SPECIES ASSESSMENT FOR GREAT BASIN SPADEFOOT TOAD (*SPEA INTERMONTANA*) IN WYOMING

prepared by

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prepared for

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

January 2005

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Summary

The Great Basin spadefoot toad (*Spea intermontana*) is currently recognized by the Canadian government as a threatened species. In addition, some state agencies throughout its range recognize *S. intermontana* as a sensitive species, often because too little is known about it to provide evaluations on population status and viability throughout its range.

In the last couple of decades, amphibians around the world have experienced population decline, range reduction, and even extinction. This observed trend has been attributed to habitat degradation and loss, chemical pollution, acid precipitation, increased ultraviolet radiation, introduced species, and pathogens, which all combine with the natural fluctuation of amphibian populations to compound the affects. This has resulted in 18 amphibians being listed on the United States federal endangered and threatened species list (one of which is in Wyoming), and it is expected that this number will continue to rise. Given the dearth of information and a suspected decline in numbers, it is possible that *S. intermontana* may be of concern. Primary threats to *S. intermontana* are habitat alteration (aquatic and terrestrial), toxic chemicals, and invasive species.

Given the scarcity of recent observations in Wyoming, it is important to determine presence and abundance of *S. intermontana* within the state. Once populations have been identified, it is important to determine habitat associations in order to apply proper conservation management for this species. Continual and consistent monitoring of known populations is recommended to help define local populations, establish habitat-use, and evaluate conservation measures. Management actions should insure that key life history stages (terrestrial and aquatic) are not disturbed, the habitat connectivity is preserved for persistence of these populations, and exposure to potentially detrimental chemicals is eliminated. More specific issues of conservation concern are discussed in

greater detail later in this assessment. Fulfilling the information needs listed at the end of this document will clarify population status and contribute to refining these conservation goals.

Introduction

This assessment addresses the biology, ecology, and conservation status of the Great Basin spadefoot toad (*Spea intermontana*) throughout its current range, with particular attention given to that portion occurring within and near Wyoming. Our goal is to provide a summary of published information and expert interpretation of this information that can be used by the Bureau of Land Management (BLM) to develop management plans. *Spea intermontana* was selected for assessment because it occurs on the Wyoming BLM sensitive species list due to the lack of biological and ecological information known about the species as a whole.

Relatively little is known about most *S. intermontana* populations and very few specifics of this species and its habitat are available for Wyoming. Therefore, this assessment attempts to summarize information documented throughout its North American range (mostly the Great Basin), and provide an objective and informed overview in order to relate this information to *S. intermontana* in Wyoming. Primary literature was the main source used, supplemented by various agency reports.

As with all pieces of literature synthesized from disparate data, this assessment has some limitations. Since most data presented comes from specific studies with restricted research areas, interpolation and extrapolation of this data must be done with caution. It seems that aspects *S. intermontana* biology, ecology, and conservation vary over the geographic extent of its range. Therefore, the information in this assessment should not be taken as definitive of *S. intermontana* in any particular area. Rather, it should be used as a guide to the range of biological parameters and behaviors possible for *S. intermontana*, which can then help direct specific investigation to clarify the status of local populations in Wyoming as a prelude to major management action.

Natural History

Morphological Description

Adult

Spea intermontana (Figure 1) are small (3.8cm – 6.3cm) in comparison to other frogs and toads and demonstrate sexual dimorphism, with males slightly smaller than females (Nussbaum et al. 1983). Indicative of its common name, the Great Basin "spadefoot" toad has a wedge-shaped, black, keratinized cutting tubercle (spade) on the inside of its hind feet that are used for burrowing (Figure 1c; Baxter and Stone 1985; Parker and Anderson 2001; Stebbins 2003). Its skin is relatively smooth, lacking the conspicuous "warts" seen in true toads (*Bufo* spp.; Baxter 1985; Parker and Anderson 2001), and the coloration is similar to that of other *Spea* or *Scaphiopus* species (i.e., western spadefoot, *S. hammondii*, plains spadefoot, *S. bombifrons*, and Couch's spadefoot, *Scaphiopus couchii*). The dorsal surface is usually tan, gray, or olive, matching the ground color (Nussbaum et al. 1983), with two lighter colored stripes running down either side of the back that create well-defined hourglass markings (Hall 1998). The dorsal surface is usually mottled with darker, reddish-orange spots (Baxter and Stone 1985; Parker and Anderson 2001; Stebbins 2003). Dark brown spots are usually present on each upper eyelid (Hall 1998; Stebbins 2003). The ventral surface of *S. intermontana* is white or creamy (Figure 1b; Parker and Anderson 2001). Adults may emit a "peanut-like" odor when handled (Stebbins 1951; Waye and Shewchuk 1995).

Spea intermontana can be distinguished from *S. bombifrons* (also found in Wyoming) by the glandular (rather than bony) interorbital boss and the longer, slightly narrower spade. In addition, it can be distinguished from other Wyoming frogs and toads by the vertically elliptical pupil (Figure 1a), teeth in the upper jaw, and no parotid glands (Baxter and Stone 1985; Hall 1998; Stebbins 2003). Male *S. intermontana* can be distinguished from females by the presence of a dark throat patch and nuptial pads (dark raised flesh) on the inner three digits that develop during breeding season (Hall 1998; Stebbins 2003).

Voice

The mating call produced by the male *S. intermontana* is a series of short rapid calls lasting 1/5 - 1 second (Stebbins 2003). Blair (1956) determined that the average call of *S. intermontana* averaged about 0.26 seconds in Utah and 0.36 seconds in Oregon, which was shorter than the intermediate call length of *S. bombifrons* and the long call of *S. hammondii*. The low-pitched hoarse snore call is a repeated "kwaah-kwaah-kwaah" and is audible for 100 to 200m and can carry up to 1.5 kilometers (Linsdale 1938; Nussbaum et al. 1983; Stebbins 2003). Calls are commercially available (see Davidson 1995 in Hall 1998).

Tadpole

Spea intermontana tadpoles are similar in shape and color to *S. hammondii*. They have large ovoid bodies (i.e., 15-25% wider than it is high; Hall et al. 2002). At hatching they are 5-7mm and can reach 70mm in total body length before metamorphosis is complete (Figures 2a and 2b). Dorsal coloration is dark gray-brown or brown to black with gold or brassy flecks and patches. The abdomen displays an overall golden iridescence (Hall 1998; Stebbins 2003). The external nares are located on the dorsal side and prominently oriented at an angle of about 35° from straight ahead. The eyes are also positioned dorsally. The mouth, or keratinized beak, is located anteriorly, and can be used as a distinguishing characteristic between the two larval forms of *S. intermontana*: carnivorous (sharp beak) or herbivorous. Also, the carnivorous form is generally larger (see Hall 1998 and Hall et al. 2002). A single spiracle located low on the left side of the body is present (Hall 1998). They are easily distinguished from *Bufo* tadpoles on the basis of color as all *Bufo* tadpoles are jet black and lack iridescence (Stebbins 2003).

Eggs

Spea intermontana eggs are laid as small, irregular packets of jelly (1.5 – 2.0cm in diameter), which contain 10-40 pigmented eggs (Figure 2c). These masses are usually attached to vegetation, pebbles, and/or are lying on the bottom of pools. A female may lay 300 – 500 eggs (maximum 800) total. *Spea intermontana* eggs can be distinguished from "true toad" (family *Bufonidae*) eggs that are laid by the thousands in long strands resembling a pearl necklace and "true frog" (family *Ranidae*) eggs that are laid in spherical or globular masses measuring 6.5 – 15.2 cm in diameter (Stebbins 1951; Stebbins 2003).

Taxonomy and Distribution

Taxonomy

The Great Basin spadefoot toad (*Spea intermontana*) is a member of the Scaphiopodidae family, or the "North American spadefoot toads", in the order Anura. Prior to 2003, *Spea intermontana* was placed together with the "Eurasian spadefoot toads" in the family Pelobatidae (Garcia-Paris et al. 2003). Within this North American family, researchers have argued as to whether one (*Scaphiopus*; i.e., Hall 1998 and Hall et al. 2002) or two (*Scaphiopus* and *Spea*; i.e., Tanner 1989 and Wiens and Titus 1991) genera exist. These arguments have been based on morphological and allozymic analysis of various specimens within the genera (see Sage et al. 1982; Wiens and Titus 1991). As a result, *S. intermontana* and has been reclassified taxonomically many times over the past 120+ years: *Scaphiopus intermontanus* (Cope 1883), *Spea hammondii intermontana* (Cope 1889), *Scaphiopus (Spea) intermontanus* (Tanner 1939), *Scaphiopus hammondii intermontanus* (Schmidt 1953), and most recently as *Spea intermontana*

(Wiens and Titus 1991; Crother 2000). To date, no recognized subspecies of *S. intermontana* exist; although, phylogenetic analysis of small population samples from the eastern and western extremes of *S. intermontana* range have found allozymic differences (see Wiens and Titus 1991). *Spea intermontana* hybridizes with Couch's spadefoot (*Scaphiopus couchi*) in eastern Utah (Stebbins 2003).

<u>Range</u>

Spea intermontana is found in western North America where suitable breeding habitat occurs, from extreme southern British Columbia, Canada, south through the Great Basin to extreme northern Arizona and New Mexico, and from the eastern base of the Cascade-Sierran mountain system to the Rocky Mountains (Figure 3; Baxter and Stone 1985; Stebbins 2003). In California, they occur east of the Sierra Nevada, and north of San Bernardino County. In Canada, Washington, and Oregon they are situated between the Cascade and Rocky Mountain Ranges. They occur throughout the lower portion of Idaho. They occur throughout Nevada and Utah east of the Colorado River, push just south into northwest Arizona, and north into northwest Colorado and southwest Wyoming (Hall 1998). Furthermore, they are found within the following BLM physiographic regions: Columbia Plateau, Upper Basin and Range, Colorado Plateau, Wyoming Basin, and the Lower Basin and Range (Hovingh et. al. 1985).

In Wyoming, *S. intermontana* distribution is patchy, with sightings recorded mostly west of the Continental Divide (Figure 4). Baxter and Stone (1985) report *S. intermontana* range in the center of Wyoming to Fremont and Natrona counties where it meets, but does not extensively overlap the range of *S. bombifrons*. This range would incorporate the Great Divide Basin and Green River Basin, with portions including the Wind River Basin (Baxter and Stone 1985; Knight 1994). *Spea intermontana* have been documented at 44 sites in Sweetwater County, six sites in

Freemont County, and one site in Uinta, Lincoln, and Natrona Counties over the past 94 years (WYNDD 2005). In 1999, unidentified spadefoot toads were reported southwest of Laramie, Wyoming. This was a site that had not been previously included in spadefoot range (Larsen 1999), but may likely have been *S. intermontana*, based on current estimated range.

Abundance and Trends

Little to no information exists on the abundance of *S. intermontana* across it range, but despite this fact it is considered relatively stable at the national level (NatureServe 2005). In part, this lack of information is due to the behavior of *S. intermontana* during non-breeding months (i.e., it is active nocturnally only on humid/rainy evenings and spends inactive periods within inconspicuous burrows). Also, the naturally fluctuating populations and sporadic breeding habits of *S. intermontana* make it difficult to monitor populations. There have been numerous reports of chorusing males in permanent or temporary water sources (see Hall 1998), especially after spring and summer rains, which would lead one to believe that they are common in suitable habitat. However, recent anecdotal evidence shows a declining number of reported occurrences and actual numbers are unknown (WYNDD unpublished data, Keinath et al. 2003). Further, in areas where *S. intermontana* have been previously observed (either historically or recently), other surveys have not documented their presence (see McGee et al. 2002; WYNDD 2005).

Assessments of individual population trends are critical to determining a species' status, but no monitoring efforts have targeted *S. intermontana* in Wyoming or throughout its range, so no information exists on population trends. Amphibian surveys that have been conducted in *S. intermontana* range periodically note the presence of *S. intermontana,* but these observations are largely incidental. In some cases *S. intermontana* has not been observed where previously documented (see Hovingh et al. 1985, Drost and Fellers 1996, and McGee et al. 2002). This may not necessarily indicate an absence of *S. intermontana*, or a decline in its population, but rather be a factor of *S. intermontana* life history (i.e., nocturnal, active on rainy evenings, sporadic breeding habits, naturally fluctuating populations); the reason is unknown. Another difficulty that exists in determining population (and distribution) trend over the past 120+ years may result from misidentification of *S. intermontana*. For example, Hall (1998) describes several cases that *S. intermontana* was identified as *S. bombifrons* in Idaho, and *S. hammondii* in California, Nevada, Oregon, and Washington, as well as other spadefoots being identified as *S. intermontana*.

Habitat Requirements

General

Spea intermontana are a xeric-adapted amphibian. They require a water source for breeding and larvae/tadpole development in the spring and summer months and loose, sandy soil within arid habitats during the nonbreeding season with adequate vegetative cover to provide foraging sites and climate protection to retain soil moisture. *Spea intermontana* are found at various elevations (i.e., from sea level up to 2800m), and therefore occupy a variety of habitats (Baxter and Stone 1986; Hall 1998; Stebbins 2003). For example, sub-steppe shrubs (*Atriplex* sp., *Sarcobatus* sp., and *Aremisia* sp.) in the basins, pinyon-juniper woodlands (*Pinus, Juniperus*) in the mid-elevations, and spruce-fir (*Picea* spp., *Abies* spp.), ponderosa pine (*Pinus ponderosa*), and Douglas-fir (*Pseudotsuga menziesii*) forests in the subalpine zones (Knight 1994; Hovingh 1997; Hall 1998; Cannings 1999). *Spea intermontana* have also been documented in agricultural areas (Linsdale 1938; Hovingh 1997; Hall 1998). It is unknown which characteristics *S. intermontana* selects a site for: type of vegetation, climate, proximity to water sources, elevation, and/or soil-type.

Since *S. intermontana* occupy xeric landscapes which are characterized by potential evaporation that greatly exceeds annual precipitation (except *Sarcobatus* spp. shrublands; Knight 1994), both juvenile and adult *S. intermontana* rely on loose, sandy soils that allow them to "burrow" below the surface and escape the adverse environmental conditions to avoid desiccation (Linsdale 1938; Nussbaum et al. 1983; Stebbins 2003; Ovaska et al. 2003). Burrows are either self-excavated or vacated by rodents and other small mammals (Linsdale 1938; Stebbins 1951; Ruibal et al. 1969; Stebbins 2003). In Wyoming, *S. intermontana* are probably found within the soil orders Aridisols (a soil type with distinct horizons that occurs in desert basins and that has accumulations of clay, calcium carbonate, gypsum, and/or soluble salts) and Entisols (soils that are young and have little or no profile development, such as those that occur on eroding slopes and along ephemeral streams; Knight 1994) based on associated vegetation (see General Requirements). Soil texture seems to be an important site characteristic, since Jansen et al. (2001) determined that another spadefoot toad (*Scaphiopus holbrookii*) was unable to burrow in grass sod (adults) and gravel (juveniles). Occasionally *S. intermontana* may use coarse woody materials or rock crevices for refuge (Svihla 1953; Sarell 2004).

Little information exists on vegetative characteristics that *S. intermontana* associate with, other than the large spread of arid to semi-arid vegetation recorded that *S. intermontana* has been observed in (see above and Hall 1998). This may be an indication that soil characteristics adjacent to suitable aquatic breeding sites are more important than vegetative cover (see Landscape Context). Bragg (1965) reported adults foraging in areas with little to no cover. Edge effects created by vegetation and water sources (or depressed lands where ephemeral pools form), or sparse vegetation that is common in xeric habitats, attracts a variety of insect prey (see Diet).

Breeding Habitat

Spea intermontana require a source of water for breeding and successful development of their young (Hall 1998; Stebbins 2003). It appears that water sites selected for breeding by *S. intermontana* are quite variable and differ from year-to-year, depending on the amount of precipitation and the presence/absence of water. They use both ephemeral and permanent water sources (i.e., rain pools, roadside and irrigation ditches, flooded fields, intermittent and permanent desert streams, and pond and reservoir edges; see Hall 1998), which is unique when compared to other spadefoot toads (i.e., breed only in ephemeral water sources; Stebbins 2003). For example, Hovingh et al. (1985) reported that *S. intermontana* utilized every type of water source available in the Bonneville Basin (only 8% were entirely natural), as long as the total dissolved solids were less than 5000mg/L. The sites varied in size from small seeps (0.08m^2 by 0.10m deep) to large reservoirs with over 1200m^3 of water, possessed a pH of 7.2 – 10.4, and were generally below 1600m (74% of the sites). The most successful breeding sites (i.e., little or no dead tadpoles observed) were at water sources that desiccated during the summer, had large draw-downs of water, or had stream beds scoured by flash floods (i.e., lacked littoral vegetative growth). However, in years of low rainfall, *S. intermontana* switched from these preferred, more successful sites to permanent springs, since the others lacked water. In springs or streams that are utilized as breeding sites and are not stagnant, emergent vegetation is probably important for the attachment of eggs (see Nussbaum et al. 1983), as well as calling males to hold onto.

Area Requirements

There are no reports in the current literature regarding the area requirements of the *S. intermontana* (i.e., home range requirements). However, given the species preferences (i.e., fossorial, sedentary lifestyle) and life history requirements (i.e., breed in water and hibernate on land), one could surmise that so long as the area contained suitable soil for burrowing adjacent to an open body of water, the area could be small (i.e., <0.5m^2; Zug 1993). There have been some reports of adults migrating up to 100 meters between breeding pools and non-breeding habitats (Lindsdale 1938; Bragg 1965); however, this may be indicative of local habitat rather than species life history in general, since others have suggested that males may travel greater than 5km to find scarce water sources (see Hovingh et al. 1985). Blaustein et al (1994) presents data on home range estimates of several amphibian species that ranged from 0.02m^2 to 24.34m^2.

<u>Landscape Context</u>

Based upon current literature, optimal S. intermontana habitat would consist of dry, sandy soils within desert shrub (i.e., Artemesia spp.) located fairly close (<5km) to ephemeral or permanent water sources required for breeding (see Habitat). The juxtaposition of these features would be important to minimize energy expenditure between foraging and breeding grounds, as well as provide excellent opportunity to forage for insects, since insects are most populous in/near vegetation and standing water.

Movement and Activity Patterns

Information on *S. intermontana* movements and activity is largely restricted to its breeding season and habitat, since that is when *S. intermontana* is most conspicuous (i.e., mating calls, migratory and dispersal movements). Otherwise, *S. intermontana* aestivate in burrows, except for occasional nocturnal foraging bouts when environmental conditions are suitable. There are very few reports on activity and movement patterns aside from breeding season. Most information known is anecdotal or surmised from similar spadefoot species.

Seasonal Movements

Migration

Adults migrate to aquatic breeding habitats (males first, then females) usually after the first warm rainfall in the spring (Bragg 1965; Hovingh et al. 1985; Stebbins 2003), although the stimulus for migration to breeding sites has been debated (see Hall 1998). Mating lasts only a few days, in which afterwards, adults will emigrate from the aquatic breeding sources to terrestrial habitat that provides productive foraging sites and adequate protection from the arid climate (see Nonbreeding Habitat). The distance *S. intermontana* travels to and from breeding sites and terrestrial habitat is largely unknown. It has been documented that they travel several hundred meters (Linsdale 1938; Bragg 1965), and suggested that they may migrate over 5km in search of adequate water sources for breeding (Hovingh et al. 1985). For most aquatic-breeding amphibians, migration finds species within 200m of aquatic breeding habitat (Semlitsch 2000). For behavior and activities associated with breeding, see Breeding Behavior.

Dispersal

After the young metamorphose at breeding sites, they immigrate to adequate terrestrial habitat. No published information is available on the distances traveled by the juveniles, but Harestad (1985) speculated that small *S. intermontana* that were captured and measured 110m from a pond, which had been monitored three weeks prior documenting the growth of *S. intermontana* larvae, may have been the same individuals that dispersed from that breeding site. Overall, aquatic-breeding amphibians are thought to disperse within 1km of their developmental site; the larger the juvenile at complete metamorphosis, the better the locomotor skills (Semlitsch 2000).

Daily Activity and Energy Budgets

Spea intermontana lead a sedentary, fossorial lifestyle when not engaged in breeding activities, which assists survival in the semi-arid to arid areas they inhabit. They are generally nocturnal, foraging when weather conditions permit (i.e., rainy, humid, and/or mild temperatures >12°C); although they have demonstrated crepuscular patterns of activity (Linsdale 1938; Dimmitt and Ruibal 1980; Nussbaum et al. 1983; Stebbins 2003; Sarell 2004). Foraging activities may be limited to only a few weeks a year (varies with local conditions); however, this is usually enough time to acquire and accumulate energy reserves in order to successfully maintain aestivation/hibernation and reproductive activities (see Dimmitt and Ruibal 1980; Storey 2002). Bragg (1965) reported that *Spea* species of spadefoots emerge from burrows more often than *Scaphiopus* species, most likely as a result of more mesic habitats (Dimmitt and Ruibal 1980). The distance traveled to foraging areas has not been documented, but most likely it is not too far from burrows in order to conserve energy and prevent desiccation. No documentation exists as to when larvae and tadpoles are active. It can be assumed that activity may be limited to nighttime to reduce the risk of predation during the day, although they do possess cryptic coloring to reduce predator detection (Hall et al. 2002). Toadlets have been observed foraging in daytime hours (Linsdale 1938), but most often forage at night.

During warmer months, *S. intermontana* escape the dry, hot conditions by aestivating in underground burrows vacated by rodents and other small mammals or into burrows that are self-excavated (Linsdale 1938; Stebbins 1951; Ruibal et al. 1996; Storey 2002; Stebbins 2003; NatureServe 2005). During the colder, winter months, *S. intermontana* will hibernate below the frostline, moving deeper in the soil if necessary (0.2m – 0.9m; Zug 1993; Ruibal et al. 1996). Ruibal et al. (1996) determined that *Scaphiopus hammondii*, a related spadefoot species, used burrows that were deeper in the winter and pre-emergence months (24cm – 91cm) than during the spring and summer months (1.3cm – 4.9cm) when rains were more regular. Dormancy is thought to be triggered by changes in photoperiod (Seymour 1973b), and is an adaptation for survival in arid, semi-arid environments (McClanahan 1972; Storey 2002).

Burrowing requires a high rate of energy expenditure. In a close relative (*Scaphiopus hammondii*), burrows were dug in bouts resting for enough time in between to maintain a constant use of energy and keep activity aerobic, rather than anaerobic (Seymour 1973b). *Spea intermontana* may aestivate for 9 – 10 months of the year (Bragg 1965; Storey 2002), which is possible by reducing their oxygen intake, thus reducing metabolic energy expenditure (Seymour 1973a). Energy acquired for long periods of inactivity is gained during feeding bouts that may only last for a week when environmental conditions exist (Dimmitt and Ruibal 1980; Storey 2002).

No studies have specifically addressed energy budgets of *S. intermontana*, and only a couple of studies (i.e., Seymour 1973a, b; Dimmitt and Ruibal 1980; Storey 2002) have investigated the energy demands of other spadefoot toads. The critical elements for long-term dormancy (i.e., aestivation and hibernation) are sufficient fuel reserves and water retention (Storey 2002). Overall, it has been determined that spadefoot toads are remarkably efficient at converting food for growth and energy, and are capable of obtaining fat (specifically in abdominal fat bodies) for over-wintering in very few meals (Dimmit and Ruibal 1980). *Spea intermontana* may emerge from hibernation with considerable fat (Stebbins and Cohen 1995), and this is thought to relate to the uncertain opportunities for breeding in these animals (Seymour 1973a). Seymour (1973a, b) and Zug (1993) present excellent discussions on the energy metabolism of dormant spadefoot toads, including rate of oxygen consumption in relation to metabolism. In addition to efficient energy use, spadefoot toads are capable of impeding water loss during dormancy (which can be greater than 50% of total body mass) by elevating osmolarity of body fluids via production of high concentrations of solutes and reabsorbing water from their bladders as they desiccate (Zug 1993; Storey 2002).

Reproduction and Survivorship

Breeding Phenology

The timing and synchrony of breeding in *S. intermontana* differs across its range and appears to be dependent on the type of breeding habitat (ephemeral vs. permanent) and possibly temperature and spring/summer rains. If ephemeral breeding habitats (i.e., flooded pastures) are utilized, breeding is sporadic and more synchronous (timing dependent on water availability), whereas in permanent breeding habitats (i.e., springs), breeding is more regular and asynchronous (Linsdale 1938; Hall et al. 1997; Morey and Reznick 2000, 2004). This variation results from the risk factor associated with the permanence of breeding habitat for successful larval development (Morey and Reznick 2000, 2004). Sexually mature adults (two – three years; Nussbaum et al. 1983) will aggregate at water sites for short time intervals (1-3 days) to breed from early April through July. Breeding may be initiated by spring and summer rains, especially if breeding sites utilized are ephemeral (Bragg 1965; Hall 1998; Cannings 1999; Stebbins 2003; Morey and Reznick 2004). However, this is debatable. Several reports have indicated breeding and/or chorusing of *S. intermontana* that did not occur directly after significant rainfall (usually in permanent water sources or location of burrows significantly far from available water sources; see Hovingh et al. 1985 and Hall 1998). There have been no reports citing optimal or even preferred breeding temperatures; however, Fouquette (1980) recorded *S. intermontana* males chorusing when the air temperature was 3.3 – 21.7°C and the water temperature was 10.2 – 24.1°C. Similarly, Hall (1998) recorded calls of *S. intermontana* at an air temperature of 19°C and a water temperature of 21°C and Blair (1956) recorded "mating" calls at air temperatures 18°C and 13°C and water temperatures 17°C and 21°C, consecutively. Morey and Reznick (2000) successfully developed *S. intermontana* eggs/larvae in a laboratory at water temperatures of 25°C, which is thought to be nearing the temperature threshold for this species.

Breeding occurs with an inguinal amplexus embrace (male clasps female with forelimbs from behind), allowing the male to juxtapose the female cloacae and ensure successful fertilization of eggs as they emerge from the cloacae (Zug 1993; Stebbins 2003). Three hundred to 500 (800 maximum) eggs are laid and attached to vegetation, pebbles, or on the bottom of the pool in clusters of 10 – 40 (Nussbaum et al. 1983; Morey and Reznick 2000; Stebbins 2003). Time for the eggs to hatch and larvae to metamorphose to juveniles and leave the breeding ponds is quite rapid (an adaptation of surviving in an arid environment) and varies across its range. Development appears to demonstrate plasticity based on environmental conditions and resource availability (see Linsdale 1938, Hall et al. 1997, 2002, and Morey and Reznick 2000, 2004), increasing with evaporating water and higher temperatures (Stebbins 1951). Eggs hatch in two to three days during warm weather and seven or more days in cooler weather (Nussbaum et al. 1983; Hall et al. 1997; Hall 1998). Larvae development (hatching to metamorphosis) takes about 48 days (range: 36-60 days; Morey and Reznick 2004) and seems to vary with food availability. For example, Morey and Reznick (2000) documented that *S. intermontana* larvae given a large diet (69mg/day) metamorphosed more quickly and grew much faster (17.8 days, 2.1g) than larvae given a small diet (6mg/day; 29.3 days, 0.78g). A complete description of larvae development, from hatching to complete metamorphosis can be found in Hall et al. (1997). Often, toadlets have not entirely lost their tails before leaving the water and foraging. This may be a result of evaporation/desiccation of temporary breeding sites (Wood 1935; Nussbaum et al. 1983; Hall et al. 1997).

Breeding Behavior

Male *S. intermontana* emerge from "hibernating" burrows within the soil and migrate to adequate water sources to initiate "mating" choruses with the purpose of "calling" female *S. intermontana* to these selected breeding sites. During mating calls, males are usually partially submerged near the shore, either sitting on the bottom of the pool or holding onto vegetation (see Hall 1998). Stimulus for the emergence of the males is largely unknown. The spring/summer rains may stimulate the emergence, especially if temporary water sources are utilized for breeding (Linsdale 1938; Hovingh et al. 1985). Ambient temperatures that provide warm enough water environments to facilitate larval development may be another stimulus (Morey and Reznick 2000). Finally, it is thought that the chorusing of other toads may initiate male *S. intermontana* emergence to breeding ponds (Hovingh et al. 1985).

Breeding is explosive (occurs over only a few days; Eggert and Guýetant 2003) and seems to occur whether or not there is a large aggregate of males chorusing (Blair 1956). However, some reports have mentioned that more female *S. intermontana* are present at breeding sites where the chorus is louder (Eggert and Guýetant 2003). Males participate in scramble competition when females arrive at the breeding sites, usually leaving females with little opportunity to select a mate (Bragg 1965; Stebbins and Cohert 1995; Eggert and Guýetant 2003). There have been no specific reports in the literature of the affect of disturbance on the mating calls of *S. intermontana*; however, authors have reported the cessation of calls in their presence that was resumed after they left the site. At the conclusion of breeding, adults migrate back to foraging habitat and replenish their fuel reserves needed to sustain them for the following months of aestivation and hibernation (Storey 2002).

It would seem likely that *S. intermontana* exhibit high breeding site fidelity, returning to the same water source year-after-year, especially if the breeding site was permanent, based on recorded migratory distances (see Migration). However, no reported information addresses fidelity specifically for *S. intermontana*.

Fecundity and Survivorship

Female *S. intermontana* are capable of producing 300 – 500 eggs at one time (Nussbaum et al. 1983), and have only been observed or reported mating once per year. Some authors have speculated that breeding may not be an annual event, and is dependent on suitable conditions for producing eggs (i.e., existent water sources, enough accumulation of fat reserves to produce eggs/sperm). Age at first breeding is two to three years (Nussbaum et al. 1983).

It is unknown how many eggs successfully hatch, how many larvae survive to complete metamorphosis, and how many juveniles survive the migration to nonbreeding habitat. In an ideal breeding habitat free of predators, resource competition, and desiccation and supplied with an ample food supply, all larvae could potentially survive to metamorphosis (see Morey and Reznick 2000). Habitat alterations and water quality play a large role in the success of survival (see Semlitsch 2000; Ovaska et al. 2003). No published information is available on the longevity of *S. intermontana*. Hall (1998) describes a personal experience of capturing an adult (two – three years of age) and keeping it alive in captivity for the next four years, and eluded to a dissertation that stated adult *S. intermontana* may live to be 8 – 10 years of age (Northen 1970 in Hall 1998).

Food Habits

Spea intermontana diet and foraging habits reflect the adaptive behavior of an ectotherm, which regulates its body temperature through the environment, rather than metabolic energy obtained from food sources. Instead, energy obtained from food is allocated to such processes as growth and reproduction, and reflects the diets and frequency of food intake by *S. intermontana* during different life stages (i.e., larvae vs. metamorphic vs. breeding adult).

Diet

Adults

It is generalized that all adult spadefoot toads (*Scaphiopus* and *Spea*) are opportunistic carnivores (Bragg 1965; Whitaker et al. 1977), eating what prey happens to come along that is smaller than them (Zug 1993; Stebbins and Cohen 1995). Very little data exists on the food items taken specifically by *S. intermontana*, but it is assumed that it varies across its range. It is known that *S. intermontana* eat ants, beetles, grasshoppers, crickets, and flies (Tanner 1931 in Whitaker et al. 1977; Stebbins 1972; Nussbaum et al. 1983). In British Columbia, it was reported that one adult regurgitated several larval Lepidopterans and a beetle (Waye and Shewchuk 1995). Whitaker et al. (1977) examined the diets of four other spadefoot toads and determined that the most important foods by volume were Lepidopterous larvae and adults, Scarabaeidae and Carabidae adults, termites, Lygaeidae, grasshoppers, crickets, and ants, which may be similar for *S. intermontana*.

Larvae/tadpoles

Spea intermontana larvae must survive to metamorphosis in habitats that are often ephemeral (Hall 1998; Hall et al. 2002), and as a result, have developed divergent morphological features that enables them to adjust to different environmental conditions. The carnivorous larvae have a higher protein diet, and thus an advantage to grow and metamorphose faster than the herbivorous or generalist larvae (Hall et al. 1997, 2002). The cannibalistic larvae diet consists of insects, carrion (carcasses of other tadpoles), and smaller tadpoles (Linsdale 1938; Bragg 1965; Hall et al. 2002). The diet of the herbivorous larval stage consists of nearly every type of water born organic matter, such as plankton, algae, organic debris and small plants. Occasionally they may consume carrion (thus “generalist”). Often times these tadpoles metamorphose to smaller sized toads

(Bragg 1965; Hall et al. 1997, 2002). Metamorphic tadpoles (toads sometimes with tails) feed on insects (see adult), including grasshoppers captured outside of the water (Cope 1889 in Hall 1998).

Foraging

Adults

Very little information has been published regarding the feeding habits and foraging strategies of adult *S. intermontana*. It is known that *S. intermontana* are primarily nocturnal feeders and emerge from burrows to feed only during rainy or extremely humid evenings, in order to prevent rapid desiccation (Whitaker et al. 1977; Dimmitt and Ruibal 1980; Nussbaum et al. 1983). During foraging bouts, which usually occur after breeding, *S. intermontana* are able to consume 6% (± 1.1%) of their body weight and convert about 26% of that meal to energy reserves (Dimmitt and Ruibal 1980), allowing rapid energy accumulation to mitigate the uncertainty of the next meal. Also, the environmental constraints may result in large groups of *S. intermontana* foraging together (see Linsdale 1938; Stebbins 1951). Bragg (1965) describes a hunting spadefoot (spp. unknown), hopping slowly along alert and orienting toward movement smaller than itself. He indicated there was some selection in larger food items (ignoring smaller food items such as ants), perhaps an adaptation to decrease energy spent foraging and hasten retreat back into "safe" burrows.

Larvae/tadpoles

Larvae forage at the surface film of water, along suspended vegetation, or along substrate found on the bottom (Linsdale 1938; Hall et al. 2002). The time of day that tadpoles and juvenile toads (toadlets) feed most is unclear; however, Linsdale (1938) suggested that most "hide" during daylight hours, even though he did observe toadlets foraging diurnally.

Water Intake

Spea intermontana only require water sources for mating and egg and tadpole development (see Breeding Habitat). Water needed for metabolic processes is not obtained from direct drinking, rather through the skin, which is thin and water permeable. *Spea intermontana* has the ability to extract moisture from the soil and from the air on humid night. Therefore, soils that contain some amount of moisture are an important component of terrestrial, nonbreeding habitat. Water is also obtained from its diet (Zug 1993). During aestivation and hibernation, *S. intermontana* will retain urea in concentrated forms, and utilize it when needed for metabolic processes (see Zug 1993; Storey 2002).

Community Ecology

Amphibians have been often deemed ecologically important. They have been considered beneficial to society by consuming a variety of pest organisms, such as insects. In addition, because their moist skin and eggs are exposed to the elements in air and water they are sensitive to environmental change. Therefore, declines in population of amphibians may be the first indicator of adverse impacts on our ecosystems (Ovaska et al. 2003).

Predators and Competitors

Predation of adult *S. intermontana* has not been well documented in published literature, although it most likely occurs. Possible predators of adult *S. intermontana* (as well as developing larvae) are birds (i.e. passerines), reptiles (i.e. snakes), other amphibians, and small mammals (i.e., felids, mustelids, viverrids, and procyonids; Zug 1993). Physiological characteristics (i.e., cryptic coloration; Bragg 1965; Zug 1993) and behavior of adult *S. intermontana* (i.e., nocturnal habits, regurgitation, and excretion of an odorous mucous; Bragg 1965; Waye and Shewchuk 1995) probably discourage or distract predators. Wright and Wright (1949 in Hall 1989) reported *S.*

intermontanus remains in the dung of coyotes (*Canis latrans*), and predation of adult *S. itnermontana* by burrowing owls (*Athene cunicularia*) was reported (Gleason and Craig 1979; Green et al. 1993). The earlier life stages of *S. intermontana* are more susceptible to predation and have been better documented in the literature. *Spea intermontana* larvae have been depredated by the western terrestrial garter snake (*Thanmophis elegans vagrans*; Wood 1935), the common crow (*Corvus brachyrhynchos*; Harestad 1985), other tadpoles (including the carnivorous form of *S. intermontana*; Hall 1998), and most likely fish species (Drost and Fellers 1996). Alterations to terrestrial habitat that create edge or unnatural corridors may increase predation risk for *S. intermontana* (see Knick et al. 2003).

Competition for *S. intermontana* is generally for food resources, especially in the development stage, and can be intra- or inter-specific. Other amphibian species utilize the same temporary and permanent water sources for breeding grounds, each depositing hundreds of larvae, which well exceed the plant and/or insect food items available, creating intense competition (Stebbins 1951; Stebbins and Cohen 1995). In some cases, it is speculated that larger carnivorous/cannibalistic forms of larvae develop to "out-compete" the herbivorous forms (Morey and Reznick 2000). Competition for food resources among adults is most likely intra-specific, since they tend to inhabit the same terrestrial foraging areas (Stebbins and Cohen 1995).

<u>Parasites and Disease</u>

Goldberg and Bursey (2002) found five different helminth species in 47% (16 of 34) of adult *S. intermontana* obtained from three (Arizona, Nevada, and Utah) different museums: (*Polystoma nearcticum* in the lung and bladder, *Distoichometra bufonis* in the small intestine, *Aplectana incerta* in the small and large intestine, *Physaloptera* sp. [larvae] in the stomach, and Acuariidea gen. sp. [larvae] in cysts on the stomach wall). However, little if no information exists on the virulence of the parasites or on the effect each of these parasites has on the health, growth, or reproductive output of *S. intermontana*, or what effects may be incurred on the population structure and dynamics (Zug 1993). Most likely these parasites are benign and/or *S. intermontana* is resistant and durable. No published documentation was found about infectious diseases in *S. intermontana* individuals or populations.

Symbiotic and Mutualistic Interactions

There are no documented symbiotic or mutalistic interactions between *S. intermontana* and other amphibian or non-amphibian species. *Spea intermontana* have been associated with the western toad (*Bufo boreas*; Blair 1956; Drost and Fellers 1996), Couch's spadefoot (*Scaphiopus couchii*; Stebbins 2003), western spadefoot (*Spea hammondii*; Linsdale 1938), *Bufo microscaphus, B. puncatus*, and *Hyla arenicolor* (Blair 1956). It is thought that the chorusing of other toads may initiate male *S. intermontana* emergence to breeding ponds (Hovingh et al. 1985).

Conservation

Conservation Status

Federal Endangered Species Act

Spea intermontana is not currently listed or being considered for listing under the United States Endangered Species Act (ESA). In Canada, however, *S. intermontana* has been listed as threatened under the Species at Risk Act of 2004 (SARA). This listing is based on a species assessment prepared by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which proposed *S. intermontana* receive a "threatened species" listing based on an increasing loss of critical habitat and breeding sites. SARA provides measures to protect and recover a listed species (COSEWIC 2004; CWS 2004).

Bureau of Land Management

The State Offices of the Bureau of Land Management (BLM) in Colorado and Wyoming list *S. intermontana* on their sensitive species lists. According to the BLM Manual 6840, this designation is meant to provide protection of *S. intermontana* and the habitat on which they depend. Therefore the BLM is responsible for reviewing programs and activities on BLM land to determine their potential effect on *S. intermontana* (USDOI BLM Wyoming 2001; Keinath et al. 2003).

Forest Service

The range of *S. intermontana* encompasses portions of 6 forest service regions, including the far western portion of the Northern Region (R1), the western half of the Rocky Mountain Region (R2), the far northwest portion of the Southwestern Region (R3), the Intermountain Region (R4), the far eastern part of the Pacific Southwest Region (R5), and the eastern half of the Pacific Northwest Region (R6). Currently, none of these regions include *S. intermontana* on their sensitive species lists.

State and Provincial Wildlife Agencies

The Wyoming Game and Fish Department (WGFD) 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. Seven classes of Native Species Status (NSS) are recognized, with NSS1 representing critically imperiled species and NSS7 representing stable or increasing species. Classes 1, 2, 3, and 4 are considered to be high priorities for conservation attention. The WGFD assigns *S. intermontana* a special concern rank of NSS4, based on their estimates that *S. intermontana* populations in Wyoming are declining and/or their habitat is vulnerable but no loss has occurred, in addition to the fact the species is not considered sensitive to human disturbance (Keinath et al. 2003).

The Colorado Division of Wildlife (CDOW) used to recognize *S. intermontana* as being of special management concern (CNHP 1996), but recent revisions have eliminated it from the list (http://wildlife.state.co.us/species_cons/list.asp). British Columbia has included *S. intermontana* on its "Blue List", indicating that it is experiencing a loss and alteration of critical habitats and breeding sites and therefore is vulnerable to possible local extinction (COSEWIC 2004).

Natural Heritage Ranks

The Natural Heritage Network assigns rangewide and state-level ranks to species based on established evaluation criteria. *Spea intermontana* merits a global rank of G5, which means that rangewide it is deemed by Heritage scientists to be Apparently Secure (NatureServe 2005). Further, nine western states have assigned a State Rank to *S. intermontana*, and two have ranked it as S2 (imperiled) or S1 (critically imperiled). Specific State Ranks are as follows: Arizona (S2), California (S5), Colorado (S3), Idaho (S4), Nevada (S4), Oregon (S5), Utah (S5), Washington (S5), and Wyoming (S3) (NatureServe 2005; Keinath et al. 2003; WYNDD 2004). In general, state ranks are assigned based on the assessed risk of extinction within a state, where S1 species are deemed critically imperiled and S5 species are deemed demonstrably secure. These assessments are based on biological information on population status, natural history, and threats at the state level.

The Wyoming Natural Diversity Database (WYNDD) gives *S. intermontana* a Wyoming Contribution Rank of "high." This rank is given to *S. intermontana* because the survival of Wyoming populations may make a large contribution to the species range-wide persistence (Keinath et al. 2003; WYNDD 2004).

Biological Conservation Issues

Declines in amphibian populations throughout the world have been noted; however, it is uncertain if these declines are a result of natural fluctuations in amphibian populations or human impacts. Long-term (decades) studies need to be conducted in order to 1) understand the natural fluctuations in amphibian populations – their magnitude, frequency, degree of regularity, and causes, and 2) determine the effects anthropogenic factors have on amphibian populations (Blaustein et al. 1994; Pechmann and Wilber 1994; Stebbins and Cohen 1995). Until then, it can only be hypothesized what has caused declines in amphibian populations throughout the world, since some declines are occurring in pristine, protected habitats (Drost and Fellers 1996; Semlitsch 2000). This assessment has attempted to identify important breeding and nonbreeding habitats as documented in published literature, as well as other factors that may influence the survival of *S. intermontana*. The next section will address possible threats to the survival and success of *S. intermontana* populations throughout its range, and management actions that can be taken to mitigate these threats.

Extrinsic Threats

Habitat Alteration

Spea intermontana are dependent on aquatic habitats for breeding and development, and terrestrial habitats for foraging areas, aestivating/hibernating sites, and dispersal routes within xeric environments. Alteration to any of these habitats could adversely affect the persistence of *S. intermontana* populations, as well as other aquatic-terrestrial amphibians. This is of particular concern to managers since wetlands are decreasing at alarming rates (i.e., 53% of original wetlands in the U.S. have been lost to human development during the last 200 years; Dahl 1990 in Semlitsch 2000), and xeric shrublands are becoming fragmented, degraded, or lost with agriculture, urban, and oil/gas development (i.e., 50-60% sagebrush steppe modified or lost in

U.S.; West 1996 in Knick et al. 2003; Cannings 1999). Management of these habitats is important at the local and regional levels to maintain viable population and genetic diversity (Semlitsch 2000). To date, few studies have assessed what effects anthropogenic disturbances (i.e., agriculture, mineral exploration, urban development, and recreation) would have on *S. intermontana* populations.

Aquatic habitat loss could occur directly from pond drainage or filling, creek diversion, water extraction, and urban development (Semlitsch 2000; Ovaska et al. 2003). For example, some studies in British Columbia attribute the decline of *S. intermontana* to be a direct result of urban development: it depletes the groundwater reserves, resulting in permanent water sources becoming seasonal, and temporary water sources becoming too ephemeral to be used successfully as breeding sites (i.e., not enough time to develop and metamorphose; Cannings 1999). However, the overall effect of such alterations on *S. intermontana* populations may not be adverse. For example, range improvements that increased irrigation in the Great Basin benefited *S. intermontana* by increasing breeding sites, since they are able to utilize both permanent and temporary water sources, unlike other spadefoot toad species (Nussbaum et al. 1983). In British Columbia, *S. intermontana* were documented using temporary and semi-permanent water sources that had been altered in urban and rural developments, as well as city parks, riparian zones, and recreational areas (Ovaska et al. 2003). Complete loss of aquatic breeding habitat, however, will limit the number of breeding sites available, and potentially cause large aggregations of *S. intermontana* (as well as other amphibian species). This aggregation could increase disease and pathogen transfer among species and affect larval growth (Semlitsch 2000; Ovaska et al. 2003).

Creation of roads in the west has increased substantially over the past couple decades and threatens amphibian populations through the loss of habitat, fragmentation and limitation of dispersal/migration capacity, alteration of adjacent terrestrial and aquatic habitat (i.e., siltation in water sources), the facilitation of invasive species and increased predation risk, and direct road mortality (Cannings 1999; Semlitch 2000; Mazerolle 2004). Fragmentation of terrestrial habitat by roads may be most detrimental to *S. intermontana* populations, since it could block natural migration and dispersal corridors, limiting the distribution of individuals and affecting overall fitness of populations (i.e., decreasing genetic diversity; Hels and Nachman 2002). In addition, road-building often occurs in warmer weather, which coincides with breeding season, and could disturb breeding sites, as noted by Bragg (1965).

Research on the effects of fire on *S. intermontana* has not been conducted; however, fire probably has little direct lethal effects on adults (remain in burrows), eggs, or tadpoles (exist in an aquatic environment). In addition, *S. intermontana* does not seem to depend on vegetative cover for survival, and therefore the change in cover and vegetative species composition as a result of fire most likely has no direct adverse effects (however, see Invasive Species below). The diversity, density, and species composition of arthropod species (*S. intermontana* diet) would be altered in both aquatic and terrestrial habitats, and therefore, may indirectly affect *S. intermontana* populations. However, it seems that *S. intermontana* (both terrestrial and aquatic life stages) are diet generalists, and so the change in arthropod prey base may not have an adverse affect on *S. intermontana* populations (Howard 1996; Franke 2000). More research is needed.

Oftentimes it is difficult to understand the exact affect alterations may have on a population because of the naturally fluctuating populations. If changes occur to habitats in a time of naturally low populations, the changes in habitat may just drive these populations to such low numbers that they may not be able to recover when environmental conditions are most favorable (Ovaska et al. 2003).

Environmental Contamination

Environmental contamination can have profound effects on amphibian populations, both directly and indirectly (reduction in prey abundance), and therefore should be considered a large factor in amphibian declines (Semlitsch 2000; Ovaska et al. 2003). There are several characteristics that make *S. intermontana* (as well as other amphibians), particularly susceptible to environmental pollutants, such as 1) life cycle, which includes both aquatic and terrestrial habitats, 2) absorptive surfaces that are permeable to gases and liquids (adults, eggs, and larvae), 3) diet (insects and plant algae), and 4) lipid-dependence during hibernation/aestivation and reproduction (see Stebbins and Cohen 1995). Therefore, pesticides and herbicides used in agricultural and forest management practices, as well as toxins and heavy metals associated with urban, agricultural, and oil and gas developments, may be responsible for some documented declines of *S. intermontana* populations. However, this connection is often difficult to establish (see Drost and Fellers 1996 and Semlitsch 2000). No studies have documented the effects of chemical toxicants on *S. intermontana* populations specifically. Only recently have ecotoxicological studies focused on amphibians (Hall and Henry 1992 in Semlitsch 2000).

Ovaska et al. (2003) provides a great summary of environmental contaminants, such as insecticides, herbicides, fungicides, and heavy metals, and their adverse affects on various amphibian species. Some adverse effects reported include: acute toxicity (i.e., direct mortality), reduced growth and development, and adverse effects on reproduction, behavior, and biochemical homeostasis (Bishop 1992). Toxicants that are present in and around aquatic habitat may be most devastating to populations, since exposure would occur during critical development and metamorphose stages (Semlitsch 2000). However, since it has been reported that different amphibian species demonstrate variable responses to the same chemical toxicant (see Stebbins and

Cohen 1995; Bridges and Semlitsch 2000; Ovaska et al. 2003), it would be difficult to extrapolate the possible effects chemical toxicants would have on *S. intermontana*.

Invasive Species

Nonnative species can affect *S. intermontana* directly through predation and competition for resources, and indirectly through habitat alteration and introduction of diseases (Semlitsch 2000; Ovaska et al. 2003). Habitat disturbance further facilitates the introduction and spread of nonnative species. No studies have specifically addressed the effects of invasive species on *S. intermontana*. Most research conducted on other amphibians has investigated the effects of predatory species on populations. However, invasive plant species could also affect amphibian populations.

Fish are considered one of the primary threats for aquatic-terrestrial amphibian populations, because they can be both predators and competitors of larvae (Semlitsch 2000). In the West, the decline or local extinction of amphibian populations have been attributed to both native and introduced fish (Orchard 1992; Bradford et al. 1993; Drost and Fellers 1996; Semlitsch 2000). *Spea intermontana* are known to use more permanent water sources for breeding sites, where predatory fish would be present, and therefore could suffer population declines, or be forced to move to less favorable breeding sites. American bullfrogs (*Rana catesbeiana*) have also been introduced to new areas in the West and have adversely affected native amphibian populations by depredating their larvae and competing for food sources (Reaser 2000; Semlitsch 2000; Ovaska et al. 2003). *Rana catesbeiana* inhabit permanent water sources in habitats similar to *S. intermontana*, and could pose a threat to *S. intermontana* populations in locales that may be occupied by both species (i.e., California, Colorado, Nevada, Utah, Washington, Oregon, and Idaho). Currently, *R. catesbeiana* does not overlap *S. intermontana* range in Wyoming (Stebbins 2003).

Cheatgrass (*Bromus tectorum*), an invasive grass species that is common in sagebrush steppe and other desert shrub ecosystems in the West (Knight 1994), could have devastating effects on terrestrial habitat of *S. intermontana*. Cheatgrass will grow in any type of soil but does best in deep, loamy, or coarse-textured soils and is common in deep sandy soils in big sagebrush stands on flat uplands and valley bottoms in mountains and foothill areas (Zouhar 2003), which are preferred by *S. intermontana* (see Nonbreeding Habitat). Unlike desert shrubs (i.e., *Artemesia* spp.) which have long taproots that exploit water reserves deep in the soil (Terminstein 1999), *B. tectorum* has fibrous roots that reduce soil moisture at the surface and to a depth of 70cm (Zouhar 2003). Through this different root system, cheatgrass has the ability to change the hydrology of the landscape, not only affecting the permanency of water sources nearby (altering the water table), but removing moisture in the soil that *S. intermontana* depends on for maintaining metabolic processes during aestivation and hibernation. In addition, the fibrous root structure of cheatgrass decreases the ease that *S. intermontana* can burrow in the soil (see Jansen et al. 2001). Actions should be taken to prevent the introduction of cheatgrass, by limiting grazing in areas known to contain *S. intermontana* populations (Terminstein 1999; Zouhar 2003).

Other

This assessment focused on what was deemed the three most critical extrinsic threats facing *S. intermontnana* popoulations in Wyoming. Other threats that have been attributed to the decline or local extinction of amphibians in the West are: acid precipitation, stochastic events (i.e., drought, flashfloods), disease and pathogens, and commercial exploitation. More detailed information on these threats can be found in Drost and Fellers (1996), Reaser (2000), Semlitsch (2000), Nyström et al. (2002), Ovaska et al. (2003), and Burrowes et al. (2004).

Intrinsic Threats

Habitat Specificity and Site Fidelity

Spea intermontana require water sources for breeding, and loose, sandy soils for burrowing to escape environmental conditions during nonbreeding seasons. If one of these is degraded or lost, *S. intermontana* could be adversely affected (i.e., unable to reproduce and recruit or unable to physically survive). In addition, *S. intermontana* probably exhibits some philopatry to breeding or over-wintering sites based on studies of other amphibian species as well as their sedentary habits, and therefore could be more vulnerable to the loss or degradation of either habitat (see Blaustein et al. 1994; Ovaska et al. 2003). There are conflicting reports regarding site fidelity. Bragg (1965) observed *S. intermontana* digging and occupying only one burrow which it returned to after foraging and mating. Linsdale (1938) observed many vacant holes while investigating a population of *S. intermontana*, possibly indicating that after returning from foraging they dug new holes.

Territoriality and Area Requirements

Movement patterns, dispersal and migration distances, and habitat requirements are not well known for *S. intermontana*. Most information for *S. intermontana* is obtained from anecdotal observations. Sarell (2004) suggested that an area of at least 10ha (dependent on the size of the water source) should be maintained in order to provide adequate habitat for breeding, foraging, and aestivation/hibernation. If agricultural practices and oil and gas development projects degrade and fragment habitats less than 10ha, *S. intermontana* populations may be adversely affected; but more information is needed. Possibly more important than size of habitat available for *S. intermontana* viability, is the juxtaposition of good burrowing substrate (i.e., loose, sandy soils), suitable aquatic breeding sites, and adequate vegetative cover for foraging. There is no information on the territoriality of *S. intermontana.*

Susceptibility to Disease

It is unknown if *S. intermontana* is especially susceptible to diseases and infections. To date, only harmless parasites have been documented in *S. intermontana* individuals (see Parasites and Disease). A close relative of *S. intermontana*, *Scaphiopus couchii*, suffers infection from a blood-feeding worm, *Pseudodiplorchis americanus*. This worm can cause chronic pathogenic effects by depleting lipid sources needed for hibernation and potentially compromising the host's ability to invest enough energy in gonad development and the expression of secondary characteristics (i.e., mating calls). *Pseudodiplorchis americanus* is transmitted both sexually and nonsexually at breeding congregations, and could easily affect an entire population (Pfennig and Tinsley 2002). However, to date, there have been no reports of *S. intermontana* individuals or populations infected with *P. americanus*, and it is not known if *S. intermontana* is susceptible to becoming infected. More studies need to be conducted, especially since situations may put *S. intermontana* at breeding sites with large congregations of other species that harbor potentially harmful diseases and parasites. Stebbins (2003) noted that in southern Utah, *S. intermontana* and *Scaphiopus couchii* do occasionally hybridize, thus putting the two species together at the same breeding grounds.

Dispersal Capability

No information has been reported on the dispersal capabilities of *S. intermontana*. It can be assumed that juveniles migrate within 1km of their aquatic development site, based on other aquatic-terrestrial amphibian species (Semlitsch 1998). Dispersal beyond their natal grounds, however, is largely dependent on connectivity of suitable habitat (i.e., burrowing and foraging habitat between other water sources; Semlitsch 2000). In addition, researchers have alluded that tadpoles that metamorphose at a larger size will have the capability of traveling farther distances that those juveniles of smaller stature (Semlitsch 2000).

Reproductive Capacity

Female *S. intermontana* are capable of laying 300 – 500 eggs during one breeding bout (Nussbaum et al. 1983), but no information is available on the success and survival of *S. intermontana* clutches through metamorphosis in its natural environment. Several factors contribute to the success of each clutch (i.e., degree of ephemeral pool, temperature, pH, predation risk). However, large clutch sizes increase the potential for at least some of the offspring to survive to adulthood (Reaser 2000). In the laboratory, researchers have had variable success (0% to 100%) of eggs hatching and surviving through metamorphosis (Morey and Reznick 2000).

Abundance and Abundance Trends

Little information exists on the population trend of *S. intermontana* throughout their range; however, certain studies indicate a decline. For example, two studies (British Columbia, Orchard 1992; Hovingh 1997, Great Basin, Nevada) indicate a decline in *S. intermontana* abundance, apparently as a result of agricultural and urban development. Another study (Drost and Fellers 1996) reported the absence of *S. intermontana* in Yosemite National Park in 1992, where previous surveys (1915 and 1919) had documented the presence of this species. The cause for this disappearance is unknown (Yosemite has been protected from development); but, introduction of nonnative fishes or pesticides used in adjacent land were speculated. The authors also implied that the "secretive" lifestyle of *S. intermontana* could make it difficult to detect, and therefore, *S. intermontana* may still be present. To gain an accurate understanding of trends within *S. intermontana* populations, long-term studies (decades) need to be conducted. To date, only a handful of long-term studies have been conducted on amphibian species (see Blaustein et al. 1994). NatureServe (2005) provides a rough distribution map of *S. intermontana* that depicts status across its range indicating possible abundance trends (see Figure 3b), and suggests that the overall population is relatively stable, with less than 25% decline rangewide.

Distribution Trends

Estimated distribution boundaries are based on survey/observation data, museum records, and habitat association (Figure 3a). Since most of the data is hypothetical (i.e., suitable habitat), historical (i.e., museum records >50 years), and anecdotal (i.e., chance observations), distribution maps may not represent the present distribution (Hall 1998). More surveys are needed in order to better approximate the current distribution of *S. intermontana* and then be used to determine possible distribution (as well as habitat) trends. There have been a few studies that have conducted surveys in areas where *S. intermontana* had previously been observed and documented, yet did not encounter *S. intermontana* (see Orchard 1992; Drost and Fellers 1996; Hovingh 1997; McGee et al. 2002; Sarell and Haney 2003; WYNDD 2005).

Habitat Trends

Spea intermontana rely on both aquatic and terrestrial habitat to complete their lifecycle and maintain viable populations. However, both habitats have been heavily impacted by human use (see Habitat Alterations), and may cause declines in *S. intermontana* populations (Semlitsch 2000). For example, a decrease in the abundance of *S. intermontana* in the Great Basin drainages over the past century can be attributed to loss of habitat from human-induced habitat modifications which have caused this species, as well as other Great Basin aquatic-terrestrial amphibians, to become confined to tributaries or springs where water quality and habitat have not been intensely altered and/or lost by various operations. Some habitat alterations that have occurred in the Great Basin drainages over the past century include: channelization, bank stabilization, land leveling for cultivation resulting in removal of oxbows, urban development, gravel mining, season long grazing of cattle, and denuding of streams (Hovingh 1997). As these practices continue in the Great Basin and other *S. intermontana* range, available breeding habitat will be reduced. On the other hand, some range improvements actions that create new habitat (i.e., man-made reservoirs) may improve habitat for *S. intermontana* which seems indifferent to natural/man-made and permanent/temporary breeding water sources (Nussbaum et al. 1983; Hovingh et al. 1985). Habitat fragmentation from roads that occur with agricultural, urban, and oil and gas development has caused connectivity between several aquatic breeding habitats to be eliminated or hindered. As a result, proper emigration and immigration among various sites does not occur, and thus the fitness of the population decreases (Blaustein et al. 1994).

Conservation Action

Existing or Future Conservation Plans

Currently there are no conservation plans within the United States that directly suggest management strategies for *S. intermontana* and its aquatic and terrestrial habitats. In the United States, some coarse-filter ecosystem plans may indirectly promote the conservation of *S. intermontana* habitat via an umbrella species such as sagebrush, wetland management, invasive species reduction, and/or fire management. However, these plans are broad and inconsistent in scope, making them insufficient for conservation of this species. One such plan in Wyoming, the Wyoming Greater Sage-Grouse Conservation Plan (Budd 2003) is an example. Another is expected from the Great Basin Working Group, which includes members from Wyoming and Colorado and has noted *S. intermontana* as one of the species that defines the Great Basin.. However, they have not held any recent meetings to finalize such a plan (B. Turner, personal communication).

More efforts have been put forth in British Columbia, Canada, where *S. intermontana* is listed as "threatened" and therefore is federally protected under the Species at Risk Act (SARA). On public lands, identified critical habitats will be protected by SARA, and on private lands it will be expected that stewardship activities and action will be taken care of by local governments, and in cases where they are not, the federal government will step in to take action (Ovaska et al. 2003).

Conservation Elements

There have been no studies explicitly investigating implications of environmental change on *S. intermontana.* However, there have been studies that provide information on aquatic breeding sites and habitat types used by *S. intermontana*, and management strategies to preserve these sites. Four main conservation elements should be addressed for *S. intermontana* conservation management. Specific approaches that have been proposed to address these conservation elements are provided in the following section on Tools and Practices.

1. **Protection of aquatic breeding habitat** – Adequate water sources that meet the requirements of *S. intermontana* (see Breeding Habitat) are the most important factor in maintaining viable populations, since they are used for mating and the development of eggs and larvae through metamorphosis. Breeding sites should be left undisturbed during breeding season so egg masses are not destroyed and water quality and availability is sufficient for tadpoles to complete metamorphosis and enter burrows. Loss, destruction, or degradation of water sources utilized could interfere with the recruitment and survival of *S. intermontana*. *Spea intermontana* utilize a variety of water sources (temporary and permanent, natural and man-made), but it has been documented that the most successful reproductive activities occurred in ephemeral pools with no vegetation growth and no fish predators present (Hovingh et al. 1985). Soil type (for burrowing) and surrounding vegetative cover (for foraging) may be as equally important when selecting a water site.
2. **Protection of terrestrial nonbreeding habitat –** In the past, most conservation efforts for amphibians have focused on aquatic breeding habitats and conservation of terrestrial habitats has been neglected. Protecting terrestrial habitat peripheral to aquatic breeding habitat is essential to maintain the viability of *S. intermontana* populations (Semlitsch 2000). Not only does this habitat provide foraging grounds for adults and juveniles, but provides cover from aerial predators and direct sunlight, as well as loose, moist soil to

burrow and escape unfavorable environmental conditions (hot, dry periods in the summer and cold periods in the winter).

3. **Maintain habitat connectivity and metapopulation dynamics –** The long-term persistence of metapopulations (regional population) is dependent on the emigration and immigration between subpopulations (local populations), and ultimately, the connectivity between microhabitats (breeding sites). It is important to maintain the connectivity of microhabitats in order to ensure distribution of genetics throughout the metapopulation and maintain viable subpopulations (Blaustein et al. 1994; Ovaska et al. 2003). Fragmentation of habitat through the creation of roads and curbs, steep embankments, and impermeable fences increase the risk of separating subpopulations. When this occurs, toads cannot disperse from degraded habitat nor recolonize viable habitat, so local extinctions become more common. A connected network of suitable wetland habitats mitigates this problem and helps insure long-term viability of a metapopulation.
4. **Elimination of exposure to chemicals –** No information exists on the exact effects environmental contaminants could have on *S. intermontana* populations; however, it can be assumed because of its life history and physiological characteristics, populations are susceptible to declines or local extinctions (see Environmental Contaminants). Use of potentially harmful chemicals need to be eliminated in and around known aquatic and terrestrial habitats of *S. intermontana* before local extinctions in Wyoming are documented and attributed to chemical-use, as in *S. intermontana* populations in Yosemite National Park (Drost and Fellers 1996) and Wyoming toad (*Bufo hemiophrys baxteri*) populations in Wyoming (Stebbins and Cohen 1995).

Tools and Practices

Acting on Conservation Elements

British Columbia has provided general suggestions of management practices for *S. intermontana* (see Ovaska et al. 2003; Sarell and Haney 2003; Sarell 2004). In addition, research that focused specifically on *S. intermontana,* or included *S. intermontana* with a group of other amphibian species, has also provided management suggestions that may provide the best opportunity to conserve suitable aquatic breeding and terrestrial nonbreeding habitat. It is important that these management suggestions are scrutinized, since they are based on specific habitats found in other areas of *S. intermontana* range, and do not necessarily relate directly to situations in Wyoming.

1. **Protection of aquatic breeding habitat** – Identify critical breeding habitat by conducting surveys during breeding seasons (April through July). Use of existing geographical information systems data may also assist in the identification of depression wetlands greater than 0.2ha to be explored for possible breeding sites (Semlitsch and Bodie 1998). This will allow protection of known breeding habitats and assist in the protection of terrestrial, nonbreeding habitat (see below). All wetlands in the vicinity of the identified breeding sites (temporary or permanent) should be preserved since these could play important roles in the dispersal of *S. intermontana* (act as stepping stones) and also provide additional breeding habitat in favorable years (Semlitsch and Bodie 1998; Semlitsch 2000; Snodgrass et al. 2000; Ovaska et al. 2003). Limit cattle grazing in identified habitats to nonbreeding seasons to prevent trampling of tadpoles, creation of craters in water holes from hooves, and polluting and stirring up the mud in pools that could suffocate tadpoles (see Orchard 1992; Cannings 1999). Preserve riparian and emergent vegetation in and around breeding sites, since it can naturally assist the maintenance of water quality by preventing sedimentation and pollutants from entering the water systems (Semlitsch 2000). Avoid draining wetlands and altering the flow of creeks, surface runoff, or groundwater. The maintenance of natural hydro-periods is essential to *S. intermontana* survival (Semlitsch 2000; Ovaska et al. 2003). Finally, protect breeding sites from invasion by fish predators, both native and exotic (Semlitsch 2000).
2. **Protection of terrestrial nonbreeding habitat** – Very little is known about the nonbreeding habitat of *S. intermontana*, which includes foraging areas, over-wintering sites, and migratory corridors. In addition, distances traveled from aquatic breeding sites to nonbreeding habitat is not really known, but has been reported to be as little as one hundred meters to possibly greater than five kilometers. This lack of information makes it difficult to manage for *S. intermontana* nonbreeding habitats. Therefore, protection of sufficient land peripheral to aquatic breeding sites is critical. A buffer zone of natural vegetation of at least 50m from identified *S. intermontana* aquatic breeding habitats (both

permanent and temporary) should be maintained (Sarell and Haney 2003). Semlitsch (1998) suggests maintaining a buffer zone of 164m, so that about 95% of a population is protected, and Sarell (2004) suggests that protecting habitat within 250m of breeding sites will protect most of the aestivation habitat of *S. intermontana*. Maintaining areas with loose, sandy soil within the buffer is especially important, since other more fibrous and rocky soils are difficult for spadefoots to burrow into (see Jansen et al. 2001). Within the buffer zones, recreational use (vehicle and foot) should be discouraged, especially during the spring and summer when *S. intermontana* are known to be most active (i.e., breeding, juvenile dispersal, and foraging; Orchard 1992; Semlitsch 2000). Domestic grazing within areas known to possess *S. intermontana* should be limited during breeding season, since cattle could subject the vegetation surrounding breeding pools (nonbreeding habitat) to severe trampling and overgrazing (Orchard 1992). In addition, limiting grazing will also reduce the likelihood of introducing exotic species such as cheatgrass, which could adversely alter the terrestrial habitat (Zouhar 2003).

3. **Maintain habitat connectivity and metapopulation dynamics –** Protection of natural corridors between potential breeding sites (whether permanent or temporary) is important to ensure habitat connectivity and maintain gene-flow among subpopulations (Snodgrass et al. 2000), especially when development projects might impede the movements (migratory and dispersal) of *S. intermontana* by blocking natural corridors. For example, roads should be developed away from key habitats in order to avoid creating such barriers. In areas where this is unavoidable, special road-crossing structures could be constructed to protect migratory corridors, as well as reduce road mortality (see Ovaska et al. 2003). Ultimately, retaining naturally existing corridors is important to reduce predation risk.
4. **Elimination of exposure to chemicals –** Until studies determine which environmental contaminants are most detrimental to *S. intermontana* populations, measures should be taken to reduce contamination to known or potential aquatic and terrestrial habitats. This can be done by restricting the use of herbicides, insecticides, and fire retardants over and adjacent to pools, streams, ponds, and ditches (Semlitsch 2000; Ovaska et al. 2003).

Inventory and Monitoring

Little is known about *S. intermontana* because they are nocturnal, remain burrowed underground for the majority of their non-breeding life cycle, are inconspicuous in color, and often select inconspicuous breeding sites (i.e., ephemeral pools) that are used for only a very short time (1-3 days breeding; 4-8 weeks development/metamorphosis). This life history of *S. intermontana* makes it difficult to develop a consistent and easy to use monitoring protocol and creates hesitation for managers to write grants for such research (B. Turner, personal communication). Below are some suggestions that may assist in the inventory and monitoring of *S. intermontana*. Detailed suggestions of amphibian monitoring are presented in several sources (e.g., Jones 1986; Karns 1986; Heyer et al. 1994; Stebbins 2003) and should be reviewed for more thorough understanding of techniques. Monitoring habitat may also assist managers in determining local population viability and trends; however, this should not be used as a surrogate method, since other factors play a major role in the activity of *S. intermontana* (i.e., amount of precipitation).

Timing

Success of surveying and monitoring *S. intermontana* is dependent on the season, temperature, rainfall, amount of annual precipitation, and time of day. *Spea intermontana* are nocturnal and most active during warm (>4°C; see Fouqutte 1980), wet (24 hours after rain; Karns 1986), and humid evenings. In addition, they maintain a fairly consistent timetable of behavior, such as breeding in the spring/summer (especially in permanent water sources; see Breeding), feeding and growing during the summer, and preparing to over-winter during the fall (Karns 1986). Targeting these more "active" time periods may be the most beneficial and cost effective, since they are inconspicuous otherwise.

Multiple sites and site types

Monitoring plans should include aquatic (breeding) and terrestrial (nonbreeding/foraging) habitats in order to determine abundance and distribution, (including daily and seasonal movements), to effectively manage for *S. intermontana*. Selecting multiple sites similar in area, elevation, and vegetative type and structure will assist researchers in determining habitat associations.

Multiple visits

Multiple sampling throughout the year is important to understand the density, seasonal movements, and activity patterns of *S. intermontana*. At minimum, an ephemeral water site with known *S. intermontana* breeding activity should be examined at least once within two months of the first warm, spring rains. For permanent water sources that are known breeding sites, sites should be visited at least once per month during the breeding season (April through July). Maintaining consistency in survey dates over time will help managers determine site fidelity, as well. In addition, long-term sampling should be employed to determine population and habitat trends, as well as determine if the trends are due to naturally fluctuating environmental conditions or due to land-use practices (Jones 1986). This is especially important since *S. intermontana* activity and population can fluctuate from year-to-year as a result of environmental changes, (i.e., precipitation). Blaustein et al. (1994) suggest for "explosive breeders" like *S. intermontana*, the best way to monitor populations would be to mark-and-release and monitor year-to-year. Since *S. intermontana* probably have fairly long life spans, long-term data could be collected every three to five years to minimize costs. These sampling methods should increase potential to recapture/resight specific individuals and increase knowledge on *S. intermontana* to be used for conservation management strategies.

Survey methods

For description of survey methods, see Heyer et al. (1994). Visual encounter surveys (road cruising or walking in known microhabitat) can be used to determine relative abundance. Audio strip transects are the most effective way to count calling male *S. intermontana* and determine relative abundance of breeding toads, to determine breeding habitat use, and to map distributions throughout a fairly large area. Quadrat sampling (random) and patch sampling are good techniques to observe fossorial species, allowing the researcher to "bring eyes and hands close to the targets". More systematic sampling (transect sampling) will allow the researcher to survey over a variety of environmental gradients, determining environmental factors that may be selected for. Drift fences and pitfall traps are methods that could be used to capture *S. intermontana*, and toe-clipping is a good way to mark individuals for capture/recapture surveys. Stomping on the ground may cause *S. intermontana* to emerge from terrestrial burrows (Stebbins 1951).

Habitat Preservation and Restoration

With agriculture, housing developments, and recreational activities increasing in areas of dry shrublands, the availability of aquatic breeding habitat available to *S. intermontana* is decreasing. Protection and restoration of identified aquatic breeding sites used by *S. intermontana*, as well as adjacent terrestrial habitat, may help mitigate possible declines in *S. intermontana* populations. For example, in British Columbia, where *S. intermontana* is listed as threatened, areas known to contain the largest breeding populations have been federally or locally protected through the creation of parks and reserves in hopes to maintain and increase viable *S. intermontana* populations. In addition, other sites continue to be identified, protected, and restored (Sarell 2004). In Wyoming, habitat preservation efforts at Mortenson Lake in Albany County have assisted the protection and reintroduction of the nearly extinct Wyoming toad (*Bufo hemiophrys baxteri*) in hopes to restore and increase natural populations (Stebbins and Cohen 1995; Parker and Anderson 2003). See Acting on Conservation Elements for guidelines of protecting and restoring sites.

Captive Propagation and Reintroduction

Currently there is not a need to breed *S. intermontana* in captivity, although it could be a solution in dire circumstances if conducted for only a short time and with the intention to reintroduce individuals into rehabilitated or existing natural habitats (Zug 1993). To date, no captive propagation or reintroduction of *S. intermontana* has been attempted. Conservation efforts for *S. intermontana* would be more profitable if spent preserving and restoring habitat (see above). In Wyoming, a captive breeding program exists for the Wyoming toad (*Bufo hemiophrys baxteri*), in conjunction with habitat preservation (Stebbins and Cohen 1995; Parker and Anderson 2003).

Information Needs

Relatively little is known about several aspects of *S. intermontana* biology and ecology that are relevant to the management of this species. The following is a list of information needs that are deemed important in order to establish effective conservation strategies for this species.

1. **Distribution and Abundance –** Very few reports document *S. intermontana* across its range, and even fewer more than once. Surveys need to be conducted in potential *S. intermontana* habitats that specifically focus on this species (most reported surveys are for amphibians and reptiles in general). This effort will aid managers in understanding habitat associations, range wide distribution, local abundance, and population trends of *S. intermontana* to assist in management decisions
2. **Trends –** It is important that once populations have been found and surveyed, they be monitored to determine trends over time. Only through monitoring can population status and response to management be evaluated. Given the ephemeral nature of secretive nature of *S. intermontana* life history, this will require developing methods targeted specifically to this species.

3. **Geographic Variation –** Phylogenetic analysis conducted on two distinct populations of *S. intermontana* [Colorado (n=1) and Oregon (n=3)], located at opposite ends of *S. intermontana* range, did not share alleles at nine of the 21 loci scored, suggesting possible geographic variation within the species, or possibly two separate species (Wiens and Titus 1991). Further research is needed to determine if *S. intermontana* populations throughout its range are the same species in order to prioritize conservation efforts and positively determine population status.
4. **Land-use Impacts –** It is unknown what affects certain practices (i.e., agriculture, gas/oil/urban development, pesticide-use) have on *S. intermontana* populations. Some studies have explored the affects of agricultural cultivation on other spadefoot toad species (i.e., *S. bombfirons* and *S. multiplicata*; see Gray et al. 2004), but breeding site preferences and range are not similar. To effectively manage for viable *S. intermontana* populations, information is needed on the short- and long-term effects of above-mentioned management actions.
5. **Pesticides/Herbicides –** There have been documented effects of pesticides/herbicides on amphibians (see Extrinsic Threats), but no research specifically on *S. intermontana*. Research efforts need to address what impacts pesticides and herbicides have on *S. intermontana* populations directly (aquatic or terrestrial habitats and consumption of affected insects) and indirectly (reduction of local prey base), since effects differ among species (see Bridges and Semlitsch 2000). Long-term studies need to be conducted since effects of some chemical toxicants may be sublethal and take generations to manifest (see Stebbins and Cohen 1995).

Figures

Figure 1: Photographs of adult *S. intermontana* showing a) the vertical pupil, b) the cream-colored ventral surface, and c) the digging spade on the inside of the hind foot. (photographs taken from Idaho Museum of Natural History website: http://imnh.isu.edu).

a)

Jonathon M. Beck © 1997

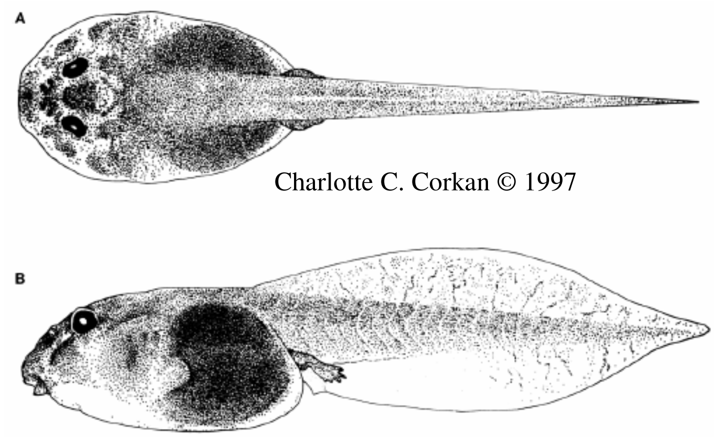
b)

Jonathon M. Beck © 1997

c)

Figure 2: *Spea intermontana* tadpoles and eggs: a) morphological drawings of tadpoles taken from Hall et al. (2002), b) photograph of tadpole and c) eggs attached to vegetation (photographs taken from Idaho Museum of Natural History website: http://imnh.isu.edu).

a)



b)

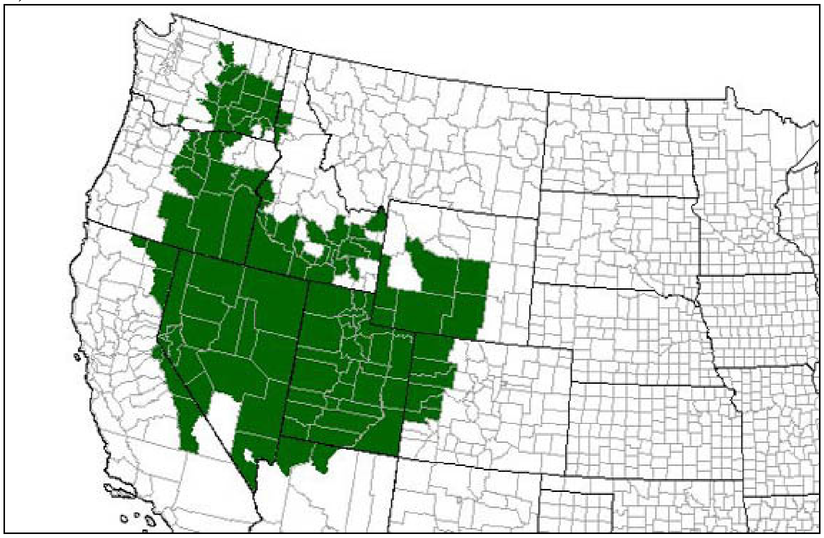
Charlotte C. Corkan © 1997

c)

Charlotte C. Corkan © 1997

Figure 3: a) North American range of *S. intermontana* (www.usgs.gov) and b) distribution map with conservation status across range (NatureServe website: www.natureserve.org).

a)



b)

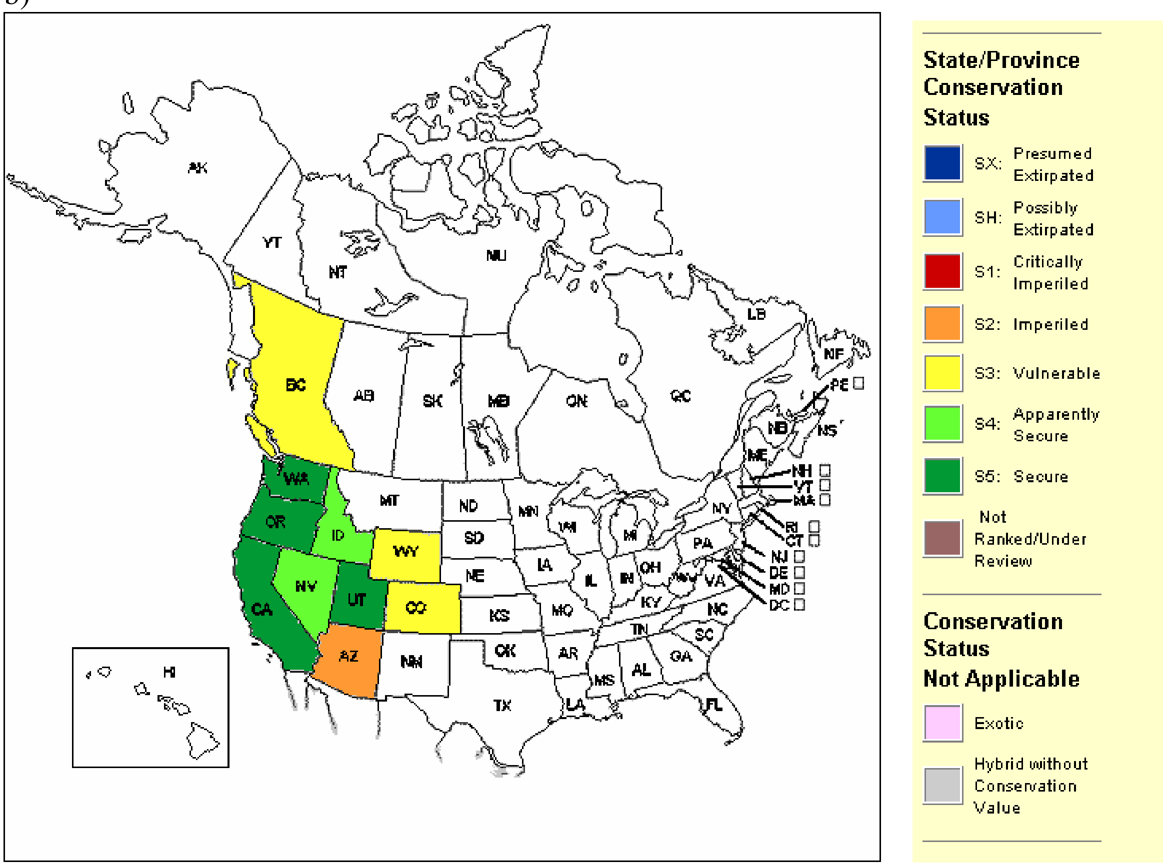
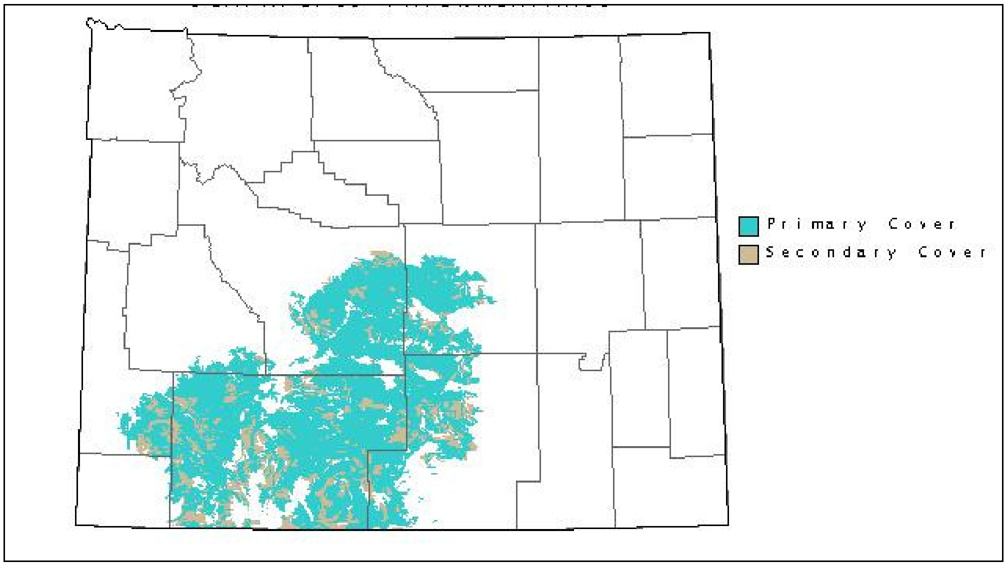


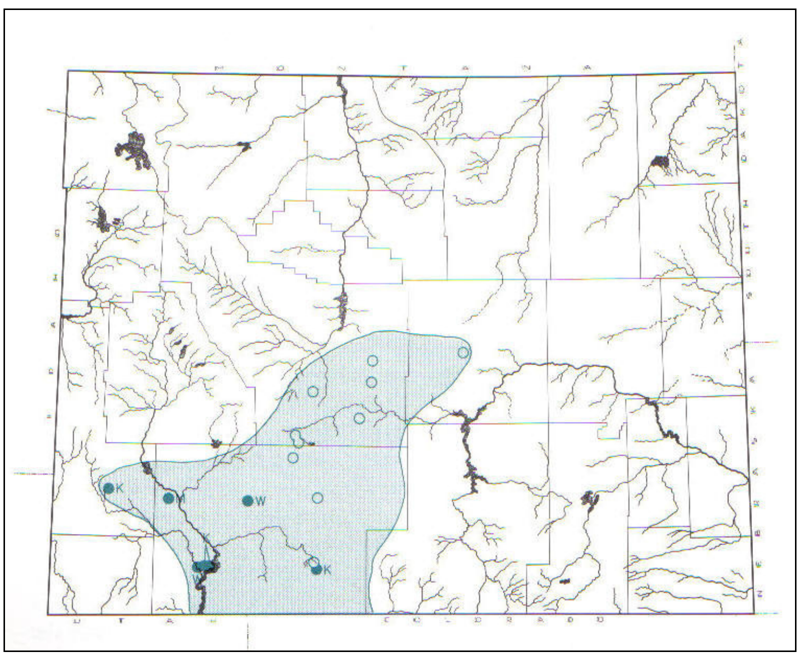
Figure 4: Potential distribution of S. intermontana in Wyoming a) obtained from WYGISC website (www.wygisc.uwyo.edu) and b) Baxter and Stone 1985, pg.26.

a)



Associated habitat: Sagebrush communities, permanent and temporary ponds, vegetated dunes, active dunes, greasewood.
Elevation: 900 – 2250m

b)



Open circles (○) represent published records of *S. intermontana*,
Closed circles (●) represent museum specimens

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