows for winter hibernation (BTRT 2001). There is not detailed information on the relative proportion of these habitat types required by boreal toads. However, research on the habitat use of boreal toads indicates that the landscape surrounding the breeding site is as important as the wetland used for breeding for survival. In general the optimal spatial mosaic of boreal toad habitats includes permanent ponds or wetlands with shallow sunny margins, adjoining willow thickets or shrub cover, and upland montane forests within an elevation range between 8000 and 11,000 feet (2440 and 3350 meters) (BTRT 2001). All of these habitat components must be within a relatively clustered arrangement on the landscape to allow boreal toads to survive. Boreal toads may migrate up to 2.5 km from breeding ponds to winter hibernacula, but is most cases this distance is much less. Therefore all of the habitat components described above should be well within 2.5 km of breeding ponds to provide optimal habitat for boreal toads. Bartelt (2000) observed that boreal toad movements and habitat use were characterized by extensive use of terrestrial habitats after breeding. Boreal toads moved up to 438 meters in 24 hours, mostly on warm, humid nights. Female toads moved as far as 2.4 km from breeding sites while male toads traveled only 0.9 km from breeding sites. He observed boreal toads moving through terrestrial habitats selected microhabitats which provided protection from evaporative water loss, and allowed toads to meet their needs for thermoregulation e.g. shrub habitats, and warm sites for basking with moist ground litter.

There is no evidence that indicates general or seasonal habitat use patterns differ greatly between the Southern and Northern Rocky Mountain Populations. Seasonal habitat use, area requirements, and landscape pattern for boreal toads in the Southern and Northern Rocky Mountain populations do not differ greatly from the general patterns described above.

Movement and Activity Patterns

Daily Activity

During the spring and at high elevations adult boreal toads are mainly active diurnally but may also be active during crepuscular or nocturnal hours when conditions are suitable. In general juveniles are active almost exclusively diurnally, and adults are more active nocturnally (Sullivan et al. 1996). Toads seek out warm areas for basking on cool days and may seek shelter in cool microhabitat areas such as small animal burrows, soft mud, or under rocks and logs during the hottest parts of the day. Bartelt (2000) tracked boreal toad activity patterns using radio telemetry on the Targhee National Forest. He observed considerable individual variation in activity patterns between toads. Surface activity rates peaked between 2100 and 2400 hours, and toads were active in a wide range of temperatures (-2° C to 27° C) and humidity (60% to 100%) levels. The distances moved by toads increased during the night as they moved from daily sheltered sites to water or warm substrates. A majority of boreal toad daily movements was less than 50 meters, and the greatest single day movement recorded was 439 meters. Feeding activity peaked during mid-day, and all activity increased as humidity increased above 75%.

Evidence from research in Rocky Mountain National Park (Corn et al. 1997) indicates that boreal toads move between two small populations approximately 5 to 6 miles apart indicating that boreal toads are capable of even longer dispersal than those observed by Bartelt (2000)

Boreal toad activity is greatly decreased during winter months when they hibernate. Campbell (1970) reported that boreal toads in Colorado moved 900 meters from summer breeding areas to hibernacula during late September and remained in the hibernacula till the following May shortly after the snow melt. Campbell (1970) observed more than 30 boreal toads occupying the same hibernacula, which were a small chamber in rocky till. Boreal toads may also use abandoned rodent burrows for hibernacula. They may also emerge from their hibernacula periodically during September and October to bask near the entrance on warm days (Hammerson 1999). Boreal toad activity increases after snow melt as they move to breeding areas during May-June in the Rocky Mountains. Bartelt (2000) recorded that boreal toad movements to and from breeding sites followed linear paths out and back to the breeding areas.

Broad-scale movement patterns

Sex and Age differences in dispersal capabilities. - Research by Bartelt (2000) on the Targhee National Forest indicates that female boreal toads on average disperse further distances from breeding sites than males. Six of eight female toads left the pond after breeding while 8 of 10 males remained after breeding. Female boreal toads dispersed up to 2.4 km while males only traveled 0.9 km from breeding sites. Baretelt (2000) speculated that this differential movement between males and females was the result of stronger fidelity to breeding sites among males, and that females may be traveling longer distances to access preferred foraging sites. Fidelity to a breeding site may increase male ability to compete for mates each spring thus reducing their movements away from breeding areas. In comparison females have very high energetic needs in order to produce an egg clutch. Female toads at higher elevation may require two or more seasons of feeding to produce a single clutch (Campbell 1970). Juvenile boreal toads have been documented dispersing into terrestrial habitats similarly to adults.

Regional differences. - There is no conclusive evidence to suggest that there are regional differences in boreal toad migration patterns in Region 2 states. Movement patterns between breeding sites and hibernacula seem to be similar for both the Northern and Southern Rocky Mountain Populations in Region 2. However, there may be some differences between high and low elevation populations in terms of the distance traveled between breeding sites and hibernacula sites. Boreal toads at higher elevations may travel shorter distances on average than those at lower elevations (Bartelt 2000, R. Scherer pers comm..).

Connectivity. - The Southern Rocky Mountain Population of boreal toads is isolated from other populations in the Wasatch and Uinta Mountains of Utah to the west and the Wind River and Salt River Ranges to the Northwest in Wyoming by physical and climatic characteristics in the dry basins between these populations. There is no potential for connectivity with the Northern Rocky Mountain Population due to inadequate habitat in these dry basins. The distance (>100 miles) as well as the habitat in riparian areas that exist along rivers are at low elevations between these areas create a barrier to movement of boreal toads.

The Northern Rocky Mountain population is contiguous with boreal toad populations in the Pacific Northwest and Canada. There appears to be relatively strong connectivity in this part of the boreal toad range as compared to the Southern Rocky Mountain Population.

Reproduction and Survivorship

Breeding Behavior

Congregations of adult toads form at breeding sites, where male boreal toads greatly outnumber females. Males typically arrive at breeding sites about five days earlier than females. Male boreal toads do not have an obvious breeding call because they lack the inflatable vocal sac found in other male amphibians. However, they have been documented producing small “chirps”, which are most likely a release call that is made when disturbed by another toad. These vocalizations may also function in the formation of male aggregations at breeding sites and in attracting females (Awbrey 1972). Groups of male boreal toads may sometimes form aggregations whose chirping can be heard from at least 25 meters away (Campbel 1970). Males in these breeding aggregations may also attempt to amplex other male toads, resulting in a chirping protest response (Black and Brunson 1971, Marco et al. 1998). Male boreal toads amplex females in shallow water (< 15 cm) and eggs are deposited and fertilized, usually within 6 meters of shore, in marshy areas with emergent sedges or shrubby willows (Patla 2001). Amplexis lasts until all eggs are deposited. Male boreal toads may amplex more than one female during a breeding season. Adult toads usually disperse soon after mating, especially females. There is almost no parental care displayed by boreal toads at breeding sites. It is common to find almost no adults present at breeding sites by midsummer. Tadpoles may aggregate in small clumps or in massive groupings extending several meters across (Koch and Peterson 1995). In riverine situations, tadpoles have also been observed dispersing downstream of the egg deposition site.

Breeding Phenology

Breeding activity may begin soon after adult toads emerge from hibernation (usually May), or it may be delayed until later in the summer (July or later) depending on elevation, weather conditions, and the thermal and physical characteristics of the breeding site. Breeding activity is delayed at breeding sites at high elevation relative to sites at lower elevation. Seasonal variation in spring snowmelt can also influence the timing of breeding activity at specific sites, since boreal toad breeding in the Rocky Mountains typically begins when snow melts or ice thaws at breeding areas. Breeding may begin anytime between May and July depending on the elevation of the breeding site and weather conditions. Egg laying occurs from mid-May to mid-July followed by hatching which occurs between June and September. Tadpoles are typically present at breeding sites from mid-July to late August, and juvenile toad are present from mid-July to late September. Boreal toads are likely to be negatively affected by management actions that impact the quality or quantity of wetlands within the period between May and July. Eggs are deposited in shallow water near shore from mid-May to mid-July followed by hatching which occurs between June and September, typically 10-14 days after eggs are deposited depending on water temperature. Adult boreal toads may disperse from the breeding site after eggs are fertilized. Tadpoles are typically present at breeding sites from mid-July to late August, and juvenile toads are present from mid-July to late September. The time to metamorphosis is highly variable depending on water temperature and site conditions. In the Rocky Mountains, this time probably varies from between 6 to 14 weeks (Patla 2001). Overwinter survival of tadpoles has not been documented in Region 2 (Fetkavitch and Livo 1999). It may be necessary to survey potential breeding sites multiple times during the summer in order to determine the presence and success of breeding boreal toads.

Breeding Habitat

Boreal toads need standing or slow running water for breeding. Mating typically occurs in shallow water (<20 cm) along the margins of ponds, streams, or rivers often in areas with emergent vegetation.

Fecundity and Survivorship

In the context of this section the life stages are defined as follows: egg- refers to fertilized eggs, larva- refers to tadpoles after hatching until metamorphosis, juvenile- refers to new metamorphs up to two years of age, and adult refers to breeding adults greater than two years old. Female boreal toads lay 6,000 to 12,000 eggs in a single clutch, and may breed only every other year. This range in clutch sizes is typical across the boreal toad range. However, as in many other amphibian species, mortality is very high among larval and juvenile life stages, so actual recruitment top the population is significantly less than indicated by the number of eggs. Boreal toads have their lowest survival rates during the egg, larval, and metamorph life stages. Nussbaum et al. (1983) estimated that mortality rates between egg deposition and the adult life stage were 99%. If boreal toads survive to adulthood and chytrid fungus is not present, they can live nine years or more (Campbell 1970). Mortality rates among adult boreal toads have not been specifically documented, but it is believed to be very low when chytrid fungus is not present.

Breeding behavior, phenology, habitat, and fecundity and survivorship in Wyoming and the Rocky Mountains does not differ from the range wide breeding behavior described above.

Population Demographics

In general boreal toads have initially high mortality, develop slowly to maturity, and have long lives. Boreal toads have their lowest survival rates during the larval and metamorph stages. Nussbaum et al. (1983) estimated that mortality rates between egg deposition and adult life stage at 99%. Campbell (1970) documented in the Front Range of Colorado that most of the observed mortalities occurred during larval and juvenile life stages, with most of the deaths caused by changes in weather, such as drought causing ponds to dry up before metamorphosis or early freezes which kill juveniles. Campbell (1970) and Livo (1999) report predation of juveniles as a common cause of mortality. Boreal toads in Colorado breed for the first time at a minimum age of 6 for females and 4 for males (Hammerson 1999). As mentioned above boreal toads are long lived, but precise estimates of maximum age are not available for wild populations. Skeletochronology studies indicate that the maximum life spans of boreal toads is approximately 12 years (BTRT 2001). Adult females likely do not breed every year in the Rocky Mountains, but they are extremely fecund and may produce as many as 12,000 eggs per clutch (Hammerson 1999). Bartelt (2000) observed that it was common for the entire reproductive effort of a population to be destroyed by early desiccation of wetlands. Bartelt also observed that this severe loss might occur for several years in succession. The implication of these demographics is that high losses of adults can put a breeding population at risk of extinction, especially if it is isolated from other breeding populations. These life history parameters indicate that reproductive output can differ greatly from recruitment to the breeding population. These characteristics indicate that any elements which result in mortality among breeding boreal toads can seriously threaten the viability of local populations.

Metapopulation Dynamics

Little research specifically addresses metapopulation dynamic in boreal toads. However, there are many examples where habitat changes or direct anthropogenic and natural factors have resulted in the loss of local amphibian populations (Bury et al. 1980, Rosen et al. 1995, Lind et al. 1996, Beebee 1997). The loss of local populations may influence the persistence of regional populations or metapopulations even in cases where habitat quantity remains constant (Hanski and Gilpin 1991, Simberloff 1993, Fahrig and Merriam 1994). Research in Arizona documented that the extirpation of native amphibians resulting from the introduction of non-indigenous species led to the extirpation of native amphibians from nearby areas when the smaller wetlands that the native species were forced into dried up during a drought (Rosen et al. 1995). This example illustrates how the loss of core habitat that supports a local source population can lead to widespread extirpations among metapopulations in the region.

The persistence of regional metapopulations of amphibians is strongly influenced by characteristic of habitat such as patch size, shape, isolation, and quality. The size of habitat patches is directly related to the probability that the patch is occupied by amphibian species (Laan and Verboom 1990, Marsh and Pearman 1997, Fahrig 1998). The distribution of patches across the landscape also influences whether a patch is occupied. Additionally, the degree of isolation is often negatively related with patch occupancy (Sjögren 1991, Vos and Stumpel 1995, Sjögren-Gulve and Ray 1996). Changes in the habitat matrix between patches can also affect occupancy as illustrated by the example of Sjögren-Gulve and Ray (1996) in which they found that drainage ditches between ponds created a barrier that isolated the populations in adjacent ponds.

A key element in understanding the dynamics of boreal toad metapopulations is the maximum dispersal and migration distances of toads in local populations, which we have discussed earlier in the Activity and Movement Patterns section. This information is unknown for many areas, and could be highly variable depending on the composition of habitats in different regions occupied by boreal toads. Radio telemetry studies of boreal toad movement and habitat use such as the research conducted by Bartelt (2000) would be very helpful in gathering this information.

Genetic Concerns

The boreal toad is a subspecies of the western toad complex that is found throughout western North America. The southern Rocky Mountain population, which ranges from southeast Wyoming to northern New Mexico, is geographically isolated from populations in western North America by dry, non-forested intermountain valleys. Evidence suggests that this population of boreal toads in Region 2 is genetically differentiated and probably represents an independently evolving lineage or species (Goebel 1996). This isolation is a concern since this population has experienced dramatic recent declines, and there is no source for a natural rescue effect from adjacent populations. There is a possibility that the distinct genetic characteristics and the fitness for habitats in the range of the southern Rocky Mountain population may be lost if this population is extirpated. Initial tests indicated that boreal toads in Utah are closely related to toads in the southern Rocky Mountain population. Recent analysis of mtDNA and nDNA from boreal toads in

Utah, Idaho, Wyoming, and Colorado indicate that boreal toads in Utah and Idaho are genetically distinct from toads in the southern Rocky Mountain population, while boreal toads in Sublette County, Wyoming, which had been classified as northern Rocky Mountain boreal toads, may be more closely related to toads in the southern Rocky Mountain population. Additional data are needed to confirm these hypotheses, and specimens collected this summer from western Wyoming will be used to help determine the genetic relationship of these boreal toads to the southern Rocky Mountain population.

Food Habits

Food items

Following metamorphosis, the boreal toad diet consists mainly of ground dwelling coleopterans and hymenopterans. Their diet also incorporates a wide variety of invertebrates, including ants, beetles, spiders, mosquitoes, grasshoppers, crane flies, stink bugs, damsel bugs, deer flies, wasps, bees, water striders, alder flies, backswimmers, muscid flies, mites, and snails (Moore and Strickland 1955, Mullaly 1958, Livezey 1961, Miller 1975, Campbell 1970, Hammerson 1999). Boreal toads also eat small vertebrates including juveniles of their own species (Cunningham 1954). Boreal toad larvae may filter suspended organic material and/or feed on bottom detritus as well as other dead tadpoles or adults (Black 1970, Franz 1971, BTRT 1998).

Bartelt (2000) observed that 75% of the organic content of boreal toad scats was remains of harvester ants (*Pogonomymes* sp.), 24% was beetles, and the remaining 1% was wasps (Bracnidae and Isoptera). Campbell (1970) also observed that ants were the principal prey item, with beetles and spiders also making up a significant portion of the diet for boreal toads in the Front Range of Colorado. Campbell observed at least 43 invertebrate families represented in the diet of boreal toads from one study site in Upper Left-hand Park, Boulder County, Colorado.

Foraging Strategy

Adult boreal toads may use olfactory cues to locate prey items (Shinn and Dole 1979, Dole et al 1981), and larvae may filter suspended organic material or feed on bottom detritus. Boreal toads usually sit and wait for prey to come within two inches, then raise their head slightly and strike at the prey with their tongue. Boreal toads feed during both day and night hours; however, Campbell (1970) observed that boreal toads may be more successful feeding during daylight based upon the increase in non-food items present in the stomachs of boreal toads feeding at night. Non-food items, such as spruce or fir needles and quartz grains, are carried to the mouth on toads' sticky tongue when they miss prey on the first strike. There is no research on the relative value of diet items or how the value of food items may influence prey selection for boreal toads. However, observations of boreal toads feeding in the wild indicate that any moving animal smaller than the toad is a potential food item (Campbell 1970). The wide variety of food items used by boreal toads indicates that they have a relatively flexible diet and appear to feed primarily on abundant easy to catch prey. Campbell (1970) observed that males tended to be more sedentary while feeding and to consume more prey than females, which were more mobile and utilized a wide range of microhabitats. These food habits appear to be consistent across the range of the boreal toad in Region 2.

Foraging Variation

Boreal toad larvae primarily filter feed suspended organic material or feed on detritus as described above, while adults feed on a wide range of insects, both aquatic and terrestrial species. There does not appear to be significant differences in the general feeding habits of boreal toads geographically, seasonally, or by sex. Research on the diet of boreal toads in the Front Range of Colorado (Campbell 1970) and in Targhee National Forest (Bartelt 2000) produced similar results in the composition of prey items recorded.

Community Ecology

Predators and Competitors

Natural predators of the boreal toad include, but are not restricted to, the common raven (*Corvus corax*) (Corn 1993; Olson 1989), gray jay (*Perisoreus canadensis*) (Beiswenger 1981), western garter snake (*Thamnophis elegans*) (Jennings et al. 1992; Arnold and Wassersug 1978), tiger salamander (*Ambystoma tigrinum*) (Hammerson 1982), badger (*Taxidea taxus)* (Long 1964), spotted sandpiper (*Actitis macularia)* (J. Goettl unpubl. 1996), red fox (*Vulpes vulpes*), robin (*Turdus migratorius*), racoon (*Procyon lotor*) (Jones, CDOW, unpubl. 1998), and predacious diving beetle larvae (*Dytiscus* sp.) (Livo 1999). The latter prey only on boreal toad larvae. There is little evidence to indicate that predation is a factor which causes population declines in boreal toads, at most predation is a very minor contributing factor to observed population declines. Introduction of game fish to historically fish-less waters has reduced many amphibian populations throughout western North America (Bradford 1989, Bradford et al. 1993, Corn 1994), but there is no direct evidence that this has contributed to the decline of boreal toads. Boreal toad eggs and tadpoles are toxic or distasteful to most predators (Licht 1969, Brodie and Formanowicz 1987, Hews 1988), and although this does not render them immune to predation, there are several current and former boreal toad breeding sites that also contain fish.

Parasites and Disease

Boreal toads are susceptible to a variety of bacterial and fungal pathogens which have been documented in Wyoming. The primary disease causing pathogen is chytrid fungus. Chytrid has caused mass deaths of amphibians in Arizona, California, Colorado, Wyoming, Central and South America, and Australia (Daszak et al. 1999, Parker 2000). Chytrid is a microscopic, parasitic fungus that attacks the keratin and skin of amphibians and has caused 90-100% mortality rates in metamorphosed amphibians. Amphibian larvae are not lethally affected by chytrid because only their mouthparts contain keratin. However, boreal toad tadpoles may carry this disease and die from it after metamorphosis. Carey (2000) hypothesizes that chytrid is responsible for the observed declines in boreal toads that began in the 1970's in Colorado, and that recent outbreaks of chytrid have caused observed declines over the past few years in remaining boreal toad populations in Colorado. Recent modeling research on the boreal toad populations in Rocky Mountain National Park by R. Scherer (unpublished 2002) at Colorado State University indicate that the observed declines fit very closely with a model of population changes following introduction of chytrid fungus. Die-offs from chytrid may take place gradually over weeks or months making it difficult to detect unless frequent surveys are conducted for dead amphibians. Populations of boreal toads infected with chytrid fungus have declined to near extinction within one year, and there are no documented cases of an infected population recovering following infection. Carey et al. (1999) hypothesized that chytrid is so detrimental to boreal toad populations because it is a recently emerged infectious disease that toads have not evolved resistance to, and that environmental stress is making toads more vulnerable to infection.

Symbiotic and Mutualistic Interactions

Boreal toad symbiotic relationships fall into two main types, those, which are commensalistic and those that are parasitic. The many pathogens that affect toads are considered parasitic in this classification scheme and are described in detail above (see *Parasites and Disease*). Beaver are a species that has a commensal relationship to boreal toads. Beavers modify wetlands and create ponds, which improve the quantity and quality of breeding habitat available for boreal toads in mountain streams. The beaver does not appear to benefit from the presence of boreal toads. A wide range of small mammal species also has a commensal relationship with the boreal toad. The burrows they create provide important over wintering habitat for boreal toads to use as hibernacula. These species do not appear to benefit directly from boreal toads.

Conservation

Conservation Status

Conservation status of boreal toad populations is provided in Table 1 and below.

Federal Endangered Species Act

The southern Rocky Mountain population of boreal toads was ranked as warranted but precluded for listing under the Endangered Species Act by the United States Fish and Wildlife Service in 1995 (USDI Fish and Wildlife Service 1995). The USFWS reached an agreement in October of 2002 in a legal settlement to decide whether to list the southern Rocky Mountain population of boreal toads by September 2005. The boreal toad is not considered threatened or endangered by the USFWS throughout the rest of its range in North America as of 2002.

Bureau of Land Management

The boreal toad is currently on the BLM sensitive species list in Wyoming (BLM Wyoming 2001) and Colorado.

Forest Service

The USDA Forest Service in Region 1 (USDA Forest Service 1999) and Region 2 (USDA Forest Service 1994) classify the boreal toad as a sensitive species.

State Wildlife Agencies

The Wyoming Game and Fish Department ranks the southern Rocky Mountain population of the boreal toad as a native species of special concern 1 (NSS1), and the northern Rocky Mountain population as NSS2 (Oakleaf et al. 2002). The Colorado Division of Wildlife ranked the southern Rocky Mountain population of the boreal toad as endangered in 1993 (Colorado Rev. Stat. Ann. §§33-2-109 et seq) (Colorado Division of Wildlife 2000). The boreal toad has been ranked as endangered in New Mexico since 1976 (New Mexico Stat. Ann. §§ 17-2-37 et seq) (New Mexico

Department of Game and Fish 1988). The boreal toad is not present in South Dakota, Nebraska, or Kansas and therefore is not ranked in these states.

Heritage Ranks and WYNDD's Wyoming Significance Rank

In Wyoming the Northern Rocky Mountain population (NRMP) of boreal toads is ranked as G4T4/S2, while the Southern Rocky Mountain population (SRMP) is ranked as G4T1Q/S1 (Fertig and Beauvais 1999, NatureServe Explorer 2001). The southern Rocky Mountain population has a medium Wyoming Significance Rank, while the northern Rocky Mountain population has a low Wyoming Significance Rank (Keinath and Beauvais 2003). In Colorado, the boreal toad is ranked as G4T1Q/S1 (Colorado Natural Heritage Program 1999, NatureServe Explorer 2001). In New Mexico the boreal toad is ranked as historically present and possibly extirpated (SH) (NatureServe Explorer 2001, NMNHP 2002).

Biological Conservation Issues

Abundance

Historically boreal toads from the Northern Rocky Mountain Population were considered common in areas where they were studied. Carpenter (1953) reported that the boreal toad was "the most wide-spread amphibian in the region", and Turner (1955) reported observing large numbers of boreal toads near Fishing Bridge and Lake Lodge in Yellowstone National Park. The Northern Rocky Mountain Population of boreal toads has recently been reported to be less abundant but still present in areas where it was recorded historically, such as Grand Teton National Park (Peterson et al. 1992, Koch and Peterson 1995). Surveys in Montana during the 1990's indicated boreal toads were absent from a large number of historical sites and that although they were still widespread across the landscape they occupied a small proportion of suitable habitat (<10%) (Werner and Reichel 1994, 1996; Reichel 1995, 1996, 1997; Hendricks and

Reichel 1996, Werner et al. 1998). Recent surveys by Maxell (2000) found boreal toads to be widespread but rare in watersheds across western Montana. Boreal toads were found in only 27% (11/40) of the watersheds surveyed, and breeding was observed in only 21% (7/33) of the watersheds with suitable breeding habitat. Additionally, boreal toads were found in only 3.7% (13/347) of the standing water bodies that were surveyed. Similar surveys conducted at 400 sites in Glacier National Park found boreal toads at less than 5 % of the sites surveyed in 1999-2000, and surveys on the Flathead Indian Reservation found boreal toads at only 4 of 9 sites where they were historically observed (Maxell 2000).

Boreal toads were historically present in the Medicine Bow, Sierra Madre, and Laramie ranges in Wyoming. Boreal toads were historically present throughout most of the mountain ranges of Colorado except the Sangre de Cristo Range, Wet Mountains, and Pikes Peak region. Currently, boreal toads are only found in a few isolated areas in Medicine Bow National Forest in Wyoming and it is reported as being virtually extirpated from its historical range in New Mexico (Degenhart et al. 1996). Further, numbers of boreal toads have been greatly reduced (in many cases to the point of extirpation) in large parts of the current range. The Boreal Toad Recovery Team reported that in the southern Rocky Mountains boreal toads are currently present in less than one percent of historic breeding areas (BTRT 2001). Thus, in addition to range contraction, much apparently suitable habitat within the current range is unoccupied.

Trends

Over the past twenty-five years boreal toad populations have crashed in Colorado, Utah, southeast Wyoming, and New Mexico (Stuart and Painter 1994, Ross et al 1995, Corn et al 1997, BTRT 1998). In general, there is very little long-term monitoring data for boreal toad populations. That of which we are aware is summarized here and in the trends portions of the Biological

Conservation Status section (see below). It is believed that this species' populations are stable range-wide, but declining in many areas especially the southern Rocky Mountains. The information available on population trends is limited to a few geographical areas and tends to be from declining populations where surveys were targeted.

Dramatic declines have been recorded in the Rocky Mountains (Corn et al. 1989, Carey 1993), the Sierra Nevada Mountains (Drost and Fellers 1996), and repeated reproductive failures have been observed in the Pacific Northwest (Blaustein and Olsen 1991, Blaustein et al. 1994). The best recent information on population trends in Region 2 is from research in Colorado (Corn et al. 1989, Carey 1993, Corn et al. 1997) and from the Greater Yellowstone Ecosystem (Koch and Peterson 1995, Patla and Peterson 1999, Van Kirk et al. 2000).

The boreal toad was once widely distributed and abundant in the southern Rocky Mountains in Colorado, southeast Wyoming, and northern New Mexico. Survey efforts in Region 2 states and adjacent areas indicate that over the past twenty-five years boreal toad populations have declined in Colorado, Utah, southeast Wyoming, and New Mexico (Stuart and Painter 1994, Ross et al 1995, Corn et al 1997, BTRT 1998). Corn et al. (1989) observed that boreal toads were absent from 83% (49/59) of historic locations in the Front and Park Ranges of Colorado and the Medicine Bow Mountains in Wyoming. Corn et al. (1989) also observed that boreal toad populations inside Rocky Mountain National Park appeared to be surviving better than those outside. Boreal toads were observed at 10% (5/48) known sites outside the park and 45% (5/11) of known sites inside the park (Corn 1989). Boreal toads were once common throughout the Elk and West Elk Mountains of western Colorado (Burger and Bragg 1947). Carey (1993) observed declines in the boreal toad populations in this region of Colorado during the 1970's and by 1982 these populations of boreal toads were extinct.

In the northern Rocky Mountain Population surveys conducted in the late 1990's indicate that boreal toads were absent from a large number of historic locations, and that they occupied a small proportion of the available suitable habitats (Werner and Reichel 1994, 1996, Reichel 1995, 1996, 1997, Hendricks and Reichel 1996, Werner et al. 1998). A recent assessment of amphibians in the Greater Yellowstone Ecosystem (Van Kirk et al. 2000) indicates that boreal toads have declined in southeastern Idaho compared to historical records. Declines are also suspected in both Grand Teton and Yellowstone National Parks, based on anecdotal evidence from reports by Carpenter (1953) and Turner (1955) in comparison to recent surveys by Koch and Peterson (1995) and Patla and Peterson (1999).

Declines in boreal toad populations have also been recently reported in Oregon (Blaustein et al. 1994, Stebbins and Cohen 1995) and California (Drost and Fellers 1996, Fisher and Shaffer 1996).

Range Context

There are two distinct populations of the boreal toad in Wyoming, the southern Rocky Mountain population which is distributed in the mountains in Albany and Carbon Counties in southeast Wyoming, and the northern Rocky Mountain population which is distributed throughout northwest Wyoming. The northern population is contiguous with boreal toads in Montana and the Pacific Northwest, while the southern population is a fragment that is geographically isolated from other boreal toad populations. The southern Rocky Mountain population is potentially a regionally endemic species that is genetically differentiated from other taxa in the western toad complex in North America (Goebel 1996).

Extrinsic Threats and Reasons for Decline

There are seven general classes of anthropogenic and natural threats that directly and indirectly affect boreal toads and their habitat. These classes of threats are 1) the loss, deterioration, and fragmentation of aquatic and terrestrial habitats; 2) introduction of non-native species; 3) environmental pollutants; 4) increases in ambient UV-B radiation; 5) climatic change; 6) pathogens and 7) human commerce.

Specific direct threats to boreal toads on lands managed by the Bureau of Land Management in Wyoming include: air quality and atmospheric deposition, timber harvest, grazing, fire and fire management activities, non-native species and their management, road and trail development, on- and off-road vehicle use, development and management of recreational facilities, development and management of water impoundments, harvest and commerce, habitat fragmentation and metapopulation impacts, and finally the lack of information on specific populations.

No single factor has been identified as the primary threat to boreal toad habitat. It is possible that any resource management that has a negative affect on mountain wetlands or ponds will also negatively affect breeding habitats for boreal toads. Conservation efforts for this species can be best applied at the local population level. Conserving specific breeding populations that are free from chytrid infection and not significantly threatened by other natural or human related factors is in the authors opinion the most effective method for conserving boreal toads in the Rocky Mountain region.

Anthropogenic Impacts

Air Quality and Atmospheric Deposition

Acidification of wetlands may be a cause of developmental abnormalities and increased mortality of boreal toads during the embryonic and larval life stages (Porter and Hakanson 1976, Corn et al. 1989, Vertucci and Corn 1996). Researchers have also investigated the effects of increased UV-B radiation due to thinning of the atmospheric ozone layer on boreal toads. Results indicate that UV radiation does not have direct lethal effects on any life stages of boreal toads in the Rocky Mountains (Corn 1998). However, in Oregon ambient levels of UV radiation has caused increased mortality of boreal toad embryos (Blaustein et al. 1994). The Boreal Toad Recovery Team has not dismissed the effects of increased levels of UV radiation as a contributing factor in recently observed declines of boreal toads in the Rocky Mountains, since these findings only investigate direct mortality and do not consider indirect effects or synergistic effects with other threats, such as pathogens. For instance, Carey (1993) hypothesized that heavy metals and UV radiation may act synergistically with other environmental stressors and depress the immune system of boreal toads making them vulnerable to infection and death from pathogens. Research on the direct effects of acid deposition on boreal toads in the Rocky Mountains indicates that the current levels of acidification are not a significant problem for boreal toads. Laboratory studies indicate that pH levels of 4.4 - 4.5 result in 50% mortality of boreal toad embryos, and that breeding habitats of boreal toads in the Rocky Mountains rarely have pH levels less than 6.0. Here again, affects other than direct mortality were not investigated. Also, the low acid neutralizing capacity of water at boreal toad breeding sites indicates that about half of the known breeding areas are sensitive to damage from acidification. Sulfate deposition rates greater than 10 kg per hectare per year may reduce the acid neutralizing capacity of the water in these breeding sites to the point where pH levels become more acidic. When pH levels drop below 6.0 changes in algal communities can occur which would effect the growth and development of boreal toad tadpoles (Corn and Vertucci 1992). The deposition of acid ions and heavy metals is a threat to boreal toads in terms of air quality and its affect on aquatic habitats. Acidification of aquatic habitats and deposition of heavy metals from mine tailings may make historical breeding sites inhospitable for boreal toads.

Timber Harvest

The impact of timber harvest on boreal toads depends greatly on the timing, method, spatial extent, configuration and location of harvest activities relative to boreal toad habitats (Maxell 2000). A thorough review of forest management practices and their affects on amphibian ecology can be found in deMaynadier and Hunter (1995). In general, boreal toads appear to be less vulnerable than other amphibian species to habitat changes following timber harvests, however their populations still can be impacted by harvests, and toad habitat can be negatively affected. Direct effects from timber sales include mortality of toads crushed by equipment used during harvest activities. Boreal toads are particularly vulnerable to impacts of timber harvesting when harvest activities occur within their dispersal range from breeding sites, and during the late summer when adults migrate into upland forested habitats (see Table 2). In 18 studies reviewed by deMaynadier and Hunter (1995) they found that anurans were less abundant on 6 month to 40 year old clearcuts as compared to abundance on uncut control plots.

Clearcuts may influence boreal toad use of migration corridors due to the lack of moisture and increased heat within the clearcut (Bartelt 2000). The structure and composition of shrub understories may be enhanced or reduced due to tree removal. Shrub understories provide important microhabitats for boreal toads that aid in thermoregulation by providing water and heat energy (Bartelt 2000). Soil compaction from harvesting activities may reduce the availability of rodent burrows used by boreal toads as over wintering hibernacula (BTRT 2001). Timber harvesting can also benefit boreal toads by increasing small mammal habitat and thus increasing burrowing habitat. Boreal toads may over winter in these burrows and also slash piles (Bartelt 2000). Disturbance of stream habitats from sedimentation is one of the greatest impacts of timber harvest on amphibian species. Timber harvest activities typically also include the development and maintenance of roads, which may also increase erosion and sedimentation in adjacent streams and wetlands. These impacts have the potential to affect boreal toads most significantly during the larval life stage when they are limited to aquatic habitats. Disturbance of terrestrial habitats within proximity of streams and wetlands may also influence the availability of hibernacula sites for over wintering boreal toads. In general, any timber harvest activities that negatively affect the quality or quantity of wetlands within the current range of boreal toads can be harmful to this species.

Livestock Grazing

Riparian areas provide critical breeding, foraging, and over wintering habitats for boreal toads and are used as dispersal corridors for juvenile toads. Given access to water and typically richer vegetation in riparian areas, these habitats are also preferred areas for livestock grazing. Livestock grazing in wetlands is likely to result in direct impacts such as mortality of toads from trampling. Livestock grazing is one of the most widespread land management practices in western North America and it has been associated with a wide range of negative impacts on habitat and vertebrate taxa (Fleischner 1994). Bartelt (1998, 2000) observed that livestock activity in and around a breeding pond on the Targhee National Forest caused significant mortality for boreal toads from trampling, and the disturbance of microhabitats. Thousands of boreal toad metamorphs were killed when sheep were herded through a drying pond where the toads were concentrated. Bartelt observed that hundreds of toads had been directly killed by trampling and hundreds more died afterward as a result of desiccation because the vegetation they had been using for cover was trampled to the point that it no longer provided moist microhabitats.

Livestock grazing may cause habitat changes that cause reduced survival of tadpoles and eggs resulting from suffixation, hydrologic changes from stock pond development, predation due to loss of cover, and poisoning from fecal contamination of wetlands. Long-term effects may include degradation of riparian and wetland areas due to decreased riparian vegetation, which functions to filter water and increase, stream bank storage that maintains stream flow during droughts.

Livestock grazing may also remove important vegetative cover that provides microhabitats for boreal toads, which are important for thermoregulation (Bartelt 2000). Loss of bankside willows may result in reduced beaver activity or extirpation of beavers; a species whose activities are responsible for the creation of amphibian breeding habitats (Donker and Fryxell 1999, Russell et al. 1999a). Grazing may also reduce the number of insect prey that amphibians depend on (Fleischner 1994). Prairie dog and other rodent control programs associated with the protection of livestock from injury may reduce the number of burrows available for winter hibernation (Sharps and Uresk 1990). Compaction of soils in riparian areas may eliminate the ability for amphibians to burrow underground in order to prevent desiccation or freezing (Duellman and Trueb 1986, Swanson et al. 1996).

Fire and Fire Management Activities

Despite the lack of research on fire effects and amphibians, wildfire, prescribed fire, and fire control actions are likely to have direct impacts on amphibians (Maxell 2000). Direct mortality of amphibians from fire occurred in wetlands in the southeastern United States (Vogl 1973). Amphibian species have a relatively low ability to escape the effects of fire especially in a forest environment due to their slow locomotion and therefore may face high rates of mortality during fires (Friend 1993, Russell et al. 1999b, Papp and Papp 2000). Detailed research on the population effects of fire on boreal toads has not been conducted.

Increased sedimentation in streams from erosion following fire may reduce the number of shallow water pools and backwaters that provide breeding habitat for adults and feeding areas for larvae. Fire may also remove vegetation and structures that provide microhabitats used by amphibians for thermoregulation. Fire is a natural event through which boreal toads have historically survived as a species. Fire suppression may indirectly affect boreal toad habitat by altering the natural succession cycles in forest communities. These changes could have both positive and negative affects on boreal toads and their habitat. Boreal toads may benefit from an increased shrub understory following re-growth after a fire, and they may be negatively affected by the removal of downed woody material, which provide refugia (Bartelt 2000).

Nonindigenous species may change environmental conditions in amphibian habitats leading to enhanced survival and numbers of pathogens. Worthylake and Hovingh (1989) observed that elevated nitrogen levels in water, caused by high numbers of sheep, increased bacterial concentrations and caused mass mortality in salamanders.

Pesticides, Herbicides, and Environmental Contaminants

Both aquatic larval and terrestrial adult life stages are vulnerable to exposure to toxic chemicals. The highly vascularized epidermis and little keritinization of amphibian skin allows easy absorption of many chemicals, and chemical contamination has been documented causing direct mortality, depressed disease resistance, inhibition of growth and development, decreased reproduction, inhibition of predator avoidance behaviors, and morphological abnormalities (Cooke 1981, Hall and Henry 1992, Boyer and Grue 1995, Carey and Bryant 1995, Sparling et al. 2000). Saunders (1970) and Harfenist et al. (1989) examined the lethal toxicity of herbicides and pesticides on amphibians. Sublethal effects such as decreased thermal tolerance (Johnson and Prine 1976), decreased corticosterone production and inhibited glucogenesis (Gendron et al. 1997), decreased growth rate and inhibition of predator response (Berrill et al. 1993, Berrill et al. 1994) may be more widespread. Many chemicals may be present in amphibian habitats and have detrimental effects long after they were used. Russel et al. (1995) detected toxic levels of DDT in tissues of spring peepers (*Pseudacris crucifer*) at Point Pelee National Park, Ontario even though DDT had not been used in the area for 26 years.

Boreal toad larvae are vulnerable to the use of piscicides in their habitat since they depend on aquatic respiration, while adults are less vulnerable since they can escape from treated areas by exiting treated waters. Research on the lethal effects of rotenone-containing piscicides on amphibians was reviewed by Fontenot et al. (1994) and McCoid and Bettoli (1996). Research suggests that the range of lethal doses of rotenone for amphibian larvae (0.1-0.580 mg/L) overlaps with the lethal doses for fish (0.0165-0.665 mg/L), and that these lethal concentrations are lower than the concentrations commonly used in fisheries management (0.5-3.0 mg/L). They also reviewed research, which documented substantial mortality of amphibian larvae from piscicide treatments. The effects of rotenone on newly metamorphososed and adult amphibians is highly variable depending on the degree of each species aquatic respiration and their likelihood of escaping from treated areas by exiting the water (Fontenot et al. 1994, McCoid and Bettoli 1996). The non-target effects of antimycin have not been formally studied, but observations by Patla (1998) indicate that it is also toxic to amphibian larvae.

Habitat Development and Fragmentation

Many of the factors described above may result in the loss or fragmentation of boreal toad habitat and the subsequent loss of local populations. A detailed understanding of the affects of habitat fragmentation on metapopulation dynamics of boreal toads is needed to effectively evaluate the threat that habitat fragmentation presents to specific populations of boreal toads in Region 2. Habitat patch size, shape, isolation, and quality could all be important characteristics that influence the persistence of local metapopulations of boreal toads. In general, any activities, which alter mountain wetland habitats, could potentially affect the persistence of boreal toads in these areas (BTRT 2001).

Roads and trails can cause the direct threats to boreal toads from vehicle road kill in boreal toad habitats and migration corridors. Amphibians are particularly vulnerable to road kill mortalities during mass migrations to or from breeding habitats across roads (Koch and Peterson 1995). In some studies, road kill mortalities have caused substantial impacts on the population level of amphibians (Lehtinen et al. 1999).

The development and management of water impoundments can significantly alter amphibian habitats and may negatively affect populations by drying up breeding areas before larvae metamorphose. Additionally, if water bodies are made more permanent they may attract predators that negatively impact amphibian populations (Scott 1996, Skelly 1996).

Recreational developments that disturb wetland habitats may cause direct mortality of amphibians from construction equipment and vehicles. Amphibians in or near recreational facilities are also at risk of mortality as a result of handling by humans and killing by human pets (e.g., Reinking et al. 1980, Coman and Brunner 1972).

In some cases the replacement of ephemeral wetlands with developed water impoundments has resulted in the loss of critical habitats for amphibians. For example, the Jordanelle Reservoir on the Provo river in Utah flooded large amounts of ephemeral wetland habitats used by Columbia spotted frogs (Wilkinson 1996).

Harvest and Commerce

Currently there is very little information on the extent to which boreal toads are collected or harvested for biological or commercial purposes in Region 2. Worldwide, the collection and harvest of amphibians for commercial use is extensive, and an estimated hundreds of millions of amphibians are collected and/or killed every year (Pough et al. 1998).

The potential threat to boreal toads from harvest and commerce is significant since non-indigenous predators (e.g. bullfrogs) are sold in pet stores along with other exotic species that may prey on boreal toads and act as vectors for diseases such as chytrid fungus (Daszak et al. 1999).

Invasive Species

Nonindigenous species can potentially threaten boreal toads directly through predation, and indirectly as competitors for resources, vectors for pathogens, and as the target of management actions that may have ancillary affects on toads (e.g., using piscicides, insecticides, or herbicides to control exotic species).

At least 104 species of fish have been introduced in Region 2 states (Colorado and Wyoming) where boreal toads are present (Fuller et al. 1999, Nico and Fuller 1999), and many native fish have been transplanted into drainages where there were historically never present (Baxter and Stone 1995). Introduced fish species have been documented causing declines of amphibian species worldwide (Sexton and Phillips 1986, Bahls 1992, Bradford et al. 1993, Bronmark and Endenhamn 1994, Brana et al. 1996, Hecnar and M'Closkey 1997, Fuller et al. 1999). Specifically, introduced salmonids at higher elevations are likely to present a significant threat to boreal toads and other amphibians that occupy high (> 800 meters) mountain lakes and streams, because 95% of these lakes in the western United States were naturally fishless prior to stocking (Bahls 1992). These high mountain lakes would have historically only supported native amphibian communities and the threat of predation from fish would have been absent. All life stages of amphibians are subject to predation by introduced fishes (Licht 1969, Semlitsch and Gibbons 1988, Liss and Larson 1991). Indirect effects of predation include:

1. adult avoidance of egg laying sites where predators are present (Resetarits and Wilbur 1989, Hopey and Petranka 1994),
2. decreased larval foraging and growth rates as a result of staying in refuges to avoid predators (Figiel and Semlitsch 1990, Skelly 1992, Kiesecker and Blaustein 1998, Tyler et al. 1998), and
3. decreased adult foraging, growth rates, and overwinter survival as a result of avoiding areas with fishes (Bradford 1983).

Boreal toad adults produce toxic secretions from glands on their skin, particularly the parotid gland behind the eyes, which provides some defense from predation by fish (Patla 2001). Tadpoles and eggs are thought to be unpalatable to predators, which might make them less vulnerable to fish predation (Nussbaum et al. 1983), and there is some evidence that salmonids fish may not routinely prey of boreal toad tadpoles (Jones and Goettl 1999).

Bullfrogs (*Rana catesbeiana*) are a noninindigenous species in Region 2 states and have been implicated as a cause of amphibian declines throughout the western United States (Moyle 1973, Hammerson 1982, Bury and Whelan 1984, Kupferberg 1994, Rosen et al. 1995, Kupferberg 1997, Lawler et al. 1999). All life history stages of amphibians may be vulnerable to predation from adult bullfrogs (Carpenter and Morrison 1973, Bury and Whelan 1984, Clarkson and DeVos 1986) and eggs and larvae may be preyed upon by bullfrog tadpoles (Ehrlich 1979, Kiesecker and Blaustein 1997).

Nonindigenous species such as bullfrogs and other amphibians sold at pet stores, and introduced fishes may act as vectors for pathogens that infect amphibians. Chytrid fungus is hypothesized to be the primary cause of amphibian declines in Australia, Central America, and the western United States, and many amphibians exported to pet stores in the United States come from the areas where chytrid fungus was first documented during dramatic amphibian declines (Daszak et al. 1999, 2000). Blaustein et al. (1994) observed that the water fungus *Saprolegnia*, a common pathogen of fish species reared and released from fish hatcheries, has been associated with amphibian declines. This suggests that releasing hatchery raised fish into the wild may increase the risk of infecting amphibians with pathogens from fish. Additionally pathogens introduced by nonindigenous species are suspected to act synergistically with other natural and anthropogenic caused threats. Kiesecker and Blaustein (1995) observed that the combination of UV radiation and *Saprolegnia* fungus increased occurrences of mortality in amphibian embryos.

There is relatively little information on the impact exotic weeds have on amphibians. However, there is some evidence that the the presence of exotic aquatic vegetation enhances the survival of nonindigenous bullfrogs (Kupferberg 1997). Management of weed and insect pests with chemical herbicides and pesticides can be a significant threat to amphibians (see above).

Genetic Factors

The boreal toad is a subspecies of the western toad complex that is found throughout western North America. The southern Rocky Mountain population, which ranges from southeast Wyoming to northern New Mexico, is geographically isolated from populations in western North America by dry, non-forested intermountain valleys. Evidence suggests that this population of boreal toads in Region 2 is genetically differentiated and probably represents an independently evolving lineage or species (Goebel 1996). This isolation is a concern since this population has experienced dramatic recent declines, and there is no source for a natural rescue effect from adjacent populations. There is a possibility that the distinct genetic characteristics and the fitness for habitats in the range of the southern Rocky Mountain population may be lost if this population is extirpated. Initial tests indicated that boreal toads in Utah are closely related to toads in the southern Rocky Mountain population. Recent analysis of mtDNA and nDNA from boreal toads in Utah, Idaho, Wyoming, and Colorado indicate that boreal toads in Utah and Idaho are genetically distinct from toads in the southern Rocky Mountain population, while boreal toads in Sublette County, Wyoming, which had been classified as northern Rocky Mountain boreal toads, may be more closely related to toads in the southern Rocky Mountain population. Additional data are needed to confirm these hypotheses, and specimens collected this summer from western Wyoming will be used to help determine the genetic relationship of these boreal toads to the southern Rocky Mountain population.

Stochastic Factors (e.g., weather events)

Climate changes have been implicated with amphibian declines in several areas around the world (Pounds and Crump 1994, Stewart 1995, Pounds et al. 1999). Periodic climate changes that alter moisture and/or temperature have the potential to make habitats inhospitable to amphibians. In the case of boreal toads the primary threats from climate change are droughts and early or late season freezing temperatures. These changes may cause breeding ponds to dry up before larvae metamorphose into terrestrial life stages or may cause deaths to toads both before they enter hibernacula or after they leave hibernacula to move top breeding sites.

Natural Predation

Natural predators of the boreal toad include, but are not restricted to, the common raven (*Corvus corax*) (Corn 1993; Olson 1989), gray jay (*Perisoreus canadensis*) (Beiswenger 1981), western garter snake (*Thamnophis elegans*) (Jennings et al. 1992; Arnold and Wassersug 1978), tiger salamander (*Ambystoma tigrinum*) (Hammerson 1982), badger (*Taxidea taxus)* (Long 1964), spotted sandpiper (*Actitis macularia)* (J. Goettl unpubl. 1996), red fox (*Vulpes vulpes*), robin (*Turdus migratorius*), and racoon (*Procyon lotor*) (Jones, CDOW, unpubl. 1998), and predacious diving beetle larvae (*Dytiscus* sp.) (Livo 1999). The latter prey only on the toad larvae. Introduction of game fish to historically fish-less waters has reduced many amphibian populations throughout western North America (Bradford 1989, Bradford et al. 1993, Corn 1994), but there is no direct evidence that this has contributed to the decline of boreal toads. Boreal toad eggs and tadpoles are toxic or distasteful to most predators (Licht 1969, Brodie and Formanowicz 1987, Hews 1988), and although this does not render them immune from predation, there are several current and former boreal toad breeding sites that also contain fish.

Intrinsic Vulnerability

Habitat Specificity and Fidelity

Boreal toads are dependent on both aquatic and terrestrial habitats for reproduction, foraging, and over wintering. Thus, they are vulnerable to changes in both of these habitats. Additionally, the necessity for this habitat juxtaposition restricts the pool of available habitat, since there are relatively limited sites that combine suitable wetland habitat adjacent to suitable terrestrial habitat. There are three main habitat components required for boreal toads: 1) shallow wetlands for breeding, 2) terrestrial habitats for foraging that provide vegetative cover, and 3) burrows for winter hibernation (BTRT 2001). There is not detailed information on the relative proportion of these habitat types required by boreal toads. However, research on the habitat use of boreal toads indicates that the landscape surrounding the breeding site is as important as the wetland used for breeding for survival. In general the optimal spatial mosaic of boreal toad habitats includes permanent ponds or wetlands with shallow sunny margins, adjoining willow thickets or shrub cover, and upland montane forests within an elevation range between 8000 and 11,000 feet (2440 and 3350 meters) (BTRT 2001). All of these habitat components must be within a relatively clustered arrangement on the landscape to allow boreal toads to survive. Boreal toads may migrate up to 2.5 km from breeding ponds to winter hibernacula, but is most cases this distance is much less. Therefore all of the habitat components described above should be well within 2.5 km of breeding ponds to provide optimal habitat for boreal toads.

Territoriality and Area Requirements

In general boreal toad area requirements are restricted during breeding and hibernation seasons to relatively localized areas, and their area requirements are larger between breeding and hibernation. During this time period boreal toads use terrestrial habitats extensively and have been observed traveling long distances away from breeding sites (Bartelt 2000). Campbell (1970) documented home ranges of two boreal toad populations in Boulder County, Colorado and observed that the size of home ranges varied greatly in relation to the amount of available habitat, the number of toads in the population, and the sex of toads. In general, toads' home ranges were larger in areas with greater amounts of quality habitat, suggesting that high population densities in some areas may not be a direct indicator of high quality habitat, but could rather be due to a limited concentration of marginal habitat in otherwise poor areas. This observation could be the result of differences between the habitats of the surveyed toad populations, and not indicative of all boreal toad populations area requirements. Campbell (1970) also observed that home ranges were larger in a population with fewer boreal toads and hypothesized that the lower density in this population allowed toads to occupy larger home ranges. It is also apparent from the data collected on these two populations that the population that consisted of a larger proportion of males had larger average home ranges than the population that consisted of a larger proportion of females. It is important to note that all of these observations may be confounded by habitat variables such as water quality, vegetative cover, or prey availability. The population tracked at Albion consisted of 29 boreal toads (75% male: 25% female) and had a larger area of available habitat. The average home range size was 516 m^2. In comparison the other population tracked consisted of 50 boreal toads (14% male: 86% female) and had a smaller area of available habitat. The average home range size was 198 m^2.

Susceptibility to Disease

Boreal toads are susceptible to a variety of bacterial and fungal pathogens which have been documented in Region 2. The primary disease causing pathogen is chytrid fungus. Which has caused mass deaths of amphibians in Arizona, California, Colorado, Wyoming, Central and South America, and Australia (Daszak et al. 1999, Parker 2000). Chytrid is a microscopic, parasitic fungus that attacks the keratin and skin of amphibians and has caused 90-100% mortality rates in metamorphosed amphibians. Amphibian larvae are not lethally affected by chytrid because only their mouthparts contain keratin. However, boreal toad tadpoles may carry this disease and die from it after metamorphosis. Carey (2000) hypothesizes that chytrid is responsible for the observed declines in boreal toads that began in the 1970's in Colorado, and that recent outbreaks of chytrid have caused observed declines over the past few years in remaining boreal toad populations in Colorado. Recent modeling research on the boreal toad populations in Rocky Mountain National Park by R. Scherer (unpublished 2002) at Colorado State University indicate that the observed declines fit very closely with a model of population changes following introduction of chytrid fungus. Die-offs from chytrid may take place gradually over weeks or months making it difficult to detect unless frequent surveys are conducted for dead amphibians. Populations of boreal toads infected with chytrid fungus have declined to near extinction within one year, and there are no documented cases of an infected population recovering following infection. Carey et al. (1999) hypothesized that chytrid is so detrimental to boreal toad populations because it is a recently emerged infectious disease that toads have not evolved resistance to, and that environmental stress is making toads more vulnerable to infection.

Dispersal Capability

Bartlet (2000) observed that boreal toads moved into terrestrial habitats surrounding wetland breeding sites up to 438 meters in 24 hours, mostly on warm, humid nights. Female toads moved as far as 2.4 km from breeding sites while male toads traveled only 0.9 km from breeding sites.

Reproductive Capacity

They are capable of producing very large clutch sizes, however females do not begin breeding until they are 6 years old, probably only breed every other year, and are not likely to live much beyond 9 years. In addition, mortality may be as high as 99% for larval and metamorph life stages. This results in a low reproductive capacity inhibiting recovery of populations from major disturbance events, meaning that any substantial mortality events among adults may effectively cause a population to become extinct.

Sensitivity to Disturbance

Any activities which damage or destroy montane wetland habitats have the potential to displace boreal toads or cause local populations to become extinct. Boreal toads are especially vulnerable to disturbances during the period from breeding to metamorphosis. During this time period larvae and eggs can be destroyed by direct disturbance of wetland habitats or changes in the hydrology which may cause breeding ponds to dry up before larvae mature.

Protected Areas

A general analysis of boreal toad range within Wyoming indicates that approximately 50% of the boreal toads range is within GAP status 1 lands, less than 1% is in GAP status 2 lands, and 30% is in GAP status 3 lands. Less than 3% of the current boreal toad occurrences in the WYNDD boreal toad records are from BLM owned lands in Wyoming.

Population Viability Analyses (PVAs)

No formal Population Viability Analyses (PVAs) have been conducted for the boreal toad populations in Wyoming. Plans to address this lack of information are currently ongoing and being reviewed by the Boreal Toad Recovery Team. A description of proposed PVA can be found in the current draft of the Boreal Toad Conservation Plan and Agreement (BTRT 2001).

Conservation Action

Existing or Future Conservation Plans

Existing Regulatory Mechanisms

Boreal toads are protected as endangered species in Colorado (Colorado Rev. Stat. Ann. §§33-2-109 et seq) and New Mexico (New Mexico Stat. Ann. §§ 17-2-37 et seq). The Wyoming Game and Fish Commission regulation (Chapter 52, Section 11) classifies boreal toads as Native Species Status 1 (NSS1), which means the species is rare and declining and that the habitat for this species is declining, but this status carries no legal, regulatory, or management weight. The Colorado designation provides a basic mandate for the Colorado Division of Wildlife to conserve the boreal toad and prohibits collection, possession, or sale of this species. However, it does not include measures to protect the habitat of boreal toads.

A federal proposal to list the Southern Rocky Mountain Population (SRMP) of boreal toads as endangered was warranted but precluded by other priorities as of 1995 (USFWS 1995). Despite these regulatory efforts to protect the boreal toad, it seems that these mandates have been inadequate to protect the toad, since it continues to decline in the southern Rocky Mountains.

The National Forest Management Act (16 U.S.C. 1600 et seq.) includes a sensitive species policy which directs the U.S. Forest Service to manage for sensitive species such as the boreal toad. This includes habitat protection measures that have been implemented for the boreal toad on National Forests. Again, except perhaps at a few localities, there has been no discernable impact on population trends in the region that can be directly attributable to these management actions, so these mechanisms seem inadequate to conserve boreal toad populations in the Rocky Mountains.

Existing Management Plans

Southern Rocky Mountain Population

The multi-agency Boreal Toad Recovery Team was formed in 1994 to provide coordinated recommendations on the conservation and management of the Southern Rocky Mountain Population. A recovery plan was finalized in the same year (Nesler and Goettl 1994) and a conservation plan followed in 1998 (BTRT 1998) and was updated in February 2001 (BTRT

2001). As stated in the revised conservation plan (BTRT 2001), management objectives are:

1. prevent the extirpation of boreal toads from the area of their historic occurrence in the southern Rocky Mountains, which includes eleven mountain ranges, or geographic areas, covering southern Wyoming, northern New Mexico, and much of Colorado,
2. avoid the need for federal listing of the boreal toad under the ESA, and
3. recover the species to a population and security level that will allow it to be de-listed from its present endangered status in Colorado and New Mexico.

Detailed descriptions of down-listing and de-listing requirements (within Colorado) and population viability are provided in the conservation plan (BTRT 2001). In general, for a population to be considered viable a specified minimum number of toads must successfully breed (i.e., there must be significant recruitment) for a set number of years and external threats to the habitat, health, or environmental conditions of the population must be eliminated. Down-listing and/or de-listing will be considered when a specified number of viable populations over an adequate geographic area are confirmed. Currently, there is no portion of the southern Rocky Mountain population that meets established viability standards.

Northern Rocky Mountain Population

No coordinated conservation efforts have thus far been made with respect to the northern Rocky Mountain Population of boreal toads in Wyoming, although much of the conceptual and biological information generated for the southern Rocky Mountain Population will be loosely applicable to the northern population. There have been reviews of boreal toad status prepared for specific regions of the northern Rocky Mountains, for example Patla (2000a, 2001) for the Bridger-Teton National Forest and Maxell (2000) for Montana. However, neither of these documents represents a coordinated management plan.

Existing Conservation Strategies

The following general steps outline the main conservation strategies recommended by the interagency Boreal Toad Recovery Team (BTRT 2001):

1. identify and inventory potential toad habitat throughout the historic range;
2. monitor breeding populations identified via inventories with the goal of obtaining reliable population trend data;
3. identify and investigate known and potential threats;
4. establish recovery goals based on population viability estimates that incorporate genetic factors;
5. protect and manage critical populations with respect to known threats;
6. pursue opportunities to expand the size and number of breeding populations including transplantation and captive reintroduction;
7. conduct a public education campaign concurrent to the above recovery efforts.

These recommended conservation strategies are accepted as the best strategies for conservation of boreal toads by a team of experts in amphibian research and management, and therefore they should be considered as the best available conservation strategies available.

Conservation Elements

Inventory and Monitoring

A thorough description of approved boreal toad survey procedures is provided by the Boreal Toad Recover Team (***), from which the following methods and elements for inventory and monitoring boreal toad populations and there habitats have been derived. These methods represent the combined suggestions of many amphibian biologists from the Rocky Mountains and should be considered the best available inventory and monitoring practices for boreal toads in this area.

One of the most important elements in any amphibian inventory and monitoring program is a standard method for minimizing the spread of disease agents and parasites between study sites.

This is especially important with boreal toads since chytrid fungus is lethal to toads and apparently spreading rapidly. The Declining Amphibian Population Task Force (DAPTF) developed the following *Code of Practice*, which is recommended by the interagency Boreal Toad Recovery Team:

1. Remove mud, snails, algae and other debris from nets, traps, boots, vehicle tires and all other surfaces. Rinse cleaned items with sterilized (e.g. boiled or treated) water before leaving each study site.
2. Boots, nets, traps etc. should then be scrubbed with 70% ethanol solution and rinsed clean with sterilized water between study sites. Avoid cleaning equipment in the immediate vicinity of a pond or wetland.
3. In remote locations, clean all equipment as described above (or with a bleach solution of 1 part bleach to 32 parts water, or stronger) upon return to the lab or "base camp". Elsewhere, when washing-machine facilities are available, remove nets from poles and wash with bleach on a "delicate" cycle, contained in a protective mesh laundry bag.
4. When working at sites with known or suspected disease problems, or when sampling populations of rare or isolated species, wear disposable gloves and change them between handling each animal. Dedicate sets of nets, boots, traps and other equipment to each site being visited. Clean and store them separately at the end of each field day.
5. When amphibians are collected, ensure the separation of animals from different sites and take great care to avoid indirect contact between them (e.g. via handling, reuse of containers) or with other captive animals. Isolation from unsterilized plants or soils that have been taken from other sites is also essential. Always use disinfected/disposable husbandry equipment.
6. Examine collected amphibians for the presence of diseases and parasites soon after capture. Prior to their release or the release of any progeny, amphibians should be quarantined for a period and thoroughly screened for the presence of any potential disease agents.
7. Used cleaning materials (liquids, etc.) should be disposed of safely and if necessary taken back to the lab for proper disposal. Used disposable gloves should be retained for safe disposal in sealed bags.

Surveys for boreal toads typically use the Visual Encounter Survey (VES) method described by Crump and Scott (1994). This method consists of walking along the perimeter of wetlands scanning for amphibians, eggs, or larvae. It is important to avoid wading through water especially in shallow aquatic vegetation in search of eggs and tadpoles since it is easy to cause damage to eggs in these areas. In large wetlands, e.g. bogs or willow thickets, it is best if survey crew members spread out and make broad zig-zags through the site to ensure complete coverage during surveys.

It is essential in conducting surveys for boreal toads that standards for what constitutes a positive occurrence are established. Presence is conclusive if boreal toad adults, eggs, or larvae are observed and identified. However, a lack of observations of boreal toads is never conclusive that boreal toads are not present. A single survey of a location is not a reliable means for determining presence or absence since toads are cryptic and sub-adults usually do not congregate at survey sites. Additionally, it can be extremely difficult to detect adult boreal toads after the breeding season. Timing surveys to target specific periods in the boreal toad life cycle (Table 2) can improve the success of survey efforts. Therefore, surveys targeting adults during the breeding season followed up by surveys for tadpoles in mid to late summer can be an effective method to maximize the probability of detecting boreal toads at a survey location.

It is important to complete survey data sheets for all sites visited, whether or not any boreal toads were observed. This negative information allows researchers to determine long-term information on the distribution and abundance of boreal toads by distinguishing between sites where no surveys have been conducted and sites where surveys were conducted and no toads were observed. It is also very important to have a centralized repository for all boreal toad information collected by past and future surveys.

An important element in conducting surveys for boreal toads is targeting appropriate habitats. Metamorphosed boreal toads are usually associated with wetland habitats above 2440 meters (8000 feet), including ponds, bogs, willow thickets, and streams. Toads use a wide variety of lentic areas for breeding from tire ruts to large lakes. Eggs are usually deposited inn shallow water, and during the day larvae concentrate in shallow sunny margins of the water body.

Potential habitats for surveys are identified using wetland inventory, elevation, and historical distribution data from boreal toad databases such as those housed at the Colorado Natural Heritage Program and the Wyoming Natural Diversity Database. Detailed information on habitat characteristics recorded during surveys at sites occupied by boreal toads also helps to develop specific habitat criteria that can be used to focus survey efforts only in suitable habitats. There are extensive areas within Region 2 that have not been adequately surveyed in order to obtain up to date accurate information on the availability of suitable habitats. It is essential that habitat surveys are conducted in areas where toad habitats could be altered by management actions. Additionally, habitat surveys should include testing for the presence of chytrid fungus within suitable boreal toad habitats. Currently there is no test that can determine whether chytrid fungus is present in boreal toad habitats. The Boreal Toad Recovery Team recommends the following priorities for surveying boreal toad habitat: 1) known historic locations, 2) areas expected to be affected by management activities, 3) areas with suitable habitat. Habitat surveys are not recommended outside the known historic range of toads particularly in habitats where boreal toads have not been known to occur (e.g. sagebrush desert) or in areas where management activities will not have a negative impact of toads or their habitat.

Known breeding sites should be surveyed during daylight hours at least weekly during the breeding season to search for adult toads and to determine the number of egg masses deposited and the development and metamorphosis of larvae. It is very helpful when conducting this type of monitoring to flag the location of known egg masses as they are found so that new egg masses can be identified and so that egg masses are not damaged during future surveys. Night surveys should also be conducted to determine the number of adult toads present at breeding sites at least once a week during the breeding season. These night surveys should be conducted between one hour after sunset and midnight, and should focus on the immediate vicinity of the wetland. Relative abundance should be determined from a count of adults from a single circuit of the wetland.

After the breeding season, sites with known breeding activity should be monitored at least once every two weeks during the rest of the summer, or until all larvae have metamorphosed and dispersed. In addition to the general data recorded on standardized data sheets it is useful to sketch the distribution of toads, tadpoles, and eggs on a copy of an aerial photo or a topographical map. This can be very helpful for locating monitoring sites during subsequent seasons, and by different personnel than conducted the initial survey.

The Boreal Toad Recovery Team established a minimum standard for monitoring boreal toad breeding sites. The minimum monitoring effort should include thorough searches of the site at least three times during the breeding season, with each survey being at least five days apart, and including at least one night survey.

Habitat Preservation and Restoration

The key element in any management of boreal toad populations or habitats is to develop an efficient method to test for and treat chytrid fungus in both infected toads and their habitats. Following this it will be necessary to manage boreal toad habitats in order to minimize the affect of the threats identified in the section on Extrinsic Threats (See above). The Boreal Toad

Recovery Team details several key elements in their strategies for habitat management that adequately address these threats (BTRT 2001).

Captive Propagation and Reintroduction

A detailed description for captive propagation and reintroduction methods can be found in the current Boreal Toad Recovery Teams' Conservation Plan and Agreement (BTRT 2001) and CDOW husbandry manual (Scherff-Norris et al 2000). Boreal toads from the southern Rocky Mountain Population are currently being breed in captivity at several facilities. Boreal toads from Colorado are being breed at the Colorado Division of Wildlife Native Aquatic Species Restoration Facility (NASRF), the Toledo Zoo, the Cheyenne Mountain Zoo, and several smaller facilities. As of November 2002, there were approximately 600 boreal toads representing 48 distinct genetic lots from 20 breeding areas throughout Colorado at the NASRF. Currently the NASRF plans to supplement this breeding stock by collecting additional boreal toads in order to enhance genetic diversity. They will also begin to track the breeding success of individual toads. Boreal toads from Wyoming are being held at the Saratoga Fish Hatchery. There are currently only 4 adults (3 females, 1 male) in this facility and there were 3 juvenile toads collected during the summer of 2002. These toads were collected from Ryan Park (four toads) and Bird Creek (three toads) in the Medicine Bow Mountains.

Reintroduction and transplantation efforts have been unsuccessful in Wyoming. The Wyoming Game and Fish Department released 4300 juvenile boreal toads in 1996 and 950 tadpoles in 1997 into beaver ponds near Owen Lake in the Medicine Bow Mountains. Surveys of these sites recorded no boreal toad observations in 1998 - 2000 indicating that the reintroduction effort was unsuccessful.

There are several key limitations that must be adequately addressed prior to reintroduction of toads. First, it must be determined based on thorough surveys that boreal toads are extirpated from a large, historically occupied area. Second, it must be unlikely that the selected reintroduction site will be re-colonized by natural migration from adjacent populations. Finally, It must be determined that the proposed reintroduction site has adequate suitable habitat to support a population of boreal toads. Once these requirements have been investigated the site must be tested to determine whether there are any significant imminent threats in the area that could result in the extirpation of boreal toads. The following elements should be investigated:

1. Water quality, including pH and presence of toxins, such as heavy metals, organochlorides, and organopesticides,
2. substrates should also be sampled for the presence of the above toxic substances,
3. the environment and amphibians or fish in the area should be tested for pathogens,
4. the site should be surveyed for introduced flora and fauna which may present a threat to boreal toads,
5. surveys should evaluate the presence and abundance of predators e.g. garter snakes, predaceous diving beetles, and tiger salamanders,
6. present and anticipated land use and ownership, including stream flow and water rights should be assessed.

Once these elements are addressed and there are adequate preferably wild or if necessary captive toads then reintroduction efforts should proceed following the methods outlined by the Boreal Toad Recovery Team in the Boreal Toad Recovery Teams current Conservation Plan and Agreement (BTRT 2001).

Information Needs

The distribution of boreal toads is well known in some parts of its range in Wyoming; however, there are gaps in our knowledge of locations where current breeding activity is occurring. Increased survey efforts in historically occupied areas and monitoring of known survey sites could provide valuable information to aid in management. Maintaining an up to date comprehensive database of boreal toad locations for Wyoming through the Wyoming Natural Diversity Database will also aid in disseminating information on the current distribution and information gaps to land managers.

The response of boreal toads to fine and broad scale changes in habitat is not completely understood. Further research is needed in order to evaluate specific effects of management or natural disturbances on boreal toad populations in Wyoming. The positive and negative affects of threats to boreal toad habitat (e.g. timber harvest, grazing, fire and fire management, nonindigenous species management, road, trail, recreational, and water developments) should be formally studied for boreal toads in Wyoming by examining pre- and post- treatment conditions and the impact on boreal toad populations.

The response of boreal toads to changes in habitat relative to reproduction, rearing, resting, and foraging should be investigated further in Wyoming using targeted manipulative experiments to determine pre- and post-treatment conditions and the affect of changes on boreal toad populations. The response of boreal toads to changes in habitat relative to prey and predators could also be researched more thoroughly in Wyoming.

The movement patterns of boreal toads have been well documented by Bartelt (2000), and his results indicate that changes to habitat within 2.5 km buffers of breeding sites have the potential to affect boreal toads. Further evaluation of the affects of management activities in proximity to breeding habitat is necessary in understanding how changes in these habitats affect seasonal movement patterns.

There is no detailed information on how insect prey population's response to habitat changes affects boreal toads. Boreal toads appear to be very flexible in their diet, and therefore may shift prey items if one group of prey becomes locally scarce due to habitat changes. Future research should investigate how specific prey species respond to habitat changes from management actions and what if any affect this may have on boreal toads.

There is generally good information on the demography of boreal toads, but information on specific populations in lacking. Research needs to be conducted to model population viability at local and regional scales in Wyoming. Ongoing research at Colorado State University modeling boreal toad population declines relative to chytrid fungus and environmental trends is beginning to address this information need (R. Sherer pers comm.).

There are sufficient methods available to monitor population trends for boreal toads (BTRT 2001). The Boreal Toad Recovery Team has developed recommended monitoring protocols for surveys at breeding sites that have been implemented in monitoring boreal toad populations in Colorado.

The Boreal Toad Recovery Team (BTRT 2001) has described methods for restoration of boreal toads in the most recent draft of the Boreal Toad Recovery Teams interagency Conservation Plan and Agreement. However, full implantation of the restoration plans is not currently possible due to the potential for chytrid fungus to eliminate any re-introduced populations. Captive breeding has been conducted successfully in several facilities so there is a source population for restoration once the problems with chytrid infections can be dealt with for re-introduced toads.

The most important information is to determine if previously documented breeding sites remain active and to identify unknown breeding sites. Annual monitoring of population trends at breeding sites is needed to determine population viability. Ideally, all known breeding sites should be visited several times per year in order to determine reproductive effort and survival. Additional genetic studies are needed to clarify the taxonomic status of the southern and northern Rocky Mountain populations and the range limits of these populations. Disease research is needed to determine means of detecting chytrid fungus both in boreal toad habitats and on live toads without taking terminal samples. Information on boreal toad home range size, dispersal, and hibernacula habitats are needed as well as research investigating the impact of anthropogenic disturbances on breeding sites and dispersal ability. Data is also needed describing the effects of piscicide treatments such as rotenone and anamyicin of tadpole life stages survival.

Tables and Figures

Table 1: Official Status of Wyoming populations

Taxon	Heritage Rank	Federal	State	WY Counties	Range Notes
Southern Rocky Mountain Population	G4T1Q/S1	USFWS -Warranted but precluded USFS R2 -Sensitive BLM -Sensitive	WYG&F- NSS1	ALB, CAR, LAR	Reg. Endm.
Northern Rocky Mountain Population	G4T4/S2	USFS R1- Sensitive BLM- Sensitive	WYG&F- NSS1	FRE, LIN, PAR, SUB,SWE,TET, UIN	SE periph

HERITAGE RANKS: WYNDD uses a standardized ranking system developed by The Natural Heritage Network to assess the global and statewide conservation status of each plant and animal species, subspecies, and variety. Each taxon is ranked on a scale of 1-5, from highest conservation concern to lowest. Codes are as follows: *G - Global rank*: rank refers to the rangewide status of a species. *T - Trinomial* rank: rank refers to the rangewide status of a subspecies or variety. *S - State rank*: rank refers to the status of the taxon (species or subspecies) in Wyoming. State ranks differ from state to state. *1 - Critically imperiled* because of extreme rarity (often known from 5 or fewer extant occurrences or very few remaining individuals) or because some factor of a species' life history makes it vulnerable to extinction. *2 - Imperiled* because of rarity (often known from 6-20 occurrences) or because of factors demonstrably making a species vulnerable to extinction. *3 - Rare* or local throughout its range or found locally in a restricted range (usually known from 21-100 occurrences). *4 - Apparently secure*, although the species may be quite rare in parts of its range, especially at the periphery. *5 - Demonstrably secure*, although the species may be rare in parts of its range, especially at the periphery.

FEDERAL MANAGEMENT STATUS: USFS Region 2 (Rocky Mountain Region) and 4 (Intermountain Region) have developed official Sensitive species lists to track organisms warranting special attention on USFS lands. Sensitive species are defined as "those plant and animal species identified by the Regional Forester for which population viability is a concern as evidenced by: (a) significant current or predicted downward trends in population numbers or density, and/or (b) significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution." US Forest Service Region 2 includes Bighorn, Black Hills, Medicine Bow, and Shoshone National Forests and Thunder Basin National Grassland. US Forest Service Region 4 includes Ashley, Bridger-Teton, Caribou, Targhee, and Wasatch-Cache National Forests.

WYOMING STATE MANAGEMENT STATUS: Wyoming Game and Fish Department (WYGF): The WYGF has developed a matrix of habitat and population variables to determine the conservation priority of all native, breeding bird and mammal species in the state. Six classes of Species of Special Concern (SSC) are recognized, of which classes 1, 2, and 3 are considered to be high priorities for conservation attention.

SSCI: Includes species with on-going significant loss of habitat and with populations that are greatly restricted or declining (extirpation appears possible).
SSC2: Species in which (1) habitat is restricted or vulnerable (but no recent or significant loss has occurred) and populations are greatly restricted or declining; or (2) species with on-going significant loss of habitat and populations that are declining or restricted in and distribution (but extirpation is not imminent).
SSC3: Species in which (1) habitat is not restricted, but populations are greatly restricted or declining extirpation appears possible); or (2) habitat is restricted or vulnerable (but no recent loss has occurred) and populations are declining or restricted in numbers or distribution (but extirpation is not imminent); or (3) significant habitat loss is on-going but the species is widely distributed and population trends are thought to be stable.

Table 2. Crucial periods in the life cycle of the boreal toad (*Bufo boreas boreas*)

Period	Events	Timing
Breeding Period	Breeding begins 2-4 weeks post appearance of open water	Mid-May to mid June (July at higher elevations)
Hatching	Eggs hatch 1 to 2 weeks after being laid	Late May to Late June (late July at higher elevation)
Metamorphosis	Tadpole metamorphosis to toadlets in approximately 2 months	Late July to late August (late September at higher elevation)
Toadlet Dispersal	Toadlets leave natal area	Highly variable
Overwintering	Adults and juveniles in winter habitat	Late September to mid-May

Figure 1: Adult boreal toads (*Bufo boreas boreas*) from the A) northern Rocky Mountain Population (Photo by Deb Patla) and B) southern Rocky Mountain population (Photo by Chuck Loeffler)

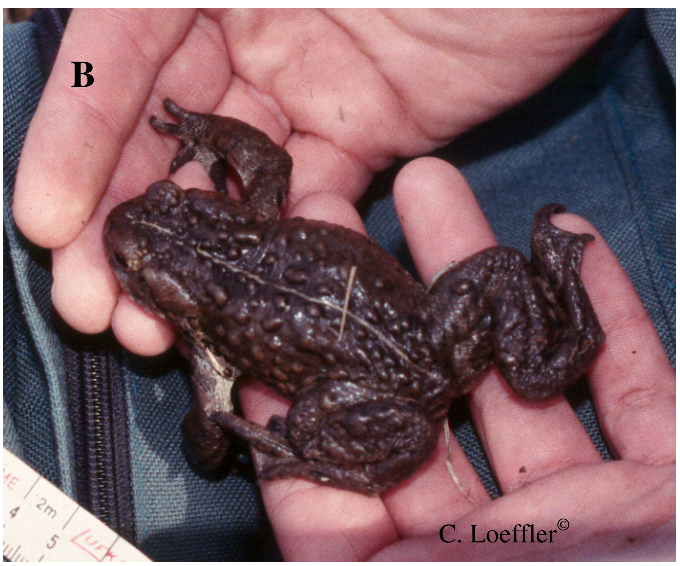

Figure 2: Juvenile boreal toad (*Bufo boreas boreas*) (Photo by Deb Patla)

Figure 3: Boreal toad (*Bufo boreas boreas*) eggs (Photo by Deb Patla).

Figure 4: Boreal toad (*Bufo boreas boreas*) tadpoles (Photo by Deb Patla).

Figure 5: North American range of the boreal toad (*Bufo boreas boreas*).

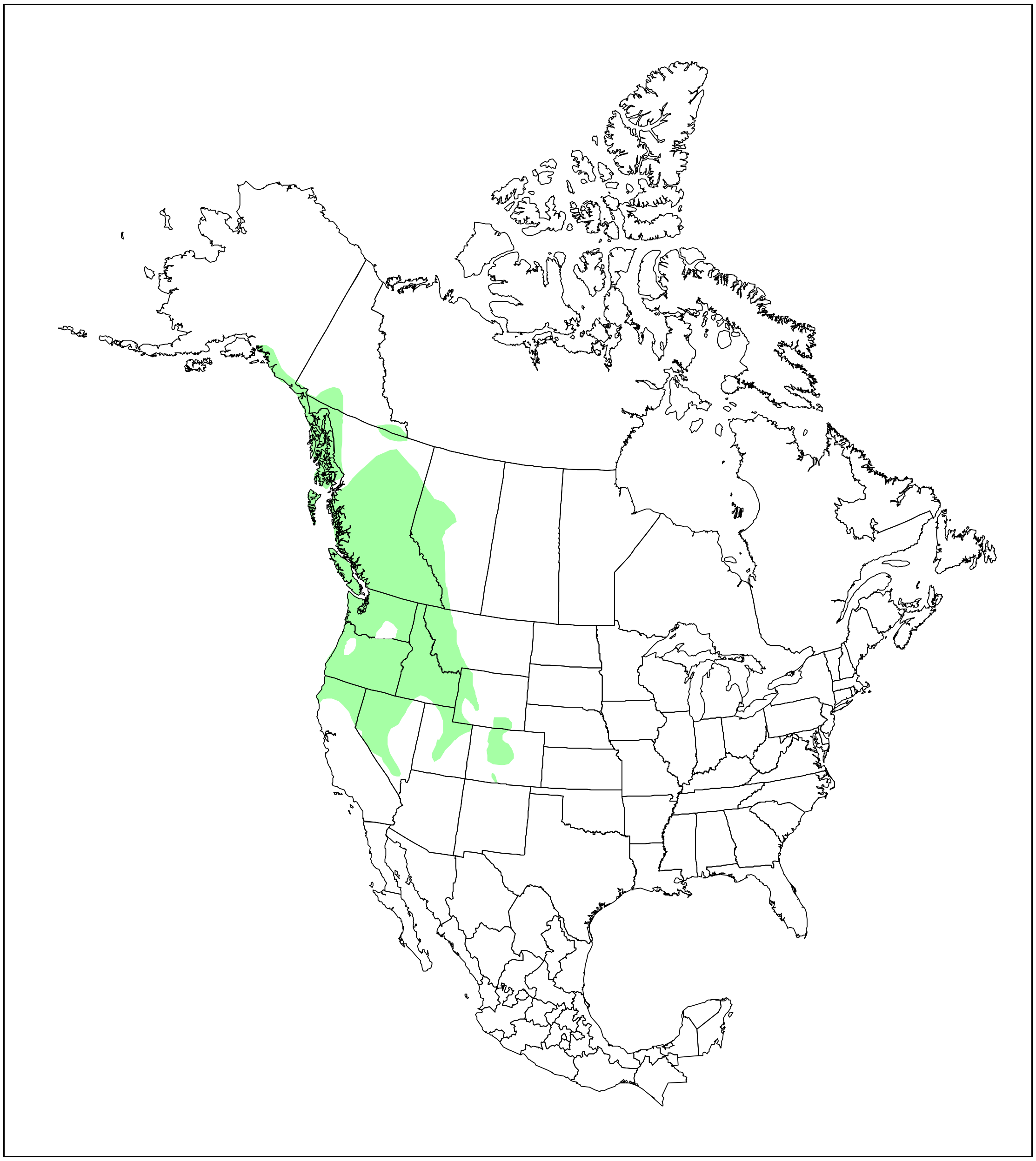

Figure 6a: Wyoming range and distribution: Map of boreal toad (*Bufo boreas boreas*) range in Wyoming.

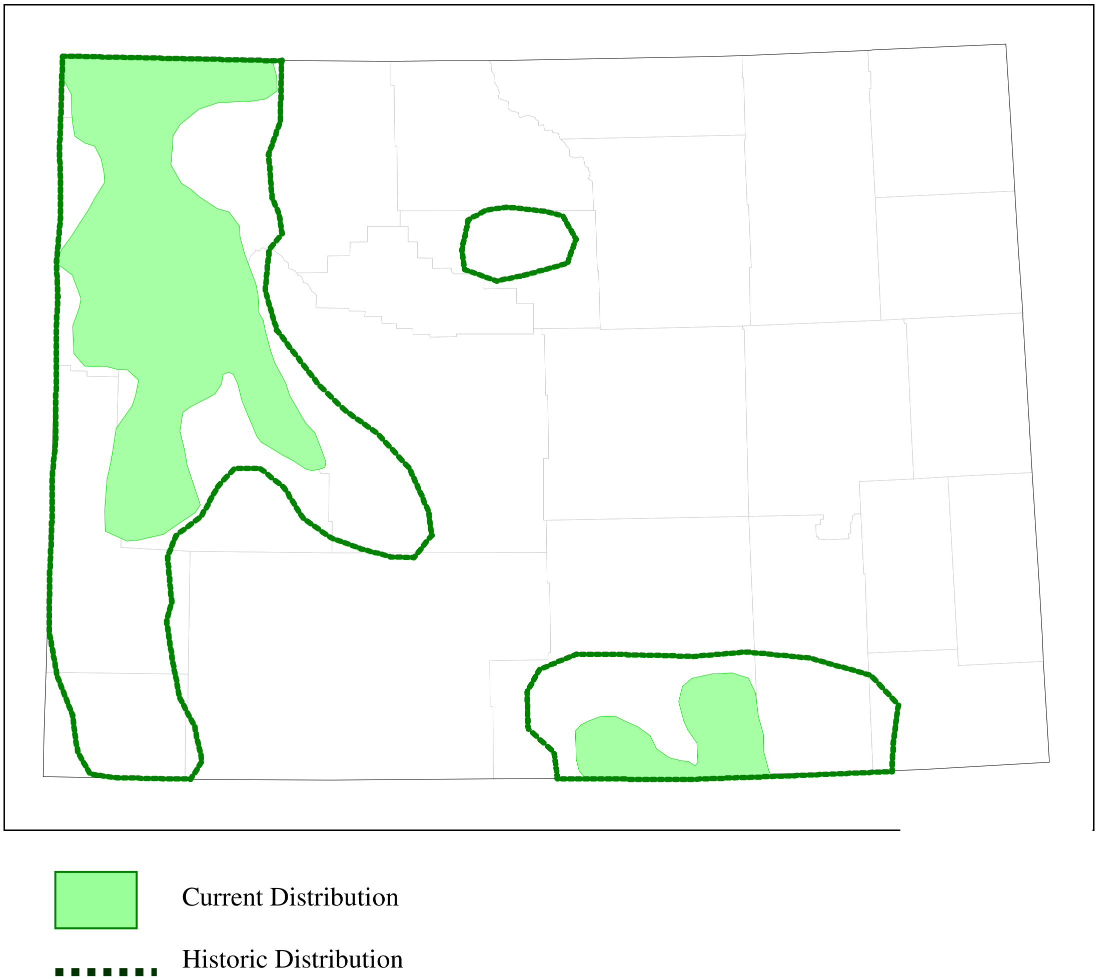

Figure 6b: Wyoming range and distribution: Current (< 10 years old) breeding and non-breeding areas for the boreal toad (*Bufo boreas boreas*) in Wyoming

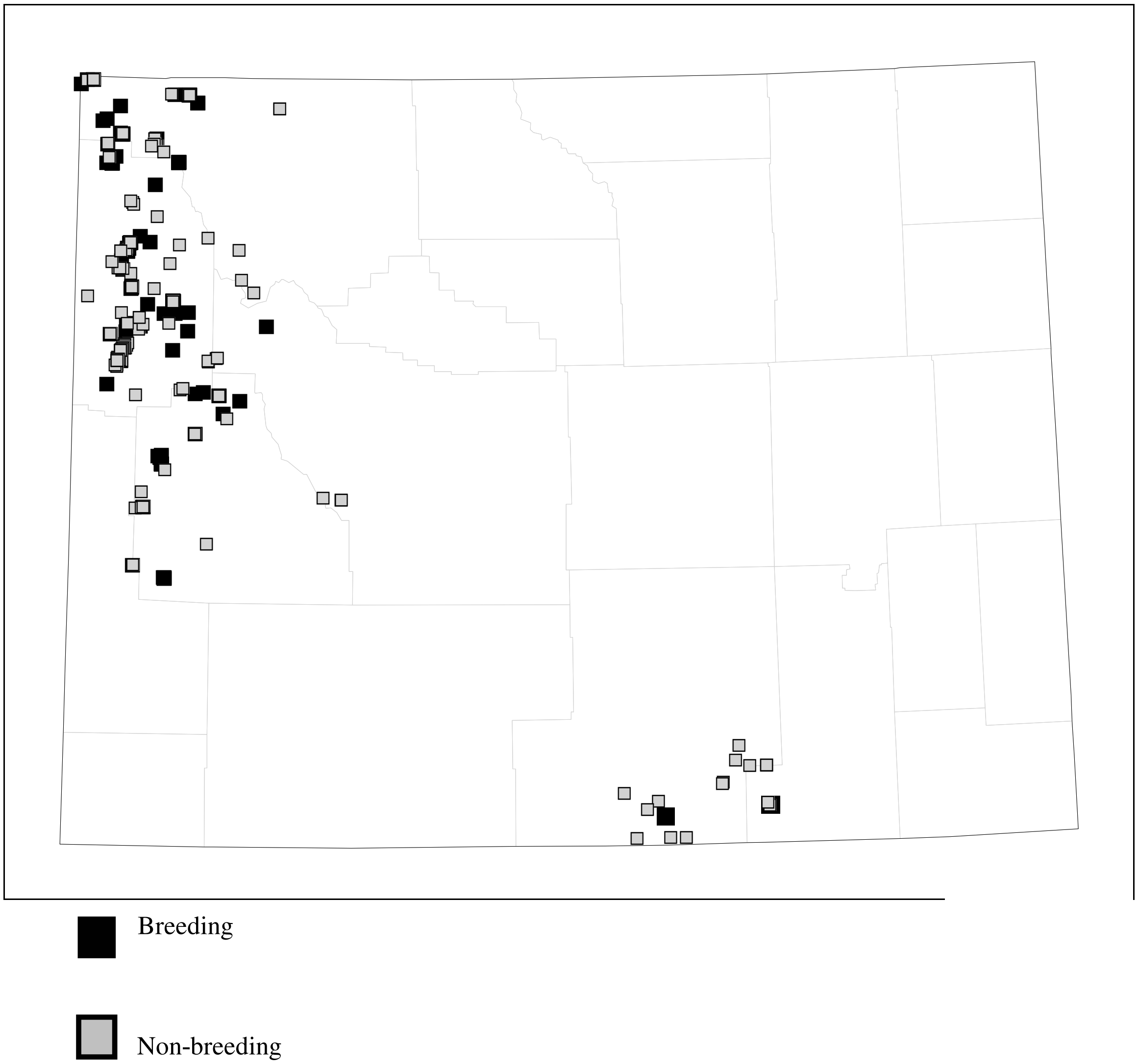

Figure 6c: Wyoming range and distribution: Historic (> 10 years old) breeding and non-breeding areas for the boreal toad (*Bufo boreas boreas*) in Wyoming

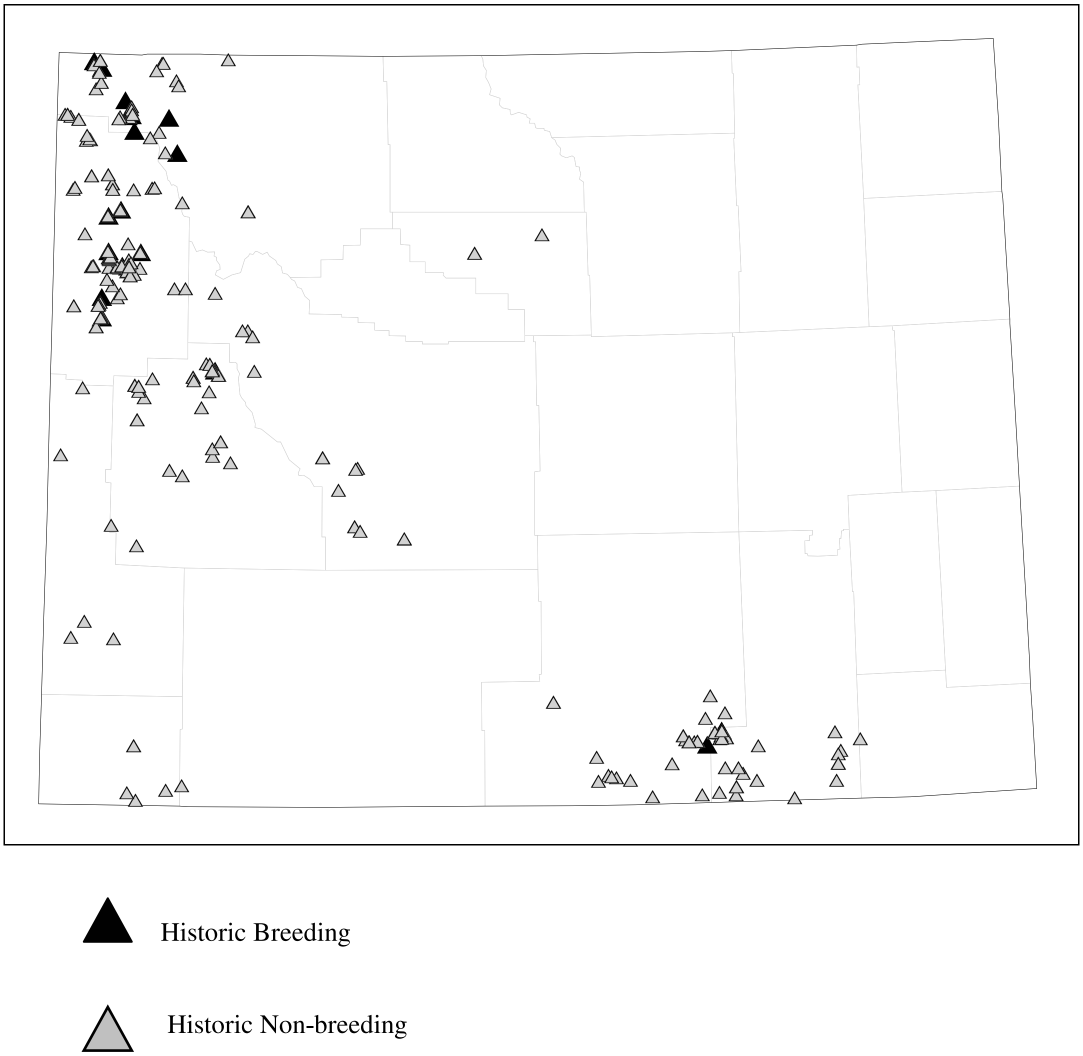

FIG. 7. Suitable boreal toad (*Bufo boreas boreas*) habitat at A) Denny Creek, Chaffee County, Colorado and B) Near Caribou, Boulder County, Colorado (Photos by Chuck Loeffler)

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