Management of Montana's Amphibians:

A Review of Factors that may Present a Risk to Population Viability and Accounts on the Identification, Distribution, Taxonomy, Habitat Use, Natural History and the Status and Conservation of Individual Species

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OVERVIEW

Amphibians play important ecological roles in transferrring energy up the food chain and shaping terrestrial and aquatic communities. In addition they may serve as valuable bioindicators of the health of certain environments. Unfortunately, some amphibian populations around the world and in Montana have recently, or are currently, undergoing declines and extirpations. Direct and indirect impacts from a variety of human activities may affect the viability of amphibian populations in Montana. Because they have complex life cycles with life history stages that require specific breeding, foraging, and overwintering habitats that may be spatially separate, management actions designed to ensure population viability must consider a complex set of habitats and a complex set of human activities that may present a risk to one or more life history stage. This document summarizes current knowledge on the distribution, status, and resource needs of Montana's amphibians in individual species accounts and reviews a variety of human activities that may pose a risk to their viability. Species that deserve special management attention include those currently listed as USFS Region 1 Sensitive Species (Coeur d'Alene salamander (*Plethodon idahoensis*), boreal toad (*Bufo boreas boreas*) and northern leopard frog (*Rana pipiens*)) as well as two species (plains spadefoot toad (*Scaphiopus bombifrons*) and the Great Plains toad (*Bufo cognatus*)) that currently lack a special management status, but deserve special attention because of the extremely low numbers of observations (< 40) and a lack of knowledge of their status, biology, and habitat use in the state. General activities that may pose a risk to population viability include timber harvest, grazing, fire and fire management activities, nonindigenous species and their management, road and trail development, on and off road vehicle use, development and management of water impoundments and recreational facilities, and the impact of habitat loss and fragmentation on regional sets of populations or metapopulations. While the extent of the impact of these and other activities is poorly understood a cautious approach to the management of these activities is justified in light of recent declines of amphibians around the world and in Montana. It is recommended that users of this document first use the tables at the beginning of the document to identify management status, likelihood of a species presence in the area of interest, and the complement of amphibian species that are typically found in each general habitat type. Users should then examine individual species accounts and risk factors in order gain a more thorough understanding of a species distribution, status, resource needs, factors that may pose a threat to population viability, and management actions that may mitigate these threats. Local personnel are encouraged to attend training courses in conducting surveys for amphibians in order to ensure that survey efforts are somewhat standardized. Surveys conducted to identify whether amphibians are present in a given watershed or at a given site should record survey results on the attached standardized data forms and should submit this information to the author and/or the database at the Montana Natural Heritage Program. Ideally local survey efforts should be coordinated with regional inventory efforts.

Presence and Status Ranks for Amphibians on National Forests in Montana

Common and Scientific Name	R1 USFS Status	Heritage Ranks	Beaverhead -Deerlodge	Bitterroot	Custer	Flathead	Gallatin	Helena	Kootenai	Lewis & Clark	Lolo
Long-toed Salamander (*Ambystoma macrodactylum*)	No Special Status	S5	Present Part	Present Entire	Not in Range	Present Entire	Outside Range	Present Part	Present Entire	Present Part	Present Entire
Tiger Salamander (*Ambystoma tigrinum*)	No Special Status	S5	Present Part	Outside Range	Present Entire	Not in Range	Present Entire	Outside Range	Present Part	Presence Possible	Outside Range
Coeur d' Alene Salamander (*Plethodon idahoensis*)	**Sensitive Species**	S2	Outside Range	Present Part	Outside Range	Outside Range	Outside Range	Outside Range	Present Part	Outside Range	Present Part
Rocky Mountain Tailed Frog (*Ascaphus montanus*)	No Special Status	Watch List	Present Part	Present Entire	Outside Range	Present Entire	Outside Range	Present Part	Present Entire	Present Part	Present Entire
[A]Plains Spadefoot (*Scaphiopus bombifrons*)	No Special Status	Watch List S3	Presence Possible	Outside Range	Present Part	Outside Range	Presence Possible	Presence Possible	Outside Range	Presence Possible	Outside Range
[B]Boreal Toad (*Bufo boreas boreas*)	**Sensitive Species**	S3S4	Present Entire	Present Entire	Present Part	Present Entire	Present Entire	Present Entire	Present Entire	Present Part	Present Entire
[A]Great Plains Toad (*Bufo cognatus*)	No Special Status	Watch List S3S4	Outside Range	Outside Range	Present Part	Outside Range	Outside Range	Outside Range	Outside Range	Presence Possible	Outside Range
[C]Canadian Toad (*Bufo hemiophrys*)	No Special Status	SH	Outside Range	Outside Range	Outside Range	Outside Range	Outside Range	Outside Range	Outside Range	Outside Range	Outside Range
Woodhouse's Toad (*Bufo woodhousei*)	No Special Status	S5	Outside Range	Outside Range	Present Part	Outside Range	Presence Possible	Outside Range	Outside Range	Presence Possible	Outside Range
Pacific Treefrog (*Hyla regilla*)	No Special Status	S5	Outside Range	Present Part	Outside Range	Present Part	Outside Range	Outside Range	Present Entire	Outside Range	Present Entire
Boreal Chorus Frog (*Pseudacris maculata*)	No Special Status	S5	Present Part	Outside Range	Present Entire	Outside Range	Present Entire	Presence Possible	Outside Range	Present Entire	Outside Range
Bullfrog (*Rana catesbeiana*)	No Special Status	SE	No Records	Continue to Spread	Presence Possible	No Records	No Records	Presence Possible	Continue to Spread	No Records	Continue to Spread
Columbia Spotted Frog (*Rana luteiventris*)	No Special Status	S5	Present Entire	Present Entire	Present Part	Present Entire	Present Entire	Present Entire	Present Entire	Present Part	Present Entire
[B]Northern Leopard Frog (*Rana pipiens*)	**Sensitive Species**	S3S4	Presence Possible	Presence Possible	Present Part	Presence Possible	Presence Possible	Presence Possible	Present Part	Presence Possible	Presence Possible

[A] The species deserves special management attention because of the extremely low numbers of observations (< 40) and a lack of knowledge of the species' status, biology, and habitat use in the state.
[B] The species deserves special management attention because they are known or thought to have undergone dramatic declines across their historic range in the state.
[C] The species has not been documented in the state with a museum voucher specimen, but observations have been reported.

General Habitat Types and Associated Amphibian Species in Montana

Habitat Type	Species Typically Present in the Habitat Type
Temporary ponds and wetlands in the mountainous regions of the state	- Long-toed Salamander (*Ambystoma macrodactylum*) - Boreal Toad (*Bufo boreas boreas*) - *Pacific Treefrog (*Hyla regilla*) - Columbia Spotted Frog (*Rana luteiventris*)
Temporary ponds and wetlands in the plains regions of the state	- Tiger Salamander (*Ambystoma tigrinum*) - Plains Spadefoot (*Scaphiopus bombifrons*) - Great Plains Toad (*Bufo cognatus*) - Woodhouse's Toad (*Bufo woodhousei*) - Boreal Chorus Frog (*Pseudacris maculata*)
Permanent lakes and ponds in mountainous regions of the state	- Long-toed Salamander (*Ambystoma macrodactylum*) - Boreal Toad (*Bufo boreas boreas*) - Pacific Treefrog (- *Bullfrog (*Rana catesbeiana*) - Columbia Spotted Frog (*Rana luteiventris*) - *+Northern Leopard Frog (*Rana pipiens*)
Permanent lakes and ponds in the plains regions of the state	- Tiger Salamander (*Ambystoma tigrinum*) - Woodhouse's Toad (*Bufo woodhousei*) - Bullfrog (*Rana catesbeiana*) - Northern Leopard Frog (*Rana pipiens*)
Riverine and riparian habitats in the mountainous regions of the state	- Rocky Mountain Tailed Frog (*Ascaphus montanus*) - Boreal Toad (*Bufo boreas boreas*) - Columbia Spotted Frog (*Rana luteiventris*) - *+Northern Leopard Frog (*Rana pipiens*)
Riverine and riparian habitats in the plains regions of the state	- Plains Spadefoot (*Scaphiopus bombifrons*) - Woodhouse's Toad (*Bufo woodhousei*) - Northern Leopard Frog (*Rana pipiens*) - Boreal Chorus Frog (*Pseudacris maculata*)
Closed forest habitats in the western portion of the state	- Long-toed Salamander (*Ambystoma macrodactylum*) - *Pacific Treefrog (*Hyla regilla*)
Prairies, badlands, and open forest habitats in the plains regions of the state	- Tiger Salamander (*Ambystoma tigrinum*) - Plains Spadefoot (*Scaphiopus bombifrons*) - Great Plains Toad (*Bufo cognatus*) - Woodhouse's Toad (*Bufo woodhousei*)
Fractured rock sites near streams, springs and spray zones in the northwestern part of the state	- Coeur d'Alene Salamander (*Plethodon idahoensis*)

*Typically at lower elevations
+Typical historical habitat prior to declines

ECOLOGICAL FUNCTION AND IMPORTANCE

Montana's 13 native amphibians represent a valuable biological and cultural resource whose conservation is essential not only to their own survival, but to the survival of other vertebrate and invertebrate taxa as well. As larvae, amphibians structure aquatic communities by being important herbivores (e.g., Dickman 1968; Seale 1980), competitors (e.g., Werner 1992), predators (e.g., Morin 1983; Wilbur et al. 1983), and prey (e.g., Wilbur 1997). Many metamorphosing amphibians act as key links between aquatic and terrestrial food webs as they transfer energy from aquatic prey to terrestrial predators (Wilbur 1997). The importance of adult amphibians in terrestrial food webs is highlighted by their efficiency at converting the prey they consume to new animal tissue; as ectotherms they are up to 50 times more efficient than mammals or birds (Pough 1980, 1983). Their importance to terrestrial food webs is further highlighted by studies conducted in eastern deciduous forests which demonstrate that amphibians rival or exceed mammals and birds with respect to numbers, biomass, and energetics (Burton and Likens 1975*a*; Burton and Likens 1975*b*; Hairston 1987).

Amphibians also contribute a great deal to human welfare. In many impoverished societies they are among the most important sources of animal protein and many affluent societies import large quantities of frog legs for culinary purposes; the U.S. imports 1,000-2,000 tons of frog legs annually, while France imports 3.4 million tons annually (Stebbins and Cohen 1995). Amphibians have been extremely important to studies of vertebrate anatomy, neurology, physiology, embryology, developmental biology, genetics, evolutionary biology, animal behavior, and community ecology (Stebbins and Cohen 1995; Petranka 1998; Pough et al. 1998). Eggs and larvae have been extensively used in toxicological studies on the effects of chemical contaminants that may impact human health (Harfenist et al. 1989). Skin secretions of some species show promise as antibiotics and as nonaddictive pain killers that are 200 times more powerful than morphine (Stebbins and Cohen 1995). They are important in the control of insect pests such as mosquitoes (Pough et al. 1998). Amphibians are also important reminders of one of the most significant events in the evolution of vertebrate life, the movement into the terrestrial environment some 360 million years ago (Pough et al. 1998). Finally, some species are valuable bioindicators of environmental health because they have highly permeable skin and egg membranes and because they have complex life cycles with both aquatic and terrestrial life history stages that are philopatric to specific breeding, foraging, and overwintering sites connected by habitats suitable for migration (Turner 1957; Duellman and Trueb 1986; Weygoldt 1989; Wake 1991; Olson 1992; Blaustein 1993, 1994; Welsh and Ollivier 1998).

AMPHIBIAN BIOLOGY AND DISTURBANCE REGIMES RELEVANT TO MANAGEMENT DECISIONS

Possibly the most important feature of the biology of amphibians that management plans need to address is that their complex life histories require a complex set of habitats connected by suitable migratory corridors. At higher latitudes all amphibians require suitable breeding/rearing, foraging and overwintering habitats in order to survive (e.g., Turner 1957, Dole 1965; Ewert 1969). Many amphibians require warmer lentic waters with emergent vegetation for breeding/rearing habitat, riparian areas that support large insect populations for foraging habitat, and terrestrial burrows, forest litter, or deep waters that are unlikely to freeze for overwintering habitats (Nussbaum et al. 1983; Stebbins and Cohen 1995). Loss or exclusion from any one of these habitats, or loss of the resources they contain, may cause the species to decline or be extirpated from a local area unless individuals dispersing from nearby areas recolonize (e.g., Hecnar and M'Closkey 1996; Patla 1997). In cases where all 3 of these habitats are present in a relatively small geographic area herpetofauna often do not undergo extensive migrations between overwintering, breeding, and foraging habitats (Sinsch 1990). In these instances, isolated populations may successfully perpetuate themselves unless the specific area is altered by natural succession or anthropogenic activity (e.g., Gulve 1994). In cases where the 3 required habitat types are isolated spatially, herpetofauna are capable of undertaking quite extensive seasonal migrations (e.g., Sinsch 1990; Dodd 1996). In these instances, they are not only dependent on suitable breeding, foraging and overwintering habitats, but are also dependent on habitats suitable for migration (Dodd and Cade 1998). Coupled with the importance of considering all habitat requirements is the importance of considering the extreme philopatry shown by many herpetofauna species to the same breeding, foraging and overwintering sites year after year (Daugherty and Sheldon 1982; Sinsch 1990; Stebbins and Cohen 1995; Pough et al. 1998).

In order to ensure the presence of habitats critical to the survival of amphibians management plans need to consider the disturbance regimes that create and maintain them. Disturbance regimes that create and drive the succession of breeding, foraging, and overwintering habitats used by amphibian species include glaciation, flooding, fire, and the dam building, wallowing, and foraging activities of beaver and other large mammals. The majority of standing water bodies in western Montana and on the plains north of the Missouri River in eastern Montana are the result of Pleistocene glaciation (Alt and Hyndman 1986, 1995). Flooding carves out depressions and eliminates vegetation so that important breeding, foraging, and basking habitats are maintained (Lind et al. 1996; Cavallo 1997). Standing water bodies that are used as breeding and overwintering sites are created and maintained as the result of the dam building and foraging activities of beaver (Donkor and Fryxell 1999; Russell et al. 1999*a*) and the foraging and wallowing activities of large mammals such as moose, elk, and bear (personal observation). Beaver seem to be particularly important in the maintenance of standing waterbodies in western Montana. For example where historic fur trapping has eliminated beaver from some mountain ranges in the central portion of the state many water bodies are approaching their final successional stages as they fill in with sediments (personal observation; Grant Hokit, Carroll College, personal communication). Finally, periodic fires may act to maintain open waters by eliminating vegetation that catches sediment, and may contribute to the amount of downed woody debris that provides habitat for terrestrial amphibians (Russell et al 1999*b*).

RISK FACTORS RELEVANT TO THE VIABILITY OF AMPHIBIAN POPULATIONS

Global Amphibian Declines

In the past few hundred years, increases in human population and our ability to impact natural ecosystems have led to a dramatic increase in the global rate of species extinction (Wilson and Peter 1988). Within this overall biodiversity crisis, evidence has accumulated during the past few decades that amphibians around the globe may be declining at a higher rate than other taxonomic groups (Blaustein and Wake 1990; Phillips 1990; Wyman 1990; Wake and Morowitz 1991; Drost and Fellers 1996; Alford and Richards 2000; Houlahan et al. 2000; but see Pechmann and Wilbur 1994). In North America, amphibian declines have been most numerous in the West and have occurred among species that occupy a variety of elevations, habitat types, and disturbance regimes (Corn 1994).

Seven major factors, and their interaction, have been implicated as causative agents of amphibian declines. These include: (1) loss, deterioration, and fragmentation of aquatic and terrestrial habitats (e.g., Bury et al. 1980; Schwalbe 1993; Van Rooy and Stumpel 1995; Lind et al. 1996; Beebee 1997); (2) introduction of nonindigenous species (e.g., Bradford 1989; Fisher and Schaffer 1996; Gamradt and Kats 1996; Kupferberg 1996; Adams 1997; Hecnar and M`Closkey 1997; Kiesecker and Blaustein 1997*a*); (3) environmental pollutants (e.g., Lewis et al. 1985; Kirk 1988; Beebee et al. 1990; Dunson et al. 1992); (4) increased ambient UV-B radiation (e.g., Blaustein et al. 1994*a*; Blaustein et al. 1995; Kiesecker and Blaustein 1995; Nagl and Hofer 1997); (5) climate change (e.g., Pounds and Crump 1994; Stewart 1995; Pounds et al. 1999); (6) pathogens (e.g., Carey 1993; Kiesecker and Blaustein 1997*b*; Berger et al. 1998; Carey et al. 1999; Daszak et al. 1999; Lips 1999) and (7) human commerce (e.g. Nace and Rosen 1979; Jennings and Hayes 1985; Buck 1997; Pough et al. 1998). Not suprisingly, a majority of these factors have also been implicated as causative agents of the overall decline in biodiversity (Wilson and Peters 1988). Thus, the conspicuous decline of amphibian populations may indeed be a good indication of the declining health of our environment.

In recent years concerns over environmental health have also been raised by the issue of amphibian deformities, an issue that seems to be completely distinct from that of amphibian declines because declines have not been reported in the species and areas where deformities have been found. Most amphibian deformities that have been reported involve missing, deformed, or multiple hind limbs (Bishop and Hamilton 1947; Sessions and Ruth 1990; Ouellet et al 1997; Sessions et al. 1999; Johnson et al. 1999). In Montana missing, malformed, and multiple hind limb deformities have been found in western toads (*Bufo boreas*), Pacific treefrogs (*Hyla regilla*), and Columbia spotted frogs (*Rana luteiventris*) at a few sites in the western portion of the state and have been reported as early as 1958 (Hebard and Brunson 1963; personal observations). Suggested causes of deformities include UVB radiation (e.g., Blaustein et al. 1997), contaminants including pesticides containing retinoic acid (Scadding and Madden 1986; Bryant and Gardiner 1992; Sessions 1999) and infection by a nematode parasite in the genus *Ribeiroia* (Johnson 1999; Kaiser 1999). Currently evidence favors two of these mechanisms, contaminants in the midwestern United States and nematode parasites in the western United States (Souder 2000). The *Ribeiroia* parasite has been documented in populations of the Pacific treefrog and the Columbia spotted frog in western Montana and may be the cause of limb deformities in western toads (Pieter Johnson, Claremont Mckenna College, personal communication). Deformities apparently result from the amphibian larvae's response to the mechanical perturbation of the cysts the parasites form after they burrow through the larvae's body wall because mechanical implants of resin beads result in almost identical deformities (Sessions and Ruth 1990; Johnson et al. 1999) While it is uncertain how long or to what extent this phenomena has occurred, accelerated eutrophication of waters due to organic pollution may cause planorbid snail (the first host of *Ribeiroia*) numbers to rise, thereby increasing the rate of parasite infection and deformities (Johnson 1999).

Montana's 13 native amphibians occupy a diverse array of habitats and vary greatly in their life history patterns (Reichel and Flath 1995; Hart et al. 1998). Furthermore, relatively few studies have investigated the impacts of human activities on amphibians. Thus, identification of all possible impacts on Montana's amphibians, and development of a comprehensive set of guidelines that would mitigate these impacts, are not possible at this time. However, because 60-70% of the predicted ranges of these species are in private lands without any formal protection from conversion of natural habitat types to anthropogenic habitat types (Hart et al. 1998; Redmond et al. 1998) a review of likely impacts is appropriate in order to ensure the viability of these populations on public lands. A review of the scientific literature identified nine major risk factors that may affect the viability of amphibian populations In no particular order they are:

1. Timber harvest
2. Grazing
3. Fire and fire management activities
4. Nonindigenous species and their management
5. Road and trail development and on- and off-road vehicle use
6. Development and management of recreational facilities and water impoundments
7. Harvest and commerce
8. Habitat fragmentation and metapopulation impacts
9. Lack of information / research needs

Specific areas of concern associated with each of these themes and a general set of management guidelines that would allow impacts to be minimized are addressed individually below.

Timber Harvest

The timing and extent of the impacts of timber harvest on Montana's amphibians likely depend on the preferred habitat, physiological adaptations, and dispersal abilities of individual species as well as the spatial, extent, location, and configuration of the harvest, the timing and method of harvest, and the speed of forest regeneration. deMaynadier and Hunter (1995) conducted a thorough review of literature on forest management and amphibian ecology in North America. In 18 studies that examined the effects of clear-cutting on amphibians they found that most amphibians (toads were sometimes an exception) were always present at lower median abundances on 6 month to 40 year old clear-cuts as compared to control plots. However, clear taxonomic differences existed: amphibians in general were 3.5 times greater on control plots; anurans (frogs and toads) were 1.7 times greater; salamanders in general were 4.3 times greater; and plethodontid salamanders were 5.0 times greater. While these reductions in species' abundances may result in some impacts on the food chain, by themselves reductions in abundance may be an acceptable consequence of timber harvest as long as species are able to persist and abundances are not reduced in the long run. Species richness may, therefore, be a more important measure of the impacts of timber harvest because it may indicate the addition or extirpation of species as a result of harvest. deMaynadier and Hunter (1995) found that patterns of species richness between clearcut and control plots across the 18 studies were less conclusive. In most studies species richness values were not changed. However, clear decreases in species richness have been reported by several studies in the Pacific Northwest and most of these indicate the loss of species that are dependent on healthy stream, streamside, or other moist microhabitats. For example, in a study of four streamside amphibians in Oregon and Washington, Corn and Bury (1989) reported that only 1 of 20 streams in logged stands contained all four species as compared to 11 of 23 streams in uncut stands. Furthermore, only 2 of the streams in the uncut stands had fewer than three species, whereas 11 streams in the logged stands had only 1 or no species present. Similarly, a number of other studies in the Pacific Northwest have reported that stream dwelling amphibians such as the tailed frog (*Ascaphus truei*) were absent or found in greatly reduced numbers in clear cuts versus mature or old growth forests, apparently as a result of decreased canopy cover and increased sedimentation (Bury 1983; Bury and Corn 1988; Corn and Bury 1990; Welsh 1990; Welsh and Lind 1988). Finally, it should be noted that many of the negative impacts associated with timber harvest may be associated with the building and maintenance of roads and road traffic (see section on road impacts below). For instance sedimentation of streams has major impacts on stream dwelling amphibians (e.g., Welsh and Lind 1998) and 90% of the sediment runoff from some harvest operations comes from roads (Anderson et al. 1976).

Although positive impacts of timber harvest have rarely been reported there may be some instances in which some amphibian species benefit. For example, in higher gradient streams, Pacific giant salamanders (*Dicamptodon ensatus*) have been documented to increase in the abundance in cut stands, apparently as a result of warmer water temperatures, increased light, and increased insect or salmonid prey (Murphy and Hall 1981; Murphy et al. 1981; Hawkins et al. 1983; Bury and Corn 1988). However, it should be noted that these apparent benefits do not hold for all streams because in lower gradient streams increased sedimentation associated with harvested stands eliminates microhabitats used by Pacific giant salamanders and other stream dwelling amphibians (Connor et al. 1988; Corn and Bury 1989). Depending on the scale of timber harvest positive impacts on individual species may include forest openings that benefit more terrestrial species by creating basking or foraging sites (e.g., Raphael 1988; Kirkland et al. 1996) and the creation of habitat by debris left over from harvest activities. For example, Bury and Martin (1973) and Bury (1983) both found that the clouded salamander (*Aneides ferreus*) was more abundant in second-growth stands, apparently because the species uses crevices and bark under downed timber. In addition, limited removal of forest trees immediately adjacent to standing waters that are used for breeding may enhance the length of time ephemeral wetlands are present by reducing evapotranspiration and may reduce the length of the larval period of many amphibians by increasing solar radiation, thereby ensuring that metamorphosis takes place prior to pond drying (deMayandier and Hunter 1999; Russell et al. 1999*b*). For example, McGraw (1997) found that larval long-toed salamanders (*Ambystoma macrodactylum)* were more abundant in ponds where a fraction of the pond margin was harvested than either ponds whose margins were completely harvested or ponds whose forest margins were completely intact.

Both the taxonomic differences in abundance and species diversity resulting from timber harvest highlight the importance of considering the individual needs of species and indicate that amphibians that rely almost exclusively on moist microhabitats or streams are likely to be the most heavily impacted by timber harvest activities. In Montana forest species that utilize these habitats include the long-toed salamander, the Coeur d'Alene salamander (*Plethodon idahoensis*), the tailed frog, and the Pacific treefrog. Unfortunately, the impacts of timber harvest has only been studied for one of these species in Montana and many of the findings for coastal sites in the Pacific Northwest may not be directly applicable here because of differences in precipitation and forest types. In a study of the long-toed salamander in Douglas-fir forests in the Swan River Valley McGraw (1997) found that areas where overstory removal (250-300 trees harvested per hectare) and new forestry (leave 13-25 dominant tree species per hectare and retain all snags and hardwoods) harvest techniques were applied had less ground cover, higher soil temperatures, and 75% fewer terrestrial salamanders than control plots. He suggested that retention of greater amounts of all types of forest debris and understory vegetation may mitigate these impacts. In their review of the management of the Coeur d'Alene salamander Groves et al. (1996) suggest that the impacts of timber harvest at sites known or likely to support populations be mitigated by: (1) avoiding concentration of harvest activities in headwater subdrainages; (2) using partial cutting that maintains at least 60% canopy cover; (3) ensuring that forest harvest activities provide for recruitment of woody debris; (4) reducing ground disturbance by winter harvesting and using low ground pressure tracked vehicles; (5) carrying out harvest activities during periods of salamander are not active on the ground surface (dry periods in the summer or during the winter); and (6) maintaining 30 meter forest buffers along both sides of all streams. Maintenance of buffer zones around streams has also been suggested by Corn and Bury (1989) (7.6-15.0 meters) and deMaynadier and Hunter (1995) (30-100 meters). A study in the Blue Mountains of Oregon provides evidence that stream buffers do provide protection for tailed frogs in drier forests similar to those found across much of Montana. Bull and Carter (1996) found that the number of tailed frogs was best predicted by a combination of stream substrates and the presence of stream buffers. deMaynadier and Hunter (1995) note that adjusting buffers proportionally to (1) stream width, (2) the intensity of the adjacent harvest, and (3) the slope of the area is likely to result in the most appropriate and efficient application of buffers. Finally, if buffers are applied it is important to ensure that they represent the habitat needs and home range of the animals they are designed to protect (Burke and Gibbons 1995). Unfortunately, information on the home range size of Montana's amphibians is virtually non existent.

<u>Research and Management Suggestions</u>

1. The impacts (both positive and negative) of timber harvest and subsequent forest succession on all amphibians that inhabit Montana's forests should be formally studied using sound experimental designs that gather pre-harvest data as well as a time series of post-harvest data. This should be done for stream and seep dwelling amphibians as well as those that use permanent and ephemeral standing waters.
2. When planning a timber harvest the area impacted by the harvest should be thoroughly surveyed for all amphibian species in order to identify the likely impacts of the harvest activities. Special emphasis should be placed on detecting the presence of Coeur d'Alene salamanders and tailed frogs because of their dependence on moist microhabitats and known sensitivities to timber harvest.
3. Harvested areas should leave 30 meter forest buffers along both sides of all streams (especially headwater streams) in order to prevent sedimentation of streams and desication of moist microhabitats adjacent to streams.
4. Timber harvest should not be allowed in areas that serve as refugia for the Coeur d'Alene salamander because of the species' dependence on moist microhabitats and the fact that populations of this species are usually isolated from one another by long distances, thereby eliminating the opportunity for recolonization.
5. Timber management practices that make use of intensive site preparation, such as plantations, and practices that modify levels of coarse woody debris and other microhabitats should not be used extensively. Harvest practices which minimize the immediate and long-term differences in abundance and distribution of moist microhabitats (e.g., woody debris or undergrowth) between harvested and nonharvested areas are preferred.
6. In areas that prove to be critical breeding, foraging, or overwintering habitat, timber harvest should be limited to periods of inactivity by amphibians (drier periods in the summer or during the winter) and during harvest ground disturbance should be minimized with low ground pressure tracked vehicles.

Livestock Grazing

Livestock grazing is one of the most widespread land management practices in western North America (70% of the western United States is grazed) and has been associated with negative impacts on a variety of plant, invertebrate, and vertebrate taxa (Fleischner 1994). However, studies reporting the impacts of livestock grazing on amphibians are virtually nonexistent. Livestock have been documented to cause the direct mortality of amphibians as a result of trampling. Individual northern leopard frogs (*Rana pipiens*) and woodhouse's toads (*Bufo woodhousii*) have been found crushed at the bottoms of cattle hoove prints at the margins of several wetlands in eastern Montana (personal observation). In some instances trampling can result in severe population-level impacts. For example, after what may have been the first successful reproductive event at a site in southeastern Idaho in 10 years Bartelt (1998) documented the deaths of thousands of western toad metamorphs when 500-1,000 sheep were herded through the drying pond the toadlets were concentrated around. He found that hundreds of animals had been directly killed underfoot and hundreds more died soon afterward as a result of dessication because the vegetation they had been hiding in had been trampled to the point that it no longer provided a moist microhabitat.

Riparian areas often provide critical breeding, foraging, and overwintering habitats and frequently serve as migratory or dispersal corridors for amphibians. These areas are also usually the preferred habitat of livestock (Kauffman and Krueger 1984; Fleischner 1994) so grazing likely has a number of indirect impacts on amphibian populations. In certain areas one possible positive impact may be that mechanical clearing of vegetation opens up basking areas that amphibians require (Bill Leonard, Washington State D.O.T., personal communication; Dick Tracy, University of Nevada at Reno, personal communication). In addition, in some areas livestock defecation and subsequent eutrophication of waters may benefit some amphibian larvae via a bottom-up control of the food web (Reaser 1996). Another possible positive impact of livestock grazing is the increased number of water bodies available to amphibians because of tanks and dams used for watering; assuming the hydroperiod is not long enough to allow exotic or native predators to become established (Scott 1996).

Unfortunately, it is likely that the majority of indirect impacts on amphibians are negative (Jones 1988). For example, contamination of waters through livestock defecation may increase fecal coliform counts and lead to mass mortality events and life history changes such as those documented and suspected, respectively, for the tiger salamander (*Ambystoma tigrinum*) (Worthylake and Hovingh 1989; Pfenning et al. 1991). Furthermore, eutrophication of waters through fecal contamination may cause planorbid snail numbers to rise, thereby increasing the number of nematode parasites and the rate of parasite infection that subsequently lead to limb deformities in amphibians (Johnson 1999). Livestock also cause major changes in the bank structure, substrate composition and vegetation in riparian habitats (Kauffman and Krueger 1984; Fleischner 1994). Elimination of bankside vegetation and collapse of overhanging banks reduces the number of moist non freezing microhabitats that are required by many amphibian species during summer foraging and overwinter periods, respectively. Compaction of soils in the riparian area may eliminate the ability of many species to burrow underground in order to prevent dessication or freezing (Duellman and Trueb 1986; Swanson et al. 1996). The collapse of banks leads to increased sedimentation which has negative impacts on stream dwelling amphibians such as the tailed frog (Kauffman and Krueger 1984; Corn and Bury 1989; Bull and Carter 1996). Loss of bankside willows may result in reduced beaver activity or possibly even the extirpation of beaver; a species whose activities are responsible for the creation of a large portion of amphibian breeding habitats (Donkor and Fryxell 1999; Russell et al. 1999*a*). Grazing may also reduce the number of insect prey that amphibians are dependent on (Fleischner 1994). Finally, a number of amphibian species may be highly dependent on the burrows created by prairie dogs and other small mammals (Reading et al. 1989; Sharps and Uresk 1990; Scott 1996). Loss of prairie dogs as a result of control programs associated with the protection of livestock from injury is, therefore, likely to have major impacts on grassland amphibians.

Research and Management Suggestions

1. The impact of different livestock grazing regimes on amphibian populations should be formally investigated using sound experimental designs.
2. Livestock should be fenced from all or portions of water bodies that are critical breeding habitat in order to prevent mass mortality as a result of disease or trampling at or prior to the time of metamorphosis.
3. Livestock should be fenced from all or portions of riparian areas that provide critical breeding, foraging, or overwintering habitats or that serve as important migratory or dispersal corridors in order to protect these critical areas from damage.
4. Hydroperiods of waterbodies should not be altered in order to provide water for livestock.
5. Prairie dog control efforts undertaken to prevent harm to livestock should be eliminated in order to conserve critical summer refugia and overwintering habitats.

Fire and Fire Management Activities

Although the impacts of fire and fire management activities have been investigated for a number of vertebrates (e.g., Lyon et al. 1978; DeBano et al. 1998), impacts on amphibians have received virtually no attention at all (Russell et al. 1999*b*). Furthermore, the little attention that has been given has been focused on scrub forests in the southeastern United States (Vogl 1973) hardwood and pine forests in the northeastern United States (Kirkland et al. 1996; McLeod and Gates 1998), and chapparal communities in California and Australia (Friend 1993; Gamradt and Kats 1997; Hannah and Smith 1997). The sparse amount of research may in part be due to the belief that the wet areas occupied by many amphibian species act as refugia from fire or that many amphibians are inactive in burrows during the dry season when fires are more frequent. Vogl's (1973) observations of a large breeding chorus of *Hyla crucifer* in a Florida wetland surrounded by still-smoking ashes and Friend's (1993) finding that most Australian anurans (frogs and toads) were inactive in burrows during the dry season support this contention. However, wildfire, prescribed fire, and fire control actions are all likely to have both direct and indirect impacts on amphibians.

Direct mortality of amphibians as a result of fire has been documented in wetlands (Vogl 1973) and the relatively low vagility of many amphibian species (Sinsch 1990) indicates that species that inhabit forest vegetation may face high rates of fire induced mortality (Friend 1993; Russell et al. 1999*b*; Papp and Papp 2000). However, the population-level impacts of direct fire induced mortality have not been examined. Indirect effects of fire may be either positive or negative. For instance, increased sedimentation following a chaparral wildfire in California reduced the number of stream pools and was apparently related to reduced numbers of California newt (*Taricha granulosa*) egg masses (Gamradt and Kats 1997) Furthermore, fire may remove the forest canopy, downed logs, leaf litter, and other structures that create moist microhabitats suitable for amphibians. This may be why both Mushinsky (1985) and McLeod and Gates (1998) found amphibian species present in greater numbers in unburned scrub and pineforest, respectively, relative to adjacent burned areas. However, fire may also have positive indirect effects by creating openings that allow more terrestrial amphibians to bask and forage (Kirkland et al. 1996). Fire may also positively impact amphibian populations by removing vegetation and opening wetlands to an earlier succession stage, thereby enhancing the life of the wetland (Russell et al. 1999*b*). In addition removal of forest trees immediately adjacent to wetlands may enhance the length of time ephemeral wetlands are present by reducing evapotranspiration (Russell et al. 1999*b*) and may reduce the length of the larval period of many amphibians by increasing solar radiation, thereby ensuring that metamorphosis takes place prior to pond drying.

The impacts of prescribed fire and fire management activities have not been investigated, but may present some serious risks to amphibian populations. For instance many of Montana's amphibians are most active on the ground surface during moist periods in the spring and fall (e.g., Turner 1957; Beneski et al. 1986; Hill 1995) when most prescribed burns take place. As these animals migrate between terrestrial and aquatic habitats they may be particularly susceptible to fire because many migrate in mass (e.g., DeLacey 1876) and most remain closer to the ground surface where they may be more easily reached by flames. Fire control activities may also present a risk to amphibians. The large volumes of water required for control efforts may decrease wetland hydroperiods and thereby desicate larvae before they are capable of metamorphoses (Rowe and Dunson 1995; Skelly 1996). Finally, no published studies of the impacts of aerially dropped fire retardant slurries on amphibian larvae were found, but it is reasonable to assume that these retardants may be toxic to amphibian larvae or adults.

Research and Management Suggestions

1. The impacts of wildfire, prescribed burns on terrestrial and aquatic amphibians should be formally investigated so that the impacts of both the timing and magnitude of fire and the subsequent succession of vegetation can be understood.
2. The toxicity of commonly used fire retardants to amphibians should be investigated for both terrestrial and aquatic species and/or life history stages at different periods of time after application.
3. Radio telemetry studies should be conducted for all amphibian species in order to gain a better understanding of how far they migrate to and from aqautic breeding habitats so that the spatial context of the impacts of wildfire, prescribed burns, and fire control efforts can be better understood.
4. Prescribed burns should not be conducted outside of the normal fire season in areas where amphibian species are present as disjunct populations unless research indicates the population is not widely present in habitat that will be impacted by the burn (i.e. on the ground surface or in vegetation that will burn).

Nonindigenous Species and Their Management

Impacts of Nonindigenous Fish

At least 52 species of fish belonging to 14 families have been introduced in Montana (Nico and Fuller 1999; Fuller et al. 1999). Of these species, 9 belonging to 3 families have been widely introduced for recreational fishing and have been implicated in the decline of native amphibians across the globe (Sexton and Phillips 1986; Bahls 1992; Bradford et al. 1993; Bronmark and Endenhamn 1994; Brana et al. 1996; Hecnar and M`Closkey 1997a; Fuller et al. 1999). These species include pumpkinseed (*Lepomis gibbosus*), blue gill (*Lepomis* macrochirus), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieu*) in the family Centrarchidae, yellow perch (*Perca flavescens*) in the family Percidae, and rainbow trout (*Oncorhynchus mykiss*), cutthroat trout (*Oncorhynchus clarki*), brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) in the family Salmonidae. Introductions of warm water centrarchids and percids and cold water salmonids have undoubtedly been made into a number of low-elevation water bodies that support or formerly supported amphibian communities. However, introductions of salmonids at higher elevations, which began as early as the 1880s (Jordan 1891), are likely to have had a particularly important impact on native amphibian communities inhabiting high (>800 meters) mountain lakes because 95% of these lakes in the western United States were naturally fishless prior to stocking (Bahls 1992). Thus, historically, as many as 15,000 lakes at elevations greater than 800 meters in the western United States may have supported native amphibian communities without the threat of predation or competition from fish. Presently, about 9,500 of the West's high-elevation lakes and virtually all of the deeper lakes contain introduced salmonids (Bahls 1992). In Montana, approximately 47% of the state's 1,650 high-elevation lakes now contain nonindigenous salmonids (Bahls 1992).

Egg, larval, and adult amphibians may be subject to direct predation by introduced warm and cold water fishes (e.g.s, Korschgen and Baskett 1963; Licht 1969; Semlitsch and Gibbons 1988; Liss and Larson 1991). Similarly, all 3 amphibian life history stages are likely to be indirectly effected by the threat of predation due to (1) adult avoidance of oviposition sites where predators are present (e.g. Resetarits and Wilbur 1989; Hopey and Petranka 1994), (2) decreased larval foraging and, therefore, growth rates as a result of staying in refuges to avoid predators (e.g., Figiel and Semlitsch 1990; Skelly 1992; Kiesecker and Blaustein 1998; Tyler et al. 1998), and (3) decreased adult foraging, growth rates, and overwinter survival as a result of avoiding areas with fishes (e.g., Bradford 1983).

Impacts of Chemical Management of Sport Fisheries

Rotenone and commercial piscicides containing rotenone have often been used to remove unwanted fish stocks from a variety of aquatic habitats (Schnick 1974). The impacts of rotenone-containing piscicides on amphibians and turtles were recently reviewed by Fontenot et al. (1994) and McCoid and Bettoli (1996). They found the range of lethal doses of rotenone-containing piscicides for amphibian larvae (0.1-0.580 mg/L) to overlap to a large extent with lethal doses for fish (0.0165-0.665 mg/L), and to be much lower than the concentrations commonly used in fisheries management (0.5-3.0 mg/L). Furthermore, they reviewed, a number of studies that noted substantial mortality of nontarget amphibian larvae. However, the effects of rotenone on newly metamorphosed and adult amphibians was found to vary with the degree of each species' aquatic respiration and their likelihood of exiting treated water bodies (Fontenot et al. 1994; McCoid and Bettoli 1996). Hockin et al. (1985) reduced nontarget mortality of amphibian larvae by providing several untreated refuge areas that could be accessed through Netlon fence divisions and by protecting one refuge area containing high densities of amphibian larvae by placing a sheet of hessian sacking soaked in a saturated potassium permanganate solution that neutralized the rotenone. The nontarget effects of another piscicide, antimycin, have apparently not been formally studied, but preliminary observations seem to indicate that antimycin is also toxic to amphibian larvae (Patla 1998). In Montana all amphibian larvae as well as tailed frog adults use some sort of aquatic respiration or may be unlikely to exit treated water bodies depending on the time of day (Daugherty and Sheldon 1982). Thus, all amphibian species are likely to suffer mortality if piscides are applied to waters they inhabit.

Impacts of Nonindigenous Bullfrogs

Bullfrogs (*Rana catesbeiana*) are native to the United States east of a line extending from northwest Wisconsin to south central Texas (Bury and Whelan 1984). However, they have now been widely introduced into permanent waters in all lower forty-eight states, with the possible exception of North Dakota, and have been implicated in the declines of a number of amphibian and reptile species throughout this area (Moyle 1973; Hammerson 1982; Bury and Whelan 1984; Kupferberg 1994; Rosen et al. 1995; Kupferberg 1997; Lawler et al. 1999). The impetus for bullfrog introduction seems largely to be due to their use as a recreational hunting and food item, apparently, in some cases, as a result of native frogs having already declined because of human hunting and consumption (Bury and Whelan 1984; Jennings and Hayes 1985). In Montana, bullfrogs were introduced for unknown reasons into the Bitterroot Valley sometime prior to 1968 and they are now continuously distributed along much of the lower Bitterroot, Flathead, and Clark Fork Rivers as well as a few other isolated localities around the state (Black 1969*a*; 1969*b*; Werner and Reichel 1994; Reichel 1995; Hendricks and Reichel 1996; Werner et al. 1998). Unfortunately, bullfrogs continue to be introduced into new sites from source populations both inside and outside of Montana despite the fact that unauthorized introduction or transplantation of wildlife into the natural environment is prohibited by Montana law (Bryce Maxell, personal observation; Levell 1995; MCA 87-5-711).

All 3 life history stages of amphibians may be subject to direct predation by adult bullfrogs (e.g., Korschgen and Baskett 1963; Carpenter and Morrison 1973; Bury and Whelan 1984; Clarkson and DeVos 1986). Additionally, both the eggs and larvae of native amphibians may be preyed upon by larval bullfrogs (e.g., Ehrlich 1979; Kiesecker and Blaustein 1997*a*). Furthermore, egg, larval and adult amphibians are also likely to be indirectly effected by the threat of predation due to (1) adult avoidance of oviposition sites where predators are present (e.g., Resetarits and Wilbur 1989), (2) decreased larval foraging and, therefore, growth rates as a result of staying in refuges to avoid predators (e.g., Kiesecker 1997; Kiesecker and Blaustein 1998), and (3) decreased adult foraging and growth rates as a result of avoiding areas with bullfrogs. Native amphibian larvae or adults may also be subject to chemically mediated interference competition (e.g., Petranka 1989; Griffiths et al. 1993) or exploitative competition for resources (e.g., Kupferberg 1997). Finally, predators that are dependent on larval or adult amphibians as a food source may also be impacted as a result of the loss of native amphibian larvae and the presence of larger bullfrog tadpoles and adults that they are unable to efficiently forage on (e.g., Kupferberg 1994).

Impacts of Nonindigenous Species as Vectors for Pathogens

Reports of mass mortality of amphibians due to pathogens are increasingly common (e.g., Nyman 1986; Worthylake and Hovingh 1989; Carey 1993; Blaustein et al. 1994*b*; Berger et al. 1998, Carey et al. 1999; Daszak 1999; Lips 1999). Nonindigenous species, such as bullfrogs and other amphibians that are sold in pet stores, and introduced centrarchid, percid, and salmonid fishes, may act as vectors for amphibian pathogens. For example, the chytrid fungus *Batrachochytrium dendrobatidis* is now the primary suspect for amphibian declines in Australia, Central America, and the Western United States, and many amphibians exported to pet stores in the United States come from these areas (Daszak et al. 1999, 2000). Similarly, the water fungus *Saprolegnia*, a common pathogen of fish species reared and released from fish hatcheries, has recently been associated with declines of amphibian populations (Blaustein et al. 1994*b*). Releasing hatchery-raised fish may, therefore, increase the inoculation rate and lead to declines in native amphibian populations. Laurance et al. (1996) suggest that declines in stream-dwelling amphibian populations in Australia are caused by an unknown pathogen and hypothesize that nonindigenous species, such as the cane toad (*Bufo marinus*) and aquarium fish, are responsible for the introduction of the pathogen. Similarly, nonindigenous organisms may change environmental conditions leading to enhanced survival and number of pathogens. For example, Worthylake and Hovingh (1989) found that elevated nitrogen levels, caused by high numbers of sheep, increased bacterial concentrations and lead to periodic mass mortality of salamanders. Finally, pathogens may act synergistically with other natural and anthropogenically caused environmental stressors. For example, Kiesecker and Blaustein (1995) found that an interaction between UV-B radiation and *Saprolegnia* fungus enhanced the mortality of amphibian embryos.

Impacts of Weeds and Weed and Pest Management Activities

Noxious weeds may be spread by the use of off-road vehicles, watercraft, recreational livestock use, and camping activities. There is little knowledge of the impacts that weeds have on amphibian communities. However, nonindigenous aquatic and terrestrial weeds often form dense stands that are likely to exclude native amphibians and enhance the probability of successful introduction of other exotic species. For example, there is some evidence that the survival of exotic bullfrogs is enhanced by the presence of exotic aquatic vegetation, which provides habitat more suitable to the bullfrogs (Kupferberg 1996).

Management of weeds and insect pests with chemical herbicides and pesticides can have major impacts on amphibian communities. In particular, several features of amphibian biology may enhance their susceptibility to chemical contamination (Stebbins and Cohen 1995). The life history of most amphibians involves both aquatic larvae and terrestrial adults, allowing exposure to toxicants in both habitats. Many amphibians have skin with vascularization in the epidermis and little keritinization, allowing easy absorption of many toxicants. In fact, many studies have demonstrated the effects of chemical contamination on amphibians (reviewed in Cooke 1981; Hall and Henry 1992; Boyer and Grue 1995; Carey and Bryant 1995). The effects range from direct mortality to sublethal effects such as depressed disease resistance, inhibition of growth and development, decreased reproductive ability, inhibition of predator avoidance behaviors, and morphological abnormalities.

Currently, there are no requirements for testing the toxicity of herbicides and pesticides on amphibians (Hall and Henry 1992). Furthermore, there are no water quality criteria established for amphibians (Boyer and Grue 1995). It is often assumed that criteria for mammals, birds, and fish will incorporate the protection needed for amphibians. The few chemicals that have been tested with fish and larval amphibians suggest that tadpoles may be more vulnerable to some toxicants than others (Hall and Henry 1992; Boyer and Grue 1995). Several studies have examined the acute (lethal) toxicity of herbicides and pesticides on amphibians. Saunders (1970) and Harfenist et al. (1989) reviewed the effects of 25 and 211 different pollutants, respectively. However, it is important to recognize sublethal effects as well. Johnson and Prine (1976) found that organophosphates affect the thermal tolerance of western toad tadpoles. Polychlorinated biphenyls (PCBs) and organochlorines can disrupt corticosterone production and inhibit glucogenesis (Gendron et al. 1997). Many pesticides result in decreased growth rate and inhibition of a predator response in amphibians (e.g., Berrill et al. 1993; Berrill et al. 1994).

Many of the newer pesticides and herbicides are designed to decompose soon after application. Although still toxic, presumably this reduces the impact area and, thus, the number of exposed individuals. However, many of the older chemicals may still be present in sediments. For example, Russell et al. (1995) found potentially toxic levels of DDT in tissues of spring peepers (*Pseudacris crucifer*) at Point Pelee National Park, Ontario, even though DDT had not been used in the area for 26 years. Levels as high as 1,188 µg/kg were found in spring peepers and implicate DDT as a possible causative agent in the local extinction of several amphibian populations.

Research and Management Suggestions

1. The impacts of introduced fish, bullfrogs, weeds, and pathogens on Montana's native amphibians should be formally investigated.
2. Introduction of nonindigenous fish species should be limited to areas where they have already been introduced and nonindigenous fish should be removed from waters that act as key overwintering or breeding sites for amphibians.
3. Streams and lakes should be thoroughly surveyed for amphibians prior to and after the application of piscicides in order to identify impacts of piscicide application.
4. If lakes are to be treated with piscicides, they should be treated in late summer after most amphibian larvae have metamorphosed and before adults enter deeper water bodies for overwintering. When amphibians are present an effort should be made to remove them before treatments begin.
5. Piscicides should not be used in streams containing tailed frogs because of the possibility of removing multiple larval and adult cohorts. Other methods of removal should be explored in these instances. If piscicide use is the only option available then pretreatment gathering and posttreatment restocking of tailed frog tadpoles and adults should be undertaken and treatment should occur in the late evening hours so that adults are more likely to exit waters.
6. The public should be educated on the possible impacts of bullfrogs on native communities and be made aware of the fact that it is illegal to introduce them into the wild in Montana.
7. Where possible, bullfrog populations should be removed. Removal may be accomplished by altering habitats from permanent waters that support exotic bullfrogs, fish, and aquatic weeds to ephemeral habitats that support native species. Removal may also be accomplished by surrounding waterbodies with a drift fence and subsequently draining the water body in the late fall after bullfrogs have moved into overwintering sites. Individuals can then either be captured by hand or left to dessicate and/or freeze.

8. The Montana state legislature could further prohibit the introduction of bullfrogs by designating them a species that is detrimental to Montana's native flora and fauna (Levell 1995; MCA 87-5-712).
9. Because animals sold in pet stores can act as vectors for pathogens they should be examined and formally certified as free of pathogens such as the chytrid fungus which seems to be responsible for amphibian population declines around the world and in the western United States.
10. The impacts of commonly used herbicides and pesticides on all life history stages of all of Montana's amphibians should be formally investigated. In the meantime herbicide and pesticide use should be limited to brands that rapidly decompose after application, and herbicides and pesticides should not be sprayed within 100 meters of water bodies or wetlands. Alternative methods of weed and pest removal should be used in these areas.

Road and Trail Development and On- and Off-Road Vehicle Use

Road Kill

Many studies have reported large numbers of amphibians killed on roadways. Ehmann and Cogger (1985) estimated that five million reptiles and frogs are killed annually on Australian roads. Thousands of amphibians may be killed in a single population if they undertake a mass migration to or from breeding habitats across a road (e.g., Koch and Peterson 1995; Langton 1989). Wyman (1991, as cited in deMaynadier and Hunter 1995) reported mortality rates ranging from 50.3 to 100% for individuals of three salamander species that tried to cross a paved rural road in New York. Although the number of mortalities reported in road-kill studies is alarming, only a few studies have taken the extra step to demonstrate an impact of such mortality at the population level (e.g., Lehtinen et al. 1999). Vos and Chardon (1998) found that the density of roads within 250 meters of a pond site was negatively associated with the size of moor frog (*Rana arvalis*) populations. Furthermore, the density of roads within 750 meters of a pond site was negatively associated with the probability that the pond would be occupied at all. van Gelder (1973) estimated that 30% of the females from a local breeding population of the common toad (*Bufo bufo*) succumbed to road kill and reported that an equivalent percentage for males was likely. Kuhn (1987, as cited in deMaynadier and Hunter 1995) correlated road use with mortality of common toads, demonstrating that 24-40 cars per hour is sufficient to kill 50% of migrating individuals. Similarly, in a study of frogs and toads, Fahrig et al. (1995) found the proportion of dead-to-live animals increased and the total density of animals decreased with increasing traffic intensity.

Several management options are available to reduce traffic mortality on established roads including culverts or underpasses, temporary road closures during major migrations, reduced speed zones, or relocating roads (Langton 1989; Yanes et al. 1995; Boarman and Sazaki 1996). For example, spotted salamanders (*Ambystoma maculatum*) appear to successfully use culverts (Jackson and Tyning 1989). However, Auiderwijk (1989) reported that less than 4% of a local toad population used culverts installed for their migration. Yanes et al. (1995) suggest that culvert dimensions, road width, height of drift fence, and vegetation along roadways may all influence the effectiveness of culverts. Funnels leading into culverts, lighted culverts, vegetation around culvert openings, and pitfall-trap entrances may all enhance the effectiveness of culverts. Many other suggestions for constructing effective culverts can be found in the studies reported by Langton (1989).

Off-Road Vehicle Impacts

The impacts of motorized vehicles on amphibian populations do not end at the roadside. Although far less studied, impacts from ORVs have been documented. In addition to direct mortality resulting from collisions, ORVs may disrupt habitat to the point that it becomes unusable by herpetofauna (see below). Furthermore, noise from on- and off-road vehicles is also likely to have negative indirect impacts on herpetofauna. For example, Nash et al. (1970) found that leopard frogs exposed to loud noises (120 decibels) remained immobilized for much longer periods of time than a similarly handled control group. Thus, an immobility reaction resulting from noise-induced fear could increase mortality of herpetofauna that inhabit areas used by ORVs or for herpetofauna undertaking road crossings by inhibiting their ability to find shelter or move across a roadway. Although I found no studies documenting the impacts of noise on breeding choruses of amphibians, it is also possible that vehicle noise may not allow amphibians to properly hear and move toward breeding aggregations. This may be especially true for species such as our native Columbia spotted frog and western toad, which do not have loud calls and may not be heard from long distances or in the presence of other noises.

Chemical Contamination and Sedimentation from Roads

Soil disturbance has been directly implicated in both lethal and sublethal effects on amphibians. If not contained, road construction may cause increased sedimentation in adjoining aquatic habitats. Road construction in Redwood National Park introduced large amounts of sediments into neighboring streams and densities of tailed frogs, Pacific giant salamanders (*Dicamptodon tenebrosus*), and southern torrent salamanders (*Rhyacotriton variegatus*) were lower in these streams compared to nearby control streams (Welsh and Ollivier 1998). Similarly, Corn and Bury (1989) reported species richness and abundance to be negatively correlated with the amount of fine sediments for four species of stream amphibians in the Pacific Northwest. The impacts of sedimentation may be further heightened if the sediments contain toxic materials. Road construction in Great Smoky Mountains National Park involved using fill from the Anakeestra rock formation that when oxidized, formed a leachate with sulfuric acid, iron, zinc, manganese, and aluminum (Huckabee et al. 1975, Kucken et al. 1994). Runoff from roadsides and culverts resulted in contamination of streams within the park and 2 stream breeding salamander species were eliminated and 2 other species exhibited a 50% reduction in population size. Declines in macroinvertebrates and fish were also noted. Similarly, disturbance of, and runoff from, mine tailings increased the acidity and heavy metal concentrations in a drainage system in Colorado (Porter and Hakanson 1976). Laboratory bioassays indicated that water in the drainage was lethal for western toad larvae and required a 1000 fold dilution before tadpoles were able to survive. Sublethal effects may also result from heavy metal poisoning (e.g., Lefcort et al. 1998). Deformities in the oral cavity were observed in bullfrog tadpoles exposed to sediments high in arsenic, barium, cadmium, chromium, and selenium (Rowe et al. 1998), and southern toads (*Bufo terrestris*) exposed to coal combustion wastes had elevated levels of stress hormones (Hopkins et al. 1997).

Contaminant runoff from roads or campground surfaces may also affect amphibians. Maintenance of gravel road surfaces with calcium or magnesium chloride or oils in order to control airborne dust and prolong the life of the road surface may present a serious biohazard. Calcium chloride has been associated with mass mortalities of migrating salamanders apparently as a result of dessication caused by the chemical (deMaynadier and Hunter 1995). Petroleum products may also contaminate aquatic habitats next to roadways or may be directly introduced from motorized watercraft. Mahaney (1994) examined the effects of crankcase oil on tadpoles of the green treefrog (*Hyla cinerea*). Concentrations of 100 mg/L inhibited tadpole growth and prevented metamorphosis. Finally, although leaded fuels are no longer a concern Birdsall et al.'s (1986) finding that lead concentrations in frog tadpoles living in roadside ponds and ditches were correlated with daily traffic volumes in Maryland and Virginia demonstrates how contaminant levels are likely to be correlated with traffic volume.

Research and Management Suggestions

1. The impacts of road and trail development, on- and off-road vehicle use, and watercraft use on Montana's amphibians should be formally studied, especially in areas of high human use.

2. Potential road and trail routes should be thoroughly surveyed for amphibians in order to identify impacts of road or trail construction and vehicle use.
3. When possible roads and trails should avoid water bodies, wetlands, and denning sites that are key habitats.
4. When new roads and trails must be constructed near water bodies or wetlands care should be taken to avoid increased sedimentation, maintain the essential hydrographic period, and allow natural processes, such as changes in river courses to continue.
5. Areas identified as key migration routes should either be closed to vehicle use during peak migration periods or culverts and underpasses should be constructed in conjunction with drift fences in order to minimize road mortality.
6. ORV use should be restricted to designated roads, trails, or pit areas.
7. Road and trail development and off-road vehicle use in areas with soils that contain mine tailings or other toxic substances should be prevented. If road and trail construction is absolutely necessary in these areas then reclamation activities should be undertaken prior to road or trail construction.

Development and Management of Water Impoundments and Recreational Facilities

Water Impoundments

The suitability of many water bodies for amphibians depends on their hydroperiod: if ponds dry up to soon, larvae desicate, and if they are too permanent they often attract native and introduced predators that may negatively impact amphibian populations (Scott 1996; Skelly 1996). In some cases water impoundments may create breeding, foraging, and overwintering habitat for amphibians or lengthen the hydroperiod of water bodies in areas that were previously inhospitable (e.g., Cooper et al. 1998). However, in a number of instances, their development can result in the loss of these key habitats. Replacement of ephemeral wetlands or water bodies with small water impoundments often attracts native predators and provides habitat suitable for introduced fish or bullfrogs that may predate and subsequently extirpate amphibians (Scott 1996). Construction of larger impoundments can have a variety of negative impacts. For example, construction of the Jordanelle Reservoir on the Provo River in Utah flooded a large amount of habitat used by Columbia spotted frogs, a species that is threatened in the region (Wilkinson 1996*a*). Water impoundments can also cause downstream riverine habitats to deteriorate as a result of changes in flow regimes. Lind et al. (1996) found that reduced water flows below dams on the Trinity River in California resulted in the loss of flood plain breeding pools and vegetational overgrowth of riparian areas used for basking and foraging by amphibians. Furthermore, manipulation of water levels in water impoundments can result in direct and indirect mortality of amphibian larvae and eggs. For example, during the summer of 1998, fluctuating water levels in Cabinet Gorge Reservoir in northwest Montana led to the dessication of Columbia spotted frog eggs and larvae when water levels dropped for power generation (personal observation). Fluctuations in water levels may also cause a decline in water temperatures as a result of increased water movement. Colder water temperatures may increase mortality by decreasing larval growth rates and increasing the length of the larval life history stage (Wilbur 1980). Colder water temperatures can also result in a decreased immune response, leaving amphibian larvae more susceptible to pathogens (Nyman 1986; Carey 1993; Maniero and Carey 1997). Some factors associated with water level fluctuations may interact in a complex manner resulting in amphibian mortality. For example, Worthylake and Hovingh (1989) describe periodic mass mortality of tiger salamanders caused by interactions between fluctuating water levels, high numbers of sheep, and high levels of a pathogenic bacteria (*Acinetobacter* spp.). High numbers of sheep increased the nitrogen input into the lake and, combined with low water levels, resulted in high nitrogen concentrations that were conducive to the pathogen. Kiesecker and Blaustein (1997*b*) describe another complex interaction. Western toads apparently lay their eggs in one particular portion of an Oregon lake, regardless of the water levels. Low water levels resulted in mass mortality of toad eggs due to the synergistic effect of UV-B radiation and the pathogenic fungus *Saprolegnia*. Moving eggs to deeper waters significantly reduced egg mortality.

Some water impoundments are managed exclusively for waterfowl production. Because many waterfowl and wading birds feed on amphibians and reptiles (Duellman and Trueb 1986), concentrated numbers of waterfowl may lead to increased depredation. Furthermore, high concentrations of migratory waterfowl have been associated with decreased water quality (Manny et al. 1994; Post et al. 1998) and habitat degradation (Kerbes et al. 1990; Ankney 1996). For example, Post et al. (1998) estimated that waterfowl increased nitrogen and phosphorus levels by 40% and 75%, respectively, on Bosque del Apache National Wildlife Refuge in the winter of 1995-1996 and Kerbes et al. (1990) reported that high concentrations of snow geese (*Chen caerulescens*) have lead to destruction of wetland vegetation.

Finally, declines in amphibian populations resulting from water impoundments would also be expected to lead to declines in predators that depend on amphibians as prey (Kupferberg 1994; Koch et al. 1996).

<u>Recreational Facilities</u>

Several aspects of recreational facilities and associated activities may negatively impact amphibians. Amphibian populations in or near recreational facilities are at risk of increased mortality as a result of handling and killing by humans (personal observation). Furthermore, amphibians may become stressed by human handling (e.g., Reinking et al. 1980) and, if translocated to unfamiliar microhabitats, may not be able to find local refugia from predators, or water to rehydrate themselves. Amphibian populations in or near recreational facilities may also face increased mortality as a result of handling and killing by human pets (e.g., Coman and Brunner 1972). In the United States there may be more than 120 million dogs and cats, with as many as 50 million of these being homeless (Denney 1974). In addition, wild predators, including ravens (*Corvus corax*), striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), coyotes (*Canis latrans*), and foxes (*Vulpes vulpes*) may be supported at artificially high numbers around areas of human activity due to the availability of human refuse and a lack of larger predators. Olson (1989) found that ravens at a recreational facility depredated more than 20% of a breeding aggregation of western toads in the Oregon Cascades. Schaaf and Garton (1970) found that raccoons ate at least 50 individuals of a breeding chorus of American toads (*Bufo americanus*). Similarly, Parker et al. (2000) concluded that predator control programs may be necessary to ensure the survival of the federally endangered Wyoming toad (*Bufo baxteri*) after at least 20% of the adult population was depredated in a single event by an unidentified mustelid.

Finally, a number of amphibians breed and forage nocturnally and it is possible that artificial lighting at recreational facilities may negatively impact these activities. For example, large choruses of breeding Pacific treefrogs in western Montana can be rapidly and completely quieted by shining a flashlight across a breeding pond, and calling may not be reinitiated for up to 5 minutes (personal observation). If breeding ponds are subject to constant illumination by a fixed light or repeated exposure to car lights near a recreational facility it is possible that breeding success may be negatively impacted. Similarly, nocturnal foraging behavior of amphibians and reptiles may be impacted by the presence of artificial lights, especially when species depend on extremely dark conditions (e.g., Hailman 1982). Buchanan (1993) found that the ability of nocturnally foraging grey treefrogs (*Hyla versicolor*) to detect and subsequently consume prey was significantly reduced when artificial light sources were present as compared to ambient-light conditions.

<u>Research and Management Suggestions</u>

1. The impact of recreational facilities, water impoundments, and associated human activities on amphibian populations should be formally investigated.
2. Current and potential sites for recreational facilities and water impoundments should be thoroughly surveyed for amphibians to identify potential impacts of these facilities.

3. New recreational facilities should not be located within 300 meters of key breeding, foraging, or overwintering habitats.
4. When past or future water impoundments have eliminated key breeding, foraging, and overwintering habitats, impacts on amphibians should be mitigated by the creation of adjacent water bodies that have deeper areas for overwintering and areas with shallow waters for larval rearing. Furthermore, fish should not be introduced to these water bodies and fluctuations in water levels at these sites should not be correlated with fluctuations in water levels in the adjacent water impoundment.
5. Downstream flows from water impoundments should mimic natural flow regimes in order to maintain flood plain breeding and foraging habitats.
6. Management of habitats exclusively for waterfowl production should be avoided. A multispecies or community approach is preferable.
7. Recreational facilities located near documented amphibian populations should contain educational signs or pamphlets pertaining to the amphibians in the area and how they may be impacted by humans and their pets.
8. If domestic or wild predators are found in high densities in areas with key breeding habitat, predator control programs may be required in order to ensure that native amphibian populations persist.
9. The subsidization of native predators should be minimized by maintaining fully enclosed waste facilities.

Harvest and Commerce

The worldwide collection and harvest of amphibians for food, sport, and commerce as pets, skins, art, souvenirs, and medicinal products is extensive. Hundreds of millions of amphibians are removed from the wild and/or killed each year for these activities and annual worldwide commerce in amphibians may be valued in the hundreds of millions, possibly even billions, of dollars annually (Scott and Siegel 1992; Wilkinson 1996*b*; Buck 1997; Pough et al. 1998). For example, each year the United States imports 1,000 to 2,000 tons of frog legs for human consumption; France imports around 3.4 million tons (Stebbins and Cohen 1995). As another example, the fishing bait industry's use of salamander larvae may be quite extensive with 2.5 million salamander larvae being sold as bait on the lower Colorado River area in 1968 alone (Collins 1981). Finally, pet shops across Montana sell a large number of amphibians annually, including bullfrogs (personal observation).

Unfortunately, we currently do not know the degree to which Montana's amphibians are collected or harvested for biological or commercial purposes. Furthermore, we do not know the extent of the impacts of selling exotic and native amphibians in pet stores. In addition to the possible introduction of exotic predators such as bullfrogs, sales of exotic species from overseas may act as a vector for diseases such as the chytrid fungus which has populations of amphibians to decline or go extinct around the world (Burger et al. 1998; Daszak et al. 1999). Sales of nonindigenous native species can also result in hybridization and genetic introgression with native populations, possibly leading to the elimination of distinct life histories and genetic makeups (Collins 1981). Unfortunately, the state of Montana currently does not have any permit requirements or regulations for the collection, harvest, or possession of wild native amphibians (Levell 1995; MCA 87-5). Thus, biologists and commercial collectors from across the country can collect unlimited numbers of Montana's native amphibians without a collecting permit.

<u>Research and Management Suggestions</u>

1. The degree to which amphibians are harvested and sold in Montana and the impacts of harvesting and selling amphibians should be formally studied.
2. Collecting or harvesting of all amphibians should be regulated and/or monitored by requiring permits to undertake these activities.
3. Because animals sold in pet stores can act as vectors for pathogens they should be examined and formally certified as free of pathogens such as the chytrid fungus which seems to be responsible for amphibian population declines around the world and in the western United States.
4. Collecting or harvesting rare species, such as the Coeur d' Alene salamander, plains spadefoot, western toad, Great Plains toad, and Canadian toad should be regulated by requiring permits in order to prevent declines in these species.
5. A public education program should be undertaken in order to encourage people to enjoy and value native amphibians in the wild.

Metapopulation Impacts

Many of the factors described above may result in the loss of amphibian habitat and the subsequent loss of local populations (e.g., Bury et al. 1980; Rosen et al. 1995; Knapp 1996; Lind et al. 1996; Beebee 1997). However, loss of individual local populations may also influence the persistence of regional populations or metapopulations,even when the total amount of habitat remains constant (e.g., Hanski and Gilpin 1991; Robinson et al. 1992; Simberloff 1993; Fahrig and Merriam 1994). For example, Rosen et al. (1995) found that extirpation of native amphibians in Arizona resulting from the introduction of nonindigenous bullfrogs and fishes into permanent water bodies led to the extirpation of native amphibians from nearby regions when smaller water bodies the natives had been exiled to dried up during a drought. Thus, loss of core habitats that support local source populations can lead to more widespread extirpations. Core habitats for Montana's amphibians are described in the table at the end of the document.

Habitat patch size, shape, isolation, and quality all influence the persistence of regional metapopulations. The size of habitat patches is often associated with the probability that a patch is occupied by amphibian species (e.g., Laan and Verboom 1990; Marsh and Pearman 1997; Fahrig 1998). Patch distribution across a landscape may also greatly influence whether a patch is occupied or not. The degree of patch isolation is often negatively associated with patch occupancy (Sjögren 1991; Vos and Stumpel 1995; Sjögren-Gulve and Ray 1996). Even manipulating the matrix habitat in between habitat patches can influence patch occupancy. For example, Sjögren-Gulve and Ray (1996) found that ditches meant to drain forest areas between frog ponds effectively isolated them even though the distance between ponds had not been altered.

Another complication is that different species respond to patchy landscapes in different ways. For example, Semlitsch (1998) found that six species of *Ambystoma* salamanders varied in their dispersal and use of habitat surrounding ponds. Some species dispersed and used terrestrial habitat up to 250 meters from the pond edge, suggesting that managers need to seriously consider providing extensive buffer zones surrounding water bodies and wetlands. Although knowledge of maximum dispersal and migration distances represents one of the most important pieces of information required to ensure the viability of amphibian metapopulations this information is currently lacking for the majority of Montana's amphibian species. Finally, species may also differ with respect to their response to habitat edges. For instance, demaynadier and Hunter (1998) found that while salamanders, frogs, and toads were all negatively effected by forest edges, salamanders were much more sensitive to abrupt forest edges than frogs and toads.

<u>Research and Management Suggestions</u>

1. The effects of habitat fragmentation should be formally investigated for all amphibian species in Montana. Specifically, the degree to which each species tolerates habitat fragmentation should be identified.
2. Loss or deterioration of overwintering, breeding, foraging, or migration habitats used by various amphibian species should be avoided.
3. When loss or deterioration of overwintering, breeding, foraging, or migration habitat is unavoidable, mitigation measures should be addressed in order to ensure that regional populations are maintained.

4. Radio telemetry studies should be conducted in order to identify common and maximum dispersal and migration distances for all of Montana's amphibian species.
5. Studies should document the demographic vital rates and/or population dynamics of individual populations and metapopulations in order to understand how the dynamics of individual populations and metapopulations are linked to landscape attributes, including elevation, distance between habitat patches, number of habitat patches in a given area, and the physical qualities of individual habitat patches and the matrix habitat between habitat patches.

Inventory and Monitoring Efforts

Several factors currently limit our ability to understand the status of, and detect declines in, amphibian populations around the world and in Montana. These include: (1) a poor understanding of the historic and current distribution of species; (2) a lack of historical or long-term data on changes in habitat occupancy and population size; (3) limited knowledge of the basic biology of species, the dynamics of individual populations, and the spatial habitat requirements of metapopulations; and (4) an insufficient understanding of the effects of various anthropogenic impacts (Pechman and Wilbur 1994). A recent extensive literature review of all published and gray literature on Montana's herpetofauna found these limitations to be especially problematic in Montana (Maxell and Hokit 1999; Maxell et al. In Prep). The lack of knowledge of the distribution, population biology, and status of many of Montana's amphibians coupled with the decline of many amphibian species around the world and in Montana highlights the need to undertake thorough inventories of our public lands, conduct research on the dynamics of individual populations and metapopulations, and establish a regional monitoring program that is capable of detecting future declines if they occur.

Initiation of a regional inventory that, if fully implemented, would establish a baseline presence/non-detection and relative species abundance database for amphibian and aquatic reptile species in up to 1/3 of 6th level hydrological unit code (HUC) watersheds and standing water bodies on U.S. Region 1 National Forests in Montana is currently being coordinated by the Region 1 office in Missoula. These survey efforts utilize a standardized survey protocol and data form, and are being conducted by crews whose sole purpose is to survey for lentic breeding amphibians and aquatic reptiles. Local forest biologists are encouraged to contribute to these inventory efforts after attending a training course to ensure that all surveys are standardized and coordinated with the regional inventory efforts to ensure that surveys are not duplicated. However, regardless of whether local biologists are able to contribute to regional inventory efforts, they are encouraged to survey any and all lentic waters in areas that are of particular local concern or interest. When doing so they are strongly encouraged to use a standardized data form and are also strongly encouraged to enter survey results in the regional inventory database which will be combined with the point observation database at the Montana Natural Heritage Program. A standardized data form for recording survey efforts in lentic waters and a standardized data form for recording incidental observations of amphibians are attached below.

Long-term monitoring of lentic breeding amphibians (see individual species accounts for monitoring Coeur d'Alene salamanders and tailed frogs) is best accomplished by monitoring presence and relative abundance of individuals at the breeding site or by obtaining counts of the number of egg masses present at the breeding site (Olson et al 1997). A regional monitoring program may be established in the near future in order to detect regional changes in the occupancy of lentic habitats by amphibians. If established these efforts would be coordinated by the regional office. However, local biologists are encouraged to initiate annual monitoring programs at sites of concern for all species and for USFS sensitive species such as the Coeur d'Alene salamander, western toad, and northern leopard frog at sites they are known to occupy. Again, attending a training course on the methods used to search for and identify individual species, and using standardized protocols and data forms is essential in order to ensure that all surveys are comparable.

Together inventory and monitoring efforts should allow the distribution and status of Montana's amphibian populations to be better understood. Furthermore, in combination with research on the factors controlling the dynamics of individual populations and metapopulations, these efforts may identify and mitigate possible mechanisms of local and regional population declines. This combination of inventory, research, and monitoring efforts is important to undertake at the present time in light of the loss of wetlands (both actual and functional), recent amphibian declines, and the future increases in anthropogenic impacts that will almost certainly result from the increasing size of the region's human population. While these efforts will be costly, they are likely to be cost efficient in the long run by providing the information needed to manage USFS lands for the continued persistence of wetland breeding amphibians. Without these efforts native amphibians could unknowingly decline to threatened or endangered status and require highly expensive recovery efforts. For example, cost estimates for recovering the Southern Rocky Mountain populations of the western toad are more than one million dollars (Loeffler 1998) and recovery efforts for the Santa Cruz long-toed salamander (*Ambystoma macrodactylum croceum*), are expected to cost more than six and a half million dollars (McLaughlin 1999).

Standardized Data Form for Lentic Breeding Amphibian and Aquatic Reptile Surveys

Date	Observer(s)	GPS Receiver	GPS File	GPS Datum	GPS EPE

Strata Number	HUC Number	Site Number	State	County	Map Name

Locality	T	R	S	Section Description

Owner	Map Elevation FT	UTM Zone:	GPS UTM North	GPS UTM East

Begin Time	End Time	Total Person Minutes of Search	Site Detection: Aerial Photo Topographic Map Incidental

Camera Number	Photo Number(s)/ Description(s)

Weather: Clear Partly Cloudy Overcast Rain Snow	Wind: Calm Light Strong

Air Temp °C	Water Temp °C	Water pH	Color: Clear Stained	Turbidity: Clear Cloudy

Site Description:	Lake/ Pond	Wetland/ Marsh	Bog/ Fen	Stream Backwater/Oxbow	Spring/ Seep	Active Beaver Pond	Inactive Beaver Pond	Site Dry

Water Connectedness: Permanent Temporary Isolated	Water Permanence: Permanent Temporary	Max Depth: < 1 M 1-2 M >2 M

Site Length:	Site Width:	~Site Area:	Percentage of Site Searched: 1-25 25-50 50-75 75-100	Percent of Site at ≤ 50 cm Depth: 0 1-25 25-50 50-75 75-100

Percentage of Site with Emergent Veg: 0 1-25 25-50 50-75 75-100	Percentage of Site with Larval Activity: 0 1-25 25-50 50-75 75-100

Rank Emergent Veg Species in Order of Abundance: ___ Sedges ___ Grasses ___Cattails ___Rushes ___Water Lily ___ Shrubs ___ Other (_________)

Primary Substrate: Silt/Mud Sand Gravel Cobble Boulder/ Bedrock	North Shoreline Characteristics: Shallows Present Shallows Absent Emergent Veg Present Emergent Veg Absent

Site Origin: Glacial Beaver Flooding Manmade Other__________	Human Impacts Or Modifications:

Distance (M) to Forest Edge:	Forest Tree Species in Order of Abundance:			

Survey Method: Visual ID Dip Net Hand Collected Aural ID Other ___________	Amphibian Overwintering Habitat Present? Yes No

Protective Cover From Fish? Yes No	Fish Present?: Yes No Unknown	Fish Species If Identified:	

Fish Spawning Habitat Present? Yes No Unknown	Inlet Width:	Inlet Depth:	Inlet Substrate	Outlet Width	Outlet Depth	Outlet Substrate

Herpetofauna Species Information

Species	Life History Stage	Number of Individuals	Range of Sizes	Comments: Including Museum Voucher Number, Genetic Sample Number, Areas of Highest Density, etc.

Site Map For Lentic Breeding Amphibian and Aquatic Reptile Surveys

Grid Scale:

N↑

*Be sure to indicate water depth profiles and indicate where, and in what direction, photo was taken with → Photo

Other Notes:

Definitions of Variables on Lentic Breeding Amphibian Survey Data Sheet

Site Data

Date: Use MM-DD-YY format (e.g. 05/12/00 for May, 12 of 2000).
Observers: List names or initials of all individuals involved with the survey of this particular site.
GPS Receiver: The equipment identification number on the GPS receiver.
GPS File: If recording differentially correctable GPS files record file name. Otherwise place an "X" in this box.
GPS Datum: The map datum used by the GPS receiver (NAD 27 or 83).
GPS EPE: The estimated position error reported by the GPS receiver in meters.
Strata Number: The sample strata in which the 6^{th} level HUC watershed lies (one of nine defined in western Montana).
HUC Number: The sample number of the 6^{th} level HUC in one of the nine sample strata defined for western Montana.
Site Number: The number preassigned to the water body within each 6^{th} level HUC. If the water body was not preassigned a number because it was not on topographic maps or aerial photos then assign it a sequential number.
State: Use the two-letter abbreviation.
County: Use the full county name.
Map Name: List the name of the USGS 7.5 minute (1:24,000 scale) topographic map quadrangle.
Locality: Describe the specific geographic location of the site so that the type of site is described and the straight line air distance from one or more permanent features on a 7.5 minute (1:24,000 scale) topographic map records the position of the site (e.g., Beaver pond, 1.5 miles south of Elephant Peak and 1.3 miles east of Engle Peak).
T: Record the Township number and whether it is north or south.
R: Record the Range number and whether it is east or west.
S: Record the Section number
Section Description: Describe the location of the site at the ¼ of ¼ section level (e.g. SENE indicates the site is in the southeast corner of the northeast corner of the section).
Owner: Use abbreviation of the government agency responsible for managing the land you surveyed. (e.g. USFS, BLM). If private land was surveyed list the owners full name to indicate that you did not trespass.
Map Elevation: the elevation of the site as indicated by the topographic map in feet (do not use GPS elevation)
UTM Zone: Universal Transverse Mercator zone recorded on the topographic map.
UTM North: Universal Transverse Mercator northing coordinate in meters as recorded on the topographic map.
UTM East: Universal Transverse Mercator easting coordinate in meters as recorded on the topographic map.
Begin Time: List the time the survey began in 24 hour format.
End Time: List the time the survey ended in 24 hour format.
Total Person Minutes of Search: Record the total person minutes the site was searched (e.g. if one person surveys for 15 minutes and another surveys for 30 minutes, but takes 5 minutes to measure a specimen) the total person minutes is 40 minutes).
Site Detection: Was the site present on an aerial photo or topographic map or was it observed incidentally while in the field. Circle both aerial photo and topographic map if the site was present on both.
Camera Number: The equipment identification number on the camera.
Photo Number(s) / Descriptions: The number of the photo as viewed on the camera's view screen and a description of the contents of the photograph.
Weather: Circle weather condition during survey.
Wind: Circle wind condition during survey (> 20 mph winds should be classified as strong).
Air Temp: Record air temperature at chest height in the shade. Record temperature in Celsius. °C = (°F – 32)/1.8
Water Temp: Record water temperature at 2cm depth 1 meter from the margin of the water body or where larvae or egg masses are observed. Record temperature in Celsius. °C = (°F – 32)/1.8
Water pH: Record water pH at the same location water temperature was recorded.
Color: Circle whether the water is clear or stained a tea or rust color from organic acids.
Turbidity: Circle whether water is clear or cloudy.
Site Description: Circle the appropriate habitat type of the site being surveyed.
Water Connectedness: Circle whether the water body has permanent connection to flowing water (Permanent), is connected to flowing water for a temporary period each year (Temporary), or never has a connection to flowing waters or other water bodies (Isolated).
Water Permanence: Circle whether the site contains water throughout the entire year (Permanent), or contains water for only a portion of the year (Temporary).
Max Depth: Circle the category corresponding to the maximum depth of the water body.
Site Length: The length of the longest dimension of the standing water body.
Site Width: The width of the second longest dimension of the standing water body.
Approximate Site Area: The product of site length and site width as defined above.

'ercentage of Site Searched: Circle the percentage of the site surveyed.
'ercentage of the Site at ≤ 50 cm Depth: Circle the appropriate percentage.
'ercentage of Site with Emergent Veg: Circle the percentage of the entire site with emergent vegetation.
'ercentage of Site with Larval Activity: Circle the percentage of the site where amphibian larvae were observed.
tank Emergent Veg Species in Order of Abundance: Record the rank order of abundance in front of the 3 most prevalent mergent vegetation species.
'rimary Substrate: Circle the substrate that covers the majority of the bottom of the site.
Iorth Shoreline Characteristics: Circle whether shallows and emergent vegetation are present or absent from the northern horeline.
ite Origin: Circle whether the site origin is glacial, beaver, flooding, manmade, or describe other processes of creation.
Iuman Impacts or Modifications: Briefly describe if, how, and when the site has been altered by human activities. If the site has ıot been altered record NA for not altered. If multiple anthropogenic impacts exist document all of these using the back of the data heet if necessary.
)istance (M) to Forest Edge: Record the closest distance between the water's edge and the forest margin in meters.
'orest Tree Species in Order of Abundance: List the three or four most prevalent forest tree species in the order of their bundance around the site.
urvey Method: Circle the method or methods used in this survey.
Amphibian Overwintering Habitat Present: Circle whether or not waters would support amphibian overwintering (i.e., would he site have standing water or moving water that would not freeze and would be likely to have adequate oxygen levels).
'rotective Cover from Fish?: Circle whether or not the site contains structural complexities such as boulders, couble, large voody debris or extensive vegetation that would provide refugia for larval or adult amphibians from predatory fish.
'ish Present?: Circle whether or not fish are present at the site.
'ish Species if Identified: List the fish species identified.
'ish Spawning Habitat Present?: Are shallow waters with adequate gravels/cobbles present that would allow fish to spawn?
nlet Width: What is the average width of the inlet stream in meters?
nlet Depth: What is the average depth of the inlet stream in centimeters?
nlet Substrate: What is the primary substrate at the inlet stream (Silt/Mud, Sand, Gravel, Cobble, or Boulder/Bedrock)?
)utlet Width: What is the average width of the outlet stream in meters?
)utlet Depth: What is the average depth of the outlet stream in centimeters?
)utlet Substrate: What is the primary substrate at the outlet stream (Silt/Mud, Sand, Gravel, Cobble, or Boulder/Bedrock)?

Ierpetofauna Species Information
pecies: Record the first two letters of the scientific genus and species names for all amphibian and reptile species found at the site e.g., BUBO for *Bufo boreas*). Use multiple lines if multiple life history stages or size classes are present as described below.
.ife History Stage: Record the life history stage of the species limited to the following life history stages: egg, larvae, metamorph the current season's metamorphs only) or neonate, and adult. For amphibians found during this inventory we will not distinguish ıetween the previous years metamorphs or sexually immature juveniles from sexually mature adults. However size frequency lasses will be distinguished as described below.
Iumber of Individuals: For each species record the number of individuals of each life history stage or distinct size class found.
tange of Sizes: Enter the range of sizes (designate cm or mm) of larvae, metamorphs (the current season's metamorphs only), and dults found at the site. For snakes, lizards, adult salamanders, and all larval amphibians measure or estimate size as the total length TL) of the individual. For turtles measure or estimate size as the carapace length (CL) of the turtle. For metamorph and adult mphibians measure size as the snout-to-vent length (SVL) of the frog or salamander. If two or more distinct size classes of any life istory stage are present at a site use a separate line to indicate the number of individuals in each specific size class for the species.
Comments: Include voucher numbers of specimens preserved as museum voucher specimens (Museum) or tissue samples ıreserved for future genetic analyses (Tissue). Include any notes of interest including breeding aggregations, individuals calling, reas of greatest densities, and interesting behaviors. If necessary use the back of the data sheet for more lengthy commentary.

ite Map for Lentic Breeding Amphibian Surveys
General: Include a rough sketch of the site including the shape of the site and the shape and spatial relations of surrounding biotic nd abiotic features. Include depth profiles of the water body, an arrow indicating the site and direction in which the photo(s) were aken, and any other notes of interest (e.g. areas of highest larval density) on this sketch. Make sure that the orientation of the ketch (i.e. the north arrow) corresponds to the site.
Grid Scale: Indicate the approximate scale of the sketch in meters.
)ther Notes: Include any other notes of interest in this space.

Standardized Data Form for Incidental Observations of Amphibians and Reptiles

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SPECIES ACCOUNTS FOR SPECIES DOCUMENTED IN MONTANA

Long-toed Salamander (*Ambystoma macrodactylum*)

Distribution/Taxonomy

Five subspecies are recognized and range from central California through the Pacific Northwest to southeast Alaska at elevations up to 2,700 M (8,859 ft) (Ferguson 1961; Petranka 1998). Only a single subspecies, the northern long-toed salamander (*A. m. krausei*), occurs in Montana. Their known range in Montana extends west of the Rocky Mountain Front and the Missouri, Jefferson, and Beaverhead Rivers at elevations up to 2,645 M (8,680 ft).

Identification

Eggs:

Laid in clusters of 9-81 (X = 23, SD = 14.5, N = 36 across 5 sites in northwest Montana). Each ovum is black or brown above, white to gray below, and surrounded by two jelly layers. Ovum diameters are approximately 2.5 mm, but total egg diameters, including the two jelly layers, are usually 12-17 mm (Slater 1936).

Larvae:

Translucent, light tan, or black dorsally and laterally with black and gold flecks. White to pinkish ventrally. Three pairs of external feathery gills eminate from the sides of the head with 9-13 gill rakers on their anterior surface (Russell and Bauer 1993). Snout to vent length (SVL) of 10-60 mm.

Juveniles and Adults:

Fourth toe on the hind foot is elongate and longer than the sole of the foot. Incomplete or fully formed yellow, orangish, or reddish dorsal stripe may extend from the tip of the snout to the tip of the tail. Eyelids are the same color as the dorsal stripe. White flecking present on the lateral and ventral surfaces over a black lateral and pink ventral base color. 12-13 costal grooves are present. SVL of 25-80 mm (Russell et al. 1996).

Similar Species:

Adult Coeur d'Alene salamanders have nasolabial grooves and their toes are webbed and shorter than the soles of their feet. See sections on habitat use for differences in habitat used by long-toed and Coeur d'Alene salamanders. Tiger salamander eggs have 3 jelly layers and have total diameters less than 10 mm, including the jelly layers. Larval tiger salamanders have larger heads are usually olive green to silvery white in base color and have 15-25 gill rakers on the anterior surface of their gills (Russell and Bauer 1993). See sections on distribution for geographic areas of possible overlap for long-toed and tiger salamanders.

Habitat Use/Natural History

Adults are found in a wide variety of habitats including semiarid sagebrush, alpine meadows, dry woodlands, humid forests, rocky shores of mountain lakes and disturbed agricultural areas (Nussbaum et al. 1983). Outside of the breeding season adults are primarily subterranean and have been documented to commonly move at least 600 meters from the nearest breeding site on the University of Montana's Lubrecht Experimental Forest (Jennifer Pierson, Wildlife Biology

Program, University of Montana, personal communication). Breeding takes place in temporary or permanent ponds or in quiet water at the edge of lakes and streams. During the breeding season adults may be found in shallow waters or under logs, rocks, and other debris near water. Although individual animals tend to use the same migration routes, no preference in habitat, relative soil moisture or vegetation is evident for the species' movements to and from breeding pools (Beneski et al. 1986). Eggs are attached to vegetation or loose on the bottom at depths up to 0.8 meters. Larvae usually transform at the end of their first summer at low elevations or at the end of their second, third or fourth summer at high elevations and in cold waters at lower elevations (Howard and Wallace 1985; personal observation). Larvae and adults feed on a variety of aquatic and terrestrial invertebrates and larvae feed on other amphibian larvae including conspecifics (Farner 1947; Anderson 1968; Walls et al. 1993; personal observation).

<u>Status and Conservation</u>

Long-toed salamanders are the most widely distributed and common amphibian species west of the Continental Divide with larvae being found in most fishless standing waterbodies with adjacent soils that provide suitable terrestrial habitat (i.e., sites that are not surrounded by extensive areas of bare rock). Their status in the front ranges east of the Continental Divide is uncertain. Risk factors relevant to the viability of populations of this species are likely to include all the general risk factors described above with the exception of harvest and commerce. Individual studies that specifically identify risk factors or other issues relevant to the conservation of long-toed salamanders include the following. (**1**) A number of studies have found adverse impacts of introduced fish on long-toed salamanders. Funk and Dunlap (1999) found that trout effectively excluded salamander populations from lakes in the Bitterroot Mountains. However, when fish went extinct in lakes that did not have spawning habitat salamanders were able to recolonize some of them over a twenty year time period. In the Palouse region of northern Idaho Monello and Wright (1999) found the presence of long-toed salamanders to be highly negatively correlated with the presence of a variety of fish species, including largemouth bass, bluegill, channel catfish, and goldfish. Tyler et al. (1998*a*) found a similar pattern in North Cascades National Park and found that nitrogen levels were positively correlated with salamander densities in fishless lakes, apparently an indication of bottom up limitations on the food web. Similarly, long-toed salamanders in the central and northern portion of the Sierra Nevada Mountains are largely restricted to fishless lakes (Bradford and Gordon 1992 as cited in Knapp 1996). Tyler et al. (1998*b*) found that when rainbow trout were stocked in experimental ponds with long-toed salamanders, larval survivorship was lower and larval body lengths were smaller than in control ponds without fish, supporting the theory that introduced trout not only impact salamanders through direct predation, but also indirectly by increasing refuge use and, thereby, reducing foraging time. (**2**) In a study of the long-toed salamander in Douglas-fir forests in the Swan River Valley McGraw (1997) found that areas where overstory removal (250-300 trees harvested per hectare) and new forestry (leave 13-25 dominant tree species per hectare and retain all snags and hardwoods) harvest techniques were applied had less ground cover, higher soil temperatures, and 75% fewer terrestrial salamanders than control plots. Interestingly, he also found that larvae were more abundant in ponds where a fraction of the pond margin was harvested than either ponds whose margins were completely harvested or ponds whose forest margins were completely intact. (**3**) Tallmon et al. (2000) found that gene flow among populations in the Bitterroot Mountains is greater between populations on the same mountain ridge than between populations on adjacent mountain ridges, indicating that drainages between ridges act as more of a barrier to dispersal than the steep terrain on the ridge itself. The dominance of terrestrial dispersal is also supported by the genetic analyses of Howard and Wallace (1981). (**4**) Fukumoto and Herrero (1998) documented mortality of a minimum of 1-2% of the adult breeding population as they crossed a roadway to the breeding site in Waterton Lakes National Park in Alberta. However, the authors suggest that actual mortality may have been considerably higher, contributing to the unusual 3:1 female biased sex ratio observed at the breeding site. (**5**) Blaustein et al. (1994) found that the species has low levels of photolyase, an enzyme that repairs UV-B radiation damage to DNA. Blaustein et al. (1997) subsequently found that only 14.5% of embryos exposed to 94% of ambient UV-B radiation survived to hatching as compared to 95% survival for larvae exposed to only 10% of ambient UV-B radiation. Together these findings suggest that enhanced UV-B radiation from thinning of the ozone layer may be impacting salamander populations now or will impact them at some time in the future. (**6**) Sessions and Ruth (1990) found that cysts of a trematode parasite apparently caused limb deformities at the site of the cyst. This parasite has now been found in larvae collected in Montana (Pieter Johnson, Claremont Mckenna College, personal communication). (**7**) The extent of the use of larval long-toed salamanders as fishing bait is unknown in Montana, however the species is known to be used in large numbers in other states (Collins 1981) so this practice does have the potential to impact populations in Montana. Accidental introduction of larvae being used for bait may result in hybridization and genetic introgression, possibly leading to the elimination of distinct genetic makeups (Collins 1981). (**8**) Bradford et al. (1994) found that the LC_{50} pH for Pacific treefrog embryos and hatchlings exposed for 7 days averaged 4.3 and that pH levels greater than or equal to 5.0 had no significant lethal or sublethal effects.

Research and Management Suggestions

1. See research and management suggestions under all of the general risk factors described above with the exception of harvest and commerce.
2. Additional information is needed on their distribution east of the Continental Divide, especially in southwest Montana. Documentation of their presence along the upper Clark Fork River and in the Pioneer and Beaverhead Mountain Ranges is poor and their presence in the southern Boulder Mountains and the Highland and Tendoy Mountains is uncertain.
3. Local and landscape wide impacts of fish introductions should be examined in order to develop fish stocking guidelines that will allow for the persistence of individual populations and connectivity between sets of local populations or metapopulations.
4. Fish stocking at both high and low elevation sites should only be carried out where fish have previously been stocked and in areas where they are contained in a limited number of water bodies (i.e., introduction in one lake in a basin will not result in the colonization of other lakes in the basin).
5. Fish removal should be considered in areas that appear to be key habitats that ensure the survival of local sets of populations.
6. The practice of using salamander larvae as fishing bait should be banned in order to protect the genetic makeup of native populations.

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Tiger Salamander (*Ambystoma tigrinum*)

Distribution/Taxonomy

The systematics of the tiger salamander species complex are under debate, but most authorities recognize 7 varieties which range from the Atlantic Ocean to the Great Basin and Columbia Plateau and from central Mexico to central Canada at elevations up to 3,350 M (11,000 ft) (Gehlbach 1967; Shaffer and McKnight 1996; Irschick and Shaffer 1997; Petranka 1998). Although the edge of the range of the gray tiger salamander, *Ambystoma t. diaboli*, approaches the northeastern corner of Montana, only a single subspecies, the blotched tiger salamander, *Ambystoma t. melanostictum*, is currently known to occur in the state. In Montana they are known to range across the prairies and, in some places, into the mountains to the east of the Continental Divide. In addition, *A. tigrinum* have recently been documented at a number of sites in the Tobacco Valley of northwestern Montana (Werner and Reichel 1996). It is not known whether this is a naturally occurring disjunct population, or whether their presence is the result of human introduction. In Montana they have been documented at elevations up to 2,538 M (8,328 ft) (Micken 1971), but are likely to occur up to the 2,800 M (9,186 ft) reported in both northwestern Wyoming (Koch and Peterson 1995) and Alberta (Russell and Bauer 1993).

Identification

Eggs:

Laid singly or in small linear clusters. Each ovum is black or brown above, light gray below, and surrounded by three jelly layers (Micken 1968). Ovum diameters are 2-3 mm, but total egg diameters, including the three jelly layers, are 7-9 mm (Micken 1968; Tanner 1971; Kaplan 1980).

Larvae:

Color is variable, but usually olive green dorsally and silvery white ventrally. Three pairs of external feathery gills eminate from the sides of the head with 15-25 gill rakers on their anterior surface (Russell and Bauer 1993). SVL of 5-98 mm. (Kaplan 1980; Hill 1995).

Juveniles and Adults:

Color is variable. Commonly mottled dorsally with green, yellow, or tan patches on a brown or black background, but some may be uniformally dark in color (Koch and Peterson 1995). Venter gray. 12-13 costal grooves are present. SVL of 70-90 mm (Russell and Bauer 1993).

Similar Species:

Long-toed salamander eggs have 2 jelly layers and have diameters greater than 10 mm, including the jelly layers. Larval long-toed salamanders have smaller heads and are translucent, light tan, or black dorsally and laterally with black and gold flecks. In addition, larval long-toed salamanders are white to pinkish ventrally and have 9-13 gill rakers on the anterior surface of their gills. See sections on distribution for geographic areas of possible overlap for tiger and long-toed salamanders.

Habitat Use/Natural History

Adults are found in virtually any habitat, providing there is a terrestrial substrate suitable for burrowing and a body of water nearby suitable for breeding. Terrestrial adults usually remain underground, in self-made burrows or in those made by rodents or other animals (Koch and Peterson 1995; Madison and Farrand 1998). Breeding takes place soon after snow melt at sites ranging from clear mountain ponds to temporary, manure-polluted pools in the lowlands. Breeding sites almost always lack predatory fishes (Micken 1971; USFWS 1964-1982; Baxter and Stone 1985; Hill 1995). Adults may migrate several hundred meters between terrestrial burrows and breeding habitats (Koch and Peterson 1995). Migrations usually occur nocturnally around the time of precipitation events when minimum daily temperatures are greater than zero degrees celsius (Hill 1995). Eggs are attached to submerged objects at shallower depths. Larvae may transform at the end of their first summer if the growing season is long enough, but may remain larvae for a second or third summer at high elevations in cold waters (Micken 1968; Hill 1995). Metamorphosed adults may spend extensive periods of time feeding in ponds after breeding. Stays of up to 159 days have been documented in Montana (Hill 1995). In some instances larvae may become sexually mature (paedogenesis) and reproduce without transforming (Micken 1968; Hill 1995). In the water larvae and adults feed on a variety of aquatic and terrestrial invertebrates and some larvae and paedomorphic adults feed on other amphibian larvae including conspecifics (Dodson and Dodson 1971; Pfenning et al. 1991). On land terrestrial adults may feed on a variety of invertebrates or even small mammals (Moore and Strickland 1955; Petranka 1998).

Status and Conservation

Tiger salamanders are widely distributed and common on the prairies east of the main Rocky Mountain chain with larvae being found in the majority of fishless ponds with adjacent soils that have not been plowed or otherwise heavily modified. However, their status in the mountains and mountain valleys east of the Continental Divide is largely uncertain. Risk factors relevant to the viability of populations of this species are likely to include grazing, nonindigenous species and their management, road and trail development and on- and off-road vehicle use, development of water impoundments, and habitat fragmentation, all as described above. Individual studies that specifically identify risk factors or other issues relevant to the conservation of tiger salamanders include the following. (**1**) A number of studies in the western United States over the past five decades have documented the almost complete exclusion of tiger salamanders from waters were predatory fish have been introduced (Blair 1951; Carpenter 1953; Levi and Levi 1955; USFWS 1964-1982; Collins et al. 1988; Geraghty 1992; Corn et al. 1997). Furthermore, at least two studies have documented multiple extinction and recolonization events by tiger salamanders as a result of the introduction, subsequent natural and human caused extinction, and subsequent reintroduction of trout in lakes in Yellowstone and Rocky Mountain National Parks (USFWS 1964-1982; Corn et al. 1997). Even larger larvae, or reproductively mature adults that fish are unable to prey on because of gape limitations are likely to be negatively impacted as a result of fish stocking because the diets of fish and salamanders largely overlap one another (Olenick and Gee 1981). (**2**) Hamilton (1941) reports that the piscicide rotenone has an LC_{50} value (i.e., causes 50% mortality) for metamorphosing tiger salamander larvae when 5% rotenone is applied at 0.1 mg/L for 24 hours. (**3**) The use of larval tiger salamanders as bait for sport fishing may have major impacts on tiger salamander populations and the entire aquatic community at both the site of collection and introduction because of there status as a top level predator in many aquatic communities (Holomuzki and Collins 1987; Holomuzki et al. 1994). Furthermore, introduction can result in hybridization and genetic introgression with native populations, possibly leading to the elimination of distinct life histories and genetic makeups (Collins 1981; Collins et al. 1988).

The bait industry's use of salamander larvae may be quite extensive. For example, the average number and wholesale value of tiger salamander larvae in South Dakota wetlands was estimated at 35,625 and $1,614 per hectare, respectively, in 1989 (Carlson and Berry 1990) and Collins (1981) notes that in 1968 2.5 million salamander larvae were sold as bait on the lower Colorado River area alone. (**4**) Mass mortalities of tiger salamanders have been observed in agricultural landscapes in eastern Montana (personal observation). Worthylake and Hovingh (1989) documented the recurring mass mortality of tiger salamanders in lakes contaminated with nitrogen from atmospheric pollution and the feces of sheep. The lakes were previously nitrogen limited and increased nitrogen levels allowed bacterial counts to increase in the summer leading to the mass mortality events. Pfenning et al. (1991) propose that contamination of waters through livestock defecation may alter life histories of tiger salamanders by limiting the number of cannibal morphs. Cannibal morphs may be more likely to spread pathogens as a result of eating infected conspecifics. Eutrophication of waters through fecal contamination may also cause planorbid snail numbers to rise, thereby increasing the number of nematode parasites and the rate of parasite infection that can subsequently lead to limb deformities (Bishop and Hamilton 1947; Johnson 1999). Finally, although they have not been linked to water quality, a number of recent mass mortality events have been caused by an iridovirus in the genus, *Ranavirus* (e.g., Bollinger et al. 1999). (**5**) Disturbance of terrestrial habitats by plowing and deep raking has been identified as a serious threat to a closely related species, the California tiger salamander (*Ambystoma californiense*) which as recently been emergency listed as a federally endangered species (Herpetological Review 31(2):68). (**6**) Lefcort et al. (1997) found that waters contaminated with motor oil and silt resulted in decreased growth and survival rates of tiger salamander larvae as well as decreasing their ability to detect predators. (**7**) Kiesecker (1996) and Whiteman et al. (1995) documented reduced growth rates, survival rates, predatory success rates, in waters with lower pH (< pH 5.0). Harte and Hoffman (1989) hypothesized that acid precipitation, in the form of an acidic pulse during snow melt, had killed salamander embryos and caused a decline of a population of tiger salamanders in central Colorado from 1982 to 1987. However, this population has now apparently recovered (Wissinger and Whiteman 1992), and there is little evidence that either chronic or episodic acidification occurs in this area at levels sufficient to directly kill embryos (Corn and Vertucci 1992; Vertucci and Corn 1994; Vertucci and Corn 1996). However, lower pH levels resulting from acidification could act synergistically with pathogens or other contaminants to cause population declines as a result of reduced function of their immune systems (Carey et al. 1999).

Research and Management Suggestions

1. See research and management suggestions under all of the general risk factors described above with the exception of timber harvest, fire and fire management activities, and harvest and commerce.
2. At the present time it is unknown whether or not they inhabit much of the region between Great Falls and the Idaho border south of Dillon.
3. Systematists should be contacted regarding the genetic makeup of the isolated population in the Tobacoo Valley near Eureka. If their presence in this region is the result of human introduction, control efforts may be required in order to protect local long-toed salamander populations from this superior predator/competitor. If they are a truely disjunct population, some conservation efforts may be justified in order to ensure their persistence.

7. Local and landscape wide impacts of fish introductions should be examined in order to develop fish stocking guidelines that will allow for the persistence of individual populations and connectivity between sets of local populations or metapopulations.
4. Fish stocking at both high and low elevation sites should only be carried out where fish have previously been stocked and in areas where they are contained in a limited number of water bodies (i.e., introduction in one lake will not result in the colonization of other nearby lakes).
5. Fish removal should be considered in areas that appear to be key habitats that ensure the survival of local sets of populations. Piscicide use in waters known to contain tiger salamanders should be limited to the late fall after most of the year's metamorphosis has taken place and adults have migrated to terrestrial overwintering sites.
6. The practice of using tiger salamander larvae as fishing bait should be banned in order to protect the genetic makeup of native tiger salamander populations they may interbreed with or other native communities they may alter as a top aquatic predator.
7. The extent and impact of agricultural runoff and contaminants from roads should be investigated in order to identify the effects on larvae or aquatic adults, especially in areas where mass mortality events have been observed.
8. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.

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Coeur d'Alene Salamander (*Plethodon idahoensis*)

Distribution/Taxonomy

The Coeur d'Alene salamander is a distinct species inhabiting the northern Rocky Mountains in northern Idaho, northwest Montana, and southeastern British Columbia at elevations up to 1,550 M (5,086 ft) (Howard et al. 1993; Petranka 1998; Wilson et al. 1997; Wilson and Larsen 1998). In Montana they have been documented at isolated localities in a narrow band west of the Bitterroot River, Salish Mountains, and Lake Koocanusa from Sweathouse Creek in the Bitterroot Valley to just north of the town of Yaak near the Canadian border. However, given the paucity of surveys that have been conducted, it is likely that their range extends further south on the west side of the Bitterroot Valley and all the way to the Canadian border. In Montana they have been documented at elevations up to 1,524 M (5,000 ft) (Wilson and Simon 1987) but a biogeographic analysis indicates that they may be found up to 1,800 M (5,906 ft) at the southern end of their range (Wilson and Larsen 1998).

Identification

Eggs:

Eggs are unlikely to be encountered because they are apparently laid in moist subterranean fractured rock sites (Lynch 1984). Laid in clusters of up to 13 eggs (Lynch 1984). Eggs are cream colored, around 5 mm in diameter, and surrounded by two jelly capsules (Larson et al. 1998).

Larvae:

There is no larval stage. Instead juveniles hatch directly from eggs.

Juveniles and Adults:

Toes are slightly webbed and shorter than the soles of the feet. A greenish-yellow, orange, or red dorsal stripe may extend from the tip of the snout to the tip of the tail and a yellowish throat patch is present. Eyelids are the same color as the dorsal stripe. White flecking is present on the lateral and ventral surfaces over a black base color. 14-15 costal grooves are present. SVL of 18 to 64 mm (Lynch 1984).

Similar Species:

Adult long-toed salamanders do not have nasolabial grooves, their toes are not webbed, and the fourth toe on their hind feet is longer than the soles of their hind feet. See sections on habitat use for differences in habitat used by long-toed and Coeur d'Alene salamanders.

Habitat Use/Natural History

Coeur d'Alene salamanders respire through their skin and lose water to the environment through evaporation. They are therefore restricted to cool, damp environments (Spotila 1972; Feder 1983). Habitats are limited to springs or seeps, waterfall spray zones and damp streambanks in talus or fractured rock sites, usually with a forest canopy cover (Wilson et al. 1997). The species is found in conjunction with both persistent and intermittent surface waters, but depends on the presence of stable subterranean water flows which can be accessed through rock fractures or talus (Groves et al. 1996; Wilson et al. 1997). Adults are usually above ground only at night during moist weather when temperatures are greater than 7 degrees Celsius (Wilson and Larsen

1988). Surface activity is negatively correlated with high daytime temperatures and days since last rain (Wilson and Larsen 1988). Adults breed terrestrially in late summer, fall, and, to a lesser extent, in the spring (Lynch 1984; Lynch and Wallace 1987). Females deposit eggs in April or May, presumably in underground rock crevices, although no nest sites have been found in the wild (Lynch 1984). Juveniles emerge directly from the eggs in mid-September (Lynch 1984). Juveniles and adults prey on a variety of small aquatic or semi-aquatic invertebrates found in the habitats used by Coeur d'Alene salamanders (Wilson and Larsen 1988; Lindeman 1993).

Status and Conservation

Coeur d'Alene salamanders have only been documented at approximately 50 localities in Montana, with virtually all populations isolated by miles of unsuitable habitat that cannot be crossed. Populations that have been documented appear to remain healthy as long as their microhabitats are not disturbed. Risk factors relevant to the viability of populations of this species are likely to include timber harvest, fire and fire management activities, road and trail development and maintenance, on-road vehicle use, development of water impoundments, and the isolation of individual populations as described above. Individual studies that specifically identify risk factors or other issues relevant to the conservation of Coeur d'Alene salamanders include the following. (**1**) (Wallace 1986) found that populations separated by 60 miles had little if any gene flow and concluded that current gene flow was not sufficient to maintain interpopulation similarity. In other words individual populations that are separated from others by several miles may be on separate evolutionary trajectories because there is no gene flow given the dry intervening habitats which do not allow individuals to disperse. (**2**) Cassirer et al. (1994) and Groves et al. (1996) both thoroughly review potential risk factors relevant to the viability of Coeur d'Alene salamander populations and give details on how these potential risk factors can be mitigated through management actions. Both of these manuscripts should be consulted closely, but their recommendations are briefly summarized below. (**3**) In a conservation assessment completed for and partially sponsored by the Region 1 USFS office Cassirer et al. (1994) give details for inventorying for and monitoring Coeur d'Alene salamander populations in all Region 1 National Forests in which they have been documented. However, their inventory and monitoring suggestions were never initiated.

Research and Management Suggestions

1. Additional surveys are needed in order to document the extent of the species northern, eastern, and southern range limits in the state and identify additional sites the species occupies within its known range so that these sites can be adequately protected.
2. The extent of recent and past levels of gene flow between what now seem to be highly isolated populations should be investigated at the local and regional scale in order to identify the conservation implications of the loss of individual populations or groups of populations.
3. Areas considered for timber harvest, prescribed burning, road or trail development and management, development of water impoundments, or application of chemicals should be thoroughly surveyed as outlined in Cassirer et al. (1994) and Groves et al. (1996) in order to identify any suitable habitat and/or the presence of a population.
4. The research and management suggestions outlined in Cassirer et al. (1994) and Groves et al. (1996) should be followed in order to understand and mitigate the impacts of the risk factors listed above. Briefly, they encourage leaving a 30 meter forest buffer around known sites,

leaving a 100 meter buffer for roads that are to be placed upstream of known sites, conducting control burns in July and August when salamanders are inactive above ground, conducting logging activities in July, August, or November through March when salamanders are inactive above ground, avoiding applications of herbicides, pesticides, or chemicals used on roads near known sites, and monitoring sites annually at least one year prior to and three years after a management activity.

5. Previously documented sites, especially those near areas of human activity, should be monitored annually, possibly as part of an experiment designed to identify the cause and effect relationship between various human activities and the status of salamander populations (see Cassirer et al. 1994).

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Rocky Mountain Tailed Frog (*Ascaphus montanus*) = (*Ascaphus truei*)

Distribution/Taxonomy

The taxonomy of tailed frogs is about to be revised. Until recently tailed frogs have been recognized as a single species with a disjunct distribution that includes a coastal population ranging from northwestern California to southwestern British Columbia separated by hundreds of miles from a Rocky Mountain population that includes isolated populations in the Blue, Wallowa and Seven Devils Mountains and a more continuous population that ranges from central Idaho to the southeast corner of British Columbia (Metter 1968). However, allozyme and mitochondrial DNA analyses indicate that the Rocky Mountain and coastal populations differ to the extent that designation of separate species is warranted (Daugherty 1979; Nielson and Lohman 2000; Marilyn Nielson, University of Idaho, personal communication). Populations in the Rocky Mountains and those in the Blue, Wallowa and Seven Devils Mountain Ranges are now recognized as the Rocky Mountain tailed frog (*Ascaphus montanus*) (Mittleman and Myers 1949; Marilyn Nielson, University of Idaho, personal communication). Across their entire range Rocky Mountain tailed frogs are known to occur at elevations up to 2,590 M (8,500 ft) (David Pilliod, Idaho State University, personal communication). In Montana they have been documented west of the Rocky Mountain Front and the upper Clark Fork, Jefferson, and Beaverhead Rivers at elevations up to 2,270 M (7,450 ft). However, it is likely that they will be found up to treeline at higher elevations in the southwest corner of the state (Nussbaum et al. 1983).

Identification

Eggs:

Laid in a jelly string as a globular mass containing 28 to 86 eggs (Noble and Putnam 1931; Franz 1970*a*). Each ovum is creamy white and surrounded by two jelly layers which themselves lie within the outer jelly string (Franz 1970*a*). Ovum diameters are approximately 4-5 mm in diameter, but total egg diameters, including the three jelly layers, are approximately 6-7 mm (Metter 1967; Adams 1993). Clutches from multiple animals may be laid together in the same nest site (Adams 1993).

Larvae:

Base color is variable from solid black, to gray, to solid brown. White flecks may be present and most larvae have a white tail spot (Metter 1967). A large sucking disk is present around the mouth. The spiracle is mid-ventral and opens under a flap (Metter 1968). Total length (TL) of 10-64 mm (Metter 1967; Franz 1971).

Juveniles and Adults:

Pupil of the eye is vertical. Lacks external ear drums (tympanums). The cloaca of males opens into a tear-shaped copulatory organ (the "tail"). Skin is a granulated texture. Base color is brown, reddish brown, or olive gray with yellow and gray mottling dorsally and a dark eye stripe. Ventrally cream to pinkish. SVL of 20 to 57 mm (Daugherty 1979; Daugherty and Sheldon 1982*a*).

Similar Species:
None. No other adult anuran species lack external ear drums (tympanums). No other larval anuran species have a large sucking disk around the mouth or are found in small swift streams.

Habitat Use/Natural History

Found in small (≤ 4.5 meters width), fast permanent forest streams with clear, cold water, cobble or boulder substrates, and little silt (Franz and Lee 1970; Franz 1971; Welsh 1990). In Montana, adults usually remain underwater hidden by rocks or debris and emerge at night or during humid weather from May to September to feed terrestrially along stream edges (Daugherty and Sheldon 1982*a*). Adults are highly philopatric, but are known to forage up to 75 meters away from water in Montana (Daugherty and Sheldon 1982*b*; personal observation). However, they may range farther from water in wetter areas because Gomez and Anthony (1996) found them in pitfall traps 200 meters from streams in the Oregon Cascades and Corn and Bury (1990) found juveniles and adults ranging more than 300 meters from the nearest stream west of the Cascade Mountains in Oregon and Washington. At high elevations in Montana adults and juveniles have been found to be active diurnally in warmer standing water bodies 50-75 meters away from streams during warm dry weather (personal observation). In Montana adults breed via internal fertilization in streams in August or September and females deposit eggs under large stones in areas with slight current the following June or July (Franz 1970*a*; Daugherty and Sheldon 1982*a*). Eggs hatch in August or September and tadpoles cling to the undersides or tops of smooth rocks which lack periphyton or silt (Nussbaum et al. 1983). Tadpoles usually metamorphose in the third summer after hatching and adults reproduce for the first time four or five years after metamorphosis; females reproduce in alternate years thereafter (Daugherty and Sheldon 1982*a*). Larvae feed mostly on diatoms, but also algae and small aquatic insects (Franz 1970*b*). Adults feed on a variety of aquatic and terrestrial invertebrates (Metter 1964).

Status and Conservation

Tailed frogs are widely distributed and common west of the Continental Divide in smaller streams that have adequate amounts of cobble substrates. Their status in the front ranges east of the Continental Divide is uncertain. Risk factors relevant to the viability of populations of this species are likely to include all the general risk factors described above (especially those which change stream morphology, and increase sedimentation and water temperature), with the exception of harvest and commerce. Individual studies that specifically identify risk factors or other issues relevant to the conservation of tailed frogs include the following. (**1**) Although the impacts of timber harvest have not been studied in Montana, numerous studies have documented the extirpation of tailed frogs at a number of locations in the Pacific Northwest as a result of increased sedimentation and water temperature resulting from timber harvest and associated road building activities (Metter 1964; Bury 1983; Bury and Corn 1988; Welsh and Lind 1988; Corn and Bury 1989; Corn and Bury 1990; Welsh 1990; Bull and Carter 1996). Because tailed frogs are highly philopatric, have limited dispersal capabilities, and are apparently somewhat reliant on old growth, streams they have been extirpated from may not be recolonized for extensive periods of time after timber harvest activities (Metter 1967; Daugherty and Sheldon 1982; Corn and Bury 1989; Welsh 1990). Furthermore, some of these same studies found that even if tailed frogs were still present after timber harvest their density and biomass was negatively affected and density and biomass were lower in younger stands than older stands (e.g., Corn and Bury 1990; Welsh 1990; Gomez and Anthony 1996). A study in the Blue Mountains of Oregon provides evidence that stream buffers do provide protection for tailed frogs in drier forests similar to those found across much of Montana. Bull and Carter (1996) found that the number of tailed frogs was best predicted by a combination of stream substrates and the presence of stream buffers. (**2**) Although the impacts of piscicides have not been formally investigated anecdotal evidence from treated areas in Montana suggests they may have major population-level impacts on tailed frogs (Andrew Sheldon, University of Montana, personal communication). Fontenot et al. (1994) and McCoid and Bettoli (1996) recently reviewed the impacts of rotenone-containing piscicides on amphibians and found that the effects of rotenone on newly metamorphosed and adult amphibians varied with the degree of each species' aquatic respiration and their likelihood of exiting treated water bodies. They found the range of lethal doses of rotenone-containing piscicides for amphibian larvae (0.1-0.580 mg/L) to overlap to a large extent with lethal doses for fish (0.0165-0.665 mg/L), and to be much lower than the concentrations commonly used in fisheries management (0.5-3.0 mg/L). The nontarget effects of another piscicide, antimycin, have apparently not been formally studied, but preliminary observations seem to indicate that antimycin is also toxic to amphibian larvae (Patla 1998). Tailed frog larvae and adults both use aquatic respiration and adults are unlikely to exit treated water bodies depending on the time of day (Daugherty and Sheldon 1982*b*).

<u>Research and Management Suggestions</u>

1. Additional information is needed on their distribution east of the Continental Divide, especially in central and southwest Montana. Documentation of their presence along the upper Clark Fork River and in the Beaverhead Mountain Range is poor and their presence in the Garnet, Elkhorn, Boulder, and Highland Mountains is uncertain. Surveys in these areas could be easily done by combining them with existing fisheries surveys.
2. The most efficient method of monitoring tailed frogs is to have fisheries crews that regularly conduct surveys in headwater streams record observations of adults and larvae in areas they have used a shocker and/or kick net. These crews should be formally trained in the identification of the species and should report observations on standard forms to the database at the Montana Natural Heritage Program.
3. Studies of the impacts of timber harvest and buffer strips designed to protect headwater streams from impacts should be conducted in Montana in order to ensure that current mitigation measures are allowing isolated headwater populations to persist. Concurrent studies of the distance individuals commonly move from streams are also needed.
4. Leaving 30 to 200 meter (15 to 100 meters on either side) wide forest buffer strips has been proposed by various authors in order to protect headwater stream habitats for the persistence of tailed frogs (Corn and Bury 1989; Gomez and Anthony 1996). However, there has been no research in drier forests in Montana to support the value of a particular buffer width.
5. Streams and lakes being considered for treatment with piscicides should be thoroughly surveyed for tailed frogs and the impacts of the proposed piscicides should be investigated in order to identify likely impacts.
6. Without formal investigation of the impacts piscicides should not be used in streams containing tailed frogs because of the possibility of removing multiple larval and adult cohorts. Other methods of removal should be explored in these instances. If piscicide use is the only option available then pretreatment gathering and posttreatment restocking of tailed frog tadpoles and adults should be undertaken and treatment should occur in the late evening hours so that adults are more likely to exit waters.

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Plains Spadefoot (*Scaphiopus bombifrons*) = (*Spea bombifrons*)

Distribution/Taxonomy

There is currently some debate as to whether the plains spadefoot and other western spadefoots should be placed in the genus *Scaphiopus* or *Spea* (Hall 1998). However, regardless of the generic name, a single distinct species is recognized as ranging across the Great Plains from northern Mexico to southern Canada at elevations up to 2,440 M (8,000 ft) (Stebbins 1985; Wiens and Titus 1991). In Montana they have been sparsely documented across the eastern plains and at a handful of locations in the mountain valleys of the upper Missouri watershed at elevations up to 1,524 M (5,000 ft).

Identification

Eggs:

Laid in smaller clusters 10-250 totaling up to 3,844 eggs per female (Mabry and Christiansen 1991). Each ovum is dark brown above, pale yellow below, and is surrounded by three jelly layers (two thin layers immediately adjacent to the ovum and a thicker outer layer) (Hoyt 1960). Ovum diameters are approximately 1.5 mm, but total egg diameters, including the three jelly layers, are approximately 3 mm (Hoyt 1960).

Larvae:

Light gray or brown dorsally and lighter irridescent golden ventrally (Hammerson 1999). Tail fin is clear with sparse yellow flecks. Eyes are located dorsally. TL of 9-68 mm (Russell and Bauer 1993; Klassen 1998).

Juveniles and Adults:

Pupil of the eye is vertical. A large and usually bony bump or boss is present between the eyes (Hall 1998). A single black digging “spade” is present on the soles of the hind feet. Base color is white ventrally and ranges from light brown to dull green dorsally. Four lighter stripes and a few darker splotches are usually present laterally and dorsally and few warts are present (Hammerson 1999). SVL of 10-60 mm (Hammerson 1999; Klassen 1998).

Similar Species:

No other adult frogs or toads that are known to inhabit Montana have a rounded bony boss directly between the eyes or a vertical eye pupil. Larvae of the western toad, Great Plains toad, and Woodhouse’s toad are all dark dorsally. Larvae of Columbia spotted frogs and northern leopard frogs are much more mottled in color with gold and black flecking. See account for the Great Basin spadefoot. Adult Great Basin spadefoots have a soft and pliable boss directly between their eyes.

Habitat Use/Natural History

Found on or adjacent to sandy soils in native grasslands and shrublands as well as pastures and haylands with non-native vegetation (Lauzon and Balagus 1998). Adults retreat to burrows excavated to depths of one meter in loose soils during periods when terrestrial conditions are not favorable (Russell and Bauer 1993). Adults are present on the surface on warm nights during damp and dry weather where they feed on a variety of insects, but seem to rely on lepidopterans, coleopterans, and homopterans to a greater extent (Kellog 1932; Whitaker et al. 1977). Breeding takes place in warm, often muddy, temporary water bodies formed by extensive rains when minimum temperatures are 7-12 degrees Celsius or warmer (Klassen 1998). Eggs are deposited on rocks, submerged vegetation, or loose on the bottom of the pool, and hatch in 2-3 days (Hammerson 1999). Tadpoles commonly have two morphologies, omnivores which feed on phytoplankton and detritus, and carnivores which feed on fairy shrimp, other invertebrates and frequently their own or other amphibian larvae (Bragg 1964; Pfenning 1990). Depending on conditions, time to metamorphosis can vary from 21 to more than 75 days, with carnivorous morphs reaching metamorphosis much sooner than omnivorous morphs (Gilmore 1934; Bragg 1964). Tadpoles are capable of surviving extended periods ($\geq$ 20 hours) out of water (Moore 1937; Black 1974). Juveniles and adults are known to disperse at least 2.25 kilometers from breeding ponds (Klassen 1998).

Status and Conservation

In the past 125 years plains spadefoots have only been documented at about 40 localities across the plains and in the mountain valleys east of the Continental Divide and at the present time their status across this region is almost completely unknown. Risk factors relevant to the viability of populations of this species are likely to include grazing, road and trail development, on- and off-road vehicle use, use of pesticides and herbicides, development of water impoundments, habitat loss/fragmentation, and metapopulation impacts, all as described above. However, the lack of information on the distribution, status, habitat use, and basic biology of the species may currently represent the greatest risk to the viability of the species (i.e., the species could have undergone, or currently be undergoing, drastic declines but we lack any kind of baseline information that would allow us to make such a determination). Individual studies that specifically identify risk factors or other issues relevant to the conservation of plains spadefoots include the following. (**1**) At least two reports indicate that non-intensive agriculture may be compatible with the survival of plains spadefoot populations. Lauzon and Balagus (1998) found them breeding in wetlands adjacent to improved pasture and haylands comprised almost completely of non-native vegetation. Klassen (1998) found spadefoots breeding in temporary pools that formed in native grasslands used as cattle pastures and some of these pools were fouled with cattle manure. However, Bragg (1937) reports that all the spadefoot eggs in pools that were heavily contaminated with fecal material from cattle died while other eggs in nearby uncontaminated pools survived. Klassen (1998) also reports that males called from a number of regularly irrigated cultivated fields and found them successfully breeding in one. Klassen (1998) indicated that irrigation may positively benefit populations by allowing regular reproduction in some areas. However, it is also conceivable that some irrigated areas may act as population sinks by drawing animals into areas where they may be impacted by agricultural chemicals or plowing which could disturb individuals in their burrows. (**2**) Both Bragg (1944) and Hammerson (1999) note that large numbers of plains spadefoots are killed on roads adjacent to breeding sites. (**3**) Hammerson (1999) notes that several populations have been extirpated due to residential and commercial development near Fort Collins, Colorado. (**4**) In a study of a congeneric species, Couch's spadefoot *Scaphiopus couchii*, Judd (1977) found that the herbicide monosodium methanearsonate killed 86 percent of juvenile toads when they were exposed to only one eighth of the concentration recommended for agricultural spraying. The relationship of this herbicide to commonly applied herbicides in Montana is not known, but it is likely that both herbicides and pesticides may represent a threat to plains spadefoot populations. (**5**) Sounds from offroad vehicles have apparently been found to impact the emergence of congeneric Couch's spadefoots from their underground burrows (Bondello and Brattstrom 1979).

Research and Management Suggestions

1. See research and management suggestions under all of the general risk factors described above with the exception of timber harvest, fire and fire management activities, and harvest and commerce.
2. More thorough documentation of their presence is needed across their entire range in the state, especially north of the Missouri River, in the mountain valleys upstream of Canyon Ferry Reservoir, and along the Tongue, Musselshell, and Judith Rivers.
3. Studies of their habitat use and population dynamics relative to grazing and dry and irrigated agricultural activities would identify both positive and negative impacts of these activities. The knowledge gained by such studies may be essential to their long term viability.
4. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.
5. Where populations are found to be in close proximity to areas of high human use the population impacts of vehicle use near known breeding or burrowing sites should be examined. If impacts are heavy or poorly understood then vehicle use should be curtailed or limited during major periods of activity (e.g., during breeding migrations/choruses or metamorphosis and dispersal).

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Boreal Toad (*Bufo boreas boreas*) = Western Toad (*Bufo boreas*)

Distribution/Taxonomy

The western toad is currently recognized as two subspecies that range from the Rocky Mountains to the Pacific Coast and from Baja Mexico to southeast Alaska and the Yukon Territory at elevations up to 3,640 M (11,940 ft) (Stebbins 1985; Hammerson 1999). One subspecies, the boreal toad, *Bufo boreas boreas* is currently recognized as occuring in Montana. However, mitochondrial DNA analysis indicates that four main phylogenetic groups exist and each may warrant recognition as separate species: (1) a southern Rocky Mountain group in Colorado and southern Wyoming; (2) a southern Utah group; (3) a northwest group including all specimens in Montana, northern Idaho, and northern Wyoming; and (4) a southwest group composed of individuals currently recognized as the California toad, *Bufo boreas halophilus*, the black toad, *Bufo exsul*, and the Amargosa toad, *Bufo nelsoni* (Goebel 1996). If these phylogenetic groups are recognized as full species it is likely that populations across Montana and the Pacific Northwest will be recognized as the boreal toad, *Bufo boreas*. In Montana the species has been documented across the mountainous portion of the state west of the Beartooth Plateau, and the eastern edge of the Castle, Little Belt, and Highwood Mountains at elevations up to 2,895 M (9,500 ft) (Black 1970*a*; Black 1971).

Identification

Eggs:

Laid in long strings that are one to three (usually two) eggs wide in a zigzag pattern and contain 1,000 to more than 18,000 eggs (usually 6,000 to 12,000) (Livezey and Wright 1947; Samallow 1980; Olson 1988; Carey et al. 2000). Each ovum is black above, white below, and is surrounded by two jelly layers (Livezey and Wright 1947). Ovum diameters are 1.5 to 1.75 mm, but total egg diameters, including both jelly layers, are approximately 5 mm (Livezey and Wright 1947; Karlstrom 1962).

Larvae:

Body and tail musculature are black and the belly may be either black or gray (personal observation). The tail fins are both clear with dendritic pigmentation, with the dorsal tail fin having more pigmentation (personal observation). TL of 10-38 mm (Carpenter 1953; Corkran and Thoms 1996).

Juveniles and Adults:

The skin is dry and warty and large parotid glands are present behind the eye and tympanum. The hind feet each have two light brown digging “spades” on their soles, but the spades lack a sharp cutting edge (Black 1970*a*; personal observation). A white stripe extends down the center of the back in older individuals, but may be absent or inconspicuous in younger individuals (personal observation). Dorsal base color is olive green or light or dark brown with reddish or light brown color on the warts and small black spots over everything (personal observation). Ventral color is cream to tan mottled with numerous dark blotches. SVL of 11-118 mm (Black 1970*a*; personal observation).

Similar Species:
The geographic range of Great Plains toads and Canadian toads do not overlap with the geographic range of boreal toads. See the geographic range of Woodhouse's toads to see the limited areas of possible overlap. Adult Woodhouse's toads have parallel cranial crests on the snout and behind the eyes in the shape of an "L". Eggs and larvae of boreal toads, and Woodhouse's toads are very similar and may not be differentiable by even thoroughly trained herpetologists.

Habitat Use/Natural History
Found in a wide variety of habitats including wetlands, forests, woodlands, sagebrush, meadows, and floodplains in the mountains and mountain valleys (Brunson 1952; Carpenter 1953; Black 1970*a*; Campbell 1970*c*; Cavallo 1997; Hart et al. 1998). Adult and juvenile toads are freeze intolerant and overwinter and shelter in underground caverns, or more commonly in rodent burrows (Mullally 1952; Black 1970*b*; Smits 1984; Jones 1999). While smaller juveniles are active almost exclusively diurnally, adults are usually active at night except during the spring and at high elevation (Mullally 1958; Lillywhite et al. 1973; Sullivan 1996; Sullivan et al. 1996). Adults feed on a variety of invertebrates, but rely most heavily on ground dwelling coleopterans and hymenopterans and are known to eat smaller vertebrates including smaller individuals of their own species (Cunningham 1954; Moore and Strickland 1955; Mullally 1958; Livezey 1961; Campbell 1970*a*; Miller 1975, 1978; Hansen and Thomason 1991). Timing of breeding is dependent on temperature, snowmelt, and/or the presence of surface water from flooding and takes place from May to July in shallow areas of large and small lakes, beaver ponds, temporary ponds, slow-moving streams, and backwater channels of rivers (Black 1970*a*; Metter 1961). Water chemistry at most breeding sites generally has a high pH (>8.0), high conductivity, and high acid-neutralizing capacity (Koch and Peterson 1995). Females wrap egg strings around emergent vegetation or loose in clumps in shallow (usually less than 15 cm) waters (Black 1970*a*; Hammerson 1999). Eggs hatch in approximately 5 days and tadpoles commonly form dense aggregations in shallow warmer waters as they feed on algae, detritus, and other dead tadpoles or adults (Black 1970*b*; Franz 1971; Loeffler 1998). Tadpoles.metamorphose in mass in 40 (personal observation) to 75 (Loeffler 1998) days and metamorphs can be found in dense aggregations adjacent to breeding grounds (Turner 1952; Black 1969; Lillywhite and Wassersug 1974; Devito et al 1998). Adults and juveniles apparently use olfactory and celestial cues primarily to orient, respectively (Tracy and Dole 1969; Tracy 1971). Adults may move more than 800 meters in night, may move more than 4 kilometers away from water after breeding and can remain away from surface water for relatively long periods of time (Pimentel 1955; Tracy and Dole 1969; Campbell 1970; Loeffler 1998). Juveniles may disperse up to or more than 4 kilometers from their natal site (Sornborger 1979).

Status and Conservation
Within the last twenty five years populations of western toads have undergone population crashes in Colorado, Utah, southeast Wyoming, and New Mexico (Stuart and Painter 1994; Ross et al. 1995; Corn et al. 1997; Loeffler 1998). *Bufo boreas* is now listed as endangered by the State of Colorado and considered a candidate species which is warranted, but precluded, for federal listing by the USFWS in the southern Rocky Mountains (Colorado, southeast Wyoming and northern New Mexico) (Ross et al. 1995; Loeffler 1998). The estimated cost of implementing the first four years of the recovery plan for the Southern Rocky Mountain

population is one million twenty-five thousand dollars (Loeffler 1998). Reports of declines in western toad populations have also been reported in Oregon and California (Blaustein et al. 1994; Stebbins and Cohen 1995; Drost and Fellers 1996; Fisher and Shaffer 1996).

Until the late 1990's many biologists believed that populations in the northern Rocky Mountains had not undergone similar declines. However, surveys in the late 1990's revealed that toads were absent from a large number of their historic localities and that although they were still widespread across the landscape they occupied an extremely small proportion of suitable habitat (less than 10% in most cases, but usually less than 5%) (Werner and Reichel 1994, 1995; Reichel 1995, 1996, 1997*b*; Koch and Peterson 1995; Koch et al. 1996; Hendricks and Reichel 1996; Werner et al. 1998; reviewed by Maxell et al. 1998). As a result of these findings the USFS listed the boreal toad as a sensitive species in all Region 1 Forests (USDAFS 1999) and initiated a regional inventory program in Montana. The systematic inventory of standing water bodies in 40 randomly chosen 6^{th} level Hydrologic Unit Code (HUC) watersheds across western Montana during the summer of 2000 also found toads to be widespread, but extremely rare. Of the 40 watersheds that were surveyed toads were found in 11 (27%), and of the 33 watersheds that contained suitable breeding habitat they were found breeding (eggs, larvae, or metamorphs observed) in 7 (21%). However, of the 347 standing water bodies that were surveyed within these watersheds toads were only found at 13 (3.7%), and were found breeding at only 9 (2.6%). Furthermore, at sites where toads were observed, only small numbers of adults or relatively small numbers of eggs or larvae were observed. Similarly, in an inventory of approximately 400 standing water bodies in Glacier National Park during the summers of 1999 and 2000, toads were found and bred at approximately 5% (Steve Corn, USGS BRD Aldo Leopold Institute, personal communication). Similar patterns have been observed on the Flathead Indian Reservation where breeding occurred at only four of nine historical sites in 1999 and 2000, and at other sites several years have been skipped between breeding events (Kirwin Werner, Salish Kootenai College, personal communication). Thus, the evidence to date suggests that boreal toads have either undergone a decline in the 1980s and are know in the process of recoverying, or they have undergone a decline and are continuing to decline because populations are small, isolated, and/or subject to one or more factors that are impacting populations separately or synergistically.

Risk factors relevant to the viability of populations of this species are likely to include all the risk factors described above As a supplement to this information managers may wish to refer to Loeffler (1998) who, for the recovery of toad populations in the Southern Rocky Mountains, reviews these and other general risk factors and provides management guidelines to mitigate their impacts. Individual studies that specifically identify risk factors or other issues relevant to the conservation of boreal toads include the following. (**1**) Carey (1993) observed the disappearance of several populations of western toads in the West Elk Mountains of Colorado between 1974 and 1982 and during this period found many toads with symptoms of red-leg disease, a common bacterial infection in amphibians and fish. She hypothesized that an unidentified environmental factor had caused sublethal stress of the toads, which caused immune response to be supressed leading to the systemic infection and death of toads. More recently the chytrid fungus *Batrachochytrium dendrobatidis*, which is suspected to be responsible for declines of amphibians in Australia, Central America, and the western United States has been found to have caused mass mortalities in western toad populations in Colorado during the summer of 1999 (Berger et al. 1998; Daszak et al. 1999, 2000; Morell 1999; Milius 1999, 2000;

Carey 2000). As was observed for declines in the late 1970's and early 1980's only metamorphosed individuals died (Carey et al. 2000). The fungus only seems to attack keratinized tissues, so metamorphosed individuals with lots of keratinized tissues die and tadpoles with keratinized tissues only around the mouthparts survive until metamorphosis (Berger et al. 1998; Morell 1999). Another line of evidence to suggest that the chytrid fungus was responsible for declines in the late 1970's and early 1980's is that northern leopard frog populations in Colorado crashed at the same time that western toad populations did in the late and museum specimens of northern leopard frogs that were collected during these time period have now been found to have the chytrid fungus (Daszak 1999; Milius 2000). Thus, the chytrid fungus may be the most likely cause of declines of boreal toads and the near extirpation of northern leopard frogs in western Montana in the late 1970's and early 1980's and clearly represents a threat to populations today. Another fungus, *Saprolegnia ferax*, has been found to cause 95% mortality of an estimated 2,496,000 western toad embryos at a site in Oregon (Blaustein et al. 1994*b*). Spread of the fungus between egg strings is enhanced by the behavior of toads because females often deposit eggs communally (Kiesecker and Blaustein 1997). (**2**) Hailman (1984) found that western toads tended to congregate around roads in the late evening and early morning. Cunningham (1954) found hundreds of toads flattened on a highway the morning following a summer thunderstorm. (**3**) Olson (1989, 1992) reports that ravens killed large number of breeding western toads (20% of the entire breeding population at one site) at three sites in the Oregon Cascades. The author speculates that human activity near these sites may serve to concentrate raven activity in the area and subsequently leads to toad predation. Similarly, Brothers (1994) found toads being preyed on by crows and Beiswenger (1981) found tadpoles being preyed upon by gray jays. Furthermore, Jones et al. (1999) report predation of western toad tadpoles, metamorphs, and adults by a number of avian and mammalian species that may be attracted to areas of human activity and/or subsidized by the presence of humans, subsequently leading to increased rates of predation. These animals included mallards, spotted sandpipers, robins, red fox, raccoon, and a domestic dog. Kagarise Sherman and Morton (1993) also report high levels of predation on breeding aggregations of the closely related Yosemite toad by Clark's nutcrackers, California Gulls, and ravens. Fisher and Shaffer (1996) implicate introduced bullfrog and fish predators in the decline of western toads in the Sacramento and San Joaquin Valleys in California. However, Jones et al. (1999) found that neither cutthroat trout or brook trout would prey on tadpoles and Licht (1968) found that toad eggs were not palatable to fish. Furthermore, both Drost and Fellers (1996) and Corn et al. (1997) found toads breeding at sites with and without fish. (**4**) After what may have been the first successful reproductive event at a site in southeastern Idaho in 10 years Bartelt (1998) documented the deaths of thousands of western toad metamorphs when 500-1,000 sheep were herded through the drying pond the toadlets were concentrated around. He found that hundreds of animals had been directly killed underfoot and hundreds more died soon afterward as a result of dessication because the vegetation they had been hiding in had been trampled to the point that it no longer provided a moist microhabitat. (**5**) Antimycin and rotenone, two commonly used piscicides, are both toxic to toad tadpoles (Loeffler 1998). (**6**) Johnson and Prine (1976) exposed juvenile western toads to the insecticides Abate, fenthion, chlorpyrifos-methyl, chlorpyrifos-ethyl, methylparathion, and the insect growth regulator Altosid for 24 hours at one half the concentrations usually applied in the field. They found that toads exposed to the insecticides reduced their activity levels and had lower tolerance to high temperatures than toads in the control group. (**7**) Porter and Hakanson (1976) found that a variety of heavy metals found in drainage water from mines in Colorado were highly lethal to western toad larvae. Furthermore, they found that lethal pH for tadpoles ranges from 3.1 to 4.0. Other studies report that no significant embryo mortality is observed for western toads until pH falls below 4.9, but embryos have an LC_{50} at pH less than or equal to 4.5 (Corn et al. 1989; Corn and Vertucci 1992; Vertucci and Corn 1996). (**8**) In Oregon Blaustein et al. (1994*a*) found that survival rates for western toad embryos was lower when they were exposed to ambient UV-B radiation than when they were shielded from UV-B radiation and attributed this to the presence of low levels of photolyase, an enzyme that is known to repair UV-B damage to DNA. However, Kiesecker and Blaustein (1995) found that UV-B may only be impacting embryo survival as a result of a synergistic interaction with the fungus *Saprolegnia ferax*. They found that embryos had 95-100% survival rates when exposed to ambient UV-B radiation in the absence of Saprolegnia. However, when embryos were infected with *Saprolegnia* survival dropped to 50% at ambient UV-B levels. Similarly, Corn (1998) failed to find a relationship between exposure to UV-B and embryo survival to hatching in Colorado and noted that a number of other studies have also failed to find a convincing impact of ambient levels of UV-B radiation on amphibian embryos. At artificially high levels of UV-B exposure Worrest and Kimeldorf (1975) report a decline in larval survivorship of western toads from 94-100% in controls to 0%, 17%, and 41% for UV-B treatments exposed to 0, 2, and 4 hours of photoreactivating (>315 nm) light following UV-B exposure.

<u>Research and Management Suggestions</u>

1. See research and management suggestions under all of the general risk factors described above. In addition, for the recovery of toad populations in the Southern Rocky Mountains Loeffler (1998) reviews these and other general risk factors and provides management guidelines to mitigate their impacts.
2. Additional information is needed on their present distribution across their known range in Montana, especially on the Beartooth Plateau, in the southwest corner of the state between the Big Hole Valley and the Madison Mountain Range, along the upper Clark Fork River, and in the Big Belt and Highwood Mountain ranges. Their presence in the Big Snowy, Crazy, Highwood, Ruby, Tendoy, and Snow Crest Mountain Ranges is uncertain. Voucher specimens should be gathered at new found breeding localities, but vouchers should be limited to larvae or metamorphs.
3. Given the results of recent surveys, all previously documented breeding sites in western Montana should be resurveyed at least twice during an upcoming summer in order to identify possible changes in the short- and long-term regional status of boreal toad populations.
4. All known breeding sites should be monitored annually in order to determine the status of populations relative to various management activities and detect and prevent future declines.
5. Demographic vital rates reported in the scientific literature and recent information on site occupancy rates across the landscape should be used in metapopulation models in order to help determine whether populations in Montana are likely to persist over the long term (e.g., 25, 50, and 100 years).
6. Demographic vital rate information (fecundity, life stage specific survival rates, longevity, and migration and dispersal distances) should be gathered at a number of sites across western Montana in order to better understand the population and metapopulation dynamics of the species and identify mechanisms of mortality for all life history stages.
11. Museum specimens collected since the late 1970's should be examined for the presence of the chytrid fungus. Furthermore, because amphibians sold in pet stores may be introduced

into the wild and act as vectors for pathogens, they should be examined and formally certified as free of pathogens such as the chytrid fungus.

7. Known toad breeding sites that are within grazing allotments should have livestock removed or fenced from the area at the time of breeding and at the time of metamorphosis in order to prevent mass mortality of aggregations of adults or metamorphs as a result of trampling.
8. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.
9. Before piscicides are used in fish removal projects the area should be surveyed for the presence of toad breeding, and/or eggs and tadpoles. If tadpoles are present in a site that is about to be treated, tadpoles can be netted, placed in holding tanks for a few days, and returned to the site after the piscicide has cleared.

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Great Plains Toad (*Bufo cognatus*)

Distribution/Taxonomy
The Great Plains toad is recognized as a distinct species that ranges across the Great Plains from central Mexico to southeastern Alberta and in the desert southwest as far west as eastern California and as far north as southern Utah at elevations up to 2,440 M (8,000 ft) (Stebbins 1985; Goebel 1996). In Montana they have been sparsely documented across the plains east of Shelby, Great Falls, Lewiston, and Billings at elevations up to 1,036 M (3,400 ft).

Identification
Eggs:
Laid communally in single or more rarely double strings containing 1,342 to 45,054 eggs (Bragg 1937*a*: Krupa 1994). Each ovum is black above, shaded progressively lighter to white below, and surrounded by two jelly layers, including the outer jelly layer that composes the string (Bragg 1937*a*). Ovum diameters are approximately 1.2 mm, but total egg diameters, including the two jelly layers are approximately 2.0 mm; jelly string widths between eggs are approximately 1.7 mm (Bragg 1937*a*).

Larvae:
Mottled brown and gray dorsally and with a light greenish-yellow and reddish iridescence ventrally (Bragg 1936). The dorsal tail fin is dendritically pigmented and highly arched while the ventral tail fin is of uniform width and transparent (Bragg 1936). TL of 8-29 mm (Bragg 1936; Bragg 1940)

Juveniles and Adults:
With the exception of small metamorphs a large bony plate or shield covers the snout from the tip of the snout to the front of the eyes. Also with the exception of small metamorphs cranial crests are present behind the eyes and also converge toward the shield on the snout to form a "V" shape between the eyes (Krupa 1990). Large parotid glands are present behind the eyes. The hind feet each have two dark digging "spades" on their soles. A white stripe usually extends down the center of the back and large paired green to brown blotches are present dorsally and are outlined or separated by white bands (Krupa 1990). Cream to white colored ventrally (Krupa 1990). SVL of 11-115 mm (Bragg 1937*b*; Bragg 1940; Krupa 1990).

Similar Species:
The geographic range of western toads does not overlap with the geographic range of Great Plains toads and adult western toads lack cranial crests. If present in Montana Canadian toads are probably limited to the extreme northeast corner of the state and adult Canadian toads either lack or have weakly developed cranial crests behind the eyes. Although overlap in habitat use exists Woodhouse's toads seem to be more commonly associated with sandy soils on floodplains while the Great plains toad is more commonly associated with heavier soils in upland habitats (Timken and Dunlap 1965). Adult Woodhouse's toads lack the shield on the tip of the snout and have "L" shaped cranial crests between and in back of each eye. Metamorph Woodhouse's toads lack the large paired dorsal blotches that are present on Great Plains Toads (Bragg 1937*b*). Eggs and larvae of Woodhouse's toads and Great Plains toads are very similar and may not be differentiable by even thoroughly trained herpetologists. However eggs and larvae of

Woodhouse's toads are much more likely to be found in permanent or semi-permanent waters than those of Great Plains toads (Bragg 1940).

Habitat Use/Natural History

Found in floodplain habitats, but more common in upland grasslands with harder packed soils (Bragg 1940; Smith and Bragg 1949; Timken and Dunlap 1965). Adults lie dormant in rodent or self-excavated burrows when terrestrial conditions are not favorable, but emerge during warmer and moister periods to feed on a variety of terrestrial invertebrates (Bragg 1937*a*; Smith and Bragg 1949; Dimmitt and Ruibal 1980; Flowers and Graves 1994, 1995). Breeding takes place in clear shallow temporary pools almost exclusively after heavy late spring and summer rains when minimum temperatures are above 12 degrees Celsius (Bragg 1937*a*; Bragg 1940; Krupa 1994). Eggs are wrapped around vegetation on the pond bottom and hatch in 2-3 days (Bragg 1937*a*; Bragg 1940). Tadpoles metamorphose in 18 to 45 days (Bragg 1937*b*; Bragg 1940; Krupa 1994). Tadpoles are herbivorous and detritivorous (Bragg 1940). Creusere and Whitford (1976) found individuals 1,600 meters from the nearest breeding site, but is likely that they range farther than this. Population explosions and mass unidirectional migrations have been reported for local areas as well as regions as large as several thousand square miles in area (Bragg and Brooks 1958).

Status and Conservation

In the past 150 years Great Plains toads have only been documented at about 30 localities across the plains east of the Rocky Mountains and at the present time their status across this region is almost completely unknown. Risk factors relevant to the viability of populations of this species are likely to include grazing, use of pesticides and herbicides, nonindigenous species, road and trail development, on- and off-road vehicle use, development of water impoundments, habitat loss/fragmentation, and metapopulation impacts, all as described above. However, the lack of information on the distribution, status, habitat use, and basic biology of the species may currently represent the greatest risk to the viability of the species (i.e., the species could have undergone, or currently be undergoing, drastic declines but we lack any kind of baseline information that would allow us to make such a determination). Individual studies that specifically identify risk factors or other issues relevant to the conservation of Great Plains toads include the following. (**1**) Bragg (1937*a*) reports that all Great Plains toad eggs in pools that were heavily contaminated with fecal material from cattle died while other eggs in nearby uncontaminated pools survived. (**2**) Several authors report that large numbers are killed on highways by motor vehicles (Bragg 1940; Bragg and Brooks 1958; Hammerson 1999). Bragg and Brooks (1958) report a mean of 60 individuals per 30 linear feet of highway were killed on roads in North Dakota and Minnesota during a population explosion and mass migration event. (**3**) Hammerson (1999) notes that several populations have been extirpated due to residential and commercial development in Colorado. (**4**) Stuart (1995) found exotic bullfrogs preying on Great Plains toads. (**5**) Great Plains toads often occupyp prairie dog burrows and these burrows may serve as critical refugia for the species (Craig Knowles, Fauna West Wildlife Consultants, personal communication).

Research and Management Suggestions

1. See research and management suggestions under all of the general risk factors described above with the exception of timber harvest, fire and fire management activities, and harvest and commerce.

2. The species has been documented at less than 30 localities across the state. More thorough documentation of their presence is needed across their entire range in the state. They have not been documented north of the Missouri River east of Tiber Reservoir or on the Crow Indian Reservation. Furthermore, on the prairies in a triangle between Havre, Glasgow and Red Lodge they have only been documented at 4 locations.
6. Studies of their habitat use and population dynamics relative to prairie dog towns and grazing and dry and irrigated agricultural activities may be essential to their long term viability.
7. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.
8. Where populations are found to be in close proximity to areas of high human use the population impacts of vehicle use near known breeding or burrowing sites should be examined. If impacts are heavy or poorly understood then vehicle use should be curtailed or limited during major periods of activity (e.g., during breeding migrations/choruses or metamorphosis and dispersal).

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Canadian Toad (*Bufo hemiophrys*)

Distribution/Taxonomy

Two subspecies are recognized. The Canadian toad, *Bufo h. hemiophrys* ranges across the prairies, aspen parkland, and boreal forest of Alberta, Saskatchewan, and southwestern Manitoba to northeastern South Dakota and central Minnesota at elvations up to 1,200 M (3,940 ft) (Stebbins 1985; Russell and Bauer 1993). The Wyoming toad, *Bufo h. baxteri* exists as an isolated and Federally endangered population in southeast Wyoming in the Laramie Basin (Baxter et al. 1982; Lewis et al. 1985; Jennings and Anderson 1997). The presence of *Bufo h. hemiophrys* in Montana has not been positively confirmed, but they were reported to have been observed in 1966 at a single site in Daniels County at an elevation of approximately 790 M (2,600 ft) (Black and Bragg 1968; Black 1970, 1971).

Identification

Eggs:

Eggs have apparently not been fully described in the scientific literature. Laid in single strings containing up to 6,660 eggs (Porter 1968; Russell and Bauer 1993). The egg string is scalloped with the jelly string being pinched between each egg (Russell and Bauer 1993). Each ovum is pigmented black above and lies within the outer jelly layer that composes the string. Ovum diameter has apparently not been reported.

Larvae:

Larvae have apparently not been fully described in the scientific literature. Blackish above and lighter below. Throat and chest are clear and tail fins are at least partly unpigmented (Stebbins 1985; Russell and Bauer 1993). The tail musculature is dark except for a narrow light ventral area (Stebbins 1985). TL has apparently not been reported.

Juveniles and Adults:

Parallel cranial crests are fused between the eyes to form a bump or boss which may or may not have a furrow between the ridges (Cope 1886; Russell and Bauer 1993). The hind feet each have two dark digging “spades” on their soles. Large parotid glands are present behind the eyes. Dorsal background color is usually grayish green to brown (more rarely reddish) with dark spots that are surrounded by white halos and are themselves spotted with red (Cope 1886; Cook 1964). A white stripe usually extends down the center of the back. The ventral surface is spotted with black or gray over a background of white which becomes more yellowish laterally (Cope 1886; Russell and Bauer 1993). SVL of 10-72 mm (Tester and Breckenridge 1964; Underhill 1961).

Similar Species:

If present, Canadian toads are likely to only be found in the extreme northeastern corner of the state. New metamorphs or juveniles may not have well developed cranial crests and may need to be compared by color patterns (see accounts). Both adult Woodhouse’s toads and adult Great Plains toads are larger and have well developed cranial crests present behind the eyes and are larger in size (see accounts). Eggs and larvae of Woodhouse’s toads, Great Plains toads, and Canadian toads are very similar and may not be differentiable by even thoroughly trained herpetologists. However eggs and larvae of Woodhouse’s toads and Canadian toads are much more likely to be found in permanent or semi-permanent waters than those of Great Plains toads.

Habitat Use/Natural History

Found closely associated with permanent waters containing emergent vetation in short-grass prairies, forests, and on river floodplains (Underhill 1961; Roberts and Lewin 1979). Adults feed on a variety of invertebrates and smaller vertebrates and apparently shelter in the water or shallow self excavated burrows in the summer, and in burrows up to 1.3 meters deep in the winter (Moore and Strickland 1954; Underhill 1961; Tester and Breckenridge 1964; Roberts and Lewin 1979; Cook and Cook 1981; Kuyt 1991). Breeding probably occurs in May or early June and eggs are deposited around vegetation or loose on the bottom of the shallower waters of lakes, ponds, ditches, marshes, or slow moving streams (Black 1970, Roberts and Lewin 1979). Tadpole diet has apparently not been described. Tadpoles usually transform in 7 to 11 weeks (Tamsitt 1962; Porter 1968; Roberts and Lewin 1979). Adults appear to be more closely tied to water than other toad species, but are known to migrate at least 215 meters from overwintering to breeding sites and movements up to 390 meters have been reported (Breckenridge and Tester 1961; Tester and Breckenridge 1964).

Status and Conservation

In the past 125 years the Canadian toad has only been reported twice along the northeastern border of the state and has never been definitively documented with a voucher specimen deposited in a museum (Cope 1886; Black 1970). Therefore, at the present time their presence in Montana must only be regarded as possible and their status must be regarded as unknown. Risk factors relevant to the viability of populations of this species are likely to include grazing, use of pesticides and herbicides, nonindigenous species, road and trail development, on- and off-road vehicle use, development of water impoundments, habitat loss/fragmentation, and metapopulation impacts, all as described above. However, the lack of information on the distribution, status, habitat use, and basic biology of the species may currently represent the greatest risk to the viability of the species (i.e., the species could have undergone, or currently be undergoing, drastic declines but we lack any kind of baseline information that would allow us to make such a determination). Individual studies that specifically identify risk factors or other issues relevant to the conservation of Canadian toads include the following. (**1**) The closely related Wyoming toad, *Bufo h. baxteri*, exists as an isolated and Federally endangered population in southeast Wyoming due to habitat purchases, a captive rearing program, and other management efforts (Baxter et al. 1982; Lewis et al. 1985; Jennings and Anderson 1997). Lewis et al. (1985) suggested that the near extirpation of this subspecies was a result of the aerial application of Fenthion, an organophosphate pesticide, used to control mosquitos in the area around Laramie. However, recent studies of the causes of mortalities of toads found dead in the wild and captivity have found that a number of fungi (*Basidiobolus ranarum*, *Mucor spp*., and *Batrachochytrium dendrobatidis*) have been responsible for virtually all of the known mortalities of free-ranging animals and the majority of animals in captivity (Taylor et al. 1999*a*; Taylor et al. 1999*b*; Steve Corn, personal communication). Furthermore, declines of populations in the wild took place at approximately the same time that northern leopard frog populations in the area were declining, and there is now evidence that the chytrid fungus *Batrachochytrium dendrobatidis* may have caused these declines (Lewis et al. 1985; Morell 1999; Milius 2000). Some of these fungi also cause mortalities in Canadian toads and there is some evidence that Canadian toads are particularly susceptible to them when there immune systems are not functioning at optimum levels (e.g., in the autumn or when animals are stressed) (Taylor et al.

1999*c*; Taylor et al. 1999*d*). Thus, a variety of environmental stressors could be acting in synergy with the fungi to cause mortalities (Carey et al. 1999). (**2**) Kuyt (1991) found a number of road killed individuals adjacent to a communal overwintering site and nearby breeding sites.

Research and Management Suggestions

1. Systematic surveys of the wetlands and streams in Sheridan, Daniels, Roosevelt, and Valley Counties should be undertaken in order to attempt to confirm the species presence in the state.
2. If populations are found, they should be closely monitored multiple times each year and studies of their habitat use and population dynamics relative to grazing and agricultural activities, including the application of herbicides and pesticides, should be conducted in order to identify negative impacts of these activities.
3. If populations are found in close proximity to areas of human use the population impacts of anthropogenic activities should be examined. If impacts are heavy or poorly understood then these activities should be curtailed or eliminated.

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Woodhouse's Toad (*Bufo woodhousii*)

Distribution/Taxonomy

The systematics of the Woodhouse's toad species complex have a long history, but most authors now seem to agree that allozyme and call differentiation studies support evidence for the existence of two subspecies that range from southern Texas to northern Montana and North Dakota, across the desert southwest to northern Utah, and as isolated populations in Idaho, Washington and California (Stebbins 1985; Conant and Collins 1991; Gergus 1994 as cited in Sullivan et al. 1996; Sullivan et al. 1996). Across this range they have been reported at elevations up to 2,440 M (8,000 ft) (Hammerson 1999). Only the Woodhouse's toad, *Bufo w. woodhousei*, is present in Montana and they have been documented across the plains east of Livingston and Fort Benton and south of the Milk and Missour Rivers at elevations up to 1,220 M (4,000 ft).

Identification

Eggs:

Laid in long single or double strings containing up to, and possibly more than, 28,493 eggs (Smith 1934; Krupa 1995). Each ovum is black above, gray below, and is loose within the outer jelly string (Smith 1934). Ovum diameters are 1.0 to 1.4 mm, but total egg diameters, including the outer jelly string are approximately 3.5 mm (Smith 1934).

Larvae:

Body and tail musculature is black to dark brown with gold flecking dorsally and laterally and gray to white ventrally (Youngstrom and Smith 1936). The dorsal tail fin is dendritically pigmented and the ventral tail fin is clear. TL of 2.5 to 35 mm (Youngstrom and Smith 1934; Hammerson 1999).

Juveniles and Adults:

With the exception of small metamorphs parallel cranial crests are found on the snout and behind the eyes in the shape of an "L". Large parotid glands are present behind the eyes. The hind feet each have two dark digging "spades" on their soles. A white stripe extends down the center of the back and is surrounded by a green and creamy yellowish mottling with more green toward the center line and more creamy yellow toward the lateral surface. Usually completely white ventrally, but some black spotting may be present (Bragg 1940; personal observation). SVL of 10-120 mm (Smith 1934; Underhill 1960).

Similar Species:

See the geographic range of western toads to see possible areas of overlap. Adult western toads lack cranial crests and are rarely found in areas far from forests. Although overlap in habitat use exists the Great Plains toad is more commonly associated with heavier soils in upland habitats (Timken and Dunlap 1965). Adult Great Plains toads have a raised shield on the tip of the snout and the cranial crests between their eyes diverge to form a "V". Metamorph Great Plains toads have large paired dorsal blotches. Eggs and larvae of western toads, Great Plains toads, and Canadian toads are very similar and may not be differentiable by even thoroughly trained herpetologists. However eggs and larvae of Great Plains toads are more likely to be found in temporary waters and the Canadian toad, if present, is likely to only occur in the extreme northeast corner of the state.

Habitat Use/Natural History

Found in upland habitats with harder soils around areas with permanent waters, but most common in floodplain habitats with loose sandy soils (Bragg 1940; Timken and Dunlap 1965; Black 1970). Adults feed on a variety of invertebrates and shelter under surface debris, in rodent burrows, or in shallow, self excavated burrows when terrestrial conditions are not favorable (Bragg 1940; Smith and Bragg 1949; Clarke 1974; Labanick and Schleuter 1996; Flowers and Graves 1995; Swanson et al. 1996). Breeding usually takes place during or after spring or summer rains when temperatures are at least 10 degrees Celsius, but choruses may form in drier weather and larger breeding choruses may only form at or above 16 degrees Celsius (Breden 1988). Egg strings are wrapped around vegetation in shallow areas of lakes, reservoirs, river backwaters, floodplain pools, and irrigation ditches (Black 1970, personal observation). Tadpoles hatch within three days, feed on algae and detritus, and usually transform in 5-8 weeks (Youngstrom and Smith 1936; Bragg 1940; Breden 1988). Adults are known to live up to 19 years of age (Engeman and Engeman 1996). Juveniles may not normally move more than a 200 meters from natal sites, but individuals are known to disperse up to 2 kilometers from natal breeding sites (Breden 1988).

Status and Conservation

Woodhouse's toads are widely distributed and common in river valleys, smaller water courses with pools, and artificial permanent water bodies on the prairies east of the Rocky Mountains and island mountain ranges. However, their status north of the Missouri River is largely uncertain. Risk factors relevant to the viability of populations of this species are likely to include grazing, nonindigenous species and their management, road and trail development and on- and off-road vehicle use, development of water impoundments, and habitat fragmentation, all as described above. Individual studies that specifically identify risk factors or other issues relevant to the conservation of tiger salamanders include the following. (**1**) Taylor et al. (1999) found that Woodhouse's toad adults exposed to 0.0011 mg/g of toad (a level similar to levels commonly applied) of the pesticide Malathion suffered 40% mortality rates. Furthermore, when exposed to Malathion and subsequently injected with the bacteria *Aeromonas hydrophila* the mortality rate. Thus, the application of the pesticide clearly reduced the immune function of toads. Similarly, Ferguson and Gilbert (1967) found juvenile Woodhouse's toads to be very sensitive to the insecticides aldrin and dieldrin, but found that animals collected from sites that were contaminated with these chemicals exhibited up to a 200-fold increase in resistence over animals collected from pristine sites. Finally, Sanders (1970) studied the sensitivities of larval Woodhouse's toads to 18 pesticides and herbicides and found most of them to result in high rates of mortality when exposed for 48 or 96 hours. However, a number of pesticides and herbices had significant impacts on survival after a 24 hour exposure. The extent of the application of these herbicides and pesticides in Montana is not known, but it is likely that both herbicides and pesticides represent lethal and sublethal threats to Woodhouse's toad populations. (**2**) Bragg (1940) and Hammerson (1999) both report that thousands of Woodhouse's toads are killed by on roads near breeding sites. Furthermore, Barrass (1986) found that noise associated with highway traffic alters the reproductive behaviour of Woodhouse's toads. Animals were less likely to move toward a breeding chorus and were more likely to call closer to one another in an established chorus in the presence of highway noise. (**3**) Freda and Dunson (1986) found embryos were intolerant of low pH (pH $\leq$ 4.0) in the lab and were absent from all ponds with pH lower than 4.1. Furthermore, they found that larvae grew significantly slower in waters with pH less than 6.0. Pierce and Montgomery (1989) exposed larvae to short term acidic conditions (three days in water at pH = 4.0) and found that while short term exposures temporarily reduced the growth rates of individuals, long-term effects on growth, size at metamorphosis, and time to metamorphosis were not evident. (**4**) Many toad larvae are unpalatable to fish and may, therefore, have some resistance to the impacts of fish introductions. Kruse and Stone (1984) found that largemouth bass (*Micropterus salmoides*) learned to avoid feeding on Woodhouse's toad tadpoles because of their unpalatibility and aggregative behavior. However, bass did still prey on some tadpoles and the indirect effects of fish may still have considerable consequences. For example, Lawler (1989) found Woodhouse's toad tadpoles to greatly reduce activity levels in the presence of a fish predator. This decreases their foraging efficiency and increases their larval period, which exposes them to other predators for a longer period of time. (**5**) Bragg (1940) reports that they are preyed upon by bullfrogs. (**6**) Bragg (1940) notes that young toads are commonly used as fish bait in Oklahoma.

Research and Management Suggestions

1. See research and management suggestions under all of the general risk factors described above with the exception of timber harvest, fire and fire management activities, and harvest and commerce.
2. Documentation of their presence between the Yellowstone and Missouri Rivers is poor and their presence north of the Missouri and Milk Rivers and west of Fort Benton is uncertain.
3. Studies of their habitat use and population dynamics relative to grazing and dry and irrigated agricultural activities would identify both positive and negative impacts of these activities.
4. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.
5. If populations are found in close proximity to areas of high human use the population impacts of vehicle use near known breeding or burrowing sites should be examined. If impacts are heavy or poorly understood then vehicle use should be curtailed or limited during major periods of activity (e.g., during breeding migrations/choruses or metamorphosis and dispersal).

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Pacific Treefrog (*Hyla regilla*) = (*Pseudacris regilla*)

Distribution/Taxonomy

There is currently some debate as to whether the Pacific treefrog should be placed in genus *Hyla* or *Pseudacris* (Hedges 1986; Cocroft 1994). However, regardless of the generic name, a single distinct species is recognized as ranging from southern British Columbia through the Pacific Northwest and western Great Basin to the tip of Baja Mexico at elevations up to 3,536 M (11,600 ft) (Stebbins 1985). In Montana they have been documented with a more or less continuous distribution north of the Missoula and Mineral County lines and west of the Mission, Swan, and Livingston Ranges at elevations up to 1,667 M (5,470 ft). In addition isolated populations are present in the southern Bitterroot Valley near Lake Como, and at several locations along the Blackfoot River between Missoula and the junction of the Clearwater River and on the upper Clark Fork River between Missoula and Drummond.

Identification

Eggs:

Although individual females are known to lay 500 to 750 eggs (Smith 1940), eggs are usually deposited in a number of clutches a few centimeters in size containing 18-119 eggs (X = 68, SD = 26.5, N = 25 across 4 sites in northwest Montana) (Werner et al. 1998; personal observation). Each ovum is dark gray to tan above, white to cream below, and is surrounded by two jelly layers (Gaudin 1965; personal observation). Ovum diameters are approximately 1.3 mm, but total egg diameters, including the two jelly layers are 4.6 to 6.7 mm (Gaudin 1965).

Larvae:

Eyes are outside the outline of the body when viewed from above (personal observation). Tail musculature and dorsal portion of the body are tan with brown mottling and metallic gold flecks. Irridescent copper color laterally and a clear to whitish color ventrally (personal observation). The dorsal and ventral tail fins are clear with numerous brown and metallic gold flecks (personal observation). TL of 8-55 mm (personal observation).

Juveniles and Adults:

Toes are long, have large disks or pads at the end, and there is very little webbing. Virtually all individuals have a black stripe extending from the snout through the nostril, eye, and tympanum to just above the front leg (personal observation). Dorsal color is commonly tan mottled with dark brown spots, but individuals that are solid green or green with black spots are also found (Schaub and Larsen 1978; personal observation). A "Y" shaped brown patch is usually present on the brown color morphs (personal observation). Ventral color is creamy white. SVL of 12-49 mm (Gaudin 1965; Werner et al. 1998).

Similar Species:

With the exception of boreal chorus frogs, adults of all the other frogs and toads in Montana have webbing between their hind toes. With the exception of boreal chorus frogs, the eyes of the tadpoles of all the other frogs and toads in Montana do not stick out beyond the body outline when viewed from above. The geographic range of boreal chorus frogs does not overlap with the geographic range of Pacific treefrogs (see sections on the distribution).

Habitat Use/Natural History

Usually not found far from forested habitats (personal observation). Adults are freeze tolerant and are presumed to overwinter in underground rodent burrows, underneath thick vegetation or debris or in the crevices of rocks and logs (Brattstrom and Warren 1955; Croes and Thomas 2000). Adults and juveniles feed on a variety of arthropods, but mostly rely on smaller insects (Brattstrom and Warren 1955; Johnson and Bury 1965). Breeding takes place in April and May in shallow, warm, fishless waters which may or may not have emergent vegetation (personal observation). Females deposit eggs on emergent vegetation at depths usually less than 20 centimeters in ponds that do not have a closed canopy (personal observation) Eggs usually hatch in 10 to 14 days and tadpoles metamorphose in two or three months during mid summer (personal observation). Tadpoles feed on algae, diatoms, detritus, and pollen (Kupferberg et al. 1994; Wagner 1986). Individuals are known to use terrestrial habitats several hundred meters away from their breeding pond and are known to travel as much as 1,000 meters in order to return to a breeding site they have been removed from (Brattstrom and Warren 1955; Jameson 1956, 1957). In northwestern Montana an individual was found at 1,456 meters (4,774 ft) elevation more than 3.25 kilometers from the nearest breeding site (personal observation).

Status and Conservation

Pacific treefrogs are commonly heard calling, and larvae are commonly found, in standing water bodies at lower elevations north of the Missoula and Mineral County lines and west of the Mission, Swan, and Livingston Mountain Ranges. However, they appear to be present in only a few isolated populations at the southern end of Bitterroot Valley near Lake Como, at several locations around the Blackfoot River between Missoula and the junction of the Clearwater River and around the upper Clark Fork River between Missoula and Drummond. Risk factors relevant to the viability of populations of this species are likely to include all the general risk factors described above with the exception of harvest and commerce. Individual studies that specifically identify risk factors or other issues relevant to the conservation of Pacific treefrogs include the following. (**1**) The eggs (Licht 1969) and larvae (personal observation) of Pacific treefrogs are readily eaten by a number of trout species and fish may be expected to exclude treefrogs from habitats they occupy through predation. In the Palouse region of northern Idaho Monello and Wright (1999) found the presence of Pacific treefrogs to be highly negatively correlated with the presence of a variety of fish species, including largemouth bass, bluegill, channel catfish, and goldfish. Bradford (1989) found that Pacific treefrogs were not found in any of the 123 lakes where trout have been introduced for 173 lakes examined in the Sierra Nevada Mountains. Similarly, Yoon (1977) found that meadow pools occupied by trout were rarely if ever occupied by Pacific treefrogs or other amphibians in the Sierra Nevada. (**2**) Jameson (1956) reported that he felt that exotic bullfrogs had excluded Pacific treefrogs from several breeding sites and found that where bullfrogs were common in the Willamette valley that treefrog choruses, egg masses, or larvae were never found. Kupferberg (1993) also documented the decline of Pacific treefrog populations behind the invasion front of exotic bullfrogs. Kupferberg (1997) found that bullfrogs significantly reduced growth and larval survival of treefrogs. Finally, Kupferberg (1994) observed that when bullfrogs replaced native treefrogs, native garter snakes were not able to forage on the larger bullfrog tadpoles as efficiently as they had on the native treefrogs. (**3**) Johnson (1980) found that when three week old Pacific treefrog tadpoles were exposed to the insecticides temephos, fenthion, methyl parathion, chlorpyrifos, and malathion for 24 hours at lower concentrations than are applied in the field for mosquito control they became thermally stressed at lower temperatures than tadpoles in a control group. Furthermore, tadpoles exposed to methyl parathion at 100 ppb or malathion at 500 ppb reduced their activity levels compared to tadpoles in the control group, possibly reducing their foraging efficiency and growth and increasing the time required to reach metamorphosis. Also, as has been noted by other studies, Schuytema et al. (1995) found that two pesticides containing the active ingredient Guthion had very different effects on Pacific treefrog larvae because of the presence of different "inactive" ingredients in the pesticide formulation. Tadpoles were 5 times more sensitive to one formulation than another because of the differences in "inactive" ingredients. The relationship of the inactive and active ingredients in these pesticides to commonly applied pesticides in Montana is not known, but it is likely that both pesticides and herbicides may represent lethal and/or sublethal threats to Pacific treefrog populations. (**4**) A number of studies in the western United States have reported rear limb deformities in Pacific treefrogs (Hebard and Brunson 1963; Reynolds and Stephens 1984; Johnson 1999). Hebard and Brunson (1963) found rear limb deformities in 20-30 percent of metamorphosing frogs at a pond in the Flathead Valley in the late 1950s and early 1960s. More recently hind limb deformities have been found at the same site and appear to be the result of infection with the nematode parasite *Ribeiroia* which has been found to be responsible for limb deformites in a number of amphibians throughout the western United States (Johnson 1999; Pieter Johnson, Claremont Mckenna College, personal communication). Deformities apparently result from the amphibian larvae's response to the mechanical perturbation of the cysts the parasites form after they burrow through the larvae's body wall because mechanical implants of resin beads result in almost identical deformities (Sessions and Ruth 1990; Johnson et al. 1999) Animals that breed in ponds, including the one reported by Hebard and Brunson (1963) and recently revisited, which are eutrophic as a result of organic inputs from livestock or agricultural activities may support high numbers of planorbid snails (the first host of *Ribeiroia*), thereby increasing the rate of parasite infection and deformities (Johnson 1999). (**5**) Several studies have found that Pacific treefrog embryos seem to be particulary resilient to exposure to ambient and enhanced UV-B radiation levels, apparently as a result of the presence of high levels of photolyase, and enzyme that is known to repair UV-B damage to DNA (Blaustein et al. 1994; Kiesecker and Blaustein 1995; Davis et al. 1996; Hays et al. 1996; Ovaska 1997; Anzalone et al. 1998; Blaustein et al. 1998). However, lab studies have shown that tadpoles and metamorphs that are chronicly exposed to enhanced UV radiation have deformities and suffer higher mortality rates than those shielded from UV radiation or exposed to ambient levels of UV radiation (Hays et al. 1996; Ovaska 1997). (**6**) Pacific treefrog embryos are apparently less likely than other amphibians to be infected and suffer mortality from the fungus *Saprolegnia ferox* because of their habit of laying eggs in small isolated clumps rather than in communal masses (Kiesecker and Blaustein 1997). (**7**) Bradford et al. (1994) found that the LC_{50} pH for Pacific treefrog embryos and hatchlings exposed for 7 days averaged 4.3 and that pH levels greater than or equal to 5.0 had no significant lethal or sublethal effects. (**8**) Weitzel and Panik (1993) reported that feral house cats either predated or mauled a number of Pacific treefrogs.

<u>Research and Management Suggestions</u>

1. See research and management suggestions under all of the general risk factors described above with the exception of harvest and commerce.
2. Additional surveys are needed in order to determine whether they are present in the valley of the North Fork of the Flathead River, in the Whitefish Mountain Range, or in the Garnet

Mountain Range between populations that have been documented on the Blackfoot and upper Clark Fork Rivers.

3. Government personnel and private citizens shoud be educated on the impacts of exotic warm water fishes and bullfrogs on Pacific treefrogs and other native amphibians and should be given suggestions on how to promote the persistence of native amphibians.
4. Removal of exotic warm water fishes and/or bullfrogs should be considered in areas that appear to be key habitats that ensure the survival of local sets of populations. This may particularly important for isolated populations at the southern end of the Bitterroot Valley and populations just east of Missoula. If fish removal can not be accomplished the impacts of these exotic species may be mitigated by constructing ephemeral water bodies that treefrogs can breed and metamorphose in, but exotic fish and bullfrogs cannot overwinter in.
5. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.
6. The population dynamics, habitat use, migration distance, and dispersal distance of adults are almost completely unknown in the region and should be investigated relative to timber harvest and fire management activities.

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Boreal Chorus Frog (*Pseudacris maculata*) = (*Pseudacris triseriata maculata*)

Distribution/Taxonomy

Although there is debate about whether subspecific or specific status should be assigned, most authorities recognize four geographic varieties of *Pseudacris triseriata* which range from Great Slave Lake and Hudson Bay to the Gulf of Mexico and from New Jersey to western Idaho at elevations up to 3,720 M (12,200 ft) (Hedges 1986; Platz and Forester 1988; Platz 1989; Conant and Collins 1991; Hammerson 1999). Only one variety, the boreal chorus frog, *Pseudacris maculata* (full species recognition) or *Pseudacris triseriata maculata* (subspecies recognition), is recognized as occuring in Montana. In Montana they have been documented east of the Continental Divide and the Big Hole Valley at elevations up to 2,170 M (7,118 ft).

Identification

Eggs:

Although individual females are known to lay 137 to 793 (mean = 455, SE = 47, N = 16 at a site in Colorado) eggs at a time, eggs are usually deposited in a number of clutches a few centimeters in size containing 7 to 190 eggs (Pack 1920; Pettus and Angleton 1967). Each ovum is black above, white to cream below and is surrounded by a single layer of jelly (personal observation). Ovum diameters are 0.8 to 1.3 mm (Pettus and Angleton 1967; personal observation), but total egg diameters, including the jelly layer may vary from 4.0 to 6.0 mm (personal observation).

Larvae:

Eyes outside the outline of the body when viewed from above. Mottled with brown and gold dorsally and pale gold to clear ventrally (personal observation). The dorsal tail fin is highly arched and dendritically pigmented with gold while the ventral tail fin is a uniform width and transparent (personal observation). TL of 4.8-52 mm (Pettus and Angleton 1967; Hammerson 1999).

Juveniles and Adults:

The ends of the toes have minute disks or toe pads and there is little webbing between any of the toes (personal observation). Dorsal base color is cream, gray, brown, or green, with three green, brown, or gray stripes or rows of spots dorsally and a one row laterally (Smith 1956; Corn 1980*a*; personal observation). Cream colored ventrally, possibly with a few small black spots. SVL of 7.0-38 mm (Blair 1951; Pettus and Angleton 1967).

Similar Species:

The adults of all other frogs and toads in Montana are much larger and, with the exception of Pacific treefrogs, have webbing between the toes on their hind feet. With the exception of Pacific treefrogs, the eyes of the tadpoles of all the other frogs and toads in Montana do not stick out beyond the body outline when viewed from above. The geographic range of the Pacific treefrog does not overlap with the geographic range of the boreal chorus frog (see sections on distribution).

Habitat Use/Natural History

Typically found within 100 meters of permanent or temporary waters in grasslands, shrublands, or forest parklands (Kramer 1974; Roberts and Lewin 1979). Adults are freeze tolerant and overwinter and aestivate in underground rodent burrows or underneath thick vegetation or debris (Whitaker 1971; Swanson et al. 1996). Adults and juveniles feed on a variety of arthropods as well as their own shed skins and vegetation (Moore and Strickland 1954; Whitaker 1971). Although adults may call throughout the spring, summer, and early fall after rains or in irrigated fields, breeding takes place from late April to June in a variety of shallow water bodies (Cope 1879; Roberts and Lewin 1979; personal observation). Females may deposit eggs over several days on grass stems or other emergent vegetation in only a few inches of water (Livezey 1952). Eggs usually hatch in 5 to 14 days and tadpoles metamorphose in approximately two months (Livezey 1952; Nussbaum et al. 1983). Tadpoles feed on a variety of algae (Whitaker 1971). Individuals may commonly undergo seasonal migrations of 250 meters, but apparently do not normally disperse more than 700 meters from their natal sites (Spencer 1964).

Status and Conservation

With larvae being found in most temporary standing waterbodies and in shallower portions of permanent standing water bodies that lack fish boreal chorus frogs may be the most widely distributed and common amphibian species at low to mid elevations east of the Continental Divide. Risk factors relevant to the viability of populations of this species are likely to include all the general risk factors described above with the exception of timber harvest and harvest and commerce. Individual studies that specifically identify risk factors or other issues relevant to the conservation of boreal chorus frogs include the following. (**1**) Sanders (1970) studied the sensitivities of one week old chorus frog tadpoles to 16 pesticides and herbicides and found most of them to result in high rates of mortality when exposed for 48 or 96 hours. Powell et al. (1982) found that the insecticide fenthion formulated with either water or diesel oil had not bioaccumulated in adult chorus frogs three days after exposure at commonly applied levels. However, as noted by the authors it may be unlikely that the adults would bioaccumulate the pesticide because individuals would not be likely to have eaten insects that had been exposed (frogs do not normally eat dead prey). The authors warn that tadpoles may be more sensitive to bioaccumulation because they injest algae that would likely be contaminated. The relationship of the inactive and active ingredients in these pesticides to commonly applied pesticides in Montana is not known, but it is likely that both pesticides and herbicides may represent lethal and/or sublethal threats to boreal chorus frog populations. (**2**) Hecnar (1995) found that acute and chronic toxic effects of ammonium nitrate were observed in chorus frog tadpoles at concentrations that are commonly exceeded in agricultural areas. Acute exposures to ammonium nitrate fertilizers at 20 mg/L for 96 hours resulted in 50 percent mortality and significant weight loss in those individuals that survived. Chronic exposures to 10 mg/L for 100 days resulted in significantly lower survivorship. (**3**) Corn et al. (1997) found that boreal chorus frogs were commonly breeding at sites where trout were present, but noted that tadpoles of the species are often only found in heavily vegetated shallow water where they are not likely to be exposed to fish predation. (**4**) Corn et al. (1989) found that embryos from a clutch of boreal chorus frog eggs did not suffer significantly higher mortality rates until pH dropped below 5.2, but had an LC_{50} at pH 4.8, and suffered 100% mortality at pH 4.6. However, at the larval stage, Kiesecker (1996) found that survival rate, growth rate, mass, and time to metamorphosis did not change when pH was at 4.5, 5.5, 6.0, and 7.0.

Research and Management Suggestions

1. See research and management suggestions under all of the general risk factors described above with the exception of timber harvest, fire and fire management activities, and harvest and commerce.
2. Additional information is needed on their distribution within the triangle between the Big Belt Mountains, the Big Hole Valley, and the southeastern corner of the Beartooth Plateau. There presence in much of this area is uncertain and it is possible that they cross the Continental Divide into the upper Clark Fork watershed near McDonald, Homestake, Pipestone, and Deerlodge passes.
3. Studies of their habitat use and population dynamics relative to grazing and dry and irrigated agricultural activities would identify both positive and negative impacts of these activities.
4. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.

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Bullfrog (*Rana catesbeiana*)

Distribution/Taxonomy

The bullfrog is recognized as a distinct species with a native range east of a line extending from northwest Wisconsin to south central Texas (Bury and Whelan 1984; Wiese 1990). However, they have now been widely introduced throughout the western United States and around the world at elevations that are typically lower than 1,900 M (6,234 ft) (Bury and Whelan 1984). They were first introduced in Montana sometime prior to 1968 and have now been documented with an almost continuous distribution in the valley bottoms along the Bitterroot River downstream of Darby, the Clark Fork River downstream of Missoula, and the Flathead River downstream of Dixon (Black 1969*a*, 1969*b*; Werner and Reichel 1994; Reichel 1995*a*; Hendricks and Reichel 1996*b*; Werner et al. 1998; personal observation). In addition reproducing populations have been reported in Laurel, Billings, and Fort Peck, and individual adults have been reported in Helena, Belgrade, near Silver City northwest of Helena, near Lake Koocanusa near the Canadian border and in Carter County. In Montana reproducing populations have been reported at elevations up to 1,190 M (3,900 ft) and individual adults have been reported at elevations up to 1,524 M (5,000 ft).

Identification

Eggs:

Deposited in a thin film, a few eggs thick, containing from 3,000 to 47,840 eggs, and spread out over a large surface area (Howard 1983; McAuliffe 1978 as cited in Bury and Whelan 1984; personal observation). Each ovum is black above, whitish below, and is surrounded by a single jelly layer (personal observation). Ovum diameters are 1.2-1.7 mm, but, total egg diameters, including the jelly layer, are 6.4-10.4 mm (Livezey and Wright 1947).

Larvae:

Tadpoles smaller than approximately a TL of 25 mm are black with transverse gold bands on the dorsal side of the head and body and with a patch of gold ventrally (Altig 1970; Corkran and Thoms 1996). The body and tail musculature of larger tadpoles are olive green to yellow in base color with flecks of yellow and numerous round black dots (personal observation). The tail fins of larger tadpoles are clear to yellow in base color with flecks of yellow and round dots and flecks of black (personal observation). The ventral body surface of larger tadpoles is creamy white to bright yellow (personal observation). TL of 3–178 mm (Corkran and Thoms 1996; Wright and Wright 1949).

Juveniles and Adults:

A fold of skin extends from the back of the eye, over the tympanum, down to the front leg. The tympanum is approximately the same size as the eye in females, but is much larger than the eye in males. Dorsal base color varies from pale green to dark olive green with small dark spots (usually on smaller individuals) or dark mottling (usually on larger individuals) (personal observation). Ventral color is cream to bright yellow with gray to dark olive green mottling usually present but giving way to a solid bright yellow throat patch in males (personal observation). SVL of 39-220 mm and weighing up to 908 grams (Lutterschmidt et al. 1996; Thomas and Wogan 1999; personal observation).

Similar Species:
Adult northern leopard frogs and Columbia spotted frogs both have tympanums smaller than their eyes, have white stripes extending from the tip of their snout to their front leg, and lack the fold of skin extending from the back of the eye, over the tympanum, down to the front leg. Larval northern leopard frogs and Columbia spotted frogs are smaller, do not have a creamy yellow ventral color, and do not have round black dots on their dorsal surface and tail musculature. Northern leopard frogs and Columbia spotted frogs lay their eggs soon after snow melt in the spring and their egg masses are round or globular. See sections on distribution to identify possible regions of co-occurrence of bullfrogs and Columbia spotted frogs or northern leopard frogs.

Habitat Use/Natural History
Bullfrogs are highly aquatic and appear to be mostly limited to warmer permanent water bodies with abundant emergent and/or aquatic vegetation (Giermakowski 1998; personal observation). Individuals are rarely found more than a few meters from the edge of the water (Raney 1940; personal observation). So far they seem to have been unable to invade colder waters and high elevations in Montana, but there is some evidence that they may be adapting to colder water beaver ponds at some localities (Nussbaum et al. 1983; Werner and Plummer 1995). Adults feed on a variety of invertebrates and vertebrates and may frequently cannibalize smaller individuals (Bury and Whelan 1984; personal observation; see below). Adults and larvae overwinter in shallow standing or flowing permanent waters on the bottom's surface (Stinner et al. 1994). Breeding takes place in warmer weather from late June through late August and females deposit eggs in a thin layer on the surface of warmer waters (personal observation). Eggs subsequently sink onto submerged vegetation and hatch in three to five days (Bury and Whelan 1984) and tadpoles overwinter. In Montana tadpoles have been found to overwinter once and metamorphose the following summer when in warmer or more ephemeral waters or overwinter twice, so that two larval cohorts are present, in cooler or more permanent waters (personal observation). Tadpoles feed on a variety of algae and bacteria, are commonly coprophagous, and may feed on eggs and smaller tadpoles (Steinwascher 1978; Ehrlich 1979; Kiesecker and Blaustein 1997). Tadpoles are commonly found with predatory fish because they are apparently not very palatable or nutritious (Lewis et al. 1961; Kirk 1967; Kruse and Francis 1977; Kats et al. 1988). Furthermore, tadpoles release chemicals that have actually been shown to inhibit reproduction in some fish (Boyd 1975). Adults typically do not move more than a few hundred meters within a season and show strong homing abilities when displaced (McAtee 1921; Raney 1940; Durham and Bennett 1963; Currie and Bellis 1969). However individuals have been known to move up to 2.8 kilometers and have been found in temporary pools up to 1.6 kilometers from permanent water (Ingram and Raney 1943; Willis et al. 1956; Hammerson 1999).

Status and Impacts on Native Species
In Montana they have been documented with an almost continuous distribution in the valley bottoms along the Bitterroot River downstream of Darby, the Clark Fork River downstream of Missoula, and the Flathead River downstream of Dixon (Hendricks and Reichel 1996b; Werner and Reichel 1996; Werner et al. 1998). In addition reproducing populations have been reported in Laurel, Billings, and Fort Peck, and individual adults have been reported in Helena, Belgrade, near Silver City northwest of Helena, and near Lake Koocanusa near the Canadian border. The

impetus for bullfrog introduction in the western United States and in Montana seems largely to be due to their use as a recreational hunting and food item, apparently, in some cases, as a result of native frogs having already declined because of human hunting and consumption (Bury and Whelan 1984; Jennings and Hayes 1985). Unfortunately, bullfrogs continue to be introduced into new sites from source populations in and outside of Montana (personal observation) despite the fact that unauthorized introduction or transplantation of wildlife into the natural environment is prohibited by Montana law (Levell 1995; MCA 87-5-711).

Bullfrogs represent a major predation and competition threat to native amphibians and other vertebrate and invertebrate species. Bullfrogs have been implicated in the declines of a number of amphibian species throughout the western United States and around the world (Dumas 1966; Black 1969*a*; Moyle 1973; Hammerson 1982, 1999; Bury and Whelan 1984; Hayes and Jennings 1988; Schwalbe and Rosen 1988; Kupferberg 1994; Lanoo et al. 1994; Arano et al. 1995; Rosen et al. 1995; Stebbins and Cohen 1995; Kupferberg 1997; Lawler et al. 1999; however, see Hayes and Jennings 1986; and Corn 1994). All 3 life history stages of amphibians may be subject to direct predation by adult bullfrogs (e.g., Korschgen and Baskett 1963; Carpenter and Morrison 1973; Bury and Whelan 1984; Clarkson and DeVos 1986; Werner et al. 1995). Additionally, both the eggs and larvae of native amphibians may be preyed upon by larval bullfrogs (e.g., Ehrlich 1979; Kiesecker and Blaustein 1997). Furthermore, egg, larval and adult amphibians are also likely to be indirectly effected by the threat of predation due to (1) adult avoidance of oviposition sites where predators are present (e.g., Resetarits and Wilbur 1989), (2) decreased larval foraging as a result of competition or staying in refuges to avoid predators (e.g., Kiesecker 1997; Kiesecker and Blaustein 1998), and (3) decreased adult foraging and growth rates as a result of avoiding areas with bullfrogs. Native amphibian larvae or adults may also be subject to chemically mediated interference competition (e.g., Petranka 1989; Griffiths et al. 1993) or exploitative competition for resources (e.g., Kupferberg 1997). Finally, native predators such as garter snakes that are dependent on larval or adult amphibians as a food source may also be impacted as a result of the loss of native amphibian larvae and the presence of larger bullfrog tadpoles and adults that they are unable to efficiently forage on (e.g., Kupferberg 1994). In addition to impacts on native amphibians, bullfrogs are known to prey on a variety of invertebrates (Carpenter and Morrison 1973) and vertebrates including young waterfowl, passerine birds, warm and cold water fishes, crayfish, snails, shrews, mice, bats, turtles, muskrat, lizards, young alligators, garter snakes, rattlesnakes, and a variety of plant matter (Korschgen and Moyle 1955; Lewis 1962; Korschgen and Baskett 1963; Black 1969*a*, Tyler and Hoestenbach 1979; Bury and Whelan 1984; Clarkson and DeVos 1986; Schwalbe and Rosen 1988; Stuart 1995; Crayon 1998).

The current impact of bullfrogs on the native herpetofauna in Montana is not fully known. Black (1969*a*) reported that bullfrogs seemed to be having a negative impact on northern leopard frog (*Rana pipiens*) and Columbia spotted frog (*Rana luteiventris*) populations in the Bitterroot Valley with the disappearance of some northern leopard frog populations apparently occurring at that time. However, northern leopard frog populations have now been extirpated from virtually all of their former range in western Montana so it is unlikely that bullfrogs were responsible for their declines unless they acted as a vector for disease. Native long-toed salamanders, Columbia spotted frogs, Pacific treefrogs, painted turtles, and western terrestrial and common garter snakes appear not to have suffered widespread extirpation as a result of bullfrog introduction and many of these species are known to have breeding populations that are syntopic with breeding populations of bullfrogs at a few localities were fish have not been introduced in Ravalli and Sanders Counties (Werner and Plummer 1995; personal observation). Corn and Hendricks (1998) found a number of invertebrates in the stomachs of 21 bullfrogs at Lee Metcalf National Wildlife Refuge, and found only one vertebrate, an unidentified fish. Thus, while bullfrogs may be responsible for local declines or extirpations from isolated breeding sites they do not appear to have caused widespread declines of the native amphibians. However, this does not mean that they are currently having no impact or will not cause extirpations of amphibians, invertebrates, or other vertebrates as they become more widespread.

Research and Management Suggestions

1. Additional surveys are needed in the areas surrounding known or reported sites of introduction across the state, especially in eastern Montana.
2. The rate of spread of all bullfrog populations should be monitored in conjunction with native amphibian populations in the area in order to identify the impacts of bullfrogs.
3. The impacts of bullfrogs on egg, larval, and adult life history stages should be thoroughly examined using field and laboratory experiments.
4. The public should be educated on the possible impacts of bullfrogs on native communities and be made aware of the fact that it is illegal to introduce them into the wild in Montana.
5. Where possible, bullfrog populations should be removed. Removal may be accomplished by altering habitats from permanent waters that support exotic bullfrogs, fish, and aquatic weeds to ephemeral habitats that support native species. Removal may also be accomplished by surrounding waterbodies with a drift fence and subsequently draining the water body in the late fall after bullfrogs have moved into overwintering sites. Individuals can then either be captured by hand or left to dessicate and/or freeze.
6. The Montana state legislature could further prohibit the introduction of bullfrogs by designating them a species that is detrimental to Montana's native flora and fauna (Levell 1995; MCA 87-5-712).

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Columbia Spotted Frog (*Rana luteiventris*)

Distribution/Taxonomy

Based on allozyme and morphological evidence the Columbia spotted frog, *Rana luteiventris*, is currently recognized as a distinct species with a more or less continuous distribution along the Northern Rocky Mountains from the southwestern Yukon to central Idaho and with isolated populations located in the Bighorn Mountains of Wyoming, and at isolated springs and mountain tops in Utah, Nevada, Idaho, and Oregon (Green et al. 1996; Green et al. 1997; Reaser 2000). However, the species' taxonomy may require future division into three or more subspecies or weakly differentiated full species in order to adequately represent the genetic differentiation of glacial relict populations that are isolated in several portions of Utah and Nevada, (Green et al. 1997; David Bos, Brigham Young University, personal communication). If future taxonomic subdivisions are made all populations north of south central Idaho would likely be the same species or subspecies (Green et al. 1997). Across their range Columbia spotted frogs are found at elevations up to 3,050 M (10,000 ft) (Stebbins 1985). In Montana the species has been documented throughout the mountainous portion of the state west of Red Lodge, Harlowton, Great Falls, and Shelby at elevations up to 3,036 M (9,960 ft).

Identification

Eggs:

Eggs are laid in a single grapefruit sized globular mass and are usually laid communally with a few to more than a hundred other egg masses (personal observation). Egg masses contain from 308 to 2,403 eggs per mass (X = 983, SD = 348, N=30 for completely counted egg masses at 8 low elevation sites in northwest Montana) (personal observation). Each ovum is black above and laterally, cream to white at the very bottom, and is surrounded by two jelly layers (Svihla 1935; personal observation). Ovum diameters are 2-3 mm (Svihla 1935; Morris and Tanner 1969; personal observation). Total egg diameters, including the jelly layers, are usually 10-12 mm, but may vary from 8 to 21 mm (Svihla 1935; Turner 1958; Morris and Tanner 1969; personal observation).

Larvae:

Body and tail musculature are mottled with light and dark brown spots, black spots, and flecks of metallic gold on a light tan to dark brown background (personal observation). The ventral body surface is pale yellow and often has a metallic copper sheen toward the edges (personal observation). The tail is about twice the length of the body and the dorsal and ventral tail fins are clear to yellowish with flecks of black and metallic gold. TL of 7-90 (Svihla 1935; Wishard 1977; personal observation).

Juveniles and Adults:

A white to yellowish stripe extends from the tip of the snout laterally underneath the eye to just above the front limb. Dorsal base color varies from light tan to reddish or dark green with small black spots that are irregular in outline and usually have a light spot in their center (Turner 1959*a*). At higher elevations large adults are often a reddish brown base color dorsally. Ventral color is white to cream in all individuals, but larger animals are usually salmon in color on their thighs and in some individuals the salmon color extends from the feet to the middle of the belly with patches on the throat as well (Turner 1959*a*; personal observation). SVL of 17-90 mm (personal observation).

Similar Species:
Adult northern leopard frogs lack red or salmon color on their ventral surface and their dorsal surface has large, oval shaped, black spots that are regular in outline and are surrounded with a white halo. Adult bullfrogs lack the white to yellowish stripe on the lateral portion of the snout, have tympanums that are the same size or larger than their eye, and have a fold of skin extending from the back of their eye, over their tympanum, down to their front leg. Larval northern leopard frogs have tails that are less than twice their body length, do not have large flecks of black on their body or tail, and lack a metallic copper sheen on the lateral edges of their ventral surfaces. Larval bullfrogs have a bright to creamy yellow ventral surface, have perfectly round black dots on their dorsal surface and tail musculature, and attain much larger sizes. Northern leopard frog egg diameters are approximately one-half those of Columbia spotted frogs because their jelly envelopes are much smaller (see descriptions) and their egg masses are usually attached underwater (Ross et al. 1994). Bullfrog eggs are laid in the middle of the summer and are spread out in a thin layer over the surface or bottom of a pond rather than a globular mass. See sections on distribution to identify possible regions of co-occurrence of spotted frogs and northern leopard frogs or bullfrogs.

Habitat Use/Natural History
Spotted frogs are normally highly aquatic and are usually not found far from the marshy edges of ponds and lakes or the algae covered pools of springs or streams. However, they commonly bask and forage outside the water several meters from the waters edge (personal observation). Adults feed on a variety of aquatic and terrestrial invertebrates (Moore and Strickland 1955; Turner 1959*b*; Miller 1978), but may commonly cannibalize smaller individuals as well (Pilliod 1999). Adults overwinter underwater in larger permanent water bodies or in springs or streams (Turner 1960; Patla 1997) and may move throughout the winter to areas of higher oxygen concentration (Evelyn Bull, USFS Pacific Northwest Research Station, personal communication). Individuals may aestivate in mud under rocks in extremely dry conditions (Ross et al. 1999). Breeding occurs from mid March to mid June depending on snow melt, temperature and elevation (personal observation). Females deposit egg masses communally in shallow waters (usually no more than 10-15 centimeters deep) with emergent vegetation (usually sedges), but egg masses are usually not attached to vegetation (personal observation). Eggs usually hatch in 5 to 21 days and tadpoles metamorphose in 8 to 16 weeks during mid summer to late fall depending on elevation and water and air temperatures (Turner 1958; Morris and Tanner 1969; personal observation). Tadpoles feed on a variety of algae as well as detritus, bacteria, and the remains of other dead tadpoles (Burke 1933; Morris and Tanner 1969). Adults typically do not move more than 50 meters within a season (Hollenbeck 1974; Patla 1997), but may move up to 1.5 kilometers to a seasonal breeding, foraging, or overwintering site (Engle 2000) and are known to disperse up to 6 or 7 kilometers (Reaser 1996*a*; Janice Engle, Boise State University, personal communication; personal observation).

Status and Conservation
Columbia spotted frogs are the most common frog in the mountains and mountain valleys of western Montana and can be expected to be found in the majority of water bodies that contain

emergent vegetation and do not have fish or bullfrogs. However, their presence and/or status in the Big Snowy, Highwood, and Bighorn Mountains is uncertain. Risk factors relevant to the viability of populations of this species in Montana are likely to include grazing, fire and fire management activities, nonindigenous species and their management, development of water impoundments, and habitat fragmentation, all as described above. Individual studies that specifically identify risk factors or other issues relevant to the conservation of Columbia spotted frogs include the following. (**1**) In 1993, the United States Fish and Wildlife Service found that isolated "distinct population segments" of Columbia spotted frogs (at the time they were still known as spotted frogs *Rana pretiosa*) throughout Utah, Nevada and southern Idaho were warranted for listing as a threatened species under the Endangered Species Act, but that their listing was precluded by other species with higher priorities for listing (USFWS 1993). Several mechanisms of decline have been proposed for the isolated populations of Columbia spotted frogs in Utah, Nevada, and southern Idaho (Koch et al. 1996). Turner (1962*a*) reported on the decline of Columbia spotted frogs in Nevada in the early and mid 1900s because of intensive water utilization for irrigation, and the introduction of bass and bullfrogs. Thirty-five years later Reaser (1996*b*, 1997, 2000) reported on further population declines in Nevada and attributed declines to alteration of natural hydrologic regimes for irrigation and livestock watering, livestock grazing, loss of beaver, and introduction of exotic bullfrogs and warm and cold water fishes. Hovingh (1993) noted that the following as factors that have contributed to the decline of Columbia spotted frog populations in the Wasatch Mountains and Bonneville basin in Utah: (a) habitat loss and fragmentation by highways, dams, reservoirs, urbanization, and the loss of natural flood disturbances because of water diversions and the channeling of rivers; (b) livestock grazing in riparian and wetland habitats; and (c) introduction of raccoons, bullfrogs, crayfish, bass, and trout. For a population inhabiting an isolated set of springs in Utah Cuellar (1994) reported that all ponds used by cattle had dark reddish water as a result of dung eutrophication, and lacked any aquatic vegetation, invertebrates, or frogs. Ross et al. (1999) found crushed individuals at the bottom of the hoove prints of cattle and reported that a decline in habitat appeared to be at least in part due to cattle grazing in the riparian areas. The construction of a dam on the Provo River in north central Utah extirpated many populations as a result of flooding of habitats (Wilkinson 1996). Populations in southwest Idaho are threatened by habitat loss as a result of livestock grazing impacts on riparian areas (Munger in Koch et al. 1996). It is likely that many of the known and postulated mechanisms of decline for the isolated southern populations pose threats to the viability of populations of Columbia spotted frogs in Montana. (**2**) Exotic warm and cold water fish have been implicated in the declines and losses of local Columbia spotted frog populations in Montana, Oregon, and Idaho. In Glacier National Park Marnell (1997) reported that fish were found within the same general wetland complexes in only 16 of 68 (23%) of the sites where frogs were found. Furthermore, at the sites where spotted frogs were found with fish they were almost always found in satellite pools isolated from the fish or in densely vegetated sloughs. With a few exceptions this same general pattern of co-occurrence only where isolated pools, dense vegetation, or some other physical barrier from the fish exists has been observed in the Bitterroot and Cabinet Mountains in Montana (personal observation). On the Palouse Prairie in northen Idaho Monello and Wright (1999) found spotted frogs to be excluded from all water bodies containing fish , including those containing gold fish. Similarly, although Columbia spotted frogs cooccurred with fish at 69% of 55 lakes surveyed in the Big Horn Crags in central Idaho, frogs only successfully reproduced at 1 (2%) of these lakes (Pilliod et al. in Koch et al. 1996). Thus, stocked lakes in this region appeared to be population “sinks” and persistence in a basin may be dependent on the number and location of stocked sites (Pilliod et al. in Koch et al. 1996). In northeast Oregon Bull and Hayes (2000) found the numbers of metamorphosed frogs at a site was inversely correlated with the presence of longnose dace and rainbow trout. (**3**) Bullfrogs, which were introduced into Montana sometime prior to 1968, have apparently extirpated Columbia spotted frogs from a number of sites along the Bitterroot, lower Flathead, and lower Clark Fork Rivers (Black 1969*a*, 1969*b*; Giermakowski 1998; Werner et al. 1998; personal observation). However, sizable Columbia spotted frog populations have been found in close proximity with bullfrogs on the floodplain of the Bitterroot River near spring brooks. Spring brooks provide summer habitat and overwintering sites for Columbia spotted frogs which are apparently too cold for bullfrogs (Cavallo 1997; personal observation) and, therefore, provide important refuges for Columbia spotted frogs around the flood plains of the mountain valleys. (**4**) Manipulation of water levels in water impoundments can result in direct and indirect mortality of amphibian larvae and eggs. For example, during the summer of 1998, fluctuating water levels in Cabinet Gorge Reservoir in northwest Montana led to the dessication of Columbia spotted frog eggs and larvae when water levels dropped for power generation (personal observation). (**5**) Kirk (1988) found a large number of dead adults in Oregon as the result of spraying with DDT (0.65-0.72 kg DDT/ha) to control Douglas fir tussock moth. Subsequent examination of the tissues of the dead frogs showed them to be heavily contaminated with DDT and its analogs relative to live individuals collected at the same site. (**6**) In northeast Oregon Bull and Hayes (2000) found that the numbers of egg masses, metamorphosed frogs, and adult frogs found at grazed and ungrazed ponds did not differ. (**7**) Patla (1997; 1998) and Patla and Peterson (1999) reported declines in a population in Yellowstone National Park as the result of highway construction and construction of an underground water pumping system which changed migratory habitat and the local hydrological regime, respectively. (**8**) Lefcort et al. (1998) reported reduced survival of Columbia spotted frog larvae when exposed to experimental chambers with heavy metal contaminated soils from a EPA Superfund site in northern Idaho. Larval survival was 0.875 in controls, 0.20 in heavily contaminated soil and 0.175 in less contaminated soil. Thus, average survival in the superfund soils represented an almost 80 percent reduction in larval survival. Furthermore, they found that exposure to most heavy metal contaminants had sublethal effects in that they greatly reduced the ability of tadpoles to respond to chemical cues from a fish predator. (**9**) Blaustein et al. (1999) found that spotted frogs had relatively high levels of photolyase, and enzyme that is known to repair UV-B damage to DNA, as compared with other amphibian species. Furthermore, at a number of field sites, hatching success was unaffected by exposure to ambient levels of UV-B. Davis et al. (1996) found that embryo survival was above 80% for those exposed to ambient or no UV-B radiation, but dropped to 56% in those exposed to UV-B radiation enhanced to 15-30% above ambient levels at mid day. Furthermore, few of the larvae survived when exposed to the enhanced UV-B radiation. (**10**) Reinking et al. (1980) found that aldosterone levels in blood plasma were over three times higher in animals held in captivity for three weeks than animals in the wild, indicating that animals face high levels of stress when held in captivity and possibly when being handled in the wild. (**11**) Historic loss of beaver may be causing gradual habitat loss in some mountain ranges in Montana as sites fill in with sediments and are no longer being replaced (Grant Hokit, Carroll College, personal communication; personal observation).

Research and Management Suggestions

1. See research and management suggestions under all of the general risk factors described above with the exception of harvest and commerce.
2. Documentation of their presence is poor in the area between the east front of the Rockies and the Swan Mountain Range south of Glacier Park, in the area between the Gallatin Range the Big Hole Valley and the Elkorn Mountains, in the Big Belt Mountains, and on the Absaroka-Beartooth Plateau. In addition their presence in the Big Snowy, Highwood, and Bighorn Mountains is uncertain.
3. Local and landscape wide impacts of fish introductions should be examined in order to develop fish stocking guidelines that will allow for the persistence of individual populations and connectivity between sets of local populations or metapopulations.
4. Fish stocking at both high and low elevation sites should only be carried out where fish have previously been stocked and in areas where they are contained in a limited number of water bodies (i.e., introduction in one lake in a basin will not result in the colonization of other lakes in the basin).
5. Fish removal should be considered in areas that appear to be key habitats that ensure the survival of local sets of populations.
6. The public should be educated on the possible impacts of bullfrogs on native communities and be made aware of the fact that it is illegal to introduce them into the wild in Montana.
7. Where possible, bullfrog populations should be removed. Removal may be accomplished by altering habitats from permanent waters that support exotic bullfrogs, fish, and aquatic weeds to ephemeral habitats that support native species. Removal may also be accomplished by surrounding waterbodies with a drift fence and subsequently draining the water body in the late fall after bullfrogs have moved into overwintering sites. Individuals can then either be captured by hand or left to dessicate and/or freeze.
8. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.
9. In areas where livestock grazing is common, studies of the habitat use and population dynamics of Columbia spotted frogs relative to grazing impacts should be conducted.
10. The impacts of the loss of beaver, the creation of water impoundments with fluctuating water levels, and fish introductions, may be mitigated by the creation of ephemeral pools.

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Northern Leopard Frog (*Rana pipiens*)

Distribution/Taxonomy

Rana pipiens has a complex taxonomic history, but is now recognized as a distinct species that historically ranged from Newfoundland and northern Alberta in the north to the Great Lakes region, the desert Southwest, and the Great Basin in the south (Pace 1974; Dunlap and Platz 1981; Hillis 1988). In addition a number of isolated populations historically existed in the Pacific Northwest and California (Stebbins 1985). Across this range populations have been documented at elevations up to 3,350 M (11,000 ft) (Hammerson 1999). In Montana they have historically been documented across the eastern plains and in many of the mountain valleys on both sides of the Continental Divide at elevations up to 1,830 M (6,000 ft). Unfortunately, over the last few decades northern leopard frog populations have undergone declines and extinctions across much of the western portion of their range (Stebbins and Cohen 1995). Most northern leopard frog populations in western Montana apparently became extinct sometime in the late 1970s or early 1980s when virtually no amphibian studies were being conducted in the state. Only two population centers are now known to exist in western Montana, one near Kalispell and one near Eureka (Werner et al. 1998; Kirwin Werner, Salish Kootenai College, personal communication). In addition, out of 47 historic sites revisited in the mid 1990s in central Montana, northern leopard frogs were only found at 9 (19%) (Reichel 1995a, 1996; Koch et al. 1996). Populations in southeastern Montana still seem to be widespread and abundant (Reichel 1995*b*; Hendricks and Reichel 1996; Koch et al. 1996).

Identification

Eggs:

Eggs are laid in a single orange to grapefruit sized globular mass and are laid individually or communally in groups of up to three dozen egg masses (Nussbaum et al. 1983). Egg masses contain from 645 to 6,272 eggs (X = 3,045, N = 68 for completely counted egg masses at five sites in Colorado and Wyoming) (Corn and Livo 1989). Each ovum is black above, white below, and is surrounded by two jelly layers (Livezey and Wright 1947). Ovum diameters are approximately 1.7 mm, but total egg diameters, including the jelly layers, are approximately 5.0 mm (Livezey and Wright 1947).

Larvae:

Body and tail musculature are dark brown to olive or gray with flecks of light gold or silver and black (personal observation). The tail musculature may be pale (Corkran and Thoms 1996). The lateral body surface has a larger proportion of light gold or silver flecks and the ventral body surface is silvery white to transparent (personal observation). The tail fine is clear to yellowish with black and light gold or silver flecks (personal observation). TL of 5.5-100 mm (Livo 1981 as cited in Hammerson 1999; Hammerson 1999).

Juveniles and Adults:

White to cream stripes extend from the tip of the snout laterally underneath the eye to just above the base of the front limb and from just behind each eye to the base of the hind limbs (personal observation). Dorsal base color is either green or brown with large, oval shaped, black spots that are regular in outline and are surrounded with a light halo (Fogleman et al. 1980). Individuals occasionally have a blue light blue base color (Black 1969; Hammerson 1999). Ventral color is white to cream with some pinkish patches, especially on the feet (personal observation). SVL of 18-110 mm (Nussbaum et al. 1983; Hammerson 1999).

Similar Species:
Adult Columbia spotted frogs often have red or salmon color on their ventral surface and their dorsal surface has small, irregularly shaped black spots with white or light yellow centers. Adult bullfrogs lack the white to yellowish stripe on the lateral portion of the snout, have tympanums that are the same size or larger than their eye, and have a fold of skin extending from the back of their eye, over their tympanum, down to their front leg. Larval Columbia spotted frogs have tails that are usually twice their body length, have large flecks of black on their body or tail, and often have a metallic copper sheen on the lateral edges of their ventral surfaces. Larval bullfrogs have a bright to creamy yellow ventral surface, have perfectly round black dots on their dorsal surface and tail musculature, and attain much larger sizes. Columbia spotted frog egg diameters are approximately twice those of northern leopard frogs because their jelly envelopes are much larger (see descriptions) and their egg masses are usually at the water's surface and not attached to vegetation (Ross et al. 1994). Bullfrog eggs are laid in the middle of the summer and are spread out in a thin layer over the surface or bottom of a pond rather than a globular mass. See sections on distribution to identify possible regions of co-occurrence of northern leopard frogs and Columbia spotted frogs or bullfrogs.

Habitat Use/Natural History
Northern leopard frogs are typically found in and adjacent to permanent slow moving or standing water bodies with considerable vegetation. However, they may range widely into moist meadows, grassy woodlands and even agricultural areas (Nussbaum et al. 1983). In Montana adults are found primarily in riparian habitats or on the prairies near permanent waters without tall dense vegetation (Mosiman and Rabb 1952, Black 1969, Miller 1978). Adults feed on a variety of invertebrates, but may cannibalize smaller individuals and injest plant matter incidentally (Knowlton 1944; Moore and Strickland 1954; Whitaker 1961; Linzey 1967; Miller 1975, 1978). Adults overwinter on the bottom surface of permanent water bodies, under rubble in streams, or in underground crevices that do not freeze (Rand 1950; Emery et al. 1972; Cunjak 1986). Breeding occurs in March and April and females deposit egg masses singly or communally in waters 7-25 cm deep attached to vegetation under the water's surface (Corn and Livo 1989; Werner and Reichel 1996; Hammerson 1999). Eggs hatch in 4 to 15 days and tadpoles metamorphose in 58 to 105 days (Corn 1981; Livo 1981 as cited in Hammerson 1999). Tadpoles feed on a variety of algae as well as detritus (DeBenedictis 1974). Adults typically do not move more than 50 meters within a seasonal homerange, but may migrate several hundred to a thousand or more meters between seasonal homeranges (Dumas 1964; Dole 1965*a*; Dole 1965*b*; Dole 1967; Dole 1968). Juveniles are known to disperse up to 8.0 kilometers from their natal ponds to their adult seasonal territories (Dole 1971; Seburn et al. 1997).

Status and Conservation
Within the last twenty to twenty five years northern leopard frog populations have declined and been extirpated from large portions of the area from the western plains of Colorado, Wyoming, Montana, and Alberta westward to Oregon and Washington (Roberts 1981, 1987, 1992; Corn and Fogleman 1984; Baxter and Stone 1985; Stebbins and Cohen 1995; Koch et al. 1996; Leonard and McAllister 1996; Leonard et al. 1999; Hammerson 1999). Suggested causes of

declines in northern leopard frog populations in this and other areas of the country included loss of wetlands and natural hydrological regimes, introductions of game fish, mosquitofish, and bullfrogs, application of pesticides and herbicides, and drought (Roberts 1981, 1987, 1992; Corn and Fogleman 1984; Koch and Peterson 1995; Stebbins and Cohen 1995; Leonard and McAllister 1996; Leonard et al. 1999; Hammerson 1999). While it is likely that all of these factors have played a role in the decline and extirpation of local northern leopard frog populations, many of the declines and extirpations were apparently associated with regional mass mortality events between 1973 and 1982 because declines were observed in relatively pristine areas as well (Roberts 1981, 1987, 1991; 1992; Corn and Fogleman 1984; Koch and Peterson 1995). Reintroduction programs have been initiated in Alberta (Roberts 1991) and have been called for in Washington state (Leonard et al. 1999).

The same general timeline for declines is evident in western Montana. Northern leopard frog populations were encountered and found to be apparently healthy by a number of masters and doctoral degree students between 1967 and 1977 (Black 1967, 1970; Miller 1975; Anderson 1977; Daugherty et al. 1978). A student at the Salish-Kootenai College noted that while he found northern leopard frogs near Kicking Horse Reservoir on the Flathead Indian Reservation during the summer of 1980, local fisherman reported that they had noticed a definite decrease in the number of leopard frogs in the area (Ryan 1980). Very little, if any, work was conducted on amphibians in Montana in the 1980s and surveys in the 1990s failed to find northern leopard frogs at any of the historical sites that were revisited and only found two remaining populations in all of western Montana west of the Continental Divide (Werner and Plummer 1994, 1995; Werner and Reichel 1994, 1996; Hendricks and Reichel 1996*a*; Koch et al. 1996; Werner et al. 1998). Furthermore, while surveys during the 1990s found them to be common east of the island mountain ranges in eastern Montana, the appeared to have been extirpated from 80% of historic localities on the northwestern plains (Reichel 1995*a*, 1995*b*; Hendricks and Reichel 1996; Koch et al. 1996; Reichel 1996*b*; Reichel 1997; Hendricks and Reichel 1998; Rauscher 1998; Roedel and Hendricks 1998*a*, 1998*b*; Hendricks 1999).

As a result of these findings the USFS listed the northern leopard frog as a sensitive species in all Region 1 Forests (USDAFS 1999). Risk factors relevant to the viability of populations of this species are likely to include all the risk factors described above. Individual studies that specifically identify risk factors or other issues relevant to the conservation of northern leopard frogs include the following. (**1**) In conjunction with similar observations for western toads Carey (1993) observed the disappearance of two populations of northern leopard frogs in the West Elk Mountains of Colorado between 1974 and 1982. During this period she found leopard frogs with symptoms of red-leg disease, a common bacterial infection in amphibians and fish. She hypothesized that an unidentified environmental factor had caused sublethal stress of both species, which caused immune response to be supressed, leading to the systemic infection and death. More recently the chytrid fungus *Batrachochytrium dendrobatidis,* which is suspected to be responsible for declines of amphibians in Australia, Central America, and the western United States has been found to have caused mass mortalities in northern leopard frog populations in southern Arizona during the summer of 1999 (Berger et al. 1998; Daszak et al. 1999, 2000; Morell 1999; Milius 1999). As was observed for declines in the late 1970’s and early 1980’s only metamorphosed individuals died (Morell 1999). The fungus only seems to attack keratinized tissues, so metamorphosed individuals with lots of keratinized tissues die and tadpoles with keratinized tissues only around the mouthparts survive until metamorphosis (Berger et al. 1998; Morell 1999). Furthermore, it now appears that the chytrid fungus was responsible for declines in the late 1970's and early 1980's as well because museum specimens of northern leopard frogs that were collected during these time period have now been found to have the chytrid fungus (Carey 1999; Daszak 1999; Milius 2000). Thus, the chytrid fungus may be the most likely cause of declines of northern leopard frog populations in the western United States and in western Montana in the late 1970's and early 1980's and clearly represents a threat to populations today. In support of Carey's (1993) immunosuppression hypothesis Maniero and Carey (1997) found that northern leopard frogs exposed to low temperatures (5 degrees C) significantly reduced the animal's immune response. Thus, leopard frogs may be particularly susceptible to the chytrid fungus or other pathogens when emerging in the early spring or in the late fall or winter or when faced with some other environmental stressor (Carey et al. 1999). (**2**) Berrill et al. (1993) found that the pyrethroid pesticides permethrin and fenvalerate did not cause significant mortality of embryos when they were exposed to commonly applied levels for 22 to 96 hours. However, tadpole growth and response to a potential predator was delayed following exposure. Berrill et al. (1994) found that the insecticide fenitrothion and the herbicides triclopyr and hexazinone had no effects on embryos, but the fenitrothion and triclopyr did kill or paralyze new hatchlings at concentrations of 2.4 to 4.8 ppm and 4.0 to 8.0 ppm, respectively. Berrill and Bertram (1997) found that northern leopard frog embryos exposed to 6 herbicides (hexazinone, triclopyr ester, triallate, trifluralin, glyphosate, and bromoxynil) and 3 insecticides (permethrin, fenvalerate, and fenitrothion) at levels that are commonly found in areas where they are used on forests or crops in Canada hatched successfully with no unusual mortality. However, when tadpoles were exposed to the same levels they suffered partial paralysis and the authors note that they would be likely to suffer high rates of mortality. Kaplan and Overpeck (1964) and Kaplan and Glaczenski (1965) found that a variety of organophosphate and halogenated hydrocarbon pesticides caused both red and white blood cell counts to decline in adult northern leopard frogs and chronic exposures to concentrations of 1 ppm caused death in some individuals. Dial and Dial (1987) found that the aquatic herbicides diquat and paraquat did not reduce embryo survival or change hatching time when applied at concentrations of 0.1 to 2.0 ppm. However, at the same concentrations young tadpoles suffered significant mortality from both chemicals and 15 day old tadpoles suffered significant mortality from paraquat. (**3**) Hecnar (1995) found that acute and chronic toxic effects of ammonium nitrate were observed in northern leopard frog tadpoles at concentrations that are commonly exceeded in agricultural areas. Acute exposures to ammonium nitrate fertilizers at 20 mg/L for 96 hours resulted in 50 percent mortality and significant weight loss in those individuals that survived. Chronic exposures to 10 mg/L for 100 days resulted in significantly lower survivorship. Cameron (1940) found that well water containing 1 ppm flourine caused embryo development to slow and time to hatching to decrease. Lande and Guttman (1973) found that embryos were not affected by copper sulfate at concentrations up to 1.56 mg/liter of copper, but the LD_{50} for tadpoles was 0.15 mg/liter and tadpole growth rates were decreased at concentrations of 0.06. (**4**) Hamilton (1941) found that rotenone applied at 0.1 mg/L caused mortality in larval through metamorphic life history stages of *Rana pipiens* over an 8 to 24 hour time period, respectively. Furthermore, Burress (1982) found that Pro-Noxfish applied at 5 µL/L caused substantial mortality in *Rana pipiens*. (**5**) Black (1969*a*) felt that exotic bullfrogs introduced in the Bitterroot Valley had lead to declines in northern leopard frog populations in the area. Similarly, Hammerson (1982) documented a decline in the abundance of northern leopard frogs as bullfrog numbers increased at a site in Colorado. (**6**) Vatnick et al.

(1999) found that adult northern leopard frogs prefered a neutral pH in a choice test and found that when they were exposed to water of pH 5.5 for 10 days they suffered 72% mortality while those exposed to a pH of 7.0 suffered only 3.5% mortality. Furthermore, frogs appeared to be much more sensitive to low pH immediately after emergence from hibernation. Those exposed to a pH of 5.5 immediately after emerging from all died within 4 days while frogs exposed after they had completed breeding activities only suffered 58% mortality over a 10 day period. Freda et al. (1991) report that a pH below 4.6 causes mortality of embryos to increase significantly from controls and all embryos die when exposed to a pH of 4.2-4.5. Corn and Vertucci (1992) report an LC_{50} of embryos at a pH of 4.5. Freda and Dunson (1985) found that tadpoles raised at a pH of 4.4 grew slower than siblings raised at a pH of 5.8. Furthermore, older tadpoles had higher survival rates at low pH than younger tadpoles. Schlicter (1981) found that sperm motility decreased below pH 6.5 and no embroys survived below a pH of 4.8. Long et al. (1995) found that low pH and UV-B acted synergistically to cause mortality in northern leopard frog embryos. Freda et al. (1990) found that at a pH below 4.8, aluminum complexed with dissolved organic carbon and became toxic to tadpoles. (**7**) Nash et al. (1970) found that loud noises resulted in an immobility reaction in leopard frogs. This could leave them at greater risk of mortality from traffic or heavy machinery. (**8**) Ankley et al. (2000) found that limb deformities were more prevalent when tadpoles were exposed to higher levels of UV-B radiation.

<u>Research and Management Suggestions</u>

1. See research and management suggestions under all of the general risk factors described above. The two populations that are known to remain in the western part of the state should thoroughly protected from the negative impacts of all management activities.
2. All historic breeding sites across the state (in western Montana in particular) should be revisited at least twice during an upcoming summer in order to identify possible changes in the short- and long-term regional status of populations.
3. A formal monitoring program should be established to detect declines and/or mechanisms behind declines for the two remnant populations west of the Continental Divide as well as for a number of randomly selected populations across the eastern plains.
4. Demographic vital rates reported in the scientific literature should be used to model the long term viability of the two populations that are known to remain in western Montana (e.g., 25, 50, and 100 years).
5. Demographic vital rate information (fecundity, life stage specific survival rates, longevity, and migration and dispersal distances) should be gathered at the two known sites in western Montana in order to better understand the population dynamics of the species and identify mechanisms of mortality for all life history stages.
6. Museum specimens collected since the 1970's should be examined for the presence of the chytrid fungus. Furthermore, because amphibians sold in pet stores may be introduced into the wild and act as vectors for pathogens, they should be examined and formally certified as free of pathogens such as the chytrid fungus.
7. The Forest Service, the state of Montana, and tribal wildlife agencies should initiate habitat improvement projects around the remaining populations in western Montana and should strongly consider initiating a captive breeding and reintroduction program at historical sites across western Montana while locally adapted source populations still exist. Prior to initiating a reintroduction program genetic studies are recommended in order to determine the genetic variation within and between the remaining populations and populations on the

eastern plains and in eastern Washington so that it is made certain that source populations are themselves native. Because reintroductions of adult amphibians are often unsuccessful due to their philopatric nature and tendency to attempt to home, reintroductions may be most successful if embryos are translocated and adequate overwintering habitat is provided at the sites of reintroduction.

8. Until the lethal and sublethal impacts of commonly used fertilizers, herbicides, and pesticides on all amphibian life history stages present in an area are examined they should not be applied within 100 meters of waterbodies or wetlands.
9. Before piscicides are used in fish removal projects the area should be surveyed for the presence of northern leopard frog breeding, and/or eggs and tadpoles. If tadpoles are present in a site that is about to be treated, tadpoles can be netted, placed in holding tanks for a few days, and returned to the site after the piscicide has cleared.

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SPECIES ACCOUNTS FOR SPECIES POTENTIALLY PRESENT IN MONTANA

Idaho Giant Salamander (*Dicamptodon aterrimus*)

Status Overview

The Idaho giant salamander (*Dicamptodon aterrimus*) has been reported or illustrated as occuring in Mineral and Ravalli counties by a number of authors (Anderson 1969; Black 1970*a*; Daugherty et al. 1983; Stebbins 1985; Good 1989; Reichel and Flath 1995; Petranka 1998). However, as noted by Nussbaum (1976) and Savage (1952) all these distributional claims are apparently based on the assumption that the holotype specimen (USNM 5242) described by Cope (1867) and later by Cope (1889) as being collected by Lieutenant Mullan from the "North Rocky Mountains" was actually collected in western Montana. Cochran (1961) adds credence to this by listing USNM 5242 as being collected by S.P. Hildreth and J. Mullan in 1860 "at the crossing of the Bitterroot River, North Rocky Mountains, (Montana)", with Montana being added by her, since this portion of Montana was actually in Washington Territory in 1860. It is worth noting that Lieutenant Mullan was involved with a variety of surveys across western Montana and Idaho during 1860 and it is possible that the specimen was actually collected in Idaho and then mislabeled as being collected at the crossing of the Bitterroot River. Idaho giant salamanders commonly occur in streams just across the state line from Mineral and Ravalli counties (Nussbaum et al. 1983). However, since USNM 5242 was collected in 1860, at a locality which must be held in question, there have been no additional specimens collected in Montana and there has only been a single sight observation reported in Mineral County, 4 miles south of Saltese in 1979 (Thompson 1982). During this time period fisheries surveys have failed to report larval *D. aterrimus* and several herpetologists have unsuccessfully searched for larval *D. aterrimus* in streams across western Montana (Franz 1971; Nussbaum 1976). Thus, although it is possible that Idaho giant salamanders occur in an isolated portion of western Montana, their presence in the state must be considered unlikely.

Identification

Eggs:

Eggs are laid singly, but placed together in a mass approximately 15 cm wide by 20 cm long containing 129 to 200 eggs (Nussbaum et al. 1983; Jones et al. 1990). Each ovum is pure white and is surrounded by six clear jelly layers (Nussbaum et al. 1983). Ovum diameters are approximately 6.5 mm (Nussbaum et al. 1983). The eggs are oblong with the long access attached to the substrate. Total egg widths are 16-21 mm and total egg heights are 22-33 mm, including the jelly layers (Jones et al. 1990).

Larvae:

Short external feathery gills are present at the base of the head. Body color varies to match the local substrate, but they usually have a dark dorsal color with lighter stripes behind the eyes (Nussbaum et al. 1983). The dorsal tail fin is mottled. Hatchlings have a TL of 34 to 40 mm and reproductively mature larvae (neotenic) larvae may reach a TL of 351 mm (Nussbaum et al. 1983; Jones et al. 1990).

Juveniles and Adults:
Dorsal color is dark brown or almost black in base color and light tan or coppery marbling is usually present and is often brightest on the head (Nussbaum et al. 1983). The size of new metamorphs is highly variable but adults may reach a TL of up to 340 mm (Nussbaum et al. 1983).

Similar Species:
No other salamander would be found as an aquatic inhabitant of streams in Montana and terrestrial adults of long-toed and tiger salamanders are much smaller (see descriptions).

Habitat Use/Natural History

Although seldom seen, adults are found terrestrially in moist coniferous forests under rocks, bark and logs and aquatically under stones in mountain streams or lakes up to 2,165 M (7,100 ft) (Nussbaum et al. 1983). Adults are active terrestrially on warm, rainy nights and may feed on a variety of invertebrates and small vertebrates (Nussbaum et al. 1983). Adults breed in the spring or fall in hidden water-filled nest chambers beneath logs and stones or in crevices in mountain streams or lakes. Females subsequently deposit eggs in these chambers and guard the eggs throughout the incubation period (Nussbaum et al. 1983). Larvae and aquatic adults are the most likely life history stage to be observed as they may reach high densities in the pools of swift, cold mountain streams and they may also be found in lakes or ponds (Nussbaum et al. 1983). Larvae feed on fish and invertebrates and usually metamorphose in 18-24 months, but may become sexually mature (paedogenesis) and reproduce as larvae (Nussbaum et al. 1983; Parker 1993).

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Great Basin Spadefoot (*Scaphiopus intermontanus*)

Status Overview

The Great Basin spadefoot (*Scaphiopus intermontanus*) has been reported as occurring in southwest Montana by Black (1970*a*; 1970*b*). In addition, in a review of amphibians and reptiles on the Beaverhead National Forest in the 1970's Timken (No Date) reported observation records for the plains spadefoot (*Scaphiopus bombifrons*) in the vicinity of Dillon, more than 100 miles southeast of the nearest reported locality for *S. bombifrons*. During the summer of 2000 spadefoot toads were heard calling on private lands at several sites immediately north of Dillon (personal observation). Due to the brevity of the visit land owners were not contacted and individuals were unable to be collected. However, breeding calls were identical to those of *S. bombifrons* and were slower than those of *S. intermontanus* (personal observation). Thus, it is likely that the spadefoots in the Dillon area are the plains spadefoot. However, it is possible that the Great Basin spadefoot may be present in southwest Montana as well. Nussbaum et al. (1983) show records of the Great Basin spadefoot north of the Snake River Plain approximately 100 miles south of Dillon and seemingly suitable habitat occurs over much of the intervening area. More thorough surveys and collections of individuals throughout southwest Montana will allow the species present in the Dillon area to be identified with certainty and will provide more support for the presence or absence of the Great Basin spadefoot. One factor hindering the detection of either species is their cryptic nature. Spadefoots spend a majority of their life underground and are usually only active on the surface at night and after heavy rains. Their loud distinctive breeding calls after heavy rains in the summer and the presence of larvae in ephemeral water bodies offer the best chance of detection.

Identification

Eggs:

Laid in smaller clusters about 15 to 20 mm in diameter containing 20 to 40 eggs (Nussbaum et al. 1983). Egg morphology has not been described in detail (Hall 1998), but would be expected to be similar to those of the plains spadefoot. Corkran and Thoms (1996) describe each ovum as tan or gray above and cream below.

Larvae:

Dark gray, brown, or black dorsally and lighter irridescent gold with gold or brassy flecks ventrally (Hall 1998). Dorsal tail fin is clear with dendritic pigmentation and ventral tail fin is clear anteriorly and dendritically pigmented posteriorly (Hall 1998). Eyes are located dorsally. TL of 5-70 mm (Hall 1998).

Juveniles and Adults:

Pupil of the eye is vertical. A large and usually soft or glandular bump or boss is present between the eyes (Hall 1998). A single black digging "spade" is present on the soles of the hind feet. Dorsal color general matches the surroundings with a base color of gray, brown, or olive mottled with a darker color (Hall 1998). Four complete or broken lighter stripes are usually present laterally and dorsally and warts may be red or orange and located within dark brown or black spots or blotches (Hall 1998). Ventral color is light gray, cream, or white. SVL of 20-63 mm (Hall 1998).

Similar Species:
See account on the plains spadefoot. Adults of the plains spadefoot have a hard bony lump or "boss" present between the eyes (Hall 1998).

Habitat Use/Natural History

Found on or adjacent to sandy soils in sagebrush flats, shrublands, and pinon-juniper woodlands, and irrigated lands (Hall 1998; Hammerson 1999). Adults retreat to self excavated burrows in loose soils during periods when terrestrial conditions are not favorable (Nussbaum et al. 1983; Hammerson 1999). Adults are present on the surface on warm nights during damp and dry weather where they feed on a variety of insects (Nussbaum et al. 1983; Hammerson 1999). Breeding and egg deposition takes place in warm temporary (more rarely permanent) water bodies formed by extensive rains from May to July (Nussbaum et al. 1983; Hammerson 1999). Eggs hatch in about two days and larvae feed on both plant and animal matter until they metamorphose in 19 to 31 days (Hall 1998).

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Wood Frog (*Rana sylvatica*)

Status Overview

Reliable records for the wood frog (*Rana sylvatica*) have been reported 40 miles south of the Wyoming state line in the Big Horn Mountains (Dunlap 1977; Garber 1992), just north of the Canadian border near Waterton Park in Alberta (Russell and Bauer 1993), and just west of the Idaho state line in northeast Idaho (Nussbaum et al. 1983). Similar, and seemingly suitable, habitat exists adjacent to these localities in the Big Horn Mountains on the Crow Indian Reservation in south-central Montana and along the state border in northwest Montana (Hart et al. 1998). To date no surveys have been conducted in the Big Horn Mountains in south-central Montana and it is possible that surveys in suitable habitat above 2,400 meters elevation may reveal the presence of isolated populations. Their presence in northwest Montana may be less likely because extensive surveys recently conducted in that area failed to detect them (Werner and Reichel 1994; Werner and Reichel 1996).

Identification

Eggs:

Eggs are laid in a single orange to grapefruit sized globular mass and are laid individually or communally in groups of up to or more than 60 egg masses (Nussbaum et al. 1983; Corn and Livo 1989). Egg masses contain from 711 to 1,248 eggs (X = 876, N = 15, for estimates at two sites in the mountains of Wyoming) (Corn and Livo 1989). Each ovum is black above, white below, and surrounded by two jelly layers (Livezey and Wright 1947). Ovum diameters are approximately 1.7 mm, but total egg diameters, including the two jelly layers, are approximately 5.0 mm (Livezey and Wright 1947).

Larvae:

Base color is blackish to olive-gray with darker speckles above, shiny bronze or pinkish laterally, and silvery pink below (Hammerson 1999). A white line occurs along the edge of the mouth (Russell and Bauer 1993). The dorsal and ventral tail fin are mostly clear, but some dark spots and blotches are present (Corkran and Thoms 1996; Hammerson 1999). TL of 7-60 mm (Nussbaum et al. 1983).

Juveniles and Adults:

A wide dark black mask extends from the tip of the snout through the eye and tympanum to just above the front leg. A white stripe may or may not extend down the center of the back (Corkran and Thoms 1996). The skin is smooth with a gray, light brown, or bronze base color with or without dark spots. Ventrally white with dark markings laterally, on the throat, and occasionally on the chest. SVL of 13-83 mm (Martof 1970).

Similar Species:

Adult Columbia spotted frogs do not have a white stripe down the center of the back, have salmon color on the thighs ventrally, and have a much thinner and fainter stripe from the snout through the eye and tympanum. In addition Columbia spotted frog adults have numerous black spots with light centers dorsally.

Habitat Use/Natural History

Found along temporary ponds, lakes and stream shores, but adults also move into shaded portions of adjacent forests or brush where there is damp ground litter. Adults are largely terrestrial during the non-breeding season, but are usually not found far from water (Nussbaum et al. 1983). In Wyoming they were found only in shallow glacial kettle ponds without fish and most frogs were found in areas with extensive shallows and dense emergent sedges on the north side of the ponds (Garber 1992). Adults are freeze tolerant and overwinter terrestrially in burrows, root channels and crevices (Nussbaum et al. 1983). Adults may migrate up to one half kilometer to small pools, backwaters and beaver ponds which are used for breeding (Hammerson 1999). Breeding takes place from March to June and eggs are often deposited communally on emergent or submerged vegetation. Eggs hatch at different times depending on water temperatures and tadpoles metamorphose in 40-90 days (Martof 1970; Nussbaum et al. 1983). Low pH in breeding ponds causes low egg and larval survival (Gascon and Planas 1986).

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