# U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

## Scientific Name:

Rana luteiventris

## Common Name:

Columbia Spotted frog

## Lead region:

Region 8 (California/Nevada Region)

## Information current as of:

04/15/2013

## Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

> ___ Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status
>
> ___ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species
>
> ___ Range is no longer a U.S. territory
>
> ___ Insufficient information exists on biological vulnerability and threats to support listing
>
> ___ Taxon mistakenly included in past notice of review
>
> ___ Taxon does not meet the definition of "species"
>
> ___ Taxon believed to be extinct
>
> ___ Conservation efforts have removed or reduced threats

___ More abundant than believed, diminished threats, or threats eliminated.

## Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 05/11/2004

90-Day Positive:05/11/2005

12 Month Positive:08/17/1997

Did the Petition request a reclassification? **No**

**For Petitioned Candidate species:**

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for this species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The Progress on Revising the Lists section of the current CNOR (http://endangered.fws.gov/) provides information on listing actions taken during the last 12 months.

## Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: Idaho, Nevada, Oregon
- **US Counties**: Owyhee, ID, Twin Falls, ID, Elko, NV, Eureka, NV, Humboldt, NV, Lander, NV, Nye, NV, Harney, OR, Lake, OR, Malheur, OR
- **Countries**: United States

## Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: Idaho, Nevada, Oregon
- **US Counties**: Elko, NV, Eureka, NV, Nye, NV, Harney, OR, Lake, OR, Malheur, OR
- **Countries**: United States

## Land Ownership:

An estimated 71 percent of all known currently occupied habitat for Columbia spotted frog (Great Basin Distinct Population Segment (DPS)) occurs on federally-managed lands. The Humboldt-Toiyabe National Forest (HTNF) in Nevada is the only national forest which has occupied Columbia spotted frog habitat within the Great Basin DPS. Occupied habitat on BLM-managed lands include the Elko and Battle Mountain District Offices in Nevada; Lakeview, Burns, and Vale District Offices in Oregon; and Jarbidge, Bruneau, and Owyhee Field Offices in Idaho. The U.S. Fish and Wildlife Services (Service) Malheur National Wildlife

Refuge in south central Oregon currently has a small population. Columbia spotted frogs occur on the Yomba-Shoshone Reservation in central Nevada and the Duck Valley Indian Reservation straddling the border of Nevada and Idaho (2.1 percent). The States manage approximately 3.3 percent of occupied habitat, and nearly 23 percent of known occupied habitat occurs on private lands including a substantial amount in southwestern Idaho.

## Lead Region Contact:

ASST REG DIR -ES-OFFICE, Jeff Waters, 916-414-6724, Jeff_Waters@fws.gov

## Lead Field Office Contact:

NV FISH AND WILDL OFC, Chad Mellison, 7758616300, chad_mellison@fws.gov

# Biological Information

## Species Description:

Ranids typically are characterized as slim-waisted, long-legged, smooth-skinned jumpers with webbed hind feet and usually with a pair of dorsolateral folds (glandular folds) that extend from behind the eyes to the lower back (Figures 14). Adult Columbia spotted frogs measure between 5 and 10 centimeters (cm) (2 and 4 inches (in)) from snout to vent, with females being larger than males (Tait 2007, pp. 1718). Dorsal colors and pattern include a light brown, dark brown, or gray, with small spots (Stebbins 2003, pp. 66, 229230) (Figures 14). Ventral coloration can differ among geographic population units and may range from yellow to salmon; however, very young individuals may have quite pale, almost white, ventral surfaces (Stebbins 2003, pp. 66, 229230) (Figures 14). The throat and the ventral region are sometimes mottled (Figures 13). The head may have a dark mask with a light stripe on the upper jaw, and the eyes are turned slightly upward (Figures 14). Adult male frogs have swollen thumbs with darkened bases (Stebbins 2003, pp. 66, 229230).

Figures 1 and 2. Columbia spotted frogs (Rana luteiventris) from the Toiyabe Mountains subpopulation in central Nevada (Used with permission: Joel Sartore/joelsartore.com).

Figures 3 and 4. Columbia spotted frogs (Rana luteiventris) from the Toiyabe Mountains subpopulation central Nevada (Used with permission: Joel Sartore/joelsartore.com).

## Taxonomy:

Spotted frogs (Rana pretiosa) were first described by Baird and Girard (1853, pp. 378379) and later split into two subspecies, R. pretiosa pretiosa and R. pretiosa luteiventris (Thompson 1913, pp. 5356). The Service accepts species-specific genetic and geographic differences in Columbia spotted frogs based on Green et al. (1996, pp. 377388; 1997, pp. 27), Bos and Sites (2001, pp. 15051511), and Funk et al. (2008, pp. 201202) which define populations in western Washington and Oregon and northeastern California as Oregon spotted frogs (R. pretiosa) and the remainder of the populations as Columbia spotted frogs (R. luteiventris). Based on further geographic and genetic characterization, Columbia spotted frogs in southwestern Idaho, southeastern Oregon, and northeastern and central Nevada are part of the Great Basin population of Columbia spotted frogs (Funk et al. 2008, pp. 201202). It was previously thought that populations in northeastern Oregon were part of the Great Basin population; however, Funk et al. (2008, pp. 201202) found that these populations belong to the Northern population (see Distinct Population Segment discussion below). A small population on the border of eastern White Pine County, Nevada, and western Toole County, Utah, has been determined through phylogenetic data to be part of the Utah population of Columbia spotted frogs (Funk et al. 2008, pp. 201202). The Committee on Standard and Scientific Names recently changed the genus name for many North

American frogs from Rana to Lithobates; however, Columbia spotted frogs maintained the genus name Rana (Crother et al. 2008, pp. 7, 11). We have carefully reviewed available taxonomic information to reach the conclusion that the species R. luteiventris is a valid taxon.

## Habitat/Life History:

Columbia spotted frogs are closely associated with clear, slow-moving or ponded surface waters, with little shade, and relatively constant water temperatures (Munger et al. 1996, p. 8; Reaser 1997a, pp. 3233; Reaser and Pilliod 2005, p. 561; Welch and MacMahon 2005, p. 477). Reproducing populations have been found in habitats characterized by springs, floating vegetation, and larger bodies of pooled water (e.g., oxbows, lakes, stock ponds, beaver-created ponds, seeps in wet meadows, backwaters) (Reaser and Pilliod 2005, p. 560). A deep silt or muck substrate may be required for hibernation and torpor (a state of lowered physiological activity, usually occuring during colder months) (Bull 2005, p. 12; Reaser and Pilliod 2005, p. 561). In colder portions of their range, Columbia spotted frogs will use areas where water does not freeze, such as spring heads and undercut streambanks with overhanging vegetation (Bull 2005, p. 12; Reaser and Pilliod 2005, p. 561); however, they can overwinter underneath ice-covered ponds (Bull and Hayes 2002, p. 143; Tattersall and Ultsch 2008, pp. 122123).

Males become sexually mature 12 years earlier than females, usually at age 2 or 3 (Reaser and Pilliod 2005, p. 561). Columbia spotted frogs employ a scramble mating system in which males race for access to females and there is little opportunity for female choice or male combat (Greene and Funk 2009, p. 244). Females usually lay egg masses in the warmest areas of a pond, typically in shallow water (1020 cm, 48 in), and clutch sizes vary (1502,400 eggs) (Bull and Shepherd 2003, pp. 109112; Bull 2005, pp. 8, 11; Reaser and Pilliod 2005, p. 560; Pearl et al. 2007a, pp. 8789). Successful egg production and the viability and metamorphosis of Columbia spotted frogs are dependent on habitat variables such as temperature, depth, and pH of water; cover; and the presence or absence of predators (Munger et al. 1996, p. 8; Reaser 1997b, pp. 2122; Bull 2005, p. 7; Reaser and Pilliod 2005, pp. 561562). Tadpoles usually metamorphose by mid to late summer; however, they have been observed in the tadpole stage as late as October (Bull 2005, p. 7; Reaser and Pilliod 2005, p. 560). Once they become adults, male Columbia spotted frogs have lower survival rates than females (Turner 1962, p. 328). While the oldest frogs documented were 1213 years old, most males live 34 years and females typically survive 58 years (Reaser 2000, pp. 11611162; Bull 2005, p. 27).

Adult Columbia spotted frogs are opportunistic feeders, consuming many types of insects, mollusks, and even other amphibians (Turner 1959, pp. 405413; Miller 1978, pp. 243248; Whitaker et al. 1983, pp. 149153; Bull 2005, pp. 1619; Reaser and Pilliod 2005, p. 561). Bull (2005, pp. 1619) conducted a diet analysis for populations in northeastern Oregon where the most common insects consumed were beetles (21 percent), ants or wasps (21 percent), and flies (10 percent). Tadpoles are grazers which consume algae and detritus (Reaser and Pilliod 2005, p. 560).

## Historical Range/Distribution:

Figure 5. Current distribution of Columbia spotted frogs within the Great Basin Distinct Population Segment. Currently occupied sites are those located from 1993 to 2012.

Figure 6. Current (19932012) and historical (pre-1993) Columbia spotted frog sites in southeastern Oregon, southwestern Idaho, and northern Nevada.

Figure 7. Current (19932012) and historical (pre-1993) Columbia spotted frog sites in central Nevada.

Current and Historical Range/DistributionNevada

Prior to the Candidate listing in 1993, Columbia spotted frogs were known to occur in 55 6th order hydrologic units (HUCs; all references to HUCs in this document are at the 6th order level) in northern and central Nevada (Figures 57). The current distribution includes 91 HUCs in northeastern and central Nevada (Figures 67). Columbia spotted frogs in Nevada are found at elevations between 1,700 and 2,650 meters (m) (5,600 and 8,700 feet (ft)). Columbia spotted frog populations in Nevada are geographically separated into three subpopulations: Jarbidge-Independence Range, Ruby Mountains, and Toiyabe Mountains. The Nevada Wildlife Action Plan defines these areas as the Great Basin (Jarbidge-Independence Range, Ruby Mountains, and Toiyabe Mountains subpopulations) and Columbia Plateau (Jarbidge-Independence Range subpopulation) Ecoregions (Nevada Department of Wildlife (NDOW) 2006, p. 66). The largest of Nevadas three subpopulation areas is the Jarbidge-Independence Range in Elko and Eureka Counties. This subpopulation area is formed by the headwaters of streams in two major hydrographic basins. The South Fork Owyhee River, Owyhee River, Bruneau River, and Salmon Falls Creek drainages flow north into the Snake River basin. Marys River, North Fork Humboldt River, and Maggie Creek drain into the interior Humboldt River basin. Columbia spotted frogs occur in the Ruby Mountains in tributaries to the South Fork Humboldt River including Green Mountain, Smith, Corral, and Rattlesnake Creeks Elko County. In the Toiyabe Mountains, Nye County, Columbia spotted frogs are found in seven drainages including the Reese River (Upper and Lower); Cow and Ledbetter Canyons; and Cloverdale, Stewart, Illinois, and Indian Valley Creeks (Figure 7; NDOW 2003b, p. S8). The Toiyabe Mountains subpopulation is geographically isolated from the Ruby Mountains and Jarbidge-Independence Range subpopulations by a large gap in suitable habitat and represents the southern-most extremity of the species range.

Current and Historical Range/DistributionIdaho

Prior to 1993, Columbia spotted frogs were known to occur at only seven locations in Owyhee County, Idaho (Figures 56; Munger et al. 1996, pp. 23, 6, 16). Since 1993, monitoring efforts have discovered more frog locations, including several in Twin Falls County, Idaho (Figures 56; Munger et al. 1996, pp. 5, 6669; La Fayette 2011, p. 12; Lohr 2012, p. 5). Frogs were found in 7 HUCs prior to 1993 and in 42 HUCs from 1993 to 2012. The Idaho Comprehensive Wildlife Conservation Strategy addresses Columbia spotted frog as a priority species within the Owyhee Uplands Ecoregion (Idaho Department of Fish and Game (IDFG) 2005, pp. 18).

Current and Historical Range/DistributionOregon

Prior to 1993, only three HUCs were known to be occupied in southeastern Oregon; however, since 1993, Columbia spotted frogs have been detected in 22 HUCs (Figures 56). The current range of the Great Basin DPS of Columbia spotted frogs in Oregon includes populations east of Highway 395 and south of Highway 20 including the Owyhee and Steens Mountains in Lake, Harney and Malheur Counties (Figures 56; Munger et al. 1998, pp. 34; Smyth 2004, pp. 37; Funk et al. 2008, p. 202; Pearl et al. 2010, pp. 58; Robertson and Funk 2012, pp. 1012, 1920). The Oregon Conservation Strategy defines this area as the Northern Basin and Range Ecoregion (Oregon Department of Fish and Wildlife (ODFW) 2006, pp. 204221).

## Current Range Distribution:

Current and Historical Range/DistributionNevada

Prior to the Candidate listing in 1993, Columbia spotted frogs were known to occur in 55 6th order hydrologic units (HUCs; all references to HUCs in this document are at the 6th order level) in northern and central Nevada (Figures 57). The current distribution includes 91 HUCs in northeastern and central Nevada (Figures 67). Columbia spotted frogs in Nevada are found at elevations between 1,700 and 2,650 meters (m) (5,600 and 8,700 feet (ft)). Columbia spotted frog populations in Nevada are geographically separated into three subpopulations: Jarbidge-Independence Range, Ruby Mountains, and Toiyabe Mountains. The Nevada Wildlife Action Plan defines these areas as the Great Basin (Jarbidge-Independence Range, Ruby Mountains, and Toiyabe Mountains subpopulations) and Columbia Plateau (Jarbidge-Independence Range subpopulation) Ecoregions (Nevada Department of Wildlife (NDOW) 2006, p. 66). The largest of Nevadas three subpopulation areas is the Jarbidge-Independence Range in Elko and Eureka Counties. This subpopulation area is formed by the headwaters of streams in two major hydrographic basins. The South Fork Owyhee River, Owyhee River, Bruneau River, and Salmon Falls Creek drainages flow north into the Snake River basin. Marys River, North Fork Humboldt River, and Maggie Creek drain into the interior Humboldt River basin. Columbia spotted frogs occur in the Ruby Mountains in tributaries to the South Fork Humboldt River including Green Mountain, Smith, Corral, and Rattlesnake Creeks Elko County. In the Toiyabe Mountains, Nye County, Columbia spotted frogs are found in seven drainages including the Reese River (Upper and Lower); Cow and Ledbetter Canyons; and Cloverdale, Stewart, Illinois, and Indian Valley Creeks (Figure 7; NDOW 2003b, p. S8). The Toiyabe Mountains subpopulation is geographically isolated from the Ruby Mountains and Jarbidge-Independence Range subpopulations by a large gap in suitable habitat and represents the southern-most extremity of the species range.

Current and Historical Range/DistributionIdaho

Prior to 1993, Columbia spotted frogs were known to occur at only seven locations in Owyhee County, Idaho (Figures 56; Munger et al. 1996, pp. 23, 6, 16). Since 1993, monitoring efforts have discovered more frog locations, including several in Twin Falls County, Idaho (Figures 56; Munger et al. 1996, pp. 5, 6669; La Fayette 2011, p. 12; Lohr 2012, p. 5). Frogs were found in 7 HUCs prior to 1993 and in 42 HUCs from 1993 to 2012. The Idaho Comprehensive Wildlife Conservation Strategy addresses Columbia spotted frog as a priority species within the Owyhee Uplands Ecoregion (Idaho Department of Fish and Game (IDFG) 2005, pp. 18).

Current and Historical Range/DistributionOregon

Prior to 1993, only three HUCs were known to be occupied in southeastern Oregon; however, since 1993, Columbia spotted frogs have been detected in 22 HUCs (Figures 56). The current range of the Great Basin DPS of Columbia spotted frogs in Oregon includes populations east of Highway 395 and south of Highway 20 including the Owyhee and Steens Mountains in Lake, Harney and Malheur Counties (Figures 56; Munger et al. 1998, pp. 34; Smyth 2004, pp. 37; Funk et al. 2008, p. 202; Pearl et al. 2010, pp. 58; Robertson and Funk 2012, pp. 1012, 1920). The Oregon Conservation Strategy defines this area as the Northern Basin and Range Ecoregion (Oregon Department of Fish and Wildlife (ODFW) 2006, pp. 204221).

## Population Estimates/Status:

Population Estimates/Status

Comparing the historical and current distributions of Columbia spotted frogs is challenging due to many factors including, but not limited to, few historical records, imprecise site locality information, and the transient nature of frog habitat associated with beaver ponds. To address some of these challenges, a watershed occupancy approach using HUCs was used to assess the status of the Great Basin DPS Columbia spotted frogs (based on the National Hydrography Dataset (NHD); see http://nhd.usgs.gov for more information). Sites occupied prior to 1993 are termed historical sites while sites detected from 1993 to 2012 are termed current sites. A HUC is considered occupied if it has at least one occupied site within its boundary. Prior to 1993, there were 65 known occupied HUCs within the Great Basin DPS (Oregon 3, Idaho 7, Nevada 55). Between 1993 and 2012, Columbia spotted frogs have been detected in 155 HUCs (Oregon 22, Idaho 42, Nevada 91). In Oregon, one historical HUC is known to still be occupied, one is thought to be extirpated, and the third has no recent survey data. In Idaho, of the seven HUCs known to exist prior to 1993, five were occupied on at least one occasion between 1995 and 2008, one is of unknown occupancy, and one (at the confluence of the Little Owyhee River and South Fork Owyhee River) may be extirpated. Of the 55 historical HUCs in Nevada, 16 have no known current occupancy. Of those 16 HUCs, 9 have a low likelihood of current occupancy due to presence of nonnative aquatic species, high anthropogenic disturbance, or no known contemporary habitat. The remaining seven HUCs have high quality habitat but have not been surveyed recently.

StatusNevada: Declines of Columbia spotted frog populations in Nevada have been recorded since 1962 when it was observed that in many Elko County localities where Columbia spotted frogs were once numerous, the species was nearly extirpated (Turner 1962, pp. 326327). Extensive loss of habitat had occurred from conversion of wetland habitats to irrigated pasture and from spring and stream dewatering by mining and irrigation practices. In addition, there were extensive impacts on riparian habitats due to intensive livestock grazing. Researchers in Nevada have documented the loss of historically occupied sites, reduced numbers of individuals within local populations, and declines in the reproduction of local populations (Turner 1962, pp. 326327; Hovingh 1990, p. 6; Reaser 1997a, pp. 3033; Hatch et al. 2002, pp. 4750; Wente et al. 2005, p. 99).

Prior to 2003, lack of standardized and extensive monitoring prevented dependable determinations of frog population numbers or trends across Nevada. However, long-term standardized monitoring protocols have been implemented for both the Toiyabe Mountains and Northeastern subpopulations (NDOW 2004b, pp. 125; 2009, pp. 121). Results from these efforts are provided below.

Within the Ruby Mountains, Jarbidge, and Mountain City Ranger Districts and the BLM Elko District in northeastern Nevada, there are approximately 256 HUCs. Of the 256 HUCs, 200 HUCs are associated with perennial water; the remaining 56 HUCs have little water and are not expected to have any frog habitat. From 2000 to present, the USFS and NDOW have conducted presence-absence surveys within 93 HUCs with perennial water. Upon completion of a HUC survey, the HUC is identified as either occupied (frogs detected), absent (no frogs detected and insufficient habitat), or unknown (no frogs detected, but more surveys needed). Of the 93 HUCs surveyed since 2000, Columbia spotted frogs have been detected in 59 (63 percent) (NDOW 2012a, p. 3).

In 2004, the USFS initiated an intensive mark-recapture survey at two sites, Green Mountain Creek, Ruby Mountains Ranger District and Tennessee Gulch, Mountain City Ranger District (and added a third site in 2005, Pole Creek, Jarbidge Ranger District), as part of an effort to determine population estimates, mortality, juvenile-to-adult recruitment, movement, and habitat preference (Meneks 2005a, pp. 13). A summary of findings is discussed below (Table 1; Van Horne 2012, pp. 117). Between 2004 and 2012, a total of 2,217 discrete adult frogs (total number marked plus total number of recaptures from previous years) were captured from all three sites. Between 2006 and 2012, the average number of adult frogs captured (mean = 41) at the Green Mountain Creek site was relatively stable and remained approximately double the numbers captured in 2004 and 2005; however, juvenile numbers have shown a more variable trend (Table 1; Van Horne 2012, pp. 35). Adult numbers captured at Tennessee Gulch between 2005 and 2009 were similar (mean = 161); however, since 2010, the mean number of adults captured has declined to 76. In addition, females outnumbered males in the population by 2 to 1, and juvenile numbers remained low for the sixth year in a row (Table 1; Van Horne 2012, pp. 710). The number of adult frogs captured at the Pole Creek site between 2005 and 2007 averaged 175 individuals; however, beginning in 2008 and continuing through 2012, the number of adults captured has declined sharply with only 15 adults captured in 2012. Additionally, juvenile numbers remained low with a total of 11 captured between 2006 and 2012. This decline at the Pole Creek site is believed to be due to the declining amount of available habitat, which is due to reduced beaver (Castor canadensis) activity (Table 1; Van Horne 2012, pp. 1114).

Table 1. Columbia spotted frog survey data for the Green Mountain (GM), Tennessee Gulch (TG), and Pole Creek (PC) sites in the Jarbidge-Independence Range and Ruby Mountains subpopulations, Northeastern Nevada. Population estimates are based on Lincoln-Petersen methodology (Modified from Van Horne 2012, pp. 314).

Table 2. Columbia spotted frog summary survey data from the Toiyabe Mountains subpopulation, central Nevada.

[1] NDOW 2012b, unpublished data; [2] Adams et al. 2013, p. 11

During the summers of 2000 and 2001, mark-recapture surveys of the Toiyabe Mountains subpopulation were conducted by the University of Nevada, Reno. Preliminary estimates of frog numbers in the Indian Valley Creek drainage were approximately 5,000 breeding individuals, which was greater than previously believed (Hatch et al. 2002, p. 3). However, during the 20002001 winter Hatch et al. (2002, p. 23) noted decreases, ranging between 66 and 86.5 percent, at several sites. Survey results suggested poor overwintering habitat contributed to the winterkill (Hatch et al. 2002, pp. 2527).

To document population dynamics within the Toiyabe Mountains subpopulation, a large mark-recapture study using PIT tags was initiated in 2004 and has continued annually. During this period, 5,581 frogs have been PIT tagged. Results from the 2012 monitoring are discussed below (Table 2; NDOW, unpublished data 2012b). Total discrete adult frog captures (total number marked plus total number of recaptures from previous years) increased substantially in 2012 (n = 2,594) compared to 2011 (n = 1,171) and 2010 (n = 1,112). Total recaptures in 2012 (n = 761) were also substantially higher compared to 2011 (n = 465) and 2010 (n = 525). Juvenile frog captures in 2012 (n = 1,134) were slightly higher compared to 2011 (n = 994) and 2010 (n = 1,003). Egg mass counts were variable until 2010 and have steadily increased the last 2 years (Table 2). Estimates of the adult population were made between 2004 and 2010 using the program MARK (Adams et al. 2013, pp. 112). Estimates have ranged from a low of 544 adults in 2005 to a high of 1,619 adults in 2010 (Table 2; Adams et al. 2013, p. 11).

StatusIdaho: Since Columbia spotted frogs were listed as a Candidate in 1993, they have been found in several more locations in southwestern Idaho comprising the Owyhee subpopulation (Figure 6). Extensive surveys began in 1995 and intensive surveys at four sites (sentinel sites) began in 1997. In 2000, a monitoring protocol was established for presence/absence surveys of Columbia spotted frogs at 51 Element Occurrences (EO) in southwestern Idaho (Engle 2000, p. 29). According to the protocol, a subset of EOs is surveyed every year on a 3-year rotation (approximately 15 EOs/year). From 2001 to 2006, Columbia spotted frogs occupied from 45 to 92 percent of surveyed EOs (Table 3). In 2007, the monitoring protocol shifted from presence/absence surveys to occupancy estimation and modeling, and survey units were based on catchment basins (HUCs broken into smaller survey units) (Moser 2007, pp. 910). From 2007 to 2011, catchment basins were surveyed and from 58 to 77 percent were occupied by Columbia spotted frogs (Table 3). Additionally, 39 different catchment basins located on private lands in southwestern Idaho were surveyed from 2009 to 2012 (LaFayette 20092012, entire documents). Columbia spotted frogs were detected in 32 (82 percent) (LaFayette 2009, pp. 617; 2010, p. 7; 2011, p. 13; 2012, p. 4).

Table 3. Columbia spotted frog percent occupancy of the Owyhee subpopulation in southwestern Idaho from 2001 to 2011.

[a]Engle (2002, p. 35), [b]Lingo and Munger (2002, p. 27), [c]Lingo and Munger (2003, p. 54), [d]Blankenship and Munger (2005, p. 2), [e]Moser and Patton (2006, p. 2), [f]Moser (2007, p. 14), [g]Lohr and Moser (2008, p. 14), [h] Lohr and Haak (2009, p. 14), [i]Lohr and Haak (2010, p. 14), [j]Lohr (2011, p. 14).

Four sentinel sites have been intensively surveyed annually since 1997 (Lohr 2012, p 217). These sites, Sam Noble Springs, Circle Pond, Cottonwood Creek, and Stoneman Creek, are located in different catchment basins and are discussed below.

Sam Noble Springs: From 2001 to 2012, 853 individual Columbia spotted frogs were PIT tagged at the Sam Noble Springs complex; 66 percent were captured over multiple years (Lohr 2013, pers. comm.). Although the timing of mark-recapture surveys was not comparable among all years, Columbia spotted frog numbers appear to be variable, but stable (Lohr 2012, pp. 1112). Population estimates using the program MARK range from a low of 66 adults in 2003 and a high of 137 in 2000; the adult population estimate for 2012 was 126 (Lohr 2012, p. 12). Additionally, egg mass counts have been conducted at Sam Noble Springs since 2000 and have remained relatively stable (Table 4). In 2012, the second highest number of egg masses (n = 52) was recorded since surveys began (Table 4; Lohr 2012, p. 10).

Circle Pond: From 1997 to 2006, 67 adult Columbia spotted frogs were PIT tagged (Lohr 2013, pers. comm.) Egg mass counts have been conducted since 2000. The number of egg masses observed has been variable, ranging from zero in 2004 and 2005 to nine in 2009 (Table 4; Lohr 2012, p. 9).

Cottonwood Creek: From 2000 to 2006, 135 adult Columbia spotted frogs were PIT tagged (Lohr 2013, pers. comm.). Egg mass surveys have been conducted since 2002 resulting in variable egg mass numbers among years (range = 433) (Table 4; Lohr 2012, p. 9).

Table 4. Total number of Columbia spotted frog egg masses observed at four sentinel sites within the Owyhee subpopulation in southwestern Idaho, 20002012 (Lohr 2012, pp. 910).

[a]18 egg masses counted on road side of site, from beaver pond downstream.

Stoneman Creek: From 1997 to 2006, 588 adult Columbia spotted frogs were PIT tagged from Stoneman Creek (Lohr 2013, pers. comm.). The population dramatically increased after 2001 following beaver reintroduction and subsequent stream damming. Egg mass surveys began in 2000, but no egg masses were detected until 2002 (Table 4). Egg mass numbers were variable but generally increasing until 2010 when a total of 167 egg masses were counted (Lohr 2011, p. 13). In early winter 2011, the beaver dams at this site were damaged by flooding, and the beaver colony moved upstream approximately 400 m (1,312 ft). By 2012, the beaver pond had reverted back to a stream channel with only a few off-channel puddles, which were too shallow to support tadpoles through metamorphosis. Breeding subsequently declined at Stoneman Creek with 105 egg masses counted in 2011 and 25 egg masses counted in 2012 (Table 4; Lohr 2012, p. 9).

In summary, long-term monitoring of the four sentinel sites indicates that these Columbia spotted frog populations appear to be variable but stable.

In addition to intensive surveys and occupancy surveys, a genetic analysis was completed in 2011 to assess the population structure in the Owyhee subpopulation (Robertson and Funk 2011, pp. 123). Despite the frogs somewhat widespread distribution in Owyhee County, Robertson and Funk found that Columbia spotted frogs there had small effective population sizes, exhibited low genetic variation, and were highly differentiated from most other sites. They divided the Owyhee subpopulation into three distinct clusters and recommended that these clusters be treated as separate management units (Robertson and Funk 2011, pp. 8, 19). They also found evidence of recent and historical bottlenecks at seven of nine sites analyzed (Robertson and Funk 2011, p. 9).

StatusOregon: In southeastern Oregon, presence-absence surveys conducted in 1997 reconfirmed a population of Columbia spotted frogs in the Dry Creek drainage in Malheur County which had been previously documented in 1939 (Munger et al. 1998, pp. 34, 12). Detailed population sampling using PIT tags has occurred in Dry Creek since 2001 (Table 5; Meyer 2012, pp. 131). During this period, 2,966 frogs were PIT tagged. Total discrete adult frog captures were substantially lower in both 2012 (n = 56) and 2011 (n = 38) compared to 2010 (n = 197) and 2009 (n = 164) (Table 5; Meyer 2012, p. 13). Subadult frog counts were also fewer in 2012 (n = 158) and 2011 (n = 121) compared to 2010 (n = 1,086) and 2009 (n = 628) (Table 5; Meyer 2012, p. 13). Based on Lincoln-Petersen estimates, the total population size (N) has generally increased since 2001 (N = 74), with large increases detected in 2008 (N = 493), 2009 (N = 890), and 2010 (N = 1,632); however, in 2011 (N = 305) and 2012 (N = 266), a substantial decrease in the population occurred (Table 5; Meyer 2012, pp. 1113). Two large spring (March and May) flow events in Dry Creek are presumed to have caused this reduction in the population. Over the 12 year study period, only 278 individuals have been recaptured, indicating that annual survival rates of adults are low (Meyer 2012, p. 20).

Table 5. Summary Columbia spotted frog survey data from the Dry Creek population, southeastern Oregon (Meyer 2012, p. 13).

Presence-absence monitoring has occurred in the Steens Mountains area, Harney County, in which small isolated populations of Columbia spotted frogs have been located (Smyth 2004, pp. 37). Between 2000 and 2003, the USGS compared regional distributions of amphibians with occurrence patterns suggested in historical (prior to 1999 in this study) data (Wente et al. 2005, pp. 9599). Visual encounter surveys were used to determine presence-absence of Columbia spotted frogs on public lands in eastern Oregon and northern Nevada. Based on occupancy models, the USGS estimated that Columbia spotted frogs occupied 53 percent of the 30 historical sites in the area surveyed (Wente et al. 2005, p. 99). Between 2000 and 2003, 6 of 16 sites proximal to historical sites were occupied (Wente et al. 2005, p. 99). Additionally, 187 sites in southeastern Oregon were randomly selected for presence-absence surveys of which only 3 sites were occupied; however, variability in occupancy between the 3 years was problematic (Wente et al. 2005, pp. 99106). More recently, USGS crews sampled 42 historical (prior to 2000 in this study) locations in southeastern Oregon and found Columbia spotted frogs at nearly 60 percent of the target sites or in nearby habitat (Pearl et al. 2010, pp. 29). The authors caution interpretation of the results because the survey was conducted in one year (2009), sites were only visited once, many of the historical records contained just a few adult frogs, and many of the historical records contained poor location data (Pearl et al. 2010, pp. 78).

Robertson and Funk (2012, pp. 120) used microsatellite markers to estimate genetic connectivity among populations, identify the number and spatial distribution of genetically distinct populations, estimate effective population sizes, and test for population declines using genetic bottleneck tests for Columbia spotted frog populations throughout Oregon (Northern and Great Basin DPSs). Results indicate that the southeastern Oregon populations are genetically distinct and isolated from each other, effective population sizes are very small and have low heterozygosity and allelic richness, and recent bottleneck events have occurred (Robertson and Funk 2012, p. 6).

In summary, monitoring efforts are being implemented throughout the range of the Columbia spotted frog in Idaho, Nevada, and Oregon. Rather extensive surveys and monitoring since 1993 have revealed that Columbia spotted frog populations are much more widespread and common than what was previously known. While some sites and HUCs are no longer occupied, Columbia spotted frogs are well distributed throughout southwestern Idaho and northeastern Nevada with isolated and disjunct populations in southeastern Oregon and central Nevada (Figure 6). We have population estimates for several intensively surveyed sites across three statespopulations at most seem to be variable, but stable. Researchers will begin work this summer to analyze long-term mark/recapture data, and develop habitat suitability maps, which will help with long-term conservation planning.

## Distinct Population Segment(DPS):

DISTINCT POPULATION SEGMENT (DPS)

Under the ESA, we must consider for listing any species, subspecies, or, for vertebrates, DPSs of these taxa, if information is sufficient to indicate that such action may be warranted. To implement the measures prescribed by the ESA and its Congressional guidance, we, along with the National Oceanic and Atmospheric Administration (NOAA) Fisheries, developed policy to clarify our interpretation of the phrase distinct population segment of any species of vertebrate fish or wildlife for the purposes of listing, delisting, and reclassifying species under the ESA (61 FR 4722; February 7, 1996). The policy allowed us to interpret the requirement of the ESA to determine whether any species is an endangered species or a threatened species (section 4(a)(1)) in a clear and consistent fashion for the term distinct population segment. Under our DPS policy, we consider three elements in a decision regarding the status of a possible DPS as endangered or threatened under the ESA. These are applied similarly for addition to the lists of endangered and threatened wildlife and plants, for reclassification, and for removal. The elements are: (1) the population segments discreteness from the remainder of the species to which it belongs; (2) the population segments significance to the species to which it belongs; and (3) the population segments conservation status in relation to the ESA standards for listing (i.e., when treated as if it were a species, is the population segment endangered or threatened?). Our policy further recognizes it may be appropriate to assign different classifications to different DPSs of the same vertebrate taxon.

Figure 8. Geographic distribution of Oregon spotted frogs (Rana pretiosa) and Columbia spotted frogs (Rana luteiventris) (Funk et al. 2008, p. 202). Reprinted with permission.

Discreteness

The DPS policy standard for discreteness allows an entity given DPS status under the ESA to be adequately defined and described in some way that distinguishes it from other representatives of its species. A population segment of a vertebrate species may be considered discrete if it satisfies either one of the following two conditions: (1) it is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (quantitative measures of genetic or morphological discontinuity may provide evidence of this separation); or (2) it is delimited by international governmental boundaries within which significant differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist.

Columbia spotted frogs in Nevada, southwestern Idaho, and most populations in the southeastern Oregon portion of the Great Basin are geographically separate from the remainder of the species (Figure 8; Funk et al. 2008, p. 204). For management purposes, populations within the Great Basin have been divided into four subpopulations. The largest of Nevadas three subpopulation areas is the Jarbidge-Independence Range in Elko and Eureka Counties. This subpopulation area is formed by the headwaters of streams in two major hydrographic basins. The South Fork Owyhee River, Owyhee River, Bruneau River, and Salmon Falls Creek drainages flow north into the Snake River basin while the Marys River, North Fork Humboldt River, and Maggie Creek drain into the interior Humboldt River basin. A smaller subpopulation of Columbia spotted frogs is located in the Ruby Mountains about 80 kilometers (km) (50 miles (mi)) south of the Jarbidge-Independence Range subpopulation. However, these two subpopulations are isolated by lack of suitable habitat and hydrologic connectivity. The Toiyabe Mountains subpopulation is isolated nearly 320 km (200 mi) southeast of the Ruby Mountains and Jarbidge-Independence Range subpopulations and represents the southern-most extremity of its range. The Owyhee subpopulation of Columbia spotted frogs appears to be widely distributed throughout southwestern Idaho (Owyhee and Twin Falls Counties) and southeastern Oregon (Lake, Malheur, and Harney Counties), but local populations within this area are generally small, with a few exceptions, and appear to be isolated from each other and from subpopulations in northeastern Nevada by either natural or human-induced habitat disruptions (Robertson and Funk 2011, pp. 59; Robertson and Funk 2012, p. 6).

All four Great Basin subpopulations are geographically isolated and separate from the main continuous Northern population of Columbia spotted frogs in the central mountains of Idaho by the Snake River Plain and adjacent lowlands in eastern Oregon. The Owyhee subpopulation in southwestern Idaho is approximately 125 km (75 mi) from the Northern population in central Idaho. Occupied habitat in the Northern population is characterized mostly by conifer forests and high elevation lake environments while habitat for the Great Basin population is characterized by sagebrush steppe and their associated stream and pond environments. However, these two habitat types converge in east-central Oregon and Columbia spotted frogs from the Northern and Great Basin populations, in the vicinity of State Highway 20, are in close proximity to each other (Figure 8; Robertson and Funk 2012, pp. 6, 20). Furthermore, the Great Basin population is both hydrologically and geographically separated from isolated populations in Utah. The subpopulation in the Ruby Mountains (Lahontan Basin) is approximately 145 km (90 mi) from the West Desert population (Bonneville Basin) near Ibapah, Utah. As detailed below, geographic isolation of the Great Basin population is supported by genetic analyses.

Three earlier genetic studies were conducted on Columbia spotted frogs which have improved our knowledge on the distribution and genetic structure of the species (Green et al. 1996, pp. 374390; Green et al. 1997, pp. 18; Bos and Sites 2001, pp. 14991513). Unfortunately, these studies did not include populations in southwestern Idaho and eastern Oregon. Because the distribution of subpopulations within the Great Basin DPS was unresolved, the USGS initiated a genetic evaluation of the Great Basin DPS (USGS 2006, pp. 13). Objectives of the study included: 1) determine the distribution of distinct subpopulations within the Great Basin DPS; 2) determine whether Columbia spotted frog populations from southeastern Oregon and southern Idaho are part of the Great Basin DPS; 3) determine whether Columbia spotted frog populations from northeastern Oregon are part of the Great Basin DPS or instead, part of the large, contiguous portion of the species range in the northern Rocky Mountains; and 4) examine population genetic structure and status in the Great Basin DPS of Columbia spotted frog. Results from this study are presented below (Funk et al. 2008, pp. 198210).

The strongest genetic evidence that Columbia spotted frog populations in the Great Basin are genetically discrete from other Columbia spotted frogs comes from Funk et al. (2008, pp. 198210) who examined mitochondrial DNA (mtDNA) sequence variation throughout the extant range of Columbia spotted frogs. These data indicate three distinct major clades (a clade is a group of taxa sharing a closer common ancestry with one another than with members of any other clade): Northern, Great Basin, and Utah (Figure 8; Funk et al. 2008, pp. 201202). The three clades are nearly as divergent from each other as they are from Oregon spotted frog, a closely related but separate species (Funk et al. 2008, p. 202). Additionally, within each major clade, well-defined nested clades are also evident. The Great Basin clade has two well-defined nested clades in southwestern Idaho-Nevada and southeastern Oregon (Figure 8; Funk et al. 2008, p. 202) (Figure 8). These two nested clades are also the most divergent among the nested clades indicating the effects of small isolated populations in southeastern Oregon (Funk et al. 2008, p. 205). The authors also found one location in east-central Oregon in which there is an overlap between the Northern and Great Basin clades (Figure 8; Funk et al. 2008, p. 204). However, a more recent study using microsatellite markers found that this site

(Kingsbury Gulch) belongs in the Northern clade (Robertson and Funk 2012, p. 5). This area of southeastern Oregon has been identified as a natural zone of hybridization for other species, such as butterflies and birds (Remington 1968, pp. 321428).

Significance

Under our DPS policy, once we have determined that a population segment is discrete, we consider its biological and ecological significance to the larger taxon to which it belongs. This consideration may include, but is not limited to, evidence of the persistence of the discrete population segment in an ecological setting that is unique for the taxon; evidence that loss of the population segment would result in a significant gap in the range of the taxon; evidence that the population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range; and evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

We have found substantial evidence that two of these significance factors are met by the Great Basin population of the Columbia spotted frog. The extinction of the Nevada, southwestern Idaho and southeastern Oregon portion of the range of the Columbia spotted frog would likely result in the loss of a significant genetic entity and the curtailment of the range of the species (Hampe and Petit 2005, pp. 462463). Particularly, the work of Funk et al. (2008, pp. 198210) indicates that Columbia spotted frogs in the Great Basin differ genetically from Columbia spotted frogs sampled in other portions of the range to a significant degree. Additionally, loss of Columbia spotted frogs in Nevada, southwestern Idaho and southeastern Oregon would eliminate the southern extent of the species range.

Conclusion

We evaluated the Great Basin population of Columbia spotted frogs, addressing the two elements which our policy requires us to consider in deciding whether a vertebrate population may be recognized as a DPS and considered for listing under the ESA. We conclude that the Great Basin population is discrete, as per our policy, based on its geographic separation and genetic divergence from the isolated populations in Utah and the main continuous populations in central and northern Idaho, northeastern Oregon, eastern Washington, western Montana, northwestern Wyoming, and southeast Alaska, and British Columbia and Alberta, Canada. We conclude that the Great Basin population of the Columbia spotted frog is significant because the loss of the species from this area would result in a significant reduction in the species range and would constitute loss of a genetically divergent portion of the species. Because the population segment meets the discreteness and significance criteria of our DPS policy, the Great Basin population of the Columbia spotted frog constitutes a DPS which qualifies for consideration for listing.

# Threats

## A. The present or threatened destruction, modification, or curtailment of its habitat or range:

Habitat modification and destruction has been implicated in the majority of amphibian declines (Bishop et al. 2003, pp. 209210; Young et al. 2004, pp. 3132; Bradford 2005, pp. 919, 921922; Vredenburg and Wake 2007, p. 5; Wells 2007, pp. 817825; Chanson et al. 2008, pp. 3942). Isolated populations of amphibians, as seen throughout the range of Columbia spotted frogs in the Great Basin, are particularly susceptible to habitat modification (Noss et al. 2006, p. 230; Tait 2007, p. 26). Columbia spotted frog habitat degradation and fragmentation is a combined result of topography, climate change, and past and current land use influences from agricultural development, intensive livestock grazing, spring development, nonnative fish stocking, urbanization, and mining activities,. Small upland streams and meadows found throughout the central Great Basin, including occupied habitat within the Toiyabe Mountains subpopulation in Nevada, are inherently unstable and have been prone to incision for at least the last 400500 years (Germanoski and Miller 2004, p. 117). Land use activities in these sensitive areas have initiated or accelerated the incision process which has changed the hydrologic function of meadow systems (Jewett et al. 2004, pp. 152155). These changes in the hydrology of meadows, mainly the lowering of the water table, can cause the vegetation communities to shift from wet meadow communities (Carex sp.) to dry upland plant communities (Artemisia sp.) (Chambers et al. 2004a, pp. 201205). The loss of meadow complexes may limit the available habitat for Columbia spotted frogs to the incised channel which may cause a crowding effect (Noss et al. 2006, p. 223). Natural fluctuations in environmental conditions (e.g., drought) tend to magnify the detrimental effects of land use activities, just as the land use activities may compound the detrimental effects of natural environmental events (Boone et al. 2003, pp. 138142).

Within the Great Basin, cold water spring habitats provide a stable, permanent source of water for frog breeding, feeding, shelter, and winter refugia (IDFG et al. 1995, p. 9; Patla and Peterson 1997, pp. 1617; Munger 2003, p.13). Analyzing 10 different factors that influence the abundance and distribution of taxa associated with spring systems in the Great Basin, Sada and Vinyard (2002, p. 280) found that anthropogenic spring development was the most important factor affecting spring associated taxa. Most spring developments affect natural springflow through the installation of a pipe or box to fully capture the water source and direct water to another location such as a livestock watering trough. Loss of this permanent source of water in semi-arid ecosystems can also lead to the loss of associated riparian habitats and wetlands used by Columbia spotted frogs. Developed spring pools could be functioning as attractive nuisances for frogs, concentrating them into isolated groups, increasing the risk of disease and predation (Noss et al. 2006, p. 223). In contrast, some springs developed into ponds for watering livestock appear to provide persistent high quality breeding and rearing sites in southwestern Idaho (La Fayette 2011, p. 19). Similarly, in northeastern Nevada, stock ponds are associated with 12 percent of known occupied sites (J. Petersen 2013, pers. comm.). Many of the springs in southwestern Idaho, eastern Oregon, and Nevada have been developed or diverted for anthropogenic reasons.

Fragmentation of habitat may be one of the most significant factors affecting Columbia spotted frog conservation and long-term population persistence (Semlitsch 2002, pp. 620623; Green 2003, pp. 340341; Opdam and Wascher 2004, pp. 285-297; Funk et al. 2005a, pp. 1415; Tait 2007, p. 26; Robertson and Funk 2011, pp. 5¬9; Robertson and Funk 2012, pp. 58). Studies in Idaho indicate that Columbia spotted frogs exhibit breeding site fidelity (Pilliod et al. 2002, pp. 18531859; Engle and Munger 2003, pp. 910). Habitat fragmentation can impede seasonal movement of frogs from hibernation ponds to breeding ponds which can lead to reduced genetic diversity, local population declines, or extirpation (Engle and Munger 2003, pp. 1213; Funk et al. 2005a, p. 15; Funk et al. 2005b, p. 494; Robertson and Funk 2011, pp. 59; Robertson and Funk 2012, pp. 58). While Columbia spotted frogs show strong site fidelity, individuals are capable of travelling relatively large distances of 5 km (3.1 mi) or more if adequate habitat is available (Funk et al. 2005a, p. 2; C. Mellison 2012, unpublished data). Local populations will become increasingly isolated as movement corridors become more fragmented (Bull and Hayes 2001, pp. 120122; Pilliod et al. 2002, pp. 18531859; Engle and Munger 2003, pp. 1213; Munger 2003, pp. 49; Funk et al. 2005a, p. 15; Funk et al. 2005b, p. 494; Semlitsch 2008, pp. 260265). Vegetation and surface water along movement corridors provide relief from high temperatures and arid environmental conditions, as well as protection from predators. Loss of riparian vegetation or surface water and the presence of nonnative species (see Factor C Predation by Nonnative Species below) can pose a significant threat to frogs moving from one area to another. Likewise, fragmentation and loss of habitat can prevent frogs from colonizing suitable sites elsewhere (Gibbs 2000, pp. 316317; Semlitsch 2002, pp. 621623; Storfer 2003, pp. 154156; Funk et al. 2005b, p. 494; Pringle 2006, pp. 243246).

Recent genetic analyses of populations in southeastern Oregon and southwestern Idaho indicate that populations are: (1) isolated from each other, (2) relatively small (small effective populations), (3) have low genetic variation, (4) several have either historical or more contemporary bottleneck signatures, and (5) highly differentiated from other Columbia spotted frog populations (Robertson and Funk 2011, pp. 59; Robertson and Funk 2012, pp. 58). These genetic analyses have not occurred for populations in Nevada. In general, isolated populations are vulnerable to extirpation through demographic stochasticity (random fluctuations in birth and death rates); environmental stochasticity (random variation in environmental attributes) and catastrophes; loss of genetic heterozygosity (genetic diversity) and rare alleles (inherited forms of a genetic trait); and human disturbance (Hedrick and Kalinowski 2000, pp. 140142; Lande 2002, pp. 1835; Reed and Frankham 2003, pp. 233234; Frankham 2005, pp. 135136; Robertson and Funk 2011, pp. 59; Robertson and Funk 2012, pp. 58). Although the literature and current genetic evaluations predict these populations are more vulnerable to extirpation, there is limited evidence of this occurring due to the lack of historical knowledge of the distribution of Columbia spotted frogs within the Great Basin DPS (Wente et al. 2005, pp. 99106; Pearl et al. 2010, pp. 29). Much of our knowledge about the current distribution of the species is from contemporary monitoring. While estimates of effective population size for populations in southeastern Oregon and southwestern Idaho are small, they are within the range of other effective population sizes of Columbia spotted frogs in the northern DPS as well as several other ranid species in the Pacific Northwest (Phillipsen et al. 2011, pp. 29362939). Isolated populations in southeastern Oregon are the most vulnerable to extirpation due to their complete isolation and small sizes (Figure 5; Robertson and Funk 2012, p. 78).

Modification and destruction of Columbia spotted frog habitat from historical and current anthropogenic disturbances have undoubtedly contributed to the current fragmented and isolated nature (and subsequent genetic character) of Columbia spotted frog populations in the Great Basin DPS. Fragmentation and isolation of populations pose a substantial threat to many of the Columbia spotted frog populations within the Great Basin DPS.

Livestock Grazing

Livestock grazing occurs throughout the range of Columbia spotted frogs and heavy utilization from livestock has been cited as detrimental to Columbia spotted frog habitat (Munger et al. 1996, p. 9; Reaser 1997a, pp. 3738; Engle 2002, pp. 4455; Service 2006, pp. 45). Though direct effects of livestock grazing on Columbia spotted frog distribution and populations are not well documented, the effects of heavy grazing on riparian areas are well documented (Kauffman et al. 1983a, pp. 684685; 1983b, pp. 686689; Kauffman and Kreuger 1984, pp. 432434; Schulz and Leininger 1990, pp. 297299; Belsky et al. 1999, pp. 425428).

Bull and Hayes (2000, pp. 292294) found no impacts of cattle grazing on the reproductive success of Columbia spotted frogs in ponds in northeastern Oregon; however, there was high variability in their results and grazing intensity and timing was not evaluated. Adams et al. (2009, pp. 135137) found no significant short-term effects of cattle exclosures on the number of Columbia spotted frog egg masses, larval survival, size of metamorphs, or water quality measurements. Moreover, nutrient levels often associated with negative impacts to amphibians, were very low to non-detectable (Adams et al. 2009, pp. 136137). In contrast, Gray et al. (2007, pp. 99100) found higher levels of Ranavirus (an emerging pathogen implicated in many amphibian declines) in green frogs (Lithobates (formerly Rana) clamitans) within ponds accessed by cattle. Howard and Munger (2003, p. 10) found lower survival of Columbia spotted frog larvae in their high livestock waste treatment; however, the high waste treatment larvae that survived had higher growth rates. Schmutzer et al. (2008, pp. 26172619) found significantly larger green frog, bullfrog (L. catesbeianus), and pickerel frog (L. palustris) larvae in ponds with cattle grazing; however, larval abundance for all three species was significantly higher in ponds with no cattle grazing. Additionally, water quality measurements including turbidity, specific conductivity, and dissolved oxygen, were significantly higher in ponds with grazing (Schmutzer et al. 2008, pp. 26182619). Capture probabilities of post-metamorphic green frogs were significantly higher in ungrazed ponds versus grazed ponds; however, the opposite was found for American toads (Anaxyrus (formerly Bufo) americanus) indicating species-specific impacts to amphibians from cattle grazing (Burton et al. 2009, pp. 272273). In a behavioral study, Shovlain et al. (2005, pp. 1012) found that Oregon spotted frogs increased their use of grazing exclosures compared to areas under heavy grazing pressure while no preferences were found between exclosures and areas under a light grazing regime. Jansen and Healey (2003, pp. 211218) found that amphibian species diversity declined and habitat condition decreased with increasing grazing intensity along a river in southeastern Australia. Recent studies have reported that changes in the timing and duration of livestock grazing and incorporating rest-rotation grazing strategies are resulting in improved riparian habitat conditions in northern Nevada (Booth et al. 2012, pp. 515518; Dalldorf et al. 2013, pp. 3841). We conclude that heavy grazing which negatively impacts stream, pond, and riparian habitat is a threat to Columbia spotted frogs; however, there is uncertainty regarding the magnitude of this threat. While livestock grazing occurs in nearly all populations, the status of Columbia spotted frog habitat as it relates to livestock use is unknown.

Beaver Management

Widespread removal of beaver from trapping throughout the Great Basin in the 19th and 20th century (Clements 1991, pp. 277278) likely impacted and contributed to Columbia spotted frog habitat fragmentation. The reduction of beaver populations has been noted as an important feature in the reduction of suitable habitat for Columbia spotted frogs (Reaser 1997a, p. 39; NDOW 2006, p. 163; ODFW 2006, p. 288). Beaver management by the States is discussed in Factor D below.

Beaver are important in the creation of small pools with slow-moving water that function as habitat for frog reproduction and create wet meadows that provide foraging habitat and protective vegetation cover (Naiman et al. 1988, pp. 754761; Amish 2006, p. 9; Cunningham et al. 2007, pp. 25202523; Stevens et al. 2007, pp. 611). In southwestern Montana (Northern DPS), Amish (2006, pp. 2832) found significantly higher amounts of lentic habitat and breeding sites for Columbia spotted frogs in watersheds containing beaver than watersheds without beaver. In northeastern Nevada, 61 percent of known occupied sites are associated with beaver ponds (J. Petersen 2013, pers. comm.). Removal of beaver in 1992 and the subsequent deterioration of the associated beaver dam on Stoneman Creek in southwestern Idaho is believed to be directly related to the decline of a spotted frog population there (Lingo and Munger 2003, pp. 36; Munger and Oelrich 2006, pp. 58). Intensive surveying of Stoneman Creek documented only one adult Columbia spotted frog in 2000 (Engle 2000, p. 4). In 2001, a beaver reintroduction project was started on Stoneman Creek (Munger and Lingo 2003, pp. 3-4). Since beaver reintroduction, annual egg mass numbers increased (0 egg masses in 2000 to 167 in 2010) until 2011 when the beaver moved upstream and the dams breached. By April 2012, the beaver ponds no longer existed and only 25 egg masses were counted in a few shallow trenches (Lohr 2012, pp. 1314).

There is a growing body of evidence linking the positive habitat influence of beaver to the presence of Columbia spotted frogs in the Great Basin DPS. We conclude that historic beaver management practices have negatively influenced Columbia spotted frog habitat. The impacts of current beaver management on Columbia spotted frogs in the Great Basin DPS are unknown at this time and should be investigated further.

Mining

The effects of mining on Great Basin Columbia spotted frogs have not been specifically studied, but the adverse effects of mining activities on water quality and quantity, other wildlife species, and amphibians in particular have been addressed in professional scientific forums (Nelson et al. 1991, pp. 425458; Ripley et al. 1996, pp. 49111; Lefcort et al. 1998, pp. 449452; Burkhart et al. 2003, pp. 111128; Unrine et al. 2004, pp. 29662969; Bridges and Semlitsch 2005, pp. 8992). Mining can contribute toxic substances into waterways, alter stream morphology, and dewater streams completely (Nelson et al. 1991, pp. 429446; Service 2008, pp. 3033). Up until 2001, Nevada had the second-highest level of atmospheric mercury releases in the nation (Miller 2004, p. 1). According to Toxic Release Inventory data from the Environmental Protection Agency (USEPA), major precious metal mining facilities in Nevada released between 5,443.1 and 5,896.7 kilograms (12,000 and 13,000 pounds) of mercury directly into the atmosphere from 1998 to 2001; however, mercury emissions have declined sharply since 2001 (USEPA 2013). Despite these reduced emissions, a recent advisory was issued by the Nevada State Health Division (NSHD) that recommends limiting human consumption of fish from six northern Nevada waters due to elevated methylmercury levels (NSHD 2007, pp. 12). In 2008, the Service published an assessment of trace-metal exposure to aquatic biota from historical mine sites in the western Great Basin (Service 2008, pp. 159). The study looked at five different streams across the western Great Basin with various levels of mining impacts (Service 2008, p. 11). The authors found low pH and increased concentrations of certain trace-metals in some streams which pose a significant threat to aquatic biota, increased concentrations of trace-metals in stream sediment, and bioaccumulation of trace-metals in macroinvertebrates and fish (Service 2008, pp. 3033).

Historical mining practices have had lasting impacts on watersheds. In Idaho, Jordan Creek, (Owyhee subpopulation) was dredged for gold during the late 1800s and early 1900s (La Fayette 2011, p. 27). Dredging is a type of placer mining which extracts ore from alluvial deposits and can cause substantial damage to aquatic habitats (Nelson 1991, pp. 427428). Evidence of this past mining activity and impacts to Jordan Creek are still evident today (La Fayette 2011, pp. 2627). Furthermore, high levels of mercury are still present in water and in stream sediments (USEPA 2011, pp. 19, 22). In southeastern Oregon, the Grassy Mountain Project (gold mine) is associated with a known occupied site for Columbia spotted frog; however, it is unknown how this project will impact this population (Calico 2012, pp. 13, 41).

In November 2006, a perched aquifer in the headwaters of the North Fork Humboldt River began to drain due to deep core drilling during mineral exploration at the Big Springs Mine (HydroGeo 2008, p. 62). Sammy Creek, a tributary to the North Fork Humboldt River, and portions of the North Fork Humboldt River have gone dry annually since 2007 due to the drained aquifer (HydroGeo 2008, p. 50; HydroGeo 2012, pp. 814). In addition to a decrease in the amount of water in the North Fork Humboldt River, water quality has also been negatively impacted with elevated levels of several constituents including arsenic and sulfate being recorded (HydroGeo 2012, pp. 2245). Columbia spotted frogs have historically (prior to the drainage event) been found within this impacted stream reach (USFS 2004, p. 10); however, individuals were only located downstream of the impacted reach in 2010 and the population level impacts are largely unknown (A. Jenne 2010, pers. comm.). Mining is an overall low threat to Columbia spotted frogs on a rangewide basis; however, it is locally important in several watersheds as mentioned above. Due to the current high price of gold, we expect this threat to intensify and expand into other areas.

In summary, Columbia spotted frogs in the Great Basin DPS have been impacted primarily by the effects of past habitat destruction and/or modification which caused increased habitat fragmentation and isolation. Current land uses continue to negatively alter or destroy important habitat throughout the range of the Columbia spotted frog which further fragments populations making them more susceptible to extirpation (Wilcox et al. 2006, pp. 857862). Despite reduced mercury emissions, recent advisories pertaining to mercury contamination indicate continuing risk to populations of Columbia spotted frogs downwind of large mining areas in northeastern Nevada. Based on our evaluation of on-going land use activities described above, we conclude there is sufficient information to develop a proposed listing rule for this species due to the present or threatened destruction, modification, or curtailment of its habitat and range.

## B. Overutilization for commercial, recreational, scientific, or educational purposes:

B. Overutilization for commercial, recreational, scientific, or educational purposes.

We have no information to support that overutilization is a threat to Great Basin Columbia spotted frogs at this time. See Factor D for a discussion of regulatory mechanisms influencing the potential for overutilization.

## C. Disease or predation:

Predation by Nonnative Species

The impact of nonnative invasive species on native species, communities, and ecosystems has been severe (Sakai et al. 2001, pp. 305332). The introductions of nonnative salmonid (Oncorhynchus, Salmo, and Salvelinus) and centrarchid (Micropterus) species for recreational fishing have negatively affected amphibian species, including Columbia spotted frogs, throughout the United States (Turner 1962, p. 327; Pilliod and

Peterson 2001, pp. 326331; Bradford 2005, pp. 919924; Tait 2007, pp. 3233; Vredenburg and Wake 2007, pp. 56; Murphy et al. 2010; pp. 36403643; Paoletti et al. 2011, pp. 164167). The effects of predation are difficult to document, particularly in stream systems. However, significant negative effects of predation on frog populations in lentic systems have been documented (Knapp and Matthews 2000, pp. 433435; Pilliod and Peterson 2001, pp. 326331; Kats and Ferrer 2003, pp. 99108; Dunham et al. 2004, pp. 1920; Bradford 2005, pp. 919924; Knapp 2005, pp. 270275; Pearl et al. 2010, pp. 4950). In the western United States, Lomnicky et al. (2007, p. 1086) found that 52 percent of stream lengths surveyed contained nonnative vertebrates. They also found that the most common nonnative vertebrates were brook trout (Salvelinus fontinalis) (17 percent of all nonnative vertebrates present), brown trout (Salmo trutta) (16 percent), and rainbow trout (Oncorhynchus mykiss) (14 percent) (Lomnicky et al. 2007, p. 1086). Using the same dataset, Whittier and Peck (2008, p. 1889) analyzed the surface area occupied by nonnative vertebrates and found that 75 percent of the waters sampled were occupied by nonnatives. They also found there is a greater likelihood of finding nonnative vertebrates in larger streams (Whittier and Peck 2008, p. 1889). When surface area is considered, the most common nonnative vertebrates are rainbow trout, carp (Cyprinus carpio), brown trout, and smallmouth bass (Micropterus dolomieu) (Whittier and Peck 2008, p. 1890). Smallmouth bass are known to occur throughout the mainstem Owyhee River watershed (including the North and South Forks) in Oregon and Idaho and the mainstem Humboldt River in Nevada. The existence of nonnative fish species within the historical range of Columbia spotted frogs, particularly along the mainstem river systems and reservoirs, further fragments populations making it difficult to recolonize habitat or exchange genetic material (see Factor A above). Conservation efforts for native salmonids (i.e., fish migration barriers, nonnative fish eradication) may indirectly benefit Columbia spotted frogs due to overlapping distributions.

The American bullfrog, a ranid species native to much of central and eastern North America, now occurs within the range of Columbia spotted frog in the Great Basin (Casper and Hendricks 2005, pp. 540541). Bullfrogs are known to compete with and prey on other frog species and they are important vectors for spreading many types of diseases and parasites to healthy populations of native amphibians (Moyle 1973, pp. 1921; Pearl et al. 2004, pp. 1618; Casper and Hendricks 2005, pp. 543544; Johnson and Lunde 2005, p. 130; Monello et al. 2006, p. 406; Tait 2007, pp. 3233). Within the Great Basin DPS, bullfrogs are known to occur in watersheds which also have Columbia spotted frogs in south-central Oregon and northeastern Nevada (BLM 2011, p. 18; Tippery and Jones 2011, pp. 1314; NDOW 2012c, unpubl. data). Sympatric bullfrog populations have not been observed in the Owyhee subpopulation in Idaho. Bullfrogs rarely co-occur with Columbia spotted frogs, but whether this is an artifact of competitive exclusion or predation is unknown at this time.

We conclude that nonnative species of fish and amphibians are a threat to Columbia spotted frogs rangewide because: (1) nonnative species have had documented negative effects on Columbia spotted frog populations; (2) efforts required to reduce or eliminate nonnative species are not currently being conducted on a rangewide basis; (3) nonnative species occur throughout the majority of unoccupied historical habitat; and (4) nonnative species continue to be stocked and/or managed for within historical Columbia spotted frog habitat (particularly in reservoirs and mainstem rivers).

Chytridiomycosis

Although a diversity of microbial species is naturally associated with amphibians, it is generally accepted that they are rarely pathogenic to amphibians except under stressful environmental conditions. Amphibian chytridiomycosis (chytrid), caused by the pathogenic fungus Batrachochytrium dendrobatidis (Bd), is an emerging panzootic fungal disease which has been associated with amphibian declines in the United States and globally (Daszak et al. 2003, pp. 143148; Blaustein et al. 2005, pp. 14641465; Briggs et al. 2005, pp. 31563158; Ouellet et al. 2005, pp. 14331438; Rachowicz et al. 2006, pp. 16761682; Pounds et al. 2006, pp. 161167; Pearl et al. 2007b, pp. 146148; Vredenburg and Wake 2007, p. 6). Clinical signs of amphibian chytrid and diagnosis are described by Daszak et al. (1999, p. 737) and include abnormal posture, lethargy, and loss of righting reflex. Gross lesions, which are usually not apparent, consist of abnormal epidermal sloughing and ulceration; hemorrhages in the skin, muscle, or eye; hyperemia of digital and ventrum skin, and congestion of viscera. Diagnosis is by identification of characteristic intracellular flask-shaped sporangia and septate thalli within the epidermis. Chytrid can be identified in some species of frogs by examining the oral discs of tadpoles which may be abnormally formed or lacking pigment (Fellers et al. 2001, pp. 946947).

Columbia spotted frogs at sites in Alberta, Canada, northeastern Oregon, and northern Idaho (Northern DPS) have tested positive for Bd (Bull 2006, pp. 34; Engle 2006, p. 16; Pearl et al. 2007b, pp. 146148; Adams et al. 2010, pp. 294298; Russell et al. 2010, pp. 226227; Stevens et al. 2012, p. 5). Bd has also been found in the Wasatch Mountains, Utah (Utah DPS) (Semon et al. 2005, pp. 1112; Wilson et al. 2005, pp. 23). Within the Great Basin DPS, Bd was confirmed in Columbia spotted frogs at the Circle Pond site, Idaho, in 2001 (Engle 2002, pp. 1519) and in Oregon at the Dry Creek site (Engle 2006, p. 16). Chytrid has not been detected at anywhere else within the Owyhee subpopulation. Bd has been recently detected at the Tennessee Gulch site in northeastern Nevada (Hanson and Glenn 2011, pp. 56, 911). In addition, Bd has been found in two bullfrog populations within Nevada. Along the Owyhee River in northern Elko County, one population of Columbia spotted frogs (which have not been tested) co-occur with infected bullfrogs (Green 2006, p. 1); the other infected bullfrog population is near Beatty, Nevada, which is approximately 225 km (140 mi) to the south of the Toiyabe Mountains subpopulation (USGS 2005, p. 1).

Chytrid has not been associated with large die-offs of Columbia spotted frogs which have plagued other amphibian species (Rachowicz et al. 2006, pp. 16761682; Adams et al. 2010, p. 300). Some evidence suggests that Columbia spotted frogs produce antimicrobial peptides in their skin which may inhibit chytrid infection (Rollins-Smith et al. 2002, pp. 473476; Rollins-Smith et al. 2005, pp. 137142); however, further understanding of how chytrid affects Columbia spotted frogs may be needed (Russell et al. 2010, pp. 228229).

Ranavirus

Iridoviruses of the genus Ranavirus were first recognized in amphibians in the 1960s and have contributed to mass mortality events worldwide (Gray et al. 2009, p. 244). Between 1996 and 2005 within the United States, the majority of amphibian mortality events reported have been linked to ranaviruses (Green et al. 2002, p. 331; Muths et al. 2006, pp. 13914). Clinical signs of ranavirus infection and diagnosis are described by Miller et al. (2011, pp. 23552357) and may include erratic swimming, buoyancy problems, lethargy, swelling, redness on legs and ventrum, and red blotching on internal organs.

Two mass mortality events of Columbia spotted frogs in northern Idaho (Northern DPS) were attributed to Ranavirus in 2009 (Russell 2011, pp. 223225). Another Columbia spotted frog mortality event in 2002 within Yellowstone National Park (Northern DPS) was attributed to chytrid and Ranavirus with Ranavirus being the ultimate cause of death (Patla and Peterson 2004, pp. 15, 5253). Ranavirus has not been detected in Columbia spotted frogs within the Great Basin DPS.

Malformations

Malformations found in amphibian populations can be caused by several different factors including pesticides, high ultraviolet-B (UV-B) radiation exposure, and parasites and pathogens (Carey et al. 2003, pp. 194197; Ankley et al. 2004, pp. 913; Johnson and Lunde 2005, pp. 125138; Sutherland 2005, pp. 109123). Pesticides and UV-B radiation are discussed further below in Factor E. The larvae of the trematode Ribeiroia ondatrae has been associated with higher than normal levels of malformations in populations of several species of amphibians, including Columbia spotted frogs (Johnson et al. 2002, pp. 155162); however, there is high variability in resistance to infection among amphibian species (Johnson and Hartson 2009, pp. 194198). Malformed frogs have higher mortality rates than non-malformed individuals and mortality can be caused directly through infection or indirectly through reduced fitness and predation (Johnson and Lunde 2005, p. 136). The life cycle of R. ondatrae includes three hosts: snails of the genus Planorbella, amphibians or fish, and finally a bird or mammal (Johnson and Lunde 2005, p. 126). In a study covering five western states, the presence and abundance of Planorbella snails was the only variable related to the presence and abundance of

R. ondatrae (Johnson et al. 2002, pp. 160161). Planorbella snails were more associated with wetlands of human origin and higher orthophosphate levels (Johnson et al. 2002, pp. 160161; Johnson and Lunde 2005, pp. 133135; Johnson et al. 2007, pp. 1578115784) indicating that stock ponds could be acting as a source for Planorbella snails. High prevalence of malformed Columbia spotted frogs outside the Great Basin DPS have been documented (Johnson et al. 2002, pp. 157159; Roberts and Dickinson 2012, 810813); however, within the Great Basin DPS, there has been no evidence of above background level malformations reported (typically less than 5 percent of the population). Increased levels of malformations may be an expanding threat to Columbia spotted frogs as Planorbella snail species are being recorded at sites beyond their previously known ranges (Johnson et al. 2002, p. 161).

In summary, nonnative fish (i.e., salmonids or bass) and amphibian (bullfrog) predators occur within the range of Columbia spotted frogs. These predators can eliminate or reduce populations or restrict movement of individuals, thus, increasing fragmentation and not allowing metapopulation dynamics to occur. Nonnative fish and amphibians can also be vectors for parasites and pathogens (i.e., chytrid fungus) which may increase susceptibility of individuals or populations to viral outbreaks or deformities which can increase mortality rates; however, population-level effects of both pathogens and parasites have yet to be documented within the Great Basin DPS. Based on our evaluation of predation described above, we conclude there is sufficient information to develop a proposed listing rule for this species due to nonnative predators.

## D. The inadequacy of existing regulatory mechanisms:

There are several Federal and State laws and regulations that are pertinent to candidate species, each of which may contribute in varying degrees to the conservation of non-listed species. These laws, most of which have been enacted in the past 3040 years, have reduced or eliminated the threats of habitat destruction and overutilization. These laws are discussed below.

Federal Protections

National Environmental Policy Act (NEPA): The NEPA (42 U.S.C. 4371 et seq.) provides some protection for candidate species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 C.F.R. 1502.16). Mitigation usually provides some protection for candidate species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

National Forest Management Act (NFMA): The NFMA (36 C.F.R. 219.20(b)(i)) requires the USFS to incorporate standards and guidelines into Land and Resource Management Plans, including provisions to support and manage plant and animal communities for diversity and for the long-term, range-wide viability of native species. The Intermountain Region (Region 4) of the USFS considers the Columbia spotted frog a sensitive species. Therefore, as part of USFS policy, the analysis related to planning under the NFMA and conducted by the USFS to evaluate potential management decisions under NEPA includes a biological evaluation which discloses potential impacts to sensitive species at both the forest planning level and on a project-by-project basis. Under USFS policy (Forest Service Manual 2620 and 2670), projects must not result in contributing to a trend towards Federal listing of species. The USFS must develop and implement management practices to ensure that species on the sensitive species list do not become threatened or endangered because of USFS actions. Management objectives must be met in cooperation with the States when projects on National Forest System lands may have a significant effect on sensitive species population numbers or distributions. Furthermore, for Federal candidate species, management objectives must be implemented in cooperation with the Service. The USFS manages approximately 17 percent of the known Columbia spotted frog occupied watersheds within the Great Basin DPS, all of which are in Nevada.

Federal Land Policy and Management Act of 1976 (FLPMA): The BLM is required to incorporate Federal, State, and local input into their management decisions through Federal law. The FLPMA (Public Law 94-579, 43 U.S.C. 1701) was written to establish public land policy; to establish guidelines for its administration; to provide for the management, protection, development and enhancement of the public lands; and for other purposes. Section 102(f) of the FLPMA states that the Secretary [of the Interior] shall allow an opportunity for public involvement and by regulation shall establish procedures to give Federal, State, and local governments and the public, adequate notice and opportunity to comment upon and participate in the formulation of plans and programs relating to the management of the public lands. Therefore, through management plans, the BLM is responsible for including input from Federal, State, and local governments and the public.

In addition, BLM policies direct management to consider candidate species on public lands under their jurisdiction. Consistent with existing laws, the BLM shall implement management plans that conserve candidate species and their habitats and shall ensure that actions authorized, funded, or carried out by the BLM do not contribute to the need for the species to become listed. Specifically, BLM policy 6840 requires the development, cooperation with, and implementation of range-wide or site-specific management plans, conservation strategies, and assessments for candidate species that include specific habitat and population management objectives designed for conservation, as well as management strategies necessary to meet those objectives. The BLM should request technical assistance from the Service, and other qualified sources, on any planned action that may contribute to the need to list a candidate species as threatened or endangered. The BLM manages approximately 52 percent of the known Columbia spotted frog occupied watersheds within the Great Basin DPS.

Clean Water Act: Under section 404, the U.S. Army Corps of Engineers (USACE) regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). In general, the term wetland refers to areas meeting the USACEs criteria of hydric soils, hydrology (either sufficient annual flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Any action with the potential to impact waters of the United States must be reviewed under the Clean Water Act, NEPA, and ESA. These reviews require consideration of impacts to listed species and their habitats, and recommendations for mitigation of significant impacts.

The USACE interprets the waters of the United States expansively to include not only traditional navigable waters and wetlands, but also other defined waters that are adjacent or hydrologically connected to traditional navigable waters. However, recent Supreme Court rulings have called into question this definition. On June 19, 2006, the U.S. Supreme Court vacated two district court judgments that upheld this interpretation as it applied to two cases involving isolated wetlands. Currently, USACE regulatory oversight of such wetlands (i.e., vernal pools) is in doubt because of their isolated nature. In response to the Supreme Court decision, the USACE and the USEPA have recently released a memorandum providing guidelines for determining jurisdiction under the Clean Water Act. The guidelines provide for a case-by-case determination of a significant nexus standard that may protect some, but not all, isolated wetland habitat (USEPA and USACE 2007, pp. 411). The overall effect of the new permit guidelines on loss of isolated wetlands is not known at this time.

The Lacey Act: The Lacey Act (Public Law 97-79), as amended in 16 U.S.C. 3371, makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any United States or Indian Tribal law, treaty, or any law or regulation of any State. The Lacey Act further makes unlawful the selling, receiving, acquisition or purchasing of any wild animal, alive or dead. The designation of wild animal includes parts, products, eggs, or offspring.

Endangered Species Act of 1973, as amended (ESA): The threatened Lahontan cutthroat trout (Oncorhynchus clarkii henshawi) (LCT) historically occurred throughout the Nevada portion of Columbia spotted frogs range and their distribution still overlaps in some watersheds. One Recovery Unit (Upper Snake

Recovery Unit) for the threatened bull trout (Salvelinus confluentus), including their designated critical habitat, overlaps currently occupied Columbia spotted frog habitat in northeastern Nevada and southwestern Idaho and eastern Oregon. Some recovery efforts and regulatory protection measures for these threatened salmonid species should benefit Columbia spotted frogs in some riverine environments where their habitats overlap.

Only species that have been proposed for listing are covered by the conference provision under section 7(a)(4) of the ESA. However, Service policy requires candidate species be treated as proposed species for purposes of intra-Service consultation where the Services actions may affect candidate species (e.g., candidate species on National Wildlife Refuges). This provides some measure of protection for the Columbia spotted frog on the Malheur National Wildlife Refuge and from Service activities.

Under the authority of section 10 of the ESA, the Service adopted policy and regulations for voluntary conservation of candidate species (64 FR 32726; June 17, 1999). Candidate Conservation Agreements (CCAs) are voluntary conservation agreements between the Service and one or more public or private parties. The Service works with its partners to identify threats to candidate species, plan the measures needed to address the threats and conserve these species, identify willing landowners, develop agreements, and design and implement conservation measures and monitor their effectiveness. Candidate Conservation Agreements with Assurances (CCAAs) expand on the success of traditional CCAs by providing non-Federal landowners with additional incentives for engaging in voluntary proactive conservation through assurances that limit future conservation obligations. One of the primary reasons for developing the CCAA program was to address landowner concerns about the potential regulatory implications of having a listed species on their land. The CCAA program specifically targets non-Federal landowners and provides them with the assurance that if they implement various conservation activities, they will not be subject to additional restrictions if the species becomes listed under the ESA. These assurances are only available to non-Federal entities for actions on non-Federal lands. Two Conservation Agreements and one CCAA have been implemented for Columbia spotted frogs within the Great Basin DPS (see Conservation Measures Planned or Implemented section below).

Tribal

Tribal governments within the Great Basin with Columbia spotted frogs do not have regulatory or protective mechanisms in place to protect Columbia spotted frogs. The status of local populations of Columbia spotted frogs on Yomba-Shoshone and Duck Valley Indian Reservation tribal lands is generally unknown.

State Protections

Columbia spotted frogs are classified as a protected amphibian by the State of Nevada under Nevada Administrative Code (NAC) 503.075(2)(a). Per NAC 503.090(1) there is no open season on those species of amphibian classified as protected. Per NAC 503.093 a person shall not hunt or take any wildlife which is classified as protected, or possess any part thereof, without first obtaining the appropriate license, permit or written authorization from the NDOW. NAC 503.094 authorizes issuance of permits for the take and possession of any species of wildlife for strictly scientific or educational purposes (NAC 2012, pp. 1416). All native amphibians are considered protected nongame species in Idaho (Idaho Administration Procedures Act (IDAPA) 2012, p. 78). No open seasons are set for protected nongame species and collection of these species is subject to IDFG issuance of a scientific collection permit except that up to four native amphibians and reptiles of a given species can be captured alive, held in captivity, killed, or possessed at any one time by holders of a valid Idaho hunting license (IDAPA 2012b, p. 4). Columbia spotted frogs are on the nongame protected wildlife list for the State of Oregon which makes it unlawful for any person to hunt, trap, pursue, kill, take, catch, angle for, or have in possession, either dead or alive, whole or in part (Oregon Administrative Rules 2012, pp. 89). Moreover, they are listed as critical on Oregons sensitive species list which is used as an early warning system and encourages voluntary actions to improve the status of species on the list (ODFW 2008, pp. 1, 11). Critical species are defined as species that are imperiled with extirpation from a specific geographic area of the state because of small population sizes, habitat loss or degradation, and/or immediate threats. Critical species may decline to a point of qualifying for threatened or endangered status if conservation actions are not taken (ODFW 2008, p. 2). All three States include Columbia spotted frogs in their State Wildlife Action Plans as a species of conservation concern (IDFG 2005, p. 71; NDOW 2006, pp. 328329; ODFW 2006, p. 337).

The importance of beaver to Columbia spotted frog habitat is discussed above. Each State regulates the take of beaver through limits, trapping methods, and seasons. Beaver trapping is relatively common in Idaho, and there is no bag limit. The season is open from November 1 to March 31 in southwestern Idaho (IDFG 2012, p. 34). Oregon allows harvest of beavers in Lake, Harney, and Malheur Counties with a season from November 15 to March 15, and no bag limit (ODFW 2013, p. 4); however, the Oregon Conservation Strategy encourages allowing beaver to contribute to wetland creation and maintenance when compatible with existing land uses (ODFW 2006, p. 312). In Nevada, beaver trapping is allowed statewide from October 1 through April 30 and there is no bag limit (NDOW 2012d).

Lands administered by the USFS and BLM are interspersed with and surround private parcels on which intensive grazing management, irrigation (diversions), agriculture, and mining activities likely typify the land-use practices. There are generally fewer State regulatory mechanisms to address activities on private lands. Heavy grazing pressure on private lands could exacerbate the adverse effects of actions on public lands to Columbia spotted frogs, as described previously. Irrigation, agriculture, and mining practices could dewater streams, create migration barriers, or negatively affect water quality. Ongoing or reasonably foreseeable future activities on private lands within the range of Columbia spotted frogs will continue to affect Columbia spotted frogs and their habitat but the extent of that impact is unknown at this time. Approximately 23 percent of the known Columbia spotted frog occupied watersheds within the Great Basin DPS are located on private lands.

In summary, regulatory mechanisms exist for the Columbia spotted frog. Federal agency policy requires that management activities do not lead to a trend to list candidate species as threatened or endangered. While policies exist to protect Columbia spotted frogs and their habitat on public lands, there is no mechanism to show the effectiveness of these policies. Other federally-listed species occur within the range of Columbia spotted frogs; however, the extent of this overlap and its effectiveness in protecting Columbia spotted frogs and their habitat is unknown. There are no known Tribal regulatory mechanisms in place to protect Columbia spotted frogs. Although all three States include Columbia spotted frog in their State Wildlife Action Plans as a species of conservation concern, Idaho and Oregon still allow some take; however, there is no evidence of any collection other than monitoring activities. Nevada does not allow take of the species without a permit. Beaver management by the States may influence Columbia spotted frog habitat; however, the extent of beaver trapping in Columbia spotted frog habitat is unknown at this time. Private lands could be very important to the conservation of Columbia spotted frogs due to their frequent locations on or near waterways.

## E. Other natural or manmade factors affecting its continued existence:

Climate Change

Our analyses under the ESA include consideration of ongoing and projected changes in climate. The terms climate and climate change are defined by the Intergovernmental Panel on Climate Change (IPCC). The term climate refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term climate change thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Warming trends due to climate change seen over the past 50 years in the United States are predicted to continue to increase (Field et al. 2007, pp. 626627); however, the magnitude varies spatially across the continent, is most pronounced during spring and winter months, and has affected daily minimum temperatures more than daily maximum temperatures (Field et al. 2007, p. 620). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is very likely (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007, pp. 56; Solomon et al. 2007, pp. 2135; Serreze 2010, pp. 1113; National Climate Assessment and Development Advisory Committee (NCADAC) 2013, pp. 2831). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl et al. 2007, pp. 747-845; Ganguly et al. 2009, pp. 11555, 15558; Prinn et al. 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007, pp. 4445; Meehl et al. 2007, pp. 760764, 797811; Ganguly et al. 2009, pp. 1555515558; Prinn et al. 2011, pp. 527, 529).

Other effects of climate change include, but are not limited to, changes in types of precipitation (Knowles et al. 2006, p. 4557; Seager et al. 2007, pp. 11811184), earlier spring run-off (Stewart et al. 2005, p. 1152), longer and more intense wildfire seasons (Brown et al. 2004, pp. 375385; Westerling et al. 2006, pp. 941942; Bachelet et al. 2007, pp. 1617), and more frequent extreme weather events (Diffenbaugh et al. 2005, pp. 1577515777; Rosenzweig et al. 2007, p. 109; Kunkel et al. 2009, pp. 62076214). Climate change is predicted to have several effects on cold water habitat including: (1) increased water temperature; (2) decreased stream flow; (3) change in the hydrograph; and (4) increased frequency and severity of extreme events such as drought and wildfire (see below) (Stewart et al. 2005, pp. 11401154; Ficke et al. 2007, pp. 583593; Bates et al. 2008, pp. 102106; Webb et al. 2008, pp. 909911; Kaushal et al. 2010, pp. 462466). These changes in climate and subsequent effects can be attributed to the combined effects of greenhouse gases, sulphate aerosols, and natural external forcing (Karoly et al. 2003, p. 1203; Barnett et al. 2008, p. 1082; Serreze 2010, pp. 1113; NCADAC 2013, pp. 2831).

The IPCC states that of all ecosystems, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change (Kundzewicz et al. 2007, p. 192). Species with narrow temperature tolerances and cold-water species (e.g., amphibians) will likely experience the greatest effects from climate change, and it is anticipated that populations located at the margins of the species hydrologic and geographic distributions will be affected first (Bates et al. 2008, p. 104; Haak et al. 2010, pp. 534535). Researchers in Italy have documented amphibian declines and have associated these declines with decreases in water availability and increases in temperature associated with climate change (DAmen and Bombi 2009, pp. 30633066). Even in relatively pristine areas (e.g., Yellowstone National Park), biologists are documenting amphibian declines and are linking these declines to long-term, large-scale climatic trends (McMenamin et al. 2008, pp. 1698816990). In contrast, McCaffery and Maxell (2010, pp. 86458647) found that decreasing winter severity associated with warmer drier winters increased the population viability of Columbia spotted frogs in a high elevation wilderness area in Idaho (Northern DPS).

Past climate scenarios have shaped Great Basin ecosystems (Tausch et al. 2004, pp. 2440). Great Basin ecosystems and their associated riparian areas are expected to be highly sensitive to any future changes in climate (Sala et al. 2000, pp. 17721773; Fleishman et al. 2004, pp. 248251; Field et al. 2007, pp. 627630). Ecological consequences of climate change to amphibians may include changes in population dynamics, timing of reproduction, changing geographic range, and broader community and ecosystem level changes (Hansen et al. 2001, pp. 766773; McCarty 2001, pp. 321325; Carey and Alexander 2003, pp. 116118; Inkley et al. 2004, p. 9; Corn 2005, pp. 6162; Parmesan 2006, pp. 637669; Rahel and Olden 2008, pp. 522531; Lawler et al. 2010, pp. 4648). Amphibians are sensitive to changes in precipitation and temperature which may increase the risk of extinction for this group of organisms (Boone et al. 2003, pp. 131136; Corn 2005, pp. 5964; Noss et al. 2006, p. 236; Pounds et al. 2007, pp. 1920; Vredenburg and Wake 2007, pp. 67).

The impacts to Columbia spotted frogs from climate change are not known with certainty. Predicted outcomes of climate change imply that negative impacts may occur through increased stream temperatures, decreased stream flow, changes in the hydrograph, and increased frequency of extreme events. Water temperatures have increased and are predicted to continue to increase in the future; however, impacts from rising water temperature are not known for Columbia spotted frogs. Rising stream temperatures may allow nonnative species to expand their current ranges into Columbia spotted frog occupied habitat (Rahel et al. 2008, pp. 553554; Sharma and Jackson 2008, pp. 474479). Reductions in streamflow are predicted to have a negative impact on Columbia spotted frog populations because of the fragmented nature of populations, the small size of most populations, and the close association of recruitment and survival to the amount of water available. Degraded aquatic systems exhibit greatly reduced resiliency to accommodate natural disturbances such as floods, fire, and drought, thereby exacerbating the effects of those events, which may further reduce the persistence of these populations (Wilcox et al. 2006, pp. 860862). These degraded conditions, combined with variability in Columbia spotted frog numbers, place greater importance on the quantity and quality of the habitat needed for survival and recovery of Columbia spotted frogs. These impacts associated with climate change will likely intensify the threats to Columbia spotted frogs previously described under Factors A and C.

Drought

Drought has been an important natural disturbance in the western United States since the early Holocene (Cook et al. 2004, p. 1017; Mensing et al. 2008, pp. 8084). Cook et al. (2004, p. 1016) report the percentage of the western United States in drought conditions has gradually increased over the last century and that the current drought rivals the drought conditions in the 1930s; however, these more recent droughts (i.e., in the last century) pale in comparison to conditions found 7001,100 years before present in terms of duration and severity. These historic drought conditions likely negatively impacted Columbia spotted frog populations throughout their range. Due to dispersal abilities, metapopulation dynamics, and unimpaired connected habitat in which they evolved, Columbia spotted frogs were able to persist and repopulate areas when conditions became favorable, despite these severe recurring drought conditions (Lake 2003, pp. 11661167; Wilcox et al. 2006, p. 859). Summer drought conditions are predicted to intensify through the end of the century which may negatively impact Columbia spotted frogs (NCADAC 2013, pp. 113, 133134, 700701, 737739). Since most populations are now fragmented and isolated, recolonization after extirpation or input of genetic material from other populations cannot occur naturally. With more frequent and severe droughts likely accompanying climate change, we conclude that effects of drought could impact Columbia spotted frogs throughout the Great Basin DPS where suitable habitat is not available or conservation measures are not being implemented.

Wildfire

Wildfire has been one of the dominant factors shaping ecosystems for millennia (Miller and Rose 1999, pp. 555558). Fire regimes in the Great Basin differ by the three main vegetation types: sagebrush shrublands, desert shrublands, and pinyon-juniper woodlands. Prior to European settlement, fire regimes in sagebrush shrublands of the Great Basin have been characterized as a combination of mixed-severity and stand-replacing fires with return intervals ranging anywhere from 10 to 70 years (Rice et al. 2008, p. 154). Desert shrubland vegetation types are characterized by infrequent, stand-replacement fires with fire return intervals between 35 years to several centuries (Rice et al. 2008, p. 155). Pinyon-juniper woodlands are characterized as a mixed fire regime; however, fire histories in pinyon-juniper woodlands are difficult to reconstruct (Paysen et al. 2000, p. 130). Return intervals in pinyon-juniper woodlands range from 10 to over 300 years depending on site productivity and plant community structure (Rice et al. 2008, p. 162). Fire regimes in the Great Basin have become more frequent due to wildfire exclusion, historical grazing practices, and the introduction of invasive nonnative plant species (Rice et al. 2008, p. 141). More frequent fires favor the establishment of nonnative plants (e.g., Bromus tectorum (cheatgrass)), which results in the loss of sagebrush and other native plant species (Rice et al. 2008, p. 154).

Riparian areas are also subject to fires; however, return intervals and fire regimes may be different than the adjacent uplands. The scant information available on fire in riparian areas indicates that return intervals and fire regime type depend on the width of the riparian area and the fuel type adjacent to the riparian area (Dwire and Kauffman 2003, pp. 6263; Pettit and Naiman 2007, pp. 675677). Smaller riparian areas are more similar to the adjacent upland areas while larger riparian areas tend to have longer return intervals and lower fire intensity (Dwire and Kauffman 2003, pp. 6263; Pettit and Naiman 2007, pp. 675677). Streamside vegetation has adapted to disturbance which contributes to the relatively rapid recovery of riparian habitat following fire; however, recovery rates depend on the condition of the riparian area prior to the fire, fire severity, post-fire flooding, and post-fire management (Miller 2000, pp. 1622; Bond and Midgley 2003, pp. S103S112; Dwire and Kauffman 2003, pp. 6771; Pettit and Naiman 2007, pp. 680682; Halofsky and Hibbs 2009, pp. 13551358; Jackson and Sullivan 2009, pp. 2731).

Changing climate has affected summer temperatures and the timing of spring snowmelt, which have contributed to increasing the length of the wildfire season, wildfire frequency, and the size of wildfires (McKenzie et al. 2004, pp. 893897; Westerling et al. 2006, p. 941). Westerling et al. (2006, p. 942) conclude that there are robust statistical associations between wildfire and climate in the western United States and that increased fire activity over recent decades reflects responses to climate change.

Direct mortality of amphibians due to fire is thought to be rare and of minor importance to most populations (Russell et al. 1999, pp. 374379; Smith 2000, pp. 20, 2930; Pilliod et al. 2003, pp. 165175; Hossack and Corn 2007, pp. 14061409); however, few studies have documented fire effects to aquatic amphibians in the western United States (Bury 2004, pp. 970973; Hossack and Pilliod 2011, pp. 133139; Hossack et al. 2013, pp. 223226). Most negative effects to aquatic species after wildfire are due to the immediate loss or alteration of habitat and indirect effects such as post-fire hydrologic events (Gresswell 1999, pp. 199211; Benda et al. 2003, pp. 107117; Miller et al. 2003, pp. 121136; Wondzell and King 2003, pp. 7584; Dunham et al. 2007, pp. 340344; Hossack and Pilliod 2011, pp. 131133). In addition, fire suppression activities, including construction of fire lines, back burning, application of water from pumps or aerial drops, and use of fire retardants and suppressant foams, could negatively affect amphibians (Little and Calfee 2002, p. 3; Backer et al. 2004, pp. 937944).

Although Columbia spotted frogs evolved in a fire-prone environment, increases in wildfire frequency and severity due to increased fuel loads, exotic species, and effects from climate change (Westerling et al. 2006, p. 941) have increased the threats due to wildfire. Current wildfires are a larger threat to Columbia spotted frogs because of existing habitat loss and the current fragmented and isolated state of occupied habitat. While we have no studies documenting negative impacts of wildfires to Columbia spotted frog populations in the Great Basin DPS, we attribute this to no known studies of populations which have been impacted by recent fires. Impacts from recent fires on Columbia spotted frog populations should be investigated further.

UV-B Radiation

Increases in UV-B radiation from depletion of stratospheric ozone have been suggested as a possible threat to amphibian populations (Blaustein et al. 1997, pp. 1373513736; Adams et al. 2005, pp. 493498; Blaustein and Belden 2005, pp. 8788; Bancroft et al. 2008, pp. 990993). UV-B mainly decreases egg survivorship and increases deformities in developing metamorphs (Blaustein et al. 1997, pp. 1373513736). Columbia spotted frogs are a species that could be susceptible to increases in UV-B radiation because they are a basking species and lay their eggs in shallow water. However, Blaustein et al. (1999, pp. 11021104) found that Columbia spotted frogs in the embryonic stage were resistant to UV-B because of high levels of photolyase (a photoreactivating enzyme) and Adams et al. (2005, p. 497) found ambiguous results on the effects of UV-B on Columbia spotted frogs. There is insufficient information to conclude that UV-B radiation is currently a threat; however, Adams et al. (2005, p. 497) suggests that the relationship should be investigated further.

Pesticides

Amphibians are sensitive to chemical contaminants due to their habitat requirements (terrestrial and aquatic), complex life history, and their unique anatomy and physiology (Burkhart et al. 2003, pp. 111112). Chemicals are the third most implicated factor in amphibian declines in the United States (Bradford 2005, p. 919). Evidence of direct mortality of amphibians is relatively sparse due to the low concentrations of individual chemicals in the environment; however, sublethal impacts, such as decreased growth, reduced fitness, or increased susceptibility to predation, may lead to population declines (Bridges and Semlitsch 2005, p. 89). Additionally, complex mixtures of various chemicals have been shown to be more toxic than individual chemicals acting alone (Burkhart et al. 2003, pp. 112115; Relyea 2009, pp. 367374).

Use of pesticides for control of grasshoppers (Melanoplus sp.) and crickets (Anabrus simplex), as well as use of herbicides to treat weeds and other vegetation, may be impacting some populations of Columbia spotted frogs, particularly on private property. Grasshopper and cricket control programs on federal lands require buffers around aquatic habitat to minimize or eliminate any impacts to aquatic organisms (U.S. Department of Agriculture 2013a, pp. 7376). While we have no evidence to suggest frogs have been directly affected in the past, we do know substantial amounts of pesticides (e.g., carbaryl), herbicides (e.g., Tordon®), and other chemicals are being used in proximity to occupied sites in Oregon, Nevada, and Idaho (Pearl et al. 2010, pp. 9496; U.S. Department of Agriculture 2013a, pp. 187; 2013b, pp. 170; 2013c, pp. 170; 2013d, pp. 157). There is insufficient information to conclude that pesticides are currently a threat; however, due to the application of chemicals known to cause negative impacts to amphibians being applied near occupied habitat, this potential threat should be investigated further.

Multiple Stressors

Many of the threats discussed above do not act alone. Multiple stressors can alter the effects of other stressors or act synergistically to affect individuals and populations (IPCC 2002, p. 22; Boone et al. 2003, pp. 138143; Westerman et al. 2003, pp. 9091; Opdam and Wascher 2004, pp. 285297; Boone et al. 2007, pp. 293297; Vredenburg and Wake 2007, p. 7; Lawler et al. 2010, p. 47; Miller et al. 2011, pp. 23602361). For example, Kiesecker and Blaustein (1995, pp. 1105011051) describe how UV-B acts with a pathogen to increase embryonic mortality above levels shown with either factor alone. Interactions between current land uses and changing climate conditions are expected to cause shifts in populations, communities, and ecosystems (Hansen et al. 2001, p. 767), which may make certain species more vulnerable to extinction (IPCC 2002, p. 22). Additionally, chemicals may exist in the environment at sub-lethal levels; however, UV light may increase the toxicity of these chemicals or may increase an individuals susceptibility to infection, disease, or predation (Boone et al. 2003, pp. 138142; Burkhart et al. 2003, pp. 116120; Bancroft et al. 2008, pp. 990993; Rohr et al. 2008, pp. 12351237; Relyea 2009, pp. 367374; Miller et al. 2011, pp. 23602361).

In summary, climate change has and is expected to continue to affect Great Basin ecosystems; however, predictions are difficult to make and the impacts to Columbia spotted frog populations are not well documented (Fleishman et al. 2004, pp. 248251; Botkin et al. 2007, pp. 227234; Field et al. 2007, pp. 627630). Corn (2005, pp. 5964) describes many negative consequences of a changing climate to amphibian species and predicts that impacts from climate change may be the greatest challenge to conserving amphibians in the future. The current state of small fragmented populations of Columbia spotted frogs in the Great Basin DPS indicates a high probability of populations disappearing due to loss of habitat from predicted climate related impacts (Corn 2005, pp. 5964; Wilcox et al. 2006, pp. 857862). Recent research on the effects of multiple stressors such as climate change, habitat destruction, pesticides, and disease has shown compelling evidence of negative impacts to amphibians; however, due to variability among species, this discipline needs further research. Protecting or improving Columbia spotted frogs and their habitat so that they can adapt to expected changes in climate may be the most important conservation action (Chambers et al. 2004b, pp. 266268; Seavy et al. 2009, pp. 331333). Based on our evaluation of other natural or manmade factors described above, we conclude there is sufficient information to develop a proposed listing rule for this species.

## Conservation Measures Planned or Implemented :

In Nevada, 10-year conservation agreements (each known as a Conservation Agreement and Strategy, or CAS) were signed in September 2003 for the Toiyabe Mountains (NDOW 2003a, pp. 143; 2003b, pp. 155) and Northeast (Jarbidge-Independence Range and Ruby Mountains) subpopulations. In Idaho, a Candidate Conservation Agreement with Assurances (CCAA) was completed in 2006 for the Owyhee subpopulation at Sam Noble Springs (Service 2006, pp. 145). At the end of 2012, 15 percent of the identified tasks listed in the Northeast Nevada CAS had been completed and an additional 80 percent of the tasks had been initiated at some level (NDOW 2012a, p. 4). At the end of 2012, 29 percent of the identified tasks listed in the Toiyabe Mountains CAS had been completed and an additional 64 percent of the tasks had been initiated at some level (NDOW 2012b, p. 18). Implementing these CASs also includes formulating future conservation actions aimed at alleviating threats to the species. For example, adequate habitat was identified as a limiting factor in the CAS for the Toiyabe Mountains subpopulation. A habitat enhancement project was completed in 2004 which included the construction or augmentation of 22 ponds in Indian Valley Creek (NDOW 2004a, pp. 46). An additional 14 ponds were constructed near Indian Valley Creek in 2009 along with plug and pond restoration techniques within Indian Valley Creek to arrest headcutting within the meadows. Habitat enhancement and beaver reintroduction projects are also being planned for Columbia spotted frog populations within the Jarbidge-Independence Range subpopulation. Effectiveness monitoring of these habitat enhancement projects as well as the effectiveness of the CASs as a conservation tool is ongoing.

In Idaho, numerous conservation actions, and a large-scale CCAA with the State of Idaho has been implemented. For example, 41 ponds were constructed or enhanced on private land in 2010 and 2011, to increase breeding habitat and connectivity between existing populations (Service 2010, pp. 45; 2011a, pp. 114; b, pp. 112). Monitoring is occurring to assess effectiveness of these conservation measures. In addition, seven beaver were released on private land at the request of a landowner in 2010 (Lohr 2010, pp. 19), and three beaver were released in Stoneman Creek in 2011. Additional pond projects and beaver transplants are planned for public and private lands in Idaho. Boise State University has conducted several research projects related to spotted frogs including the reintroduction of beaver for Columbia spotted frog habitat restoration (Munger and Lingo 2003, pp. 16), effects of grazing (Howard and Munger 2003, pp. 913), spotted frog habitat evaluations (Munger 2003, pp. 412), and sentinel site surveys (Lingo and Munger 2003, pp. 169; Blankinship and Munger 2005, pp. 165; Munger and Oelrich 2006, pp. 119). Surveys on private lands within Owyhee County are expected to continue. This work has resulted in improved relationships with private landowners, identification of and progress toward implementing on-the-ground conservation measures for frogs, and increased knowledge of the species distribution and relative abundance on private lands.

To minimize the effects of livestock grazing on Columbia spotted frog habitat, many grazing allotment closures and grazing exclosure projects have been implemented throughout the frogs range including on Cloverdale Creek and Indian Valley Creek (Toiyabe Mountains subpopulation), and Dry Creek, Circle Pond, Sam Noble Springs, and Stoneman Creek (Owyhee subpopulation), as well as study sites in northeastern Oregon (Bull 2005, pp. 2, 3536). Effectiveness monitoring of these projects is vital in determining the impacts of grazing on Columbia spotted frogs in these areas and the validity of these management actions in protecting and enhancing Columbia spotted frog habitat. Active monitoring, research, and habitat improvement projects are occurring or are planned throughout the range of the Great Basin DPS of Columbia spotted frogs, which are increasing our knowledge of life history characteristics, population fluctuations, effectiveness of habitat improvement projects, genetics, and threats to the species.

## Summary of Threats :

Small, highly fragmented populations, characteristic of the majority of existing populations of Columbia spotted frogs in the Great Basin, are highly susceptible to extinction processes. Historical and to some extent current management of Columbia spotted frog habitat including water development, improper grazing, mining activities, beaver management, and nonnative species have and continue to contribute to the degradation and fragmentation of habitat. Emerging viral and fungal diseases such as Ranavirus and chytridiomycosis and the spread of parasites are not currently factors threatening Columbia spotted frog populations within the Great Basin DPS but may be contributing to declines in other portions of its range. Effects of climate change such as drought and stochastic events such as fire can have detrimental effects to small isolated populations and can exacerbate existing threats. Based on our evaluation of the five listing factors affecting the continued existence of Columbia spotted frogs in the Great Basin described above, we conclude there is sufficient information to develop a proposed listing rule for this species. We find that this DPS is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

**For species that are being removed from candidate status:**

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

## Recommended Conservation Measures :

RECOMMENDED CONSERVATION MEASURES:

- Identify and reduce threats to Columbia spotted frogs and their habitat

- Maintain, enhance, and restore populations of Columbia spotted frogs and their habitat throughout their current and historical range

- Assess nonnative aquatic species distributions within the historical and current range of Columbia spotted frogs within the Great Basin DPS to understand the overall impact of this threat

- Conduct genetic analyses to determine the impacts of small isolated populations for Nevada populations (Idaho and Oregon populations have been completed)

- Assess the abundance of Columbia spotted frogs, trends, habitat conditions, and existing and potential threats in a comparable manner throughout their range. Long-term datasets exist for many populations. Detailed analyses should be performed using these data

- Conduct research that directly supports conservation and management of Columbia spotted frogs and their habitats (e.g., nonnative species removal, climate change, synergistic threats, habitat enhancement/connectivity)

- The effectiveness of existing and future habitat enhancement projects in conserving Columbia spotted frog populations, via beaver reintroduction, meadow restoration, or pond construction, should be evaluated.

# Priority Table

| Magnitude | Immediacy | Taxonomy | Priority |
|---|---|---|---|
| High | Imminent | Monotypic genus | 1 |
| | | Species | 2 |
| | | Subspecies/Population | 3 |
| | Non-imminent | Monotypic genus | 4 |
| | | Species | 5 |
| | | Subspecies/Population | 6 |
| **Moderate to Low** | **Imminent** | Monotypic genus | 7 |
| | | Species | 8 |
| | | **Subspecies/Population** | **9** |
| | Non-Imminent | Monotype genus | 10 |
| | | Species | 11 |
| | | Subspecies/Population | 12 |

## Rationale for Change in Listing Priority Number:

We are not proposing to change the Listing Priority Number.

## Magnitude:

Magnitude:
Columbia spotted frog habitat degradation and fragmentation is a combined result of past and current land use influences from agricultural development, intensive livestock grazing, spring development, urbanization, mining activities, beaver management, nonnative species, and climate change. The current state of small isolated populations throughout the range of Columbia spotted frogs in the Great Basin DPS indicates they are susceptible to extinction events. The existence of nonnative predatory fish species within the historical range of Columbia spotted frogs (particularly in mainstem rivers and reservoirs) further fragments populations making it difficult to recolonize habitat or exchange genetic material; however, a complete distribution of nonnative aquatic species in the current and historical distribution of Columbia spotted frogs in the Great Basin DPS is unknown at this time. The impacts to Columbia spotted frogs from climate change are not known with certainty; however, predicted outcomes of climate change imply that negative impacts will occur through increased stream temperatures, decreased stream flow, changes in the hydrograph, and increased frequency of extreme events. The ecological consequences of climate change to amphibians may include changes in population dynamics, timing of reproduction, changing geographic range, and broader community and ecosystem level changes. Many of these threats occur across the range of Columbia spotted frogs at various intensities, while others only impact local populations. Thus, the overall magnitude of threats is moderate to low.

## Imminence :

Imminence:
Many populations of Columbia spotted frogs within the Great Basin DPS are small and fragmented. Threats to the species habitat have occurred for over 100 years and continue to threaten the species today. Nonnative species occur within the range of Columbia spotted frogs which are further fragmenting and isolating some populations. Climate change and its associated extreme weather conditions are occurring now and are expected to increase in the future. Therefore, we regard these threats as imminent.

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

## Emergency Listing Review

__No__ Is Emergency Listing Warranted?

While most threats to the species are imminent, the threats are affecting the species at varying magnitudes and intensities. The two CASs as well as existing and future CCAAs should provide a roadmap towards recovery. Monitoring the effectiveness of these agreements and willingness of the participants to continue implementation will remain a priority. As a candidate species, Columbia spotted frogs are afforded higher protection by Federal land management agencies.

## Description of Monitoring:

Numerous mark-recapture and presence-absence surveys are occurring throughout the range of the Great Basin DPS of Columbia spotted frogs. Monitoring and research is being conducted by Colorado State University, USGS, BLM, USFS, Service, IDFG, NDOW, and the Nevada Natural Heritage Program. Annual reports and research papers are obtained by the Services Nevada Fish and Wildlife Office and summarized for the CNOR. A rangewide Columbia spotted frog meeting (initiated in 2002) is held every 2 years to discuss various research, monitoring, and conservation activities occurring throughout the entire range of the species. The last meeting was held on March 10, 2010, in Reno, Nevada.

Substantial effort is needed to monitor this species because little is known about the historical distribution of Columbia spotted frogs within the Great Basin DPS, it is a wide ranging species, and it occupies diverse and remote habitat. Because of this, there is a need to conduct all three levels of monitoring (base, mid, and apex) as described in the Amphibian Research and Monitoring Initiative (Muths et al. 2006, pp. 177). Base-level monitoring has been occurring throughout most of the currently occupied range of the species (Wente et al. 2005, pp. 95106; Moser et al. 2007, pp. 117; Pearl et al. 2010, pp. 1104; Lohr 2011, pp. 119; NDOW 2011a, pp. 123). Mid-level monitoring documents trends in site occupancy that may be the most useful metric for assessing changes in amphibian status (Muths et al. 2006, pp. 56). Mid-level monitoring is also being conducted throughout the currently occupied habitat (Moser et al. 2007, pp. 117; Meyer 2011, pp. 125; Lohr 2011, pp. 119; NDOW 2011a, pp. 123; Van Horne 2012, pp. 117). In addition to mid-level monitoring, intensive apex-level surveys being conducted annually in southeastern Oregon (Dry Creek), southwestern Idaho (Sam Noble Springs), and northeastern (Green Mountain, Tennessee Gulch, Pole Creek) and central (Toiyabe) Nevada must continue. Like most aquatic species, amphibian populations fluctuate yearly due to weather variability (i.e., temperature, precipitation) (Corn 2005, p. 60). It is important to track population changes annually and for significant time periods to distinguish between anthropogenic effects to the species and its habitat and natural population fluctuations.

**Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:**

Oregon

**Indicate which State(s) did not provide any information or comment:**

Idaho

## State Coordination:

Nevada, Idaho, and Oregon comprise the extent of all historical and current Columbia spotted frog populations within the Great Basin DPS. The NDOW and IDFG contributed valuable information on the species for this CNOR. ODFW provided information on nonnative fish species occurrences.

## Literature Cited:


LITERATURE CITED

Adams, M.J., C. Mellison, S.K. Galvan. 2013. Population estimates for the Toiyabe population of the Columbia spotted frog (Rana luteiventris), 200410. U.S. Geological Survey Open-File Report 20131036. 30 pp.

Adams, M.J., B.R. Hossack, R.A. Knapp, P.S. Corn, S.A. Diamond, P.C. Trenham, and D.B. Fagre. 2005. Distribution patterns of lentic breeding amphibians in relation to ultraviolet radiation exposure in western North America. Ecosystems 8:488500.

Adams, M.J., C.A. Pearl, B. McCreary, S.K. Galvan, S.J. Wessell, W.H. Wente, C.W. Anderson, and A.B. Kuehl. 2009. Short-term effect of cattle exclosures on Columbia spotted frog (Rana luteiventris) populations and habitat in northeastern Oregon. Journal of Herpetology 43:132138.

Adams, M.J., N.D. Chelgren, D. Reinitz, R.A. Cole, L.J. Rachowicz, S. Galvan, B. McCreary, C.A. Pearl, L.L. Bailey, J. Bettaso, E.L. Bull, and M. Leu. 2010. Using occupancy models to understand the distribution of an amphibian pathogen, Batrachochytrium dendrobatidis. Ecological Applications 20:289302.

Amish, S.J. 2006. Ecosystem engineering: beaver and the population structure of Columbia spotted frogs in western Montana. M.S. Thesis, University of Montana, Missoula, Montana. 96 pp.

Ankley, G.T., S.J. Degitz, S.A. Diamond, and TJ.E. Tietge. 2004. Assessment of environmental stressors potentially responsible for malformations in North American anuran amphibians. Ecotoxicology and Environmental Safety 58:716.

Bachelet, D., J.M. Lenihan, and R.P. Neilson. 2007. Wildfires and global climate change: the importance of climate change for future wildfire scenarios in the western United States. Pages 2241 in K.L. Ebi, G.A. Meehl, D. Bachelet, J.M. Lenihan, and R.P. Neilson, R.R. Twilley, D.F. Boesch, V.J. Coles, D.G. Kimmel, and W.D. Miller (contributors), Regional impacts of climate change: four case studies in the United States. Pew Center on Global Climate Change, Arlington, Virginia.

Backer, D.M., S.E. Jensen, and G.R. McPherson. 2004. Impacts of fire suppression activities on natural communities. Conservation Biology 18:937946.

Baird, S.F., and C. Girard. 1853. Communication. Proceedings of the Academy of Natural Sciences Philadelphia 6:378379.

Bancroft, B.A., N.J. Baker, and A.R. Blaustein. 2008. A meta-analysis of the effects of ultraviolet B radiation and its synergistic interactions with pH, contaminants, and disease on amphibian survival. Conservation Biology 22:987996.

Bates, B.C., Z.W. Kundzewicz, S. Wu, and J.P. Palutikof (editors). 2008. Climate change and water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva. 210 pp.

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54:419431.

Benda, L., D. Miller, P. Bigelow, and K. Andras. 2003. Effects of post-wildfire erosion on channel environments, Boise River, Idaho. Forest Ecology and Management 178:105119.

Bishop, C.A., D.C. Cunnington, G.M. Fellers, J.P. Gibbs, B.D. Pauli, and B.B. Rothermel. 2003. Physical habitat and its alteration: a common ground for exposure of amphibians to environmental stressors. Pages 209241 in G.L. Linder, S.K. Krest, and D.W. Sparling (editors), Amphibian decline: an integrated analysis of multiple stressor effects. SETAC Press, Pensacola, Florida.

Blankinship, M.E., and J.C. Munger. 2005. Columbia spotted frog monitoring in the Owyhee Mountains of southwestern Idaho: year 2004 results. Field Report from a cost share agreement between Boise State University and the Bureau of Land Management, Idaho Department of Fish and Game, and the U.S. Fish and Wildlife Service. Boise, Idaho. 65 pp.

Blaustein, A.R., and L.K. Belden. 2005. Ultraviolet radiation. Pages 8788 in M. Lannoo (editor), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, California.

Blaustein, A.R., J.M. Kiesecker, D.P. Chivers, and R.G. Anthony. 1997. Ambient UV-B radiation causes deformities in amphibian embryos. Proceedings of the National Academy of Sciences of the United States of America 94:1373513737.

Blaustein, A.R., J.B. Hays, P.D. Hoffman, D.P. Chivers, J.M. Kiesecker, W.P. Leonard, A. Marco, D.H. Olson, J.K. Reaser, and R.G. Anthony. 1999. DNA repair and resistance to UV-B radiation in western spotted frogs. Ecological Applications 9:11001105.

Blaustein, A.R., J.M. Romansic, E.A. Scheessele, B.A. Han, A.P. Pessier, and J.E. Longcore. 2005. Interspecific variation in susceptibility of frog tadpoles to the pathogenic fungus Batrachochytrium dendrobatidis. Conservation Biology 19:14601468.

Bond, W.J., and J.J. Midgley. 2003. The evolutionary ecology of sprouting in woody plants. International Journal of Plant Science 164(supplement):S103S114.

Boone, M.D., P.S. Corn, M.A. Donnelly, E.E. Little, and P.H. Niewiarowski. 2003. Physical stressors. Pages 129151 in G.L. Linder, S.K. Krest, and D.W. Sparling (editors), Amphibian decline: an integrated analysis of multiple stressor effects. SETAC Press, Pensacola, Florida.

Boone, M.D., R.D. Semlitsch, E.E. Little, and M.C. Doyle. 2007. Multiple stressors in amphibian communities: effects of chemical contamination, bullfrogs, and fish. Ecological Applications 17:291301.

Booth, D.T., S.E. Cox, G. Simonds, and E.D. Sant. 2012. Willow cover as a stream-recovery indicator under a conservation grazing plan. Ecological Indicators 18:512519.

Bos, D.H., and J.W. Sites, Jr. 2001. Phylogeography and conservation genetics of the Columbia spotted frog (Rana luteiventris; Amphibia, Ranidae). Molecular Ecology 10:14991513.

Botkin, D.B., H. Saxe, M.B. Araújo, R. Betts, R.H.W. Bradshaw, T. Cedhagen, P. Chesson, T.P. Dawson, J.R. Etterson, D.P. Faith, S. Ferrier, A. Guisan, A.S. Hansen, D.W. Hilbert, C. Loehle, C. Margules, M. New, M.J. Sobel, and D.R.B. Stockwell. 2007. Forecasting the effects of global warming on biodiversity. BioScience 57:227236.

Bradford, D.F. 2005. Factors implicated in amphibian population declines in the United States. Pages 915925 in M. Lannoo (editor), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, California.

Bridges, C.M., and R.D. Semlitsch. 2005. Xenobiotics. Pages 8992 in M. Lannoo (editor), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, California.

Briggs, C.J., V.T. Vredenburg, R.A. Knapp, and L.J. Rachowicz. 2005. Investigating the population level effects of chytridiomycosis: an emerging infectious disease of amphibians. Ecology 86:31493159.

Brown, T.J., B.L. Hall, and A.L. Westerling. 2004. The impact of twenty-first century climate change on wildland fire danger in the western United States: an application perspective. Climatic Change 62:365388.

Bull, E.L. 2005. Ecology of the Columbia spotted frog in northeastern Oregon. General Technical Report PNWGTR640. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 46 pp.

Bull, E.L. 2006. Monitoring populations and the presence of Batrachochytrium dendrobatidis in Columbia spotted frogs (Rana luteiventris) in northeastern Oregon. 2006 Annual Report. Pacific Northwest Research Station. La Grande, Oregon. 10 pp.

Bull, E.L., and M.P. Hayes. 2000. Livestock effects on reproduction of the Columbia spotted frog. Journal of Range Management 53:291294.

Bull, E.L., and M.P. Hayes. 2001. Post-breeding season movements of Columbia spotted frogs (Rana luteiventris) in northeastern Oregon. Western North American Naturalist 61:119123.

Bull, E.L., and M.P. Hayes. 2002. Overwintering of Columbia spotted frogs in northeastern Oregon. Northwest Science 76:141147.

Bull, E.L., and J.F. Shepherd. 2003. Water temperature at oviposition sites of Rana luteiventris in northeastern Oregon. Western North American Naturalist 63:108113.

Bureau of Land Management (BLM). 2011. Maggie and Susie Creek fish barriers. Environmental Assessment (DOIBLMNVN02020110035EA), Elko District, Tuscarora Field Office, Elko, Nevada. 42 pp.

Burkhart, J.G., J.R. Bidwell, D.J. Fort, and S.R. Sheffield. 2003. Chemical stressors. Pages 111128 in G.L. Linder, S.K. Krest, and D.W. Sparling (editors), Amphibian decline: an integrated analysis of multiple stressor effects. SETAC Press, Pensacola, Florida.

Burton, E.C., M.J. Gray, A.C. Schmutzer, D.L. Miller. 2009. Differential responses of postmetamorphic amphibians to cattle grazing in wetlands. Journal of Wildlife Management 73:269277.

Bury, R.B. 2004. Wildfire, fuel reduction, and herpetofaunas across diverse landscape mosaics in northwestern forests. Conservation Biology 18:968975.

Calico Resources USA Corporation. 2012. Draft Environmental Baseline Study Work Plans for the Grassy Mountain Project, Malheur County, Oregon. Prepared by HDR Engineering, Incorporated, Boise, Idaho and RTR Resource Management, Boise Idaho. September 2012. 66 pp. + appendicies.

Carey, C., and M.A. Alexander. 2003. Climate change and amphibian declines: is there a link? Diversity and Distributions 9:111121.

Carey, C., D.F. Bradford, J.L. Brunner, J.P. Collins, E.W. Davidson, J.E. Londcore, M. Ouellet, A.P. Pessier, and D.M. Schock. 2003. Biotic factors in amphibian population declines. Pages 153208 in G.L. Linder, S.K. Krest, and D.W. Sparling (editors), Amphibian decline: an integrated analysis of multiple stressor effects. SETAC Press, Pensacola, Florida.

Casper, G.S., and R. Hendricks. 2005. Rana catesbeiana, American bullfrog. Pages 540546 in M. Lannoo (editor), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, California.

Center for Biological Diversity, J. Goodall, E.O. Wilson, P. Ehrlich, J. Terborgh, N. Eldredge, T. Eisner, R. Hass, B. Kingsolver, C. Bowden, M. Sheen, the Xerces Society, and Biodiversity Conservation Alliance. 2004. Petition to list 225 plants and animals as endangered species under the Endangered Species Act. Submitted to the Secretary of Interior, May 11, 2004.

Chambers, J.C., R.J. Tausch, J.L. Korfmacher, D. Germanoski, J.R. Miller, and D. Jewett. 2004a. Effects of geomorphic processes and hydrologic regimes on riparian vegetation. Pages 196231 in J.C. Chambers, and J.R. Miller (editors), Great Basin Riparian Ecosystems: Ecology, Management, and Restoration. Island Press, Washington DC.

Chambers, J.C., J.R. Miller, D. Germanoski, and D.A. Weixelman. 2004b. Process based approaches for managing and restoring riparian ecosystems. Pages 261292 in J.C. Chambers, and J.R. Miller (editors), Great Basin Riparian Ecosystems: Ecology, Management, and Restoration. Island Press, Washington DC.

Chanson, J., M. Hoffman, N. Cox, and S. Stuart. 2008. The state of the worlds amphibians. Pages 3352 in S.N. Stuart, M. Hoffmann, J.S. Chanson, N.A. Cox, R.J. Berridge, P. Ramani, and B.E. Young (editors), Threatened Amphibians of the World. Lynx Edicions, Barcelona, Spain; IUCN, Gland, Switzerland; and Conservation International, Arlington, Virginia, USA.

Clements, C. 1991. Beavers and riparian ecosystems. Rangelands 13:277279.

Cook, E.R., C.A. Woodhouse, C.M. Eakin, D.M. Meko, and D.W. Stahle. 2004. Long-term aridity changes in the western United States. Science 306:10151018.

Corn, P.S. 2005. Climate change and amphibians. Animal Biodiversity and Conservation 28:5967.

Crother, B.I. (Chair, Joint Committee on Standard English and Scientific Names). 2008. Scientific and standard English names of amphibians and reptiles of North America north of Mexico with comments regarding confidence in our understanding. Herpetological Circular Number 37, Society for the Study of Amphibians and Reptiles. Sixth Edition. 94 pp.

Cunningham, J.M., A.J.K. Calhoun, and W.E. Glanz. 2007. Pond-breeding amphibian species richness and habitat selection in a beaver-modified landscape. Journal of Wildlife Management 71:25172526.

Dalldorf, K.N., S.R. Swanson, D.F. Kozlowski, K.M. Schmidt, R.S. Shane, and G. Fernandez. 2013. Influence of livestock grazing strategies on riparian response to wildfire in northern Nevada. Rangeland Ecology and Management 66:3442.

DAmen, M., and P. Bombi. 2009. Global warming and biodiversity: evidence of climate linked amphibian declines in Italy. Biological Conservation 142:30603067.

Daszak, P., L. Berger, A.A. Cunningham, A.D. Hyatt, D.E. Green, and R. Speare. 1999. Emerging infectious diseases and amphibian population declines. Emerging Infectious Diseases 5:735748.

Daszak, P., A.A. Cunningham, and A.D. Hyatt. 2003. Infectious disease and amphibian population declines. Diversity and Distributions 9:141150.

Diffenbaugh, N.S., J.S. Pal, R.J. Trapp, and F. Giorgi. 2005. Fine-scale processes regulate the response of extreme events to global climate change. Proceedings of the National Academy of Sciences 102:1577415778.

Dunham, J.B., D.S. Pilliod, and M.K. Young. 2004. Assessing the consequences of nonnative trout in headwater ecosystems in western North America. Fisheries 29:1826.

Dunham, J.B., A.E. Rosenberger, C.H. Luce, and B.E. Rieman. 2007. Influences of wildfire and channel reorganization on spatial and temporal variation in stream temperature and the distribution of fish and amphibians. Ecosystems 10:335346.

Dwire, K.A., and J.B. Kauffman. 2003. Fire and riparian ecosystems in landscapes of the western USA. Forest Ecology and Management 178:6174.

Engle, J.C. 2000. Columbia spotted frog Great Basin population (Owyhee Mountains subpopulation) long-term monitoring plan. Final report from a cost share agreement between Boise State University and the Bureau of Land Management. Boise, Idaho. November 2000. 90 pp.

Engle, J.C. 2002. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan. Year 2001 results. Idaho Department of Fish and Game Report. Boise, Idaho. 64 pp.

Engle, J.C. 2006. Columbia spotted frog (Rana luteiventris) 2006 Monitoring Report Dry Creek, Oregon. Prepared for the Vale District Bureau of Land Management. 57 pp.

Engle, J.C., and J.C. Munger. 2003. Population fragmentation of spotted frogs in the Owyhee Mountains. Bureau of Land Management Technical Bulletin No. 038. Boise, Idaho. April 2003. 15 pp.

Fellers, G.M., D.E. Green, and J.E. Longcore. 2001. Oral chytridiomycosis in the mountain yellow-legged frog (Rana muscosa). Copeia 2001:945953.

Ficke, A.D., C.A. Myrick, and L.J. Hansen. 2007. Potential impacts of global climate change on freshwater fisheries. Reviews in Fish Biology and Fisheries 17:581613.

Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running, and M.J. Scott. 2007. North America. Pages 617652 in M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (editors), Climate change 2007: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

Fleishman, E., J.B. Dunham, D.D. Murphy, and P.F. Brussard. 2004. Explanation, prediction, and maintenance of native species richness and composition. Pages 232260 in J.C. Chambers, and J.R. Miller (editors), Great Basin Riparian Ecosystems: Ecology, Management, and Restoration. Island Press, Washington, DC.

Frankham, R. 2005. Genetics and extinction. Biological Conservation 126:131140.

Funk, W.C., A.E. Greene, P.S. Corn, and F.W. Allendorf. 2005a. High dispersal in a frog suggests that it is vulnerable to habitat fragmentation. Biology Letters 1:1316.

Funk, W.C., M.S. Blouin, P.S. Corn, B.A. Maxwell, D.S. Pilliod, S. Amish, and F.W. Allendorf. 2005b. Population structure of Columbia spotted frogs (Rana luteiventris) is strongly affected by the landscape. Molecular Ecology 14:483496.

Funk, W.C., C.A Pearl, H.M. Draheim, M.J. Adams, T.D. Mullins, and S.M. Haig. 2008. Range-wide phylogenetic analysis of the spotted frog complex (Rana luteiventris and Rana pretiosa) in northwestern North America. Molecular Phylogenetics and Evolution 49:198210.

Ganguly, A., K. Steinhaeuser, D. Erickson, M. Branstetter, E. Parish, N. Singh, J. Drake, and L. Buja. 2009. Higher trends but larger uncertainty and geographic variability in 21st century temperature and heat waves. Proceedings of the National Academy of Sciences 106:1555515559.

Germanoski, D., and J.R. Miller. 2004. Basin sensitivity to channel incision in response to natural and anthropogenic disturbance. Pages 88123 in J.C. Chambers, and J.R. Miller (editors), Great Basin Riparian Ecosystems: Ecology, Management, and Restoration. Island Press, Washington, DC.

Gibbs, J.P. 2000. Wetland loss and biodiversity conservation. Conservation Biology 14:314317.

Gray, M.J., D.L. Miller, A.C. Schmutzer, C.A. Baldwin. 2007. Frog virus 3 prevalence in tadpole populations inhabiting cattle-access and non-access wetlands in Tennessee, USA. Diseases of Aquatic Organisms 77:97103.

Gray, M.J., D.L. Miller, and J.T. Hoverman. 2009. Ecology and pathology of amphibian ranaviruses. Diseases of Aquatic Organisms 87:243266.

Green, D.E., K.A. Converse, and A.K. Schrader. 2002. Epizootiology of sixty-four amphibian morbidity and mortality events in the USA, 19962001. Annals of the New York Academy of Sciences 969:323339.

Green, D.M. 2003. The ecology of extinction: population fluctuation and decline in amphibians. Biological Conservation 111:331343.

Green, D.M. 2006. U.S. Geological Survey, National Wildlife Health Center, Madison, Wisconsin. RE: Prelim Findings on larval bullfrogs from Owyhee River, Elko Co. Electronic mail to Chris Drake, Nevada Department of Wildlife, Elko, Nevada. Dated August 30, 2006. 2 pp.

Green, D.M., T.F. Sharbel, J. Kearsley, and H. Kaiser. 1996. Postglacial range fluctuation, genetic subdivision and speciation in the western North American spotted frog complex, Rana pretiosa. Evolution 50:374390.

Green, D.M., H. Kaiser, T.F. Sharbel, J. Kearsley, and K.R. McAllister. 1997. Cryptic species of spotted frogs, Rana pretiosa complex, in Western North America. Copeia 1997:18.

Greene, A.E., and W.C. Funk. 2009. Sexual selection on morphology in an explosive breeding amphibian, the Columbia spotted frog (Rana luteiventris). Journal of Herpetology 43:244251.

Gresswell, R.E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society 128:193221.

Haak, A.L., J.E. Williams, H.M. Neville, D.C. Dauwalter, and W.T. Colyer. 2010. Conserving peripheral trout populations: the values and risks of life on the edge. Fisheries 35:530549.

Halofsky, J.E., and D.E. Hibbs. 2009. Controls on early post-fire woody plant colonization in riparian areas. Forest Ecology and Management 258:13501358.

Hampe, A., and R.J. Petit. 2005. Conserving biodiversity under climate change: the rear edge matters. Ecology Letters 8:461467.

Hansen, A.J., R.P. Neilson, V.H. Dale, C.H. Flather, L.R. Iverson, D.J. Currie, S. Shafer, R. Cook, and P.J. Bartlein. 2001. Global change in forests: responses of species, communities, and biomes. BioScience 51:765779.

Hanson, K.C., and R.A. Glenn. 2011. Results of screening for the presence of amphibian chytridiomycosis fungal infection in Columbia spotted frog (Rana luteiventris) populations in Nevada. Final Report submitted to Nevada Fish and Wildlife Office, Reno, Nevada. U.S. Fish and Wildlife Service, Abernathy Fish Technology Center, Longview, Washington. 15 pp.

Hatch, K., C.R. Tracy, J.K. Reaser, and S. Blomquist. 2002. Status of the Columbia spotted frog (Rana luteiventris) on U.S. Forest Service land in the Toiyabe Mountains, NV. University of Nevada, Reno, Reno, Nevada. 64 pp.

Hedrick, P.W., and S.T. Kalinowski. 2000. Inbreeding depression in conservation biology. Annual Reviews in Ecology and Systematics 31:139162.

Hossack, B.R., and P.S. Corn. 2007. Responses of pond-breeding amphibians to wildfire: short-term patterns in occupancy and colonization. Ecological Applications 17:14031410.

Hossack, B.R., and D.S. Pilliod. 2011. Amphibian responses to wildfire in the western United States: emerging patterns from short-term studies. Fire Ecology 7:129144.

Hossack, B.R., W.H. Lowe, and P.S. Corn. 2013. Rapid increases and time-lagged declines in amphibian occupancy after wildfire. Conservation Biology 1:219228.

Hovingh, P. 1990. Investigations of aquatic resources in the Great Basin and adjacent regions with respect to amphibians, mollusks and leeches: a preliminary report for the tri-state region of Idaho, Nevada, and Utah. March 1990. 12 pp. + appendices.

Howard, A., and J.C. Munger. 2003. Effects of livestock grazing on the invertebrate prey base and on the survival and growth of larvae of the Columbia spotted frog, Rana luteiventris. Bureau of Land Management Technical Bulletin No. 037. Boise, Idaho. April 2003. 28 pp.

Huber, M., and R. Knutti. 2011. Anthropogenic and natural warming inferred from changes in Earths energy balance. Nature Geoscience. Published online December 4, 2011; DOI: 10.1038/NGEO1327. 6 pp. + supplemental material.

HydroGeo. 2008. Final surface and groundwater hydrology technical report: Big Springs exploration project. Report submitted to Great Basin Ecology, Elko, Nevada. HydroGeo, Incorporated, Crested Butte, Colorado. September, 2008. 114 pp.

HydroGeo. 2012. Annual hydrologic monitoring report (2011): Big Springs project. Final Report submitted to Victoria Gold Corporation, Reno, Nevada. March 2012. HydroGeo, Incorporated, Crested Butte, Colorado. 55 pp.

Idaho Administration Procedures Act (IDAPA). 2012a. Rules of the Idaho Fish and Game Commission, IDAPA 13.01.06, Rules Governing Classification and Protection of Wildlife. Boise, Idaho. 9 pp. http://adminrules.idaho.gov/rules/current/13/index.html

Idaho Administration Procedures Act (IDAPA). 2012b. Rules of the Idaho Fish and Game Commission, IDAPA 13.01.10, Rules Governing the Importation, Possession, Release, Sale, or Salvage of Wildlife. Boise, Idaho. 16 pp. http://adminrules.idaho.gov/rules/current/13/index.html

Idaho Department of Fish and Game (IDFG), Idaho Department of Parks and Recreation, Bureau of Land Management, Regions 1 and 4 of U.S. Forest Service, and U.S. Fish and Wildlife Service. 1995. Habitat Conservation Assessment and Conservation Strategy: Spotted Frog (Rana pretiosa). (Draft) Idaho State Conservation Effort. 33 pp.

Idaho Department of Fish and Game (IDFG). 2005. Idaho Comprehensive Wildlife Conservation Strategy. Idaho Conservation Data Center, Boise, Idaho. September 2005. http://fishandgame.idaho.gov/cms/tech/CDC/cwcs.cfm

Idaho Department of Fish and Game (IDFG). 2012. Upland game, furbearer, and turkey seasons and rules, 2012-2013 and 2013-2014. Boise, Idaho. 56 pp. http://fishandgame.idaho.gov

Inkley, D.B., M.G. Anderson, A.R. Blaustein, V.R. Burkett, B. Felzer, B. Griffith, J. Price, and T.L. Root. 2004. Global climate change and wildlife in North America. Wildlife Society Technical Review 042. The Wildlife Society, Bethesda, Maryland. 26 pp.

Intergovernmental Panel on Climate Change (IPCC). 2002. Climate Change and Biodiversity. IPCC Technical Paper V. H. Gitay, A. Suárez, T. Watson, and D.J. Dokken (editors), WMO-UNEP. 86 pp. http://www.ipcc.ch/pub/tpbiodiv.pdf

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K., and A. Reisinger (editors)]. Geneva, Switzerland. 104 pp.

Jackson, B.K., and S.M. Sullivan. 2009. Influence of wildfire severity on riparian plant community heterogeneity in an Idaho, USA wilderness. Forest Ecology and Management 259:2432.

Jansen, A., and M. Healey. 2003. Frog communities and wetland condition: relationships with grazing by domestic livestock along an Australian floodplain river. Biological Conservation 109:207219.

Jewett, D.G., M.L. Lord, J.R. Miller, and J.C. Chambers. 2004. Geomorphic and hydrologic controls on surface and subsurface flow regimes in riparian meadow ecosystems. Pages 124161 in J.C. Chambers, and J.R. Miller (editors), Great Basin Riparian Ecosystems: Ecology, Management, and Restoration. Island Press, Washington DC.

Johnson, P.T.J., and R.B. Hartson. 2009. All hosts are not created equal: explaining differential patterns of malformations in an amphibian community. Journal of Animal Ecology 78:191201.

Johnson, P.T.J., and K.B. Lunde. 2005. Parasite infection and limb malformations: a growing problem in amphibian conservation. Pages 124138 in M. Lannoo (editor), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, California.

Johnson, P.T.J., K.B. Lunde, E.M. Thurman, E.G. Ritchie, S.N. Wray, D.R. Sutherland, J.M. Kapfer, T.J. Frest, J. Bowerman, and A.R. Blaustein. 2002. Parasite (Ribeiroia ondatrae) infection linked to amphibian malformations in the western United States. Ecological Monographs 72:151168.

Johnson, P.T.J., J.M. Chase, K.L. Dosch, R.B. Hartson, J.A. Gross, D.J. Larson, D.R. Sutherland, and S.R. Carpenter. 2007. Aquatic eutrophication promotes pathogenic infection in amphibians. Proceedings of the

National Academy of Sciences 104:1578115786.

Kats, L.B., and R.P. Ferrer. 2003. Alien predators and amphibian declines: review of two decades of science and the transition to conservation. Diversity and Distributions 9:99110.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian plant communities and stream-side management implications, a review. Journal of Range Management 37:430437.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983a. Impacts of cattle on streambanks in northeastern Oregon. Journal of Range Management 36:683685.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983b. Effects of late season cattle grazing on riparian plant communities. Journal of Range Management 36:685691.

Kaushal, S.S., G.E. Likens, N.A. Jaworski, M.L. Pace, A.M. Sides, D. Seekell, K.T. Belt, D.H. Secor, R.L. Wingate. 2010. Rising stream and river temperatures in the United States. Frontiers in Ecology and the Environment 8:461466.

Kiesecker, J.M., and A.R. Blaustein. 1995. Synergism between UV-B radiation and a pathogen magnifies amphibian embryo mortality in nature. Proceedings of the National Academy of Sciences of the United States of America 92:1104911052.

Knapp, R.A. 2005. Effects of nonnative fish and habitat characteristics on lentic herpetofauna in Yosemite National Park, USA. Biological Conservation 121:265279.

Knapp, R.A., and K.R. Matthews. 2000. Non-native fish introductions and the decline of the mountain yellow-legged frog from within protected areas. Conservation Biology 14:428438.

Knowles, N., M.D. Dettinger, and D.R. Cayan. 2006. Trends in snowfall versus rainfall for the western United States, 19492004. Journal of Climate 19:45454559.

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen, and I.A. Shiklomanov. 2007. Freshwater resources and their management. Pages 174210 in M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (editors), Climate change 2007: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

Kunkel, K.E., M.A. Palecki, L. Ensor, D. Easterling, K.G. Hubbard, D. Robinson, and K. Redmond. 2009. Trends in Twentieth-Century U.S. extreme snowfall seasons. Journal of Climate 22:62046216.

La Fayette, D. 2009. 2009 Columbia spotted frog survey on private property, Owyhee County, Idaho. La Fayette Consulting LLC. Nampa, Idaho. 18 pp. + appendices.

La Fayette, D. 2010. 2010 Columbia spotted frog survey on private property, Owyhee County, Idaho. La Fayette Consulting LLC. Nampa, Idaho. December 2010. 46 pp. + appendices.

La Fayette, D. 2011. 2011 Columbia spotted frog survey on private property, Owyhee County, Idaho. La Fayette Consulting LLC. Nampa, Idaho. September 2011. 51 pp. + appendices.

La Fayette, D. 2012. 2012 Columbia spotted frog survey on private property, Owyhee County, Idaho. La Fayette Consulting LLC. Nampa, Idaho. August 6, 2012. 4 pp.

Lake, P.S. 2003. Ecological effects of perturbation by drought in flowing waters. Freshwater Biology 48:11611172.

Lande, R. 2002. Incorporating stochasticity in population viability analysis. Pages 1840 in S.R. Beissinger, and D.R. McCullough (editors), Population Viability Analysis. University of Chicago Press, Chicago, Illinois.

Lawler, J.J., S.L. Shafer, B.A. Bancroft, and A.R. Blaustein. 2010. Projected climate impacts for amphibians of the Western Hemisphere. Conservation Biology 24:3850.

Lefcort, H., R.A. Meguire, L.H. Wilson, and W.F. Ettinger. 1998. Heavy metals alter the survival, growth, metamorphosis, and antipredatory behavior of Columbia spotted frog (Rana luteiventris) tadpoles. Archives of Environmental Contamination and Toxicology 35:447456.

Lingo, H.A., and J.C. Munger. 2003. Progress report July 1, 2002 June 30, 2003: Columbia spotted frog-Great Basin population. Idaho Department of Fish and Game Report October 2003. Boise, Idaho. 69 pp.

Little, E.E., and R.D. Calfee. 2002. Environmental implications of fire-retardant chemicals: project summary. Report to the Forest Service, June, 2002. U.S. Geological Survey, Columbia Environment Research Center, Columbia, Missouri. 9 pp.

Lohr, K. 2011. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan: Year 2011 Results. Idaho Department of Fish and Game Progress Report. Boise, Idaho. December 2011. 19 pp.

Lohr, K. 2010. Idaho Fish and Game, Nampa, Idaho. More beaver releases. Electronic mail to Chris Reighn, U.S. Fish and Wildlife Service, Boise, Idaho. Dated June 1, 2010. 9 pp.

Lohr, K. 2012. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan: Year 2012 Results. Idaho Department of Fish and Game Progress Report. Boise, Idaho. December 2012. 18 pp.

Lohr, K., and B. Haak. 2009. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan: Year 2009 Results. Idaho Department of Fish and Game Progress Report. Boise, Idaho. November 2009. 19 pp.

Lohr, K., and B. Haak. 2010. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan: Year 2010 Results. Idaho Department of Fish and Game Progress Report. Boise, Idaho. December 2010. 20 pp.

Lohr, K., and A. Moser. 2008. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan: Year 2008 Results. Idaho Department of Fish and Game Progress Report. Boise, Idaho. October 2008. 21 pp.

Lomnicky, G.A., T.R. Whittier, R.M. Hughes, and D.V. Peck. 2007. Distribution of nonnative aquatic vertebrates in western U.S. streams and rivers. North American Journal of Fisheries Management 27:10821093.

McCaffery, R.M, and B.A. Maxell. 2010. Decreased winter severity increases viability of a montane frog population. Proceedings of the National Academy of Sciences of the United States of America 107:86448649.

McCarty, J.P. 2001. Ecological consequences of recent climate change. Conservation Biology 15:320331.

McKenzie, D., Z. Gedalof, D.L. Peterson, and P. Mote. 2004. Climate change, wildfire, and conservation. Conservation Biology 18:890902.

McMenamin, S.K., E.A. Hadly, and C.K. Wright. 2008. Climatic change and wetland desiccation cause amphibian decline in Yellowstone National Park. Proceedings of the National Academy of Sciences 105:1698816993.

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver, and Z.C. Zhao. 2007. Global Climate Projections. Pages 747845 in S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (editors), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom. 996 pp.

Mellison, C. 2012. U.S. Fish and Wildlife Service, Nevada Fish and Wildlife Office, Reno, Nevada. Unpublished data.

Mensing, S.A., J. Smith, K.B. Norman, and M. Allan. 2008. Extended drought in the Great Basin of western North America in the last two millennia reconstructed from pollen records. Quaternary International 188:7989.

Meyer, M. 2012. Columbia spotted frog 2012 Monitoring Report, Dry Creek, Oregon. Prepared for the Vale District Bureau of Land Management. U.S. Fish and Wildlife Service, LaGrande, Oregon. 31 pp.

Miller, G.C. 2004. Interim Report- Mercury wet deposition in Nevada. University of Nevada, Reno. Prepared for U.S. Environmental Protection Agency, Office of Water, Region IX, San Francisco, California. 4 pp.

Miller, J.D. 1978. Observations on the diets of Rana pretiosa, Rana pipiens, and Bufo boreas from western Montana. Northwest Science 52:243249.

Miller, M. 2000. Fire Autecology. Pages 934 in J.K. Brown, and J.K. Smith (editors), Wildland fire in ecosystems: effects of fire on flora. General Technical Report RMRSGTR42volume 2. Ogden, Utah: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 pp.

Miller, R.F., and J.A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management 52:550559.

Miller, D., M. Gray, and A. Storfer. 2011. Ecopathology of ranaviruses infecting amphibians. Viruses 3:23512373.

Miller, D., C. Luce, and L. Benda. 2003. Time, space, and episodicity of physical disturbance in streams. Forest Ecology and Management 178:121140.

Monello, R.J., J.J. Dennehy, D.L. Murray, and A.J. Wirsing. 2006. Growth and behavioral responses of tadpoles of two native frogs to an exotic competitor, Rana catesbeiana. Journal of Herpetology 40:403407.

Moser, A., and the Owyhee Columbia Spotted Frog Working Group. 2007. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan: Revised 2007. Idaho Department of Fish and Game, Boise, Idaho. August 2007. 17 pp.

Moser, A., and G. Patton. 2006. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan: Year 2006 Results at Sam Noble Springs. Idaho Department of Fish and Game, Boise, Idaho. December 2006. 16 pp.

Moyle, P.B. 1973. Effects of introduced bullfrogs, Rana catesbeiana, on the native frogs of the San Joaquin Valley, California. Copeia 1973:1822.

Munger, J.C. 2003. Critical habitat elements for Columbia spotted frogs in the Owyhee Mountains. Report on a challenge cost share agreement between Boise State University and the Bureau of Land Management. Boise, Idaho. January 10, 2003. 15 pp.

Munger, J.C., and H.A. Lingo. 2003. Reintroduction of beaver to aid restoration of the spotted frog population in Stoneman Creek. Report on the FY2001 and FY2002 research funded by a challenge cost share agreement between Boise State University and the Bureau of Land Management. Boise, Idaho. February 10, 2003. 7 pp.

Munger, J.C., and K. Oelrich. 2006. Columbia spotted frog Great Basin population (Owyhee subpopulation) long-term monitoring plan: year 2005 results. Field Report from a cost share agreement between Boise State University and the Bureau of Land Management, Idaho Department of Fish and Game, and the U.S. Fish and Wildlife Service. Boise, Idaho. April 4, 2006. 19 pp.

Munger, J.C., M. Gerber, M. Carroll, K. Madric, and C. Peterson. 1996. Status and habitat associations of the spotted frog (Rana pretiosa) in southwestern Idaho. Bureau of Land Management Technical Bulletin No. 961. Boise, Idaho. 112 pp.

Munger, J.C., M. Gerber, and J. Lauders. 1998. Distribution of the Columbia spotted frog, Rana luteiventris, in the Dry Creek drainage and other sites in Malheur County, Oregon. Final Report from a cost share agreement between Boise State University and the Bureau of Land Management. Vale, Oregon. February 1, 1998. 67 pp.

Murphy, M.A., R. Dezzani, D.S. Pilliod, and A. Storfers. 2010. Landscape genetics of high mountain frog metapopulations. Molecular Ecology 19:36343649.

Muths, E., A.L. Gallant, G. Campbell, H. Evan, W.A. Battaglin, D.E. Green, J.S. Staiger, S.C. Walls, M.S. Gunzburger, and R.F. Kearney. 2006. The amphibian research and monitoring initiative (ARMI): 5year report: U.S. Geological Survey Scientific Investigations Report 20065224. 77 pp.

Naiman, R.J., C.A. Johnston, and J.C. Kelley. 1988. Alteration of North American streams by beaver. BioScience 38:753762.

National Climate Assessment and Development Advisory Committee (NCADAC). 2013. Draft National Climate Assessment Report. Department of Commerce, Washington DC. January 2013. 1,193 pp. http://ncadac.globalchange.gov/

Nevada Administrative Code (NAC). 2012. Chapter 503Hunting, fishing, and trapping; miscellaneous protective measures. Revised June 8, 2012. 62 pp. http://www.leg.state.nv.us/NAC/NAC-503.html

Nevada Department of Wildlife (NDOW). 2003a. Conservation agreement and strategy for the Columbia spotted frog (Rana luteiventris)- Great Basin Population Nevada- Toiyabe subpopulation, September 2003. Reno, Nevada. Interagency document. 43 pp.

Nevada Department of Wildlife (NDOW). 2003b. Conservation agreement and strategy for the Columbia spotted frog (Rana luteiventris)- Great Basin Population Nevada- Northeast subpopulation, September 2003. Reno, Nevada. Interagency document. 51 pp.

Nevada Department of Wildlife (NDOW). 2004a. Toiyabe spotted frog conservation agreement and strategy implementation: 2004 annual report. Southern Region, Las Vegas, Nevada. 13 pp.

Nevada Department of Wildlife (NDOW). 2004b. Toiyabe spotted frog Great Basin subpopulation long-term monitoring plan. Southern Region, Las Vegas, Nevada. 25 pp.

Nevada Department of Wildlife (NDOW). 2006. Nevada Wildlife Action Plan. Reno, Nevada. June 23, 2006. 546 pp. + appendicies.

Nevada Department of Wildlife (NDOW). 2009. Columbia spotted frog (Rana luteiventris) northeastern Nevada Great Basin population long-term monitoring plan. Eastern Region, Elko, Nevada. 21 pp.

Nevada Department of Wildlife (NDOW). 2012a. Great Basin population of Columbia spotted frog, Northeastern subpopulations: Conservation agreement and strategy implementation 2012 annual report. Eastern Region, Elko, Nevada. November 2012. 25 pp.

Nevada Department of Wildlife (NDOW). 2012b. Unpublished data from 2012 surveys, Toiyabe subpopulation. Southern Region, Las Vegas, Nevada.

Nevada Department of Wildlife (NDOW). 2012c. Unpublished data regarding bullfrog and Columbia spotted frog locations in northeast Nevada. Eastern Region, Elko, Nevada.

Nevada Department of Wildlife (NDOW). 2012d. Nevada furbearer seasons 2011-2012. Reno, Nevada. Accessed on March 14, 2012. http://www.ndow.org/hunt/seasons/fur/furbearer.shtm

Nevada State Health Division (NSHD). 2007. The Nevada State Health Division issues fish consumption advisories for six bodies of water. March 8, 2007. 2 pp. http://health.nv.gov

Noss, R., B. Csuti, and M.J. Groom. 2006. Habitat fragmentation. Pages 213251 in M.J. Groom, G.K. Meffe, and C.R. Carroll (editors), Principles of Conservation Biology (Third Edition). Sinauer Associates, Incorporated, Sunderland, Massachusetts.

Opdam, P., and D. Wascher. 2004. Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. Biological Conservation 117:285297.

Oregon Administrative Rules. 2012. Holding, propagating, protected wildlife, Division 044 (6350440130). Oregon Department of Fish and Wildlife, Salem, Oregon. Updated August 2012. 20 pp. http://arcweb.sos.state.or.us/pages/rules/oars_600/oar_635/635_tofc.html

Oregon Department of Fish and Wildlife (ODFW). 2006. The Oregon conservation strategy. Salem, Oregon. February 2006. 375 pp. + appendices.

Oregon Department of Fish and Wildlife (ODFW). 2008. Oregon Department of Fish and Wildlife Sensitive Species List. Salem, Oregon. 13 pp.

Oregon Department of Fish and Wildlife (ODFW). 2013. Oregon furbearer trapping and hunting regulations, July 1, 2012 through June 30, 2014. Salem, Oregon. 12 pp. http://www.dfw.state.or.us/resources/hunting/small_game/

Ouellet, M., I. Mikaelian, B.D. Pauli, J. Rodrigue, and D.M. Green. 2005. Historical evidence of widespread chytrid infection in North American amphibian populations. Conservation Biology 19:14311440.

Paoletti, D.J., D.H. Olson, and A.R. Blaustein. 2011. Responses of Foothill yellow-legged frog (Rana boylii) larvae to an introduced predator. Copeia 2011:161168.

Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution, and Systematics 37:637669.

Patla, D.A., and C.R. Peterson. 1997. The effects of habitat modification on a spotted frog population in Yellowstone National Park. Pages 1617 in E.D. Koch, G. Wood, C.R. Peterson, and P.S. Corn (editors), A summary of the conference on declining and sensitive amphibians in the Rocky Mountains and Pacific Northwest. Idaho Herpetological Society and U.S. Fish and Wildlife Service, Snake River Basin Office Report, Boise, Idaho. 96 pp.

Patla, D.A., and C.R. Peterson. 2004. Amphibian and reptile monitoring inventory and monitoring Grand Teton and Yellowstone National Parks, 2000-2003: Final Report. Idaho State University, Pocatello, Idaho. 59 pp.

Paysen, T.E., R.J. Ansley, J.K. Brown, G.J. Gottfried, S.M. Haase, M.G. Harrington, M.G. Narog, S.S. Sackett, and R.C. Wilson. 2000. Fire in western shrubland, woodland, and grassland ecosystems. Pages 121159 in K.J. Brown, and J.K. Smith (editors), Wildland fire and ecosystems: effects of fire on flora. General Technical Report RMRSGTR42Vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 pp.

Pearl, C.A., M.J. Adams, R.B. Bury, and B. McCreary. 2004. Asymmetrical effects of introduced bullfrogs (Rana catesbeiana) on native ranid frogs in Oregon. Copeia 2004:1120.

Pearl, C.A., M.J. Adams, and W.H. Wente. 2007a. Characteristics of Columbia spotted frog (Rana luteiventris) oviposition sites in northeastern Oregon, USA. Western North American Naturalist 67:8691.

Pearl, C.A., E.L. Bull, D.E. Green, J. Bowerman, M.J. Adams, A. Hyatt, and W.H. Wente. 2007b. Occurrence of the amphibian pathogen Batrachochytrium dendrobatidis in the Pacific Northwest. Journal of Herpetology 41:145149.

Pearl, C.A., S.K. Galvin, M.J. Adams, and B. McCreary. 2010. Columbia spotted frog (Rana luteiventris) in southeastern Oregon: a survey of historical localities, 2009. U.S. Geological Survey Open File Report 20101235. 96 pp.

Pettit, N.E., and R.J. Naiman. 2007. Fire in the riparian zone: characteristics and ecological consequences. Ecosystems 10:673687.

Phillipsen, I.C., W.C. Funk, E.A. Hoffman, K.J. Monsen, and M.S. Blouin. 2011. Comparative analyses of effective population size within and among species: ranid frogs as a case study. Evolution 65:29272945.

Pilliod, D.S., and C.R. Peterson. 2001. Local and landscape effects of introduced trout on amphibians in historically fishless watersheds. Ecosystems 4:322333.

Pilliod, D.S., C.R. Peterson, and P.I. Ritson. 2002. Seasonal migration of Columbia spotted frogs (Rana luteiventris) among complementary resources in a high mountain basin. Canadian Journal of Zoology 80:18491862.

Pilliod, D.S., R.B. Bury, E.J. Hyde, C.A. Pearl, and C.S. Corn. 2003. Fire and amphibians in North America. Forest Ecology and Management 178:163181.

Pounds, J.A., M.R. Bustamante, L.A. Coloma, J.A. Consuegra, M.P.L. Fogden, P.N. Foster, E. La Marca, K.L. Masters, A. Merino-Viteri, R. Puschendorf, S.R. Ron, G.A. Sánchez-Azofeifa, C.J. Still, and B.E. Young. 2006. Widespread amphibian extinctions from epidemic disease driven by global warming. Nature 439:161167.

Pounds, J.A., A.C.O.Q. Carnaval, and P.S. Corn. 2007. Climate change, biodiversity loss, and amphibian declines. Pages 1920 in C. Gascon, J.P. Collins, R.D. Moore, D.R. Church, J.E. McKay, and J.R. Mendelson III (editors), Amphibian Conservation Action Plan. Proceedings: IUCN/SSC Amphibian Conservation Summit 2005. IUCN/SSC Specialist Group. Gland, Switzerland and Cambridge, United Kingdom. 64 pp.

Pringle, C. 2006. The fragmentation of aquatic ecosystems and the alteration of hydrologic connectivity. Pages 243246 in M.J. Groom, G.K. Meffe, and C.R. Carroll (editors), Principles of Conservation Biology (Third Edition). Sinauer Associates, Incorporated, Sunderland, Massachusetts.

Prinn, R., S. Paltsev, A. Sokolov, M. Sarofim, J. Reilly, and H. Jacoby. 2011. Scenarios with MIT integrated global systems model: significant global warming regardless of different approaches. Climatic Change 104:515537.

Rachowicz, L.J., R.A. Knapp, J.A.T. Morgan, M.J. Stice, V.T. Vredenburg, J.M. Parker, and C.J. Briggs. 2006. Emerging infectious disease as a proximate cause of amphibian mass mortality. Ecology 87:16711683.

Rahel, F.J., and J.D. Olden. 2008. Assessing the effects of climate change on aquatic invasive species. Conservation Biology 22:512533.

Rahel, F.J., B. Bierwagen, and Y. Taniguchi. 2008. Managing aquatic species of conservation concern in the face of climate change and invasive species. Conservation Biology 22:551561.

Reaser, J.K. 1997a. Amphibian declines: Conservation science and adaptive management. Doctoral Dissertation. Stanford University. California. 148 pp.

Reaser, J.K. 1997b. Conservation of the spotted frog (Rana pretiosa) in Nevada: Multi-scale population status and trends assessment. Pages 2122 in E.D. Koch, G. Wood, C.R. Peterson, and P.S. Corn (editors), A Summary of the Conference on Declining and Sensitive Amphibians in the Rocky Mountains and Pacific Northwest. Idaho Herpetological Society and U.S. Fish and Wildlife Service, Snake River Basin Office Report, Boise, Idaho, February, 1997. 96 pp.

Reaser, J.K. 2000. Demographic analyses of the Columbia spotted frog (Rana luteiventris): case study in spatiotemporal variation. Canadian Journal of Zoology 78:11581167.

Reaser, J.K., and D.S. Pilliod. 2005. Rana luteiventris, Columbia spotted frog. Pages 559562 in M. Lannoo (editor), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, California.

Reed, D.H., and R. Frankham. 2003. Correlation between fitness and genetic diversity. Conservation Biology 17:230237.

Relyea, R.A. 2009. A cocktail of contaminants: how mixtures of pesticides at low concentrations affect aquatic communities. Oecologia 159:363376.

Remington, C.L. 1968. Suture-zones of hybrid interaction between recently joined biotas. Pages 321428 in T. Dobzhansky, M.K. Hecht, and W.C. Steere (editors), Evolutionary Biology. Plenum, New York.

Rice, P.M., G.R. McPherson, and L.J. Rew. 2008. Fire and nonnative invasive plants in the Interior West Bioregion. Pages 141173 in K. Zouhar, J.K. Smith, S. Sutherland, and M.L. Brooks (editors), Wildland fire in ecosystems: fire and nonnative invasive plants. General Technical Report RMRSGTR42volume 6. Ogden, Utah: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 355 pp.

Ripley, E.A., R.E. Redmann, and A.A. Crowder. 1996. Environmental effects of mining. St. Lucie Press, Delray Beach, Florida. 356 pp.

Roberts, C.D., and T.E. Dickinson. 2012. Ribeiroia ondatrae causes limb abnormalities in a Canadian amphibian community. Canadian Journal of Zoology 90:808814.

Robertson, J.M., and W.C. Funk. 2011. Population genetic analysis of Columbia spotted frogs (Rana luteiventris) in southwestern Idaho. Final Report submitted to Bureau of Land Management, Boise, Idaho. Colorado State University, Fort Collins, Colorado. September 30, 2011. 23 pp.

Robertson, J.M., and W.C. Funk. 2012. Population genetic analysis of Columbia spotted frogs (Rana luteiventris) in southeastern Oregon. Final Report submitted to Bureau of Land Management, Portland, Oregon. Colorado State University, Fort Collins, Colorado. April 9, 2012. 20 pp.

Rohr, J.R., A.M. Schotthoefer, T.R. Raffel, H.J. Carrick, N. Halstead, J.T. Hoverman, C.M. Johnson, L.B. Johnson, C. Lieske, M.D. Piwoni, P.K. Schoff, and V.R. Beasley. 2008. Agrochemicals increase trematode infections in a declining amphibian species. Nature 455:12351239.

Rollins-Smith, L.A., C. Carey, J. Longcore, J.K. Doersam, A. Boutte, J.E. Bruzgal, and J.M. Conlon. 2002. Activity of antimicrobial skin peptides from ranid frogs against Batrachochytrium dendrobatidis, the chytrid fungus associated with global amphibian declines. Developmental and Comparative Immunology 26:471479.

Rollins-Smith, L.A., L.K. Reinert, C.J. OLeary, L.E. Houston, and D.C. Woodhams. 2005. Antimicrobial peptide defenses in amphibian skin. Integrative and Comparative Biology 45:137142.

Rosenzweig, C., G. Casassa, D.J. Karoly, A. Imeson, C. Liu, A. Menzel, S. Rawlins, T.L. Root, B. Seguin, and P. Tryjanowski. 2007. Assessment of observed changes and responses in natural and managed systems. Pages 79131 in M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (editors), Climate change 2007: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

Russell, D.M., C.S. Goldberg, L.P. Waits, E.B. Rosenblum. 2010. Batrachochytrium dendrobatidis infection dynamics in the Columbia spotted frog Rana luteiventris in north Idaho, USA. Diseases of Aquatic Organisms 92:223230.

Russell, D.M., C.S. Goldberg, L. Sprague, L.P. Waits, D.E. Green, K.L. Schuler, and E.B. Rosenblum. 2011. Ranavirus outbreaks in amphibian populations of northern Idaho. Herpetological Review 42:223225.

Russell, K.R., D.H. Van Lear, and D.C. Guynn, Jr. 1999. Prescribed fire effects on herpetofauna: review and management implications. Wildlife Society Bulletin 27:374384.

Sada, D.W., and G.L. Vinyard. 2002. Anthropogenic changes in biogeography of Great Basin aquatic biota. Pages 277293 in R. Hershler, D.B. Madsen, and D.R. Currey (editors), Great Basin Aquatic Systems History. Smithsonian Contributions to the Earth Sciences, Number 33, Washington, DC.

Sakai, A.K., F.W. Allendorf, J.S. Holt, D.M. Lodge, J. Molofsky, K.A. With, S. Baughman, R.J. Cabin, J.E. Cohen, N.C. Ellstrand, D.E. McCauley, P. ONeil, I.M. Parker, J.N. Thompson, and S.G. Weller. 2001. The population biology of invasive species. Annual Review in Ecology and Systematics 32:305332.

Sala, O.E., F.S. Chapin III, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker, and D.H. Wall. 2000. Global biodiversity scenarios for the year 2100. Science 287:17701774.

Schmutzer, A.C., M.J. Gray, E.C. Burton, and D.L. Miller. 2008. Impacts of cattle on amphibian larvae and the aquatic environment. Freshwater Biology 53:26132625.

Schulz, T.T., and W.C. Leininger. 1990. Differences in riparian vegetation structure between grazed areas and exclosures. Journal of Range Management 43:295299.

Seager, R., M. Ting, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H.P. Huang, N. Harnik, A. Leetmaa, N.C. Lau, C. Li, J. Velez, and N. Naik. 2007. Model projections of an imminent transition to a more arid climate in southwestern North America. Science 316:11811184.

Seavy, N.E., T. Gardali, G.H. Golet, F.T. Griggs, C.A. Howell, R. Kelsey, S.L. Small, J.H. Viers, and J.F. Weigand. 2009. Why climate change makes riparian restoration more important than ever: recommendations for practice and research. Ecological Restoration 27:330338.

Semlitsch, R.D. 2002. Critical elements for biologically based recovery plans of aquatic-breeding amphibians. Conservation Biology 16:619629.

Semlitsch, R.D. 2008. Differentiating migration and dispersal processes for pond-breeding amphibians. Journal of Wildlife Management 72:260267.

Semon, H.L., R.M. Bogardus, K.A. Hatch. 2005. The extent and impact of chytrid infection on Utahs spotted frog (Rana luteiventris). Report prepared for the Utah Division of Wildlife Resources. Brigham Young University, Provo, Utah. 15 pp.

Serreze, M.C. 2010. Understanding recent climate change. Conservation Biology 24:1017.

Sharma, S., and D.A. Jackson. 2008. Predicting smallmouth bass (Micropterus dolomieu) occurrence across North America under climate change: a comparison of statistical approaches. Canadian Journal of Fisheries Management 65:471481.

Shovlain, A.M., D.H. Olson, G.M. Riegel, and W.J. Ripple. 2005. Oregon spotted frog (Rana pretiosa) habitat use and herbage (or biomass) removal of grazing at Jack Creek, Klamath County, Oregon. M.S. Thesis, Oregon State University, Corvallis, Oregon. 29 pp.

Smith, J.K. (editor). 2000. Wildland fire in ecosystems: effects of fire on fauna. General Technical Report RMRSGTR421. Ogden, Utah: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 83 pp.

Smyth, M. 2004. Final Report 2004 Spotted Frog Survey Project. Bureau of Land Management, Andrews Resource Area, Burns District, Oregon. September 25, 2004. 11 pp.

Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood, and D. Wratt. 2007. Technical Summary. Pages 1991 in S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (editors), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom. 996 pp.

Stebbins, R.C. 2003. A field guide to western reptiles and amphibians. Third Edition. Houghton Mifflin Company, Boston, Massachusetts.

Stevens, C.E., C.A. Paszkowski, and A.L. Foote. 2007. Beaver (Castor canadensis) as a surrogate species for conserving anuran amphibians on boreal streams in Alberta, Canada. Biological Conservation 134:113.

Stevens, S.D., D.R.C. Prescott, and D.P. Whiteside. 2012. Occurrence and prevalence of chytrid fungus (Batrachochytrium dendrobatidis) in amphibian species of Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 143, Edmonton, Alberta. 24 pp.

Stewart, I.T., D.R. Cayan, and D.M. Dettinger. 2005. Changes toward earlier streamflow timing across the western North America. Journal of Climate 18:11361155.

Storfer, A. 2003. Amphibian declines: future directions. Diversity and Distributions 9:151163.

Sutherland, D. 2005. Parasites of North American frogs. Pages 109123 in M. Lannoo (editor), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, California.

Tait, C. 2007. Conservation assessment of the Great Basin population of the Columbia spotted frog. USDA Forest Service, Intermountain Region, Ogden, Utah. 79 pp.

Tattersall, G.J., and G.R. Ultsch. 2008. Physiological ecology of aquatic overwintering in Ranid frogs. Biological Reviews 83:119140.

Tausch, R.J., C.L. Nowak, and S.A. Mensing. 2004. Climate change and associated vegetation dynamics during the Holocene: the paleoecological record. Pages 2448 in J.C. Chambers, and J.R. Miller (editors), Great Basin Riparian Ecosystems: Ecology, Management, and Restoration. Island Press, Washington, DC.

Thompson, H.B. 1913. Description of a new subspecies of Rana pretiosa from Nevada. Proceedings of the Biological Society of Washington 26:5356.

Tippery, S.E., and K.K. Jones. 2011. Amphibian distribution in wadeable streams and ponds in western and southeast Oregon, 20092010. Oregon Department of Fish and Wildlife, Fish Research Project, Progress Report, Corvalis, Oregon. April 2011. 21 pp.

Turner, F.B. 1959. An analysis of the feeding habits of Rana p. pretiosa in Yellowstone Park, Wyoming. The American Midland Naturalist 61:403413.

Turner, F.B. 1962. An analysis of geographic variation and distribution of Rana pretiosa. American Philosophical Society Yearbook 1962:325328.

U.S. Department of Agriculture. 2013a. Grasshopper and mormon cricket suppression program for southern Idaho. Environmental Assessment ID1301. Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Boise, Idaho. February 5, 2013. 91 pp.

U.S. Department of Agriculture. 2013b. Rangeland grasshopper and mormon cricket suppression program Elko, Eureka, and Lander Counties, Nevada. Environmental Assessment NV0413. Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Reno, Nevada. 70 pp.

U.S. Department of Agriculture. 2013c. Rangeland grasshopper and mormon cricket suppression program Esmeralda, Lincoln, Nye, and White Pine Counties, Nevada. Environmental Assessment NV0213. Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Reno, Nevada. 70 pp.

U.S. Department of Agriculture. 2013d. Rangeland grasshopper and mormon cricket suppression program eastern Oregon. Environmental Assessment OR1301. Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Portland, Oregon. February 14, 2013. 53 pp.

U.S. Environmental Protection Agency (USEPA). 2011. Draft total maximum daily load for mercury in the waters of Jordan Creek, Idaho. Region 10, Seattle, Washington. August 2011. 55 pp.

U.S. Environmental Protection Agency (USEPA). 2013. Toxics release inventory data: mercury and mercury compounds. http://www.epa.gov/tri/index.htm. Accessed on March 13, 2013.

U.S. Environmental Protection Agency (USEPA) and U.S. Army Corps of Engineers (USACE). 2007. Memorandum: Clean Water Act jurisdiction following the U.S. Supreme Courts decision in Rapanos v. United States and Carabell v. United States. June 5, 2007.

U.S. Fish and Wildlife Service (Service). 2006. Candidate Conservation Agreement with Assurances for Columbia spotted frog at Sam Noble Springs, Owyhee County, Idaho. Snake River Basin Office, Boise, Idaho. 45 pp.

U.S. Fish and Wildlife Service (Service). 2008. Final Report: Preliminary Assessment of Trace-Metal Exposures to Aquatic Biota from Historical Mine Sites in the Western Great Basin. Project ID: 11301F41. Nevada Fish and Wildlife Office, Reno, Nevada. 43 pp.

U.S. Fish and Wildlife Service (Service). 2010. Wildlife Extension Agreement, Columbia spotted frog habitat enhancement project-Upper Rock Creek, Long Tom Creek, Hurry Back Creek and Pole Creek. Idaho Fish and Wildlife Office, Boise, Idaho. 11 pp. Note: Personally identifying information (PPI) contained. Do not release before removing PPI.

U.S. Fish and Wildlife Service (Service). 2011a. Wildlife Extension Agreement, Columbia spotted frog habitat enhancement project Sheep Creek and Long Tom Creek. Idaho Fish and Wildlife Office, Boise, Idaho. 12 pp. Note: Personally identifying information (PPI) contained. Do not release before removing PPI.

U.S. Fish and Wildlife Service (Service). 2011b. Wildlife Extension Agreement, Columbia spotted frog habitat enhancement project Reynolds Creek. Idaho Fish and Wildlife Office, Boise, Idaho. 12 pp. Note: Personally identifying information (PPI) contained. Do not release before removing PPI.

U.S. Forest Service (USFS). 2004. Biological assessment for fish and wildlife on the 2004 Big Springs exploration project. Humboldt-Toiyabe National Forest, Sparks, Nevada. July 2004. 14 pp.

U.S. Geological Survey (USGS). 2005. Pathology report on larval bullfrogs from Death Valley National Monument, Nye County, Nevada. National Wildlife Health Center, Madison, Wisconsin. 3 pp.

U.S. Geological Survey (USGS). 2006. Genetic evaluation of the Great Basin distinct population segment in Columbia spotted frogs (Rana luteiventris). Fiscal Year 2006 SSP Proposal. Forest and Rangeland Ecosystem Science Center, Corvallis, Oregon. 6 pp.

Unrine, J.M., C.H. Jagoe, W.A. Hopkins, and H.A. Brant. 2004. Adverse effects of ecologically relevant dietary mercury exposure in southern leopard frogs (Rana sphenocephala) larvae. Environmental Toxicology and Chemistry 23:29642970.

Utah Nature Study Society. 1989. A petition to the U.S. Fish and Wildlife Service to place the spotted frog, Rana pretiosa, in general, and the Wasatch population in particular, on the List of Endangered and Threatened wildlife and plants. May 1, 1989. 12 pp.

Van Horne, R. 2012. Columbia spotted frog (Rana luteiventris) Northeast Nevada 2012 Forest Service

Summary Report. Humboldt-Toiyabe National Forest, Sparks, Nevada. October, 2012. 17 pp.

Vredenburg, V.T., and B.D. Wake. 2007. Global declines of amphibians. Encyclopedia of Biodiversity 2007:19.

Webb, B.W., D.M. Hannah, R.D. Moore, L.E. Brown, and F. Nobilis. 2008. Recent advances in stream and river temperature research. Hydrological Processes 22:902918.

Welch, N.E., and J.A. MacMahon. 2005. Identifying habitat variables important to the rare Columbia spotted frog in Utah (U.S.A.): an information-theoretic approach. Conservation Biology 19:473481.

Wells, K.D. 2007. The ecology and behavior of amphibians. The University of Chicago Press, Chicago, Illinois. 1,147 pp.

Wente, W.H., M.J. Adams, and C.A. Pearl. 2005. Evidence of decline for Bufo boreas and Rana luteiventris in and around the northern Great Basin, western USA. Alytes 22:95108.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313:940943.

Westerman, A.G., W. van der Schalie, S.L. Levine, B. Palmer, D. Shank, and R.G. Stahl. 2003. Linking stressors with potential effects on amphibian populations. Pages 73109 in G.L. Linder, S.K. Krest, and D.W. Sparling (editors), Amphibian decline: an integrated analysis of multiple stressor effects. Pensacola, Florida, USA: Society of Environmental Toxicology and Chemistry.

Whitaker, J.O., S.P. Cross, J.M. Skovlin, and C. Maser. 1983. Food habits of the spotted frog (Rana pretiosa) from managed sites in Grant County, Oregon. Northwest Science 57:147154.

Whittier, T.R., and D.V. Peck. 2008. Surface area estimates of streams and rivers occupied by nonnative fish and amphibians in the western USA. North American Journal of Fisheries Management 28:18871893.

Wilcox, C., B.J. Cairns, and H.P. Possingham. 2006. The role of habitat disturbance and recovery in metapopulation persistence. Ecology 87:855863.

Wilson, K.W., M.D. Mills, E.M. DuRoss. 2005. Columbia spotted frog (Rana luteiventris) chytrid monitoring summary. Utah Division of Wildlife Resources, Central Region. Springville, Utah. 5 pp.

Wondzell, S.M., and J.G. King. 2003. Postfire erosional processes in the Pacific Northwest and Rocky Mountain regions. Forest Ecology and Management 178:7587.

Young, B.E., S.N. Stuart, J.S. Chanson, N.A. Cox, and T.M. Boucher. 2004. Disappearing jewels: The status of New World amphibians. NatureServe, Arlington, Virginia. 54 pp.

Personal Communications

Jenne, Alan. 2010. Personal communication with Alan Jenne regarding incidental frog detections while conduction fish population surveys on the North Fork Humboldt River. Nevada Department of Wildlife, Eastern Region, Elko, Nevada. December 2010.

Lohr, Kristin. 2013. Personal communication with K. Lohr regarding 2012 sampling efforts for Columbia spotted frogs in southwestern Idaho. U.S. Fish and Wildlife Service, Boise, Idaho. February 2013.

Petersen, Jeff. 2013. Fisheries Biologist, Eastern Region, Nevada Department of Wildlife, Elko, Nevada.

Electronic mail received on March 6, 2013. Subject: Columbia spotted frogs and beaver.

## Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: 05/30/2013
Date

Concur: 10/28/2013
Date

Did not concur: ____________________ ____________
Date

Director's Remarks: