BEFORE THE SECRETARY OF THE INTERIOR

PETITION TO LIST
42 SPECIES OF GREAT BASIN SPRINGSNAILS
FROM NEVADA, UTAH, AND CALIFORNIA
AS THREATENED OR ENDANGERED
UNDER THE ENDANGERED SPECIES ACT

Pyrgulopsis deaconi © Robert Hershler
Scanning electron micrograph of shell. Paratype USNM 860676. Scale bar = 1.0 mm.

CENTER *for* BIOLOGICAL DIVERSITY *Because life is good.*

February 17, 2009

Mr. Ken Salazar
Department of the Interior
18th and "C" Street, N.W.
Washington, D.C. 20240

Dear Mr. Salazar:

The Center for Biological Diversity, Tierra Curry, Noah Greenwald, Dr. James Deacon, Don Duff, and The Freshwater Mollusk Conservation Society hereby formally petition the U.S. Fish and Wildlife Service (FWS) to list 42 springsnail species from the Great Basin and Mojave ecosystems in Nevada, Utah, and California as Threatened or Endangered under the Endangered Species Act, and to designate critical habitat for them concurrent with listing.

Petitioners file this petition under the Endangered Species Act, 16 U.S.C. sections 1531-1543 (1982). This petition is filed under 5 U.S.C. section 553(e), and 50 C.F.R. part 424.14 (1990), which grants interested parties the right to petition for issuance of a rule from the Assistant Secretary of the Interior. The petitioners request that Critical Habitat be designated as required by 16 U.S.C. 1533(b)(6)(C) and 50 CFR 424.12, and pursuant to the Administrative Procedures Act (5 U.S.C. 553). Petitioners realize this petition sets in motion a specific process placing definite response requirements on the FWS and very specific time constraints upon those responses.

The U.S. Fish and Wildlife Service (FWS) has long recognized the benefit of providing protection for multiple species for improving efficiency of listing and recovery and ultimately protection of ecosystems. In 1976, for instance, the FWS issued several proposed rules to list multiple species based on common threats, ecosystems, habitats, taxonomy, or other factors (e.g., USDI FWS 1976). In 1992, the FWS itself stated in a legal Settlement Agreement (1992) that:

> "Defendants [FWS] recognize that a multi-species, ecosystem approach to their listing responsibilities under the ESA will assist them in better analyzing the common nature and magnitude of threats facing ecosystems, help them in understanding the relationships among imperiled species in ecosystems, and be more cost-effective than a species-by-species approach to listing responsibilities" (p. 7).

In 1994, the FWS (1994) specifically stated its policy to undertake "Group listing decisions on a geographic, taxonomic, or ecosystem basis where possible" (p. 34724). In furtherance of this policy, the FWS (1994) developed listing guidance that specifically encourages "Multi-species listings…when several species have common threats, habitat, distribution, landowners, or features that would group the species and provide more efficient listing and subsequent recovery" (p. iv). Accordingly, we hereby petition for 42 aquatic snail species from Great Basin and Mojave ecosystems which are threatened primarily by habitat loss and degradation due to groundwater development.

Petitioners:

The Center for Biological Diversity is a nonprofit conservation organization with more than 200,000 members and online activists dedicated to the protection of endangered species and wild places. www.biologicaldiversity.org

The Freshwater Mollusk Conservation Society is a non-profit organization devoted to the advocacy for, public education about, and conservation science of freshwater mollusks, North America's most imperiled fauna.

Dr. James E. Deacon is a retired professor from the University of Nevada Las Vegas where his research focused on ecology and conservation biology of desert fishes and on issues of sustainable use of water in the Southwest. His research and conservation efforts have been funded by The National Science Foundation, Environmental Protection Agency, National Park Service, Fish and Wildlife Service, and a variety of other agencies. His more than 85 scientific papers, articles, and contributions to books and other compendia, have brought him awards and recognition from The American Fisheries Society, National Wildlife Federation, Nevada Department of Museums and History, Nature Conservancy, and others.

Don Duff is a retired aquatic ecologist from the USDA Forest Service with some career time spent with the USDI BLM and Fish & Wildlife Service, with 43 years of government service in aquatic ecology and freshwater fishes and their riparian-aquatic ecosystems. He has worked on these desert waters and ecosystems for over 30 years and is familiar with the aquatic systems that provide occupied habitats for species in this petition. He is a Certified Fisheries Scientist with the American Fisheries Society (AFS) and his career work has brought him awards from the AFS, Trout Unlimited, Environmental Protection Agency, and others.

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I. EXECUTIVE SUMMARY

The 42 species of springsnails included in this petition are endemic to the Great Basin and Mojave ecosystems of Nevada, Utah, and California. These species are primarily distributed as isolated populations and need the protection of the Endangered Species Act to ensure their continued survival. The probability of extinction is high for all of these springsnail species because of their limited distribution and the severity of threats they face.

These springsnails are threatened with extinction for several reasons. The overarching threat to the majority of the petitioned species is groundwater development which could cause the springs on which they depend to become dry. The snails are also threatened by spring development and diversion, grazing, and recreational activities. In addition, they are threatened by global climate change which will likely alter spring recharge and discharge, and by the spread of invasive species. These springsnails are intrinsically vulnerable to extinction due to their extremely limited mobility and restricted distribution as endemic species. Fourteen of the species occur at only a single location, and 39 occur at ten or fewer locations.

Collectively petitioning these 42 species of springsnails allows the U.S. Fish and Wildlife Service to consider their listing simultaneously which improves efficiency and conserves agency resources.

The Endangered Species Act states that a species shall be determined to be endangered or threatened based on any one of five factors (16 U.S.C. § 1533 (a)(1)). Each of the 42 species meets one or more of these factors and thus warrants listing as a threatened or endangered species:

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

Most of the species of springsnails presented in this petition are threatened with habitat destruction and modification due to existing and proposed groundwater withdrawal projects. Proposed groundwater withdrawal could desiccate the springs on which these species depend for their continued existence. The snails' habitat is also threatened by spring development and diversion and excessive anthropogenic use of spring water, recreational activities, and grazing by cattle, horses, and burros.

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

The petitioned springsnails are collected for scientific and educational purposes and in conjunction with other factors this could pose a threat to their survival, particularly for those species that occur in only one to a few locations. We recognize that scientific study and collection are essential to understanding species biology and that collection is a miniscule threat compared to habitat loss and other threats.

C. Disease or predation:

Springsnails are an essential component of the food web, typically occurring at high densities, and are consumed by other invertebrates, fish, amphibians, reptiles, birds, and small mammals. In conjunction with other threats, natural predation could increasingly threaten the species. The risks of both predation and disease are magnified by the spread of invasive, non-native species.

D. Other natural or human caused factors:

The springsnails included in this petition are threatened by other natural and human-caused factors including reduced spring discharge due to global climate change, the spread of invasive species, and inherent vulnerability to extinction due to their limited distribution. Altered precipitation patterns and reduced spring discharge and recharge due to global climate change could lead to decreases in water availability for the petitioned species, especially in conjunction with groundwater withdrawal and spring development. The ecosystems associated with many of the petitioned springsnails have been altered by the introduction of predatory and competing non-native invasive species. All of these springsnails may be intrinsically vulnerable to extinction due to their extremely limited distribution and poor dispersal ability. Because reproduction is thought to be annual and individuals live for only a year, in the few species that have been studied in this regard, conditions which prohibit recruitment could eradicate a population.

E. Inadequacy of existing regulatory mechanisms:

Existing regulatory mechanisms do not provide the petitioned springsnails with any tangible protection. Because many of these snails occur at only one to a few sites, the degradation of their habitat will likely result in the extinction of the species.

Endangered Species Act protection for the petitioned springsnails will benefit the mollusks, their ecosystems, and the citizens of the United States. Healthy molluscan populations are an essential component of and indicator of a healthy environment and maintaining them ultimately benefits the human community.

II. INTRODUCTION

Springsnails are an umbrella species for the conservation of other wildlife, meaning that by protecting the ecosystem conditions on which springsnails depend, habitat would be simultaneously protected for other species. Protecting the petitioned species will protect the springflow which sustains not only the snails but also myriad other wildlife species which would be negatively affected by spring desiccation due to groundwater pumping and spring diversion.

Freshwater invertebrates perform many ecological functions and services of importance to humans (Strayer 2006). Wallace and Webster (1996) state, “The many roles performed by stream-dwelling macroinvertebrates underscore the importance of their conservation.”

Invertebrates influence water chemistry, nutrient cycling, rates of productivity and decomposition, and are vital links in the food web. Strayer (2006) explains:

> "Invertebrates play important roles in the functioning of freshwater ecosystems and directly affect human welfare. Invertebrates regulate rates of primary production, decomposition, water clarity, thermal stratification, and nutrient cycling in lakes, streams, and rivers (e.g., Mazumder et al. 1990, Feminella and Hawkins 1995, Wallace and Webster 1996, Graca 2001, Vaughn and Hakenkamp 2001, Vanni 2002). Invertebrates are the primary food of many freshwater fish (Gerking 1994), as well as many other vertebrates that live in or around the water (e.g., Gray 1993, Krusic et al. 1996), and so are key links in food webs."

Springsnails are primary consumers, converting algae, microorganisms, epiphytes, and decaying matter into an accessible food source for other invertebrates, fish, amphibians, turtles, birds, and small mammals (Churchfield 1984, Hershler 1984, Bronmark 1989, Frest and Johannes 1995, Myler 2000, Hurt 2004, Johnson et al. 2007). Concerning the importance of mollusks in energy transfer, Lysne et al. (2008) state:

> "These generally small, inconspicuous members of our freshwater faunas have a disproportionately large role in the transfer of energy through aquatic systems (Newbold et al. 1983, Richardson et al. 1988, Brown 2001), primarily because of their numerical abundance in some systems."

In many springs, freshwater snails occur at high densities and constitute the majority of the invertebrate biomass (Sada 2008). They influence ecosystem processes by acting as hosts for parasites (Blair et al. 2001). In addition, freshwater snails have a "great impact" on the biomass, productivity and species composition of epiphytic communities, which in turn influences the health of macrophytic plant communities (Bronmark 1989). Springsnails affect algal productivity and amounts of particulate organic matter (Wallace and Webster 1996). Frest and Johannes (1995) call the effects of mollusks upon periphyton, macrophyte, and aufwuchs communities "profound and complex." Hurt (2004) states, "Despite their often small size and inconspicuous nature, molluscs play a key role in maintaining ecosystem health."

Springsnails are useful as indicators of water quality. Freshwater mollusks are sensitive to environmental change (Hurt 2004) and are sensitive to pollution (Burch 1989). Frest and Johannes (1995) refer to freshwater snails, including *Pyrgulopsis*, as "readily useful indicator species." They expound:

> "[M]ollusks are an especially practical group for use in assessing the general health of the terrestrial and aquatic ecosystem . . . Many species are stenotopic (tolerant only to a narrow range of environmental conditions) and unusually sensitive to various kinds of disturbance or pollution. Most species respond quickly and obviously to disturbance. As almost all are relatively sessile and complete their life cycles in place, they are particularly convenient for site-specific assessments."

Springsnails have narrow environmental preferences, and their presence indicates stable ecological conditions over time, which gives them high biogeographical significance (Frest and Johannes 1995). Hurt (2004) states:

> "[S]pringsnails are excellent candidates to serve as bioindicators for managing habitats rich in invertebrate diversity. Endemic springsnail populations in the southwest are relictual; fossil evidence for species of *Pyrgulopsis* dates back to the Pliocene and early Pleistocene (Taylor 1985, 1988). It follows that their distribution reflects habitats that were historically widespread, but are now limited and are likely to contain other endemic species."

Springsnails exhibit habitat specificity and low dispersal ability, and endemism is prevalent. In the genus *Pyrgulopsis*, many species occur at only a single site (Landye 1981, Ponder and Colgan 2002, Hurt 2004). This trend is demonstrated in the Great Basin, one of the driest physiographic provinces in North America, where surface waters are scattered over desert landscapes and many springsnail species have evolved in isolation over time (Hershler 1998, Sada and Vinyard 2002). Great Basin spring systems tend to be hotspots of biodiversity, "critical to the persistence of many plant and animal species found in the region" (Golden et al. 2007). Sada and Vinyard (2002) found that 118 species and 45 subspecies of aquatic organisms were endemic to the Great Basin.

Because many springsnail species in the western United States are found at only one to a few isolated springs, they are at considerable risk of extinction (Brown et al. 2008). Endemic populations are particularly vulnerable to disturbance, and many organisms unique to the Great Basin have experienced declines in distribution and abundance, including 16 taxa which have already gone extinct (Sada and Vinyard 2002). The imperilment of freshwater fauna is not unique to the desert, and many freshwater mollusks are at risk of extinction throughout North America (Brown et al. 2008). Over 40% of freshwater snail species are estimated to be negatively affected by anthropogenic factors (Neves et al. 1997), which has lead to numerous gastropod extinctions in North America (Master et al. 2000). Greater than 60% of all described North American freshwater snail species have NatureServe global rankings of G1 (critically imperiled), G2 (imperiled), or GH–GX (presumed or possibly extinct) (Lysne et al. 2008). Approximately 74% of U.S. hydrobiid (*sensu lato)* species are considered at risk of extinction with a NatureServe ranking of G1 (critically imperiled) or G2 (imperiled) (Brown et al. 2008).

Several species of North American freshwater snails are already extinct. Hurt (2004) states, "Three described species of *Pyrgulopsis* have gone extinct since their description in the early 1900s and it is likely that other species have been lost before they have been discovered." Three species of Nevada *Pyrgulopsis* are presumed to be extinct-- the Carinate Duckwater Pyrg *(Pyrgulopsis carinata*) from Nye County, the Fish Lake Pyrg *(Pyrgulopsis ruinosa)* from Esmeralda County, and the Corded Pyrg from Washoe County (Hershler and Thompson 1987, Hershler 1998). Three freshwater snails from Utah are also presumed to be extinct-- the Fish Lake Physa (*Physella microstriata*), the Fish Springs Marshsnail (*Stagnicola pilsbryi),* and the Thickshell Pondsnail (*Stagnicola utahensis*) (NatureServe 2008).

Hershler (1998) and Sada (2008; field notes) recorded the extirpation of 13 springsnail populations in the western United States in the past decade. Two populations of petitioned species have possibly been extirpated. One known population of the Spring Mountain Pyrg (*Pyrgulopsis deaconi*) has been extirpated, likely due to groundwater withdrawal (Hershler 1998). A population of the Bifid Duct Pyrg (*Pyrgulopsis peculiaris)* may also have been extirpated-- Golden et al. (2007) were unable to find this species at the known location at Turnley / Woodsman Spring. Likewise, Golden et al. (2007) were unable to locate previously known populations of Toquerville Springsnails (not included in this petition) at the unnamed springs near Cleve Creek in Spring Valley and at Knoll Spring in Snake Valley.

Habitat loss and degradation, groundwater withdrawal, water diversions, pollution, and invasive species are all known to have contributed to the imperilment of freshwater snails. Lysne et al. (2008) state:

> "Unfortunately, their (freshwater snails) dispersal abilities, life histories, and habitat requirements do not appear to be well suited for coping with the rapid landscape changes and losses of habitat observed over the past two centuries in North America. The primary causes of imperilment for listed snail species are loss or alteration of habitat. . . . In the Intermountain West, the loss of spring habitats because of water withdrawal from regional aquifers and diversions of surface springs for irrigation also is of serious concern (Sada and Vinyard 2002, Myler et al. 2007). Other threats, such as water pollution and invasive species, combine with habitat loss or alteration to result in one of the best documented declines of a group of organisms worldwide (Lydeard et al. 2004)."

In addition to habitat alteration and surface diversion of springs, the continued survival of most of the petitioned springsnails is threatened by groundwater development. Freshwater ecosystems are increasingly stressed globally and in the United States, imperiling freshwater fauna. Lysne et al. (2008) state:

> "Of particular importance in the conservation of freshwater snails in North America is the state of our increasingly scarce water resources. . . increased use of groundwater can lead to decreased flows in rivers and streams. If even conservative global population-growth and water-use projections are realized, the stresses on freshwater systems and the species that live in them are expected to increase significantly (Postel 2000)."

Likewise, Strayer (2006) iterates:

> "Groundwaters and springs typically support highly endemic invertebrate faunas that probably disperse slowly and are sensitive to human impacts. Humans in arid regions around the world are pumping water out of aquifers for agriculture and domestic use faster than it can be replenished. . . We do not know if the groundwater biota can keep up with such rapid declines. Groundwater withdrawals already have dried up many springs. Further withdrawals will dry up many more springs, aquifers, and small streams, resulting in species extinctions (e.g., Ponder 1986)."

Endangered Species Act protection is desperately needed to ensure the survival of the 42 species of desert springsnails presented in this petition. Without legal protection these springsnails are very likely to become extinct due to spring diversion and/or spring failure caused by groundwater development. Because of their ecological importance, their role in energy transfer and the food web, their usefulness as biological indicators, and their inherent right to exist, these species deserve to be protected. Protecting the petitioned species under the Endangered Species Act will safeguard the species themselves, will shelter the aquatic biota with which they co-exist, and will help preserve the ecological integrity of the Mojave and Great Basin ecosystems.

III. NATURAL HISTORY AND ECOLOGY

Hydrobiid springsnails represent the most diversified family of gastropods in western North America, but knowledge on their population and community ecology is lacking (Brown et al. 2008). Many species occupy the smallest aquatic habitats in the most arid regions of the western United States and are at risk of extinction (Ibid). Most species are limited to specific areas in persistent aquatic habitats that are minimally affected by drought (Taylor 1985, Hershler 1998). Springsnails are commonly the most abundant benthic macroinvertebrate in springs where they occur, and springs generally host only one springsnail species (Sada 2008, Brown et al. 2008).

A. Taxonomy

The petitioned species are in the phylum Mollusca, class Gastropoda, superorder Caenogastropoda (Bouchet and Rocroi 2005). *Pyrgulopsis* is in the family Hydrobiidae, and *Tryonia* is in the family Cochliopidae (Wilke et al. 2001).

Hydrobiidae is the largest family of North American freshwater gastropods. Springsnails, especially the genera *Pyrgulopsis* and *Tryonia*, have undergone extensive diversification in the western United States and northern Mexico in the Great Basin and Rio Grande regions (Hershler 1984, Taylor 1985, 1987, Hershler and Thompson 1992, Liu and Hershler 2005, Brown et al. 2008).

Thirty-seven of the petitioned species are in the genus *Pyrgulopsis* (Table 1). *Pyrgulopsis* is the largest genus of freshwater gastropods in North America, containing 127 described species (Hershler 1994, 1995, 1998, Hershler and Sada 2002, Liu and Hershler 2005, Hershler et al. 2008). *Pyrgulopsis* springsnails are found from the Pacific Coast lowlands, through the Rocky Mountains to just east of the continental divide, and in southwestern Canada (Hershler and Liu 2004, Liu and Hershler 2005). The Great Basin harbors the greatest diversity of *Pyrgulopsis*, with more than 80 species occurring in its scattered aquatic habitats (Hershler and Sada 2002, Brown et al. 2008).

Five of the petitioned species are in the genus *Tryonia* (Table 1). *Tryonia* contains 18 described species that are distributed in major drainages of the Great Basin and the southwest and in the Gulf Coast and Atlantic-slope drainages of Florida (Hershler and Thompson 1987, Taylor 1987, Hershler 1999, 2001, Hershler et al. 1999).

B. Distribution

All of the petitioned springsnails are endemic to springs in the Great Basin and Mojave ecosystems of Nevada, Utah, and California (Figure 1; Table 2). Springsnails are inextricably linked with their aquatic habitat and are often endemic to single water bodies (particularly springs) or local drainage systems (Hershler 1998). Of the 58 new species described by Hershler (1998), 22 appear to be restricted to single localities. Fourteen of the petitioned species occur at only a single site, and eleven are known from only two sites. Additional surveys would further the current knowledge of species distribution which may not be comprehensive.

Species included in this petition were identified by Deacon et al. (2007) as being threatened by groundwater development by the Southern Nevada Water Authority. The species are thus primarily distributed in Nevada, but the distribution of one species extends into California, and several species which occur in Utah are threatened by groundwater withdrawal in Nevada due to the hydrological connectivity of the regional carbonate aquifer.

Forty of the petitioned species occur in Nevada, and 37 of the species occur in Nevada only, in Clark, Lincoln, Nye, and White Pine Counties. In Clark County, the Blue Point Pyrg (*P. coloradensis)* occurs in the Lake Mead watershed. The Moapa Pebblesnail (*P. avernalis)*, Moapa Valley Pyrg (*P. carinifera*), and Grated Tryonia (*T. clathrata*) occur in the Moapa Valley in the Muddy River watershed. The Spring Mountains Pyrg (*P. deaconi*), Corn Creek Pyrg (*P. fausta),* and Southeast Nevada Pyrg (*P. turbatrix*) occur in Las Vegas Valley. The Southeast Nevada Pyrg also occurs in Indian Springs Valley. The Spring Mountains Pyrg also occurs in the Pahrump Valley in Clark County.

In Nye County, ten of the springsnails occur in the Upper Amargosa watershed: the Amargosa Tryonia (*Tryonia variegata),* the Minute Tryonia (*T. ericae),* the Point of Rocks Tryonia (*T. elata*), the Sportinggoods Tryonia (*T. angulata*), the Ash Meadows Pebblesnail (*Pyrgulopsis erythropoma),* the Crystal Springsnail (*P. crystalis),* the Distal Gland Springsnail (*P. nanus)*, the Elongate Gland Springsnail (*P. isolatus)*, the Fairbanks Springsnail (*P. fairbanksensis),* and the Median Gland Nevada Pyrg (*P. pisteri).* Seven of the species occur in Nye County in the White River watershed: the Butterfield Pyrg (*Pyrgulopsis lata*), the Emigrant Pyrg (*P. gracilis*), the Hardy Pyrg (*P. marcida*), the Hubbs Pyrg (*P. hubbsi*), the Pahranagat Pebblesnail (*P. merriami*), the White River Valley Pyrg (*P. sathos*), and the Grated Tryonia (*T. clathrata*). The Hubbs Pyrg also occurs in the Pahranagat Valley in Nye County. Five of the species occur in Duckwater Valley (Railroad Valley watershed) in Nye County: the Big Warm Spring Pyrg (*Pyrgulopsis papillata),* Duckwater Pyrg *(P. aloba)*, Duckwater Warm Springs Pyrg (*P. villacampae)*, Lockes Pyrg (*Pyrgulopsis lockensis*), and the Southern Duckwater Pyrg (*P. anatina).* The Sterile Basin Pyrg (*P. sterilis)* occurs in Nye County in the Ralston-Stone Cabin Valley watershed. The Spring Mountains Pyrg (*P. deaconi*) occurs in Nye County in the Pahrump Valley.

Table 1. Petitioned Springsnail Species. Page number refers to Individual Species Account.

Common Name	Latin Name	Page #
Duckwater Pyrg	*Pyrgulopsis aloba*	73
Southern Duckwater Pyrg	*Pyrgulopsis anatina*	73
Longitudinal Gland Pyrg	*Pyrgulopsis anguina*	101
Moapa Pebblesnail	*Pyrgulopsis avernalis*	90
Flag Pyrg	*Pyrgulopsis breviloba*	71
Moapa Valley Pyrg	*Pyrgulopsis carinifera*	90
Blue Point Pyrg	*Pyrgulopsis coloradensis*	82
Crystal Springsnail	*Pyrgulopsis crystalis*	60
Spring Mountains Pyrg	*Pyrgulopsis deaconi*	85
Ash Meadows Pebblesnail	*Pyrgulopsis erythropoma*	61
Fairbanks Springsnail	*Pyrgulopsis fairbanksensis*	61
Corn Creek Pyrg	*Pyrgulopsis fausta*	86
Emigrant Pyrg	*Pyrgulopsis gracilis*	111
Hamlin Valley Pyrg	*Pyrgulopsis hamlinensis*	76
Hubbs Pyrg	*Pyrgulopsis hubbsi*	96
Elongate Gland Springsnail	*Pyrgulopsis isolatus*	62
Landyes Pyrg	*Pyrgulopsis landyei*	106
Butterfield Pyrg	*Pyrgulopsis lata*	112
Lockes Pyrg	*Pyrgulopsis lockensis*	74
Hardy Pyrg	*Pyrgulopsis marcida*	69
Pahranagat Pebblesnail	*Pyrgulopsis merriami*	97
Camp Valley Pyrg	*Pyrgulopsis montana*	88
Distal Gland Springsnail	*Pyrgulopsis nanus*	62
Neritiform Steptoe Ranch Pyrg	*Pyrgulopsis neritella*	107
Sub-globose Steptoe Ranch Pyrg	*Pyrgulopsis orbiculata*	107
Big Warm Spring Pyrg	*Pyrgulopsis papillata*	74
Bifid Duct Pyrg	*Pyrgulopsis peculiaris*	101
Median Gland Nevada Pyrg	*Pyrgulopsis pisteri*	63
Flat-topped Steptoe Pyrg	*Pyrgulopsis planulata*	107
White River Valley Pyrg	*Pyrgulopsis sathos*	112
Sub-globose Snake Pyrg	*Pyrgulopsis saxatilis*	102
Northern Steptoe Pyrg	*Pyrgulopsis serrata*	108
Sterile Basin Pyrg	*Pyrgulopsis sterilis*	99
Lake Valley Pyrg	*Pyrgulopsis sublata*	84
Southern Steptoe Pyrg	*Pyrgulopsis sulcata*	108
Southeast Nevada Pyrg	*Pyrgulopsis turbatrix*	78
Duckwater Warm Springs Pyrg	*Pyrgulopsis villacampae*	75
Sportinggoods Tryonia	*Tryonia angulata*	63
Grated Tryonia	*Tryonia clathrata*	91
Point of Rocks Tryonia	*Tryonia elata*	64
Minute Tryonia	*Tryonia ericae*	64
Amargosa Tryonia	*Tryonia variegata*	65

In Lincoln County, the Camp Valley Pyrg (*P. montana*) occurs in Upper Camp Valley. The Flag Pyrg (*P. breviloba)* occurs in Dry Lake Valley. The Hardy Pyrg (*P. marcida*) occurs in Cave Valley. The Pahranagat Pebblesnail (*P. merriami*) and Grated Tryonia (*T. clathrata*) occur in the Pahranagat Valley in Lincoln County. The White River Valley Pyrg (*P. sathos*) occurs in the White River watershed in Lincoln County. The Lake Valley Pyrg (*P. sublata*) occurs in the Lake Valley in Lincoln County.

In White Pine County, the Bifid Duct Pyrg (*P. peculiaris*) and Longitudinal Gland Pyrg (*P. anguina*) occur in Snake Valley. The Flat-topped Steptoe Pyrg (*P. planulata*), Landyes Pyrg (*P. landyei*), Neritiform Steptoe Ranch Pyrg *(P. neritella)*, Northern Steptoe Pyrg (*P. serrata*), Southern Steptoe Pyrg (*P. sulcata*), and Sub-globose Steptoe Ranch Pyrg (*P. orbiculata*) occur in Steptoe Valley. Pyrgulopsis serrata also occurs in the Steptoe Valley in Elko County. The Hardy Pyrg (*P. marcida*) and White River Valley Pyrg (*P. sathos*) occur in the White River Valley in White Pine County.

Four species are found in Utah-- the Bifid Duct Pyrg (*Pyrgulopsis peculiaris),* Hamlin Valley Pyrg (*P. hamlinensis)*, Longitudinal Gland Pyrg (*P. anguina),* and Sub-Globose Snake Pyrg (*P. saxatilis)*. The Hamlin Valley Pyrg occurs in the Hamlin Valley watershed in Beaver County, Utah, and the other three species occur in the Snake Valley watershed in Millard County. Only one petitioned species is found in California-- the Amargosa Tryonia (*Tryonia variegata)* occurs in the Upper Amargosa watershed in Inyo County.

As endemic species, the petitioned springsnails are naturally limited in distribution and most have very poor dispersal abilities. Because these snails are unable to disperse to new territory, habitat loss will result in population extirpation or species extinction.

Table 2. Species by Watershed. Note: several species occur in more than one watershed.

WATERSHED	COMMON NAME	LATIN NAME
Amargosa Desert	Crystal Springsnail	*Pyrgulopsis crystalis*
	Ash Meadows Pebblesnail	*Pyrgulopsis erythropoma*
	Fairbanks Springsnail	*Pyrgulopsis fairbanksensis*
	Elongate Gland Springsnail	*Pyrgulopsis isolatus*
	Distal Gland Springsnail	*Pyrgulopsis nanus*
	Median Gland Nevada Pyrg	*Pyrgulopsis pisteri*
	Sportinggoods Tryonia	*Tryonia angulata*
	Point of Rocks Tryonia	*Tryonia elata*
	Minute Tryonia	*Tryonia ericae*
	Amargosa Tryonia	*Tryonia variegata*
Cave Valley	Hardy Pyrg	*Pyrgulopsis marcida*
Dry Lake Valley	Flag Pyrg	*Pyrgulopsis breviloba*
Duckwater (Railroad) Valley	Duckwater Pyrg	*Pyrgulopsis aloba*
	Southern Duckwater Pyrg	*Pyrgulopsis anatina*
	Lockes Pyrg	*Pyrgulopsis lockensis*
	Big Warm Spring Pyrg	*Pyrgulopsis papillata*
	Duckwater Warm Springs Pyrg	*Pyrgulopsis villacampae*

Hamlin Valley	Hamlin Valley Pyrg	*Pyrgulopsis hamlinensis*
Indian Springs Valley	Southeast Nevada Pyrg	*Pyrgulopsis turbatrix*
Lake Mead	Blue Point Pyrg	*Pyrgulopsis coloradensis*
Lake Valley	Lake Valley Pyrg	*Pyrgulopsis sublata*
Las Vegas Valley	Spring Mountains Pyrg	*Pyrgulopsis deaconi*
	Corn Creek Pyrg	*Pyrgulopsis fausta*
	Southeast Nevada Pyrg	*Pyrgulopsis turbatrix*
Meadow Valley Wash (Camp Valley)	Camp Valley Pyrg	*Pyrgulopsis montana*
Muddy River	Moapa Pebblesnail	*Pyrgulopsis avernalis*
	Moapa Valley Pyrg	*Pyrgulopsis carinifera*
	Grated Tryonia	*Tryonia clathrata*
Pahranagat Valley	Hubbs Pyrg	*Pyrgulopsis hubbsi*
	Pahranagat Pebblesnail	*Pyrgulopsis merriami*
	Grated Tryonia	*Tryonia clathrata*
Ralston and Stone Cabin Valleys	Sterile Basin Pyrg	*Pyrgulopsis sterilis*
Snake Valley	Longitudinal Gland Pyrg	*Pyrgulopsis anguina*
	Bifid Duct Pyrg	*Pyrgulopsis peculiaris*
	Sub-globose Snake Pyrg	*Pyrgulopsis saxatilis*
Spring Valley	Bifid Duct Pyrg	*Pyrgulopsis peculiaris*
Steptoe Valley	Landyes Pyrg	*Pyrgulopsis landyei*
	Neritiform Steptoe Ranch Pyrg	*Pyrgulopsis neritella*
	Sub-globose Steptoe Ranch Pyrg	*Pyrgulopsis orbiculata*
	Flat-topped Steptoe Pyrg	*Pyrgulopsis planulata*
	Northern Steptoe Pyrg	*Pyrgulopsis serrata*
	Southern Steptoe Pyrg	*Pyrgulopsis sulcata*
Stone Cabin Valley	Sterile Basin Pyrg	*Pyrgulopsis sterilis*
White River Valley	Flag Pyrg	*Pyrgulopsis breviloba*
	Emigrant Pyrg	*Pyrgulopsis gracilis*
	Butterfield Pyrg	*Pyrgulopsis lata*
	Hardy Pyrg	*Pyrgulopsis marcida*
	Pahranagat Pebblesnail	*Pyrgulopsis merriami*
	White River Valley Pyrg	*Pyrgulopsis sathos*
	Grated Tryonia	*Tryonia clathrata*

C. Description

All freshwater snails have a shell which protects the soft body. Shells usually consist of several inner layers of calcium carbonate and an outer layer, the periostracum, which is usually pigmented and is composed mostly of organic material (Frest and Johannes 1999). Each complete turn of the shell is called a whorl, and all whorls collectively except the last one are called the spire. The first one to two whorls, called the protoconch, are generally formed prior to hatching. The shell opening is referred to as the aperture and some taxa have a corneous cover which seals the aperture called the operculum. In Hydrobiids, the body is made up of two regions, the head-foot and visceral coil (covered by the mantle). The head-foot includes the snout, cephalic tentacles, eye spots, neck, and foot (Frest and Johannes 1999).

Springsnail species are generally distinguished by shell and penial characters (Hershler 2001). Whereas female genitalia are internal, male genitalia include an external penis (behind the snout) which often includes accessory lobes and glands that are useful in species differentiation (Frest and Johannes 1999). Female genitalia have been shown to be informative in differentiating hydrobiid snails, but have not been as thoroughly studied (Ponder 1988, Hershler et al. 1999).

All of the petitioned species are in the family Hydrobiidae, a large worldwide group of over 1000 species. Hydrobiids are generally small (less than 1-2 cm in height) with a solid shell, thin periostracum, and horny operculum (Frest and Johannes 1999).

Thirty-seven of the petitioned species are in the genus *Pyrgulopsis*, a large genus with over 100 known species in western North America. *Pyrgulopsis* is distinguished from other taxa by the combination of its small size, relatively thin and ovate to ovate-conic shell, and penis with relatively few glands (Hershler 1998). The taxonomy of *Pyrgulopsis* is based largely on the anatomical features. Five of the petitioned species are in the genus *Tryonia*. Members of this genus are differentiated by shell and penial characters and by the morphology of the female sperm duct (Hershler et al. 1999, Hershler 1999, 2001). Species of *Tryonia* are minute to large with elongate-conic to turriform (tower-shaped) shells that are smooth or variously sculptured and ornamented penises with glandular papillae (Hershler 1999, 2001).

For descriptions of each species, please refer to the Individual Species Account section beginning on page 60.

D. General Habitat Requirements

The most important habitat requirement for springsnails is clean, continuous spring flow. Hydrobiids are gill-breathing and are “restricted to waters of unquestioned permanence and stability” (USDI et al. 1998, p. 2). It cannot be overemphasized that *Pyrgulopsis* and *Tryonia* do not well tolerate desiccation and that reduced flow and altered spring conditions could be lethal to these species.

Hydrobiids occur in a variety of perpetual spring-fed water bodies in desert ecosystems, from small seeps to large springs, including brackish and/or thermal habitats (Hershler 1998). Most of the springs inhabited by springsnails in the Great Basin are small and fishless (Ibid.). *Pyrgulopsis* is most commonly found in rheocrenes, springs that emerge from the ground as flowing streams and discharge into a defined channel. Members of the genus also occur in limnocrenes, where the headspring forms a natural pool before entering a defined channel, and in helocrenes, comparatively shallow marsh-like springs without an open pool (Hershler 1998). Pyrgs are often found inhabiting the moist zone around spring margins (Ibid.). While some species are montane, springsnails generally occur on valley floors or along the base of mountain blocks at springs less than 2,400 m (~8000 ft) elevation (Hershler 1998, Sada 2008).

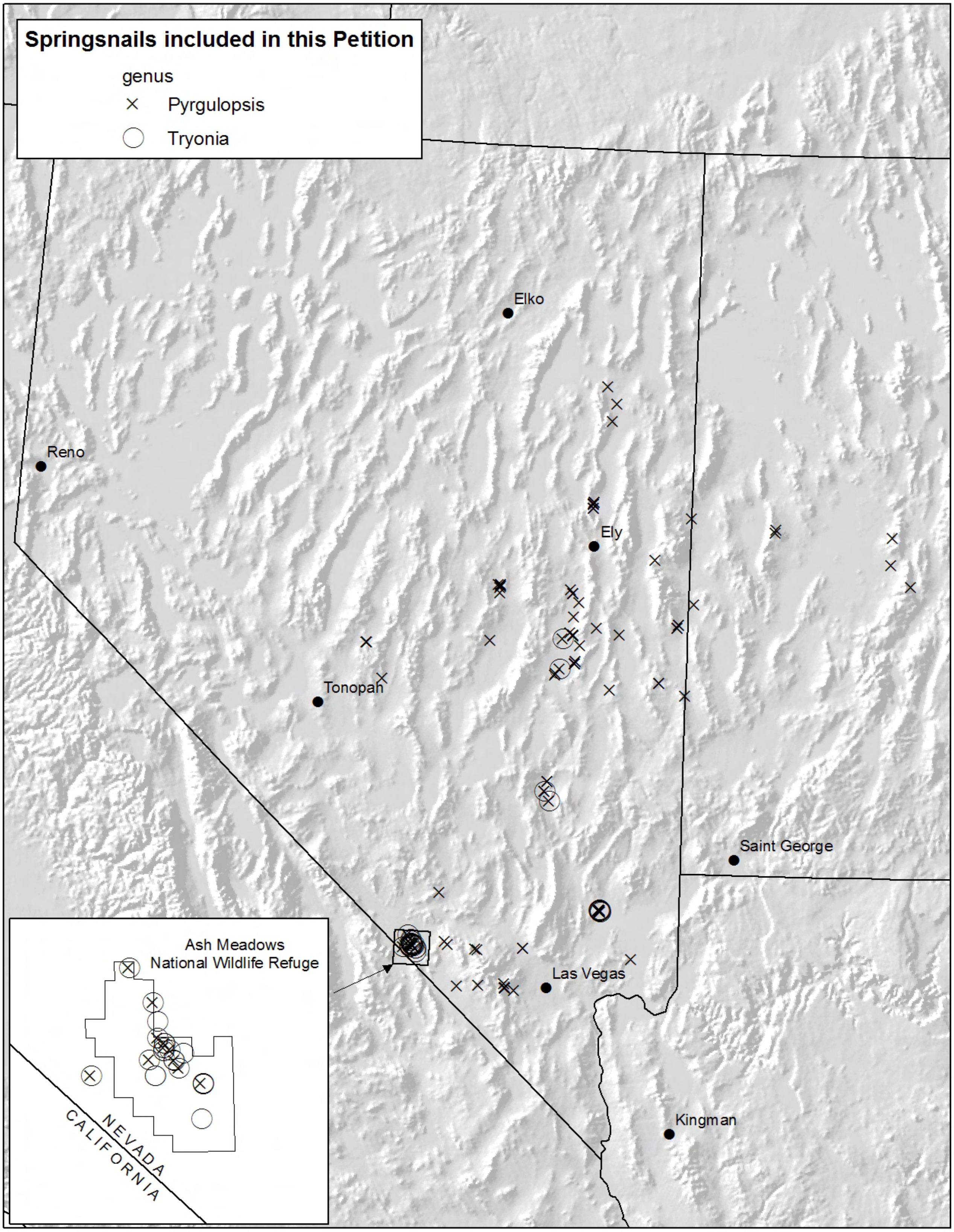

Figure 1. Distribution of petitioned springsnail species.

Springsnails frequently occur among aquatic vegetation including *Rorippa* (water cress), which can form dense mats lining spring outflows. Snails can also be found on a variety of aquatic plants including Bladderwort (*Utricularia*), Spike rush (*Eleocharis*), and Tule (*Scirpus*). Pyrgs also occur on hard substrates such as bedrock or pieces of travertine (calcium carbonate rock), and less often on or in soft sediment (Hershler 1998). *Tryonia* species occur on hard substrates or soft sediment (Hershler and Sada 1987).

Of the few species that have studied in this regard, springsnails are primary plant consumers which graze on aufwuchs (diatoms, bacteria, and epiphytic algal taxa attached to stones and plants) (Mladenka 1992, Frest and Johannes 1995). Some species also graze on periphyton or detritus or feed on larger macrophytes (Frest and Johannes 1995).

Factors that influence the abundance and habitat use of hydrobiids include substrate size, stream shading, water velocity, temperature, dissolved oxygen, flood frequency, acidity, salinity, hardness, and food availability (Brown et al. 2008). Abiotic variables exert strong influences on population density and abundance. Springsnails exhibit "extreme habitat specificity" based on water availability, chemistry and depth (Hurt 2004). Within a spring, abundance is influenced by CO_2 concentration, water depth, current velocity, substrate composition, and aquatic vegetation (Hershler and Sada 1987, Hershler 1998, O'Brien and Blinn 1999, Sada 2008).

The temperature of waters occupied by springsnails ranges from 10^{o} C to 40^{o} C. Pyrgs generally inhabit springs with medium (10-21º C) to thermal (greater than 21º C) temperatures (Hershler and Sada 1987, Hershler 1998). Conductivity in *Pyrgulopsis* habitat ranges from 70 µmhos/cm to 37,000 µmhos/cm (Hershler and Sada 1987, Hershler 1998). *Tryonia* species generally occur in thermal and highly mineralized springs (Hershler 2001). Mladenka and Minshall (2001) found that water temperature influences springsnail demographic variables and feeding behavior. Thermal endemic aquatic species require a relatively narrow temperature regime to maintain healthy populations (Hershler 1998, 2001, Deacon 2007).

Sada (2008) examined the habitat preferences, niche breadth and overlap, and environmental factors influencing the structure of an assemblage of native springsnails (*Pyrgulopsis avernalis*, *P. carinifera*, and *Tryonia clathrata*) and the non-native red-rimmed melania (*Melanoides turberculata*) in a thermal spring province in Nevada and found that water temperature, current velocity, and substrate type were the most important physical factors structuring the assemblage. He found that springbrook wetted width, presence of armored and incised banks, and location of sample sites across the wetted width were significant, but less important factors. Each species exhibited habitat preferences for a range of depths, velocities, temperatures, or substrates. These findings suggest that springsnails are restricted to portions of a spring that provide suitable physicochemical conditions, and that each springsnail taxon may exhibit specific habitat requirements for discharge and water depth, substrate composition, current velocity, and water temperature (Sada 2008).

Springsnails exhibit preferences for specific physical components of the environment, and each taxon may be physiologically restricted to springs and portions of individual springs with suitable physiochemical conditions and minimum environmental variability (Taylor 1985, Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008, Brown et al. 2008). Snail densities are highest near spring sources where the physicochemical environment is relatively stable compared to downstream reaches where daily and seasonal variability is greater (Hershler 1998, McCabe 1998, Sada 2008). Because each species is adapted to very specific conditions, water level fluctuations and the accompanying effects on water quality parameters could have serious negative consequences for springsnail populations (Taylor 1985, Ponder et al. 1989, Hershler 1998, McCabe 1998, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Deacon 2007, Sada 2008, Brown et al. 2008). Altered spring discharge could extirpate springsnail populations:

> "Any alteration in water flow or water quality of springs, including diversion or impoundment, and alteration in temperature, clarity, or mineral content of spring water, may result in direct loss of springsnails" (USDI 2000, p. 5.41).

In general, springsnails require "high quality habitats with little disturbance" (Sada and Nachlinger 1996, p. 17).

E. Movement

Springsnails have very limited dispersal abilities, rarely moving more than a few meters per generation (Hurt 2004), though a few species may have greater dispersal abilities than previously thought (Liu et al. 2003, Liu and Hershler 2007). Springsnails are restricted to springs and portions of springs with suitable environmental parameters (Taylor 1985, Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008, Brown et al. 2008), and are physiologically incapable of crossing dry habitat or even wet habitat with inhospitable conditions. Aquatic snails can disperse via flood waters and via attachment to waterfowl and shorebirds, but these mechanisms are stochastic (Silvey and Williams 1996, Martinez and Sorensen 2007). Because of their narrow environmental requirements and poor dispersal ability, once a springsnail population has been extirpated from a water body, recolonization is highly unlikely (Ponder and Colgan 2002, Hurt 2004).

F. Life History

Springsnails typically occur at high densities (Hershler 2001, Brown et al. 2008). Pyrgs occur at densities from hundreds up to 10,000 individuals per square meter (Hershler 1998, Brown et al. 2008). The amount of habitat occupied by springsnail populations ranges from less than one square meter in small springs to more than 100 square meters in large springs (Sada 2008).

Hydrobiids have annual reproduction, with continuous recruitment in warm springs and seasonal recruitment in cold systems (Hershler 1984, Kellogg 1985, Mladenka and Minshall 2001, Martinez and Thome 2006). It is speculated that *Pyrgulopsis* live only one year, require several months to reach breeding age, and are semelparous (reproduce only once) (Frest and Johannes 1995). Hydrobiid sex ratio is typically skewed toward females (Thompson 1968). Reproduction is usually sexual, although one species of *Tryonia* [*Tryonia* *porrecta* (= *T. protea*)] is known to be parthenogenic (Hershler et al. 2005). Sexual dimorphism is pronounced with females generally being larger than males (Hershler 1984, Taylor 1987). Pyrgs are oviparous with females depositing single, small, hemispherical egg capsules with single embryos in each on hard substrates often in protected settings (Taylor 1987, Hershler 1998, Frest and Johannes 1999). Hatching occurs in a little over a week and shell length of hatchlings is 0.3 mm (Ibid.) *Tryonia* is ovoviviparous and broods a few young in the female genital duct in which the capsule gland is thin-walled and functions as a brood pouch (Hershler and Thompson 1992, Hershler 1999). Isolated springsnail populations are sustained chiefly by births rather than immigration because of their minimal dispersal capabilities (Martinez and Sorensen 2007).

Limited dispersal ability and restricted distribution make endemic springsnail species inherently vulnerable to extinction (Dillon 1988). Because they have restrictive habitat requirements, and are sensitive to changes in water level, chemistry, and temperature, drastic changes in flow could cause population declines or extirpation (Taylor 1985, Ponder et al. 1989, Sada and Nachlinger 1996, Hershler 1998, McCabe 1998, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Deacon 2007, Brown et al. 2008, Sada 2008). Because springsnails are poor dispersers, recolonization following disturbance is unlikely to impossible (O'Brien & Blinn 1999, Mladenka & Minshall 2001, Hurt 2004). Because reproduction may be annual and individuals may live for only a year, conditions which prohibit recruitment could eradicate a population.

IV. LEGAL REQUIREMENTS FOR DETERMINING IF SPECIES WARRANT LISTING:

Under the ESA, 16 U.S.C. § 1533(a)(1), USFWS is required to list a species for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range. In making such a determination, USFWS must analyze the species' status in light of five statutory listing factors:

(A) the present or threatened destruction, modification, or curtailment of its habitat or range;
(B) overutilization for commercial, recreational, scientific, or educational purposes;
(C) disease or predation;
(D) the inadequacy of existing regulatory mechanisms;
(E) other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(a)(1)(A)-(E); 50 C.F.R. § 424.11(c)(1) - (5).

A species is "endangered" if it is "in danger of extinction throughout all or a significant portion of its range" due to one or more of the five listing factors. 16 U.S.C. § 1531(6). A species is "threatened" if it is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1531(20). While the ESA does not define the "foreseeable future," the FWS must use a definition that is reasonable, that ensures protection of the petitioned species, and that gives the benefit of the doubt regarding any scientific uncertainty to the species.

At least one, and in many cases three or more, of the factors set forth in § 424.11(c) are applicable to the present status of the petitioned springsnail species.

V. THREATS TO THE PETITIONED SPECIES

Overview

Springsnails, as their name implies, are completely dependent on springs. Their survival depends on the persistence of the water quantity, quality, and vegetative and substrate conditions to which they are adapted. In arid desert landscapes, both human users and wildlife species rely on springs and spring-fed riparian areas, which are often the only reliable source of water. Human activities, such as water diversion, groundwater pumping, grazing, and recreation can degrade or completely desiccate spring habitat. For endemic species that exist at only a single site, as goes the spring, so does the species. Sada et al. (2005) state:

> "When springs are either desiccated or degraded severely by natural or anthropogenic environmental change, their aquatic assemblages can be eradicated completely (Minckley and Deacon 1968, Johnson and Hubbs 1989, Sada and Vinyard 2002)."

Unlike the often complex causes of extinction for some taxa, the loss of springsnail species is directly attributable to human activities that alter water discharge, depth, velocity, temperature, or substrate composition (Sada 2008). Current and proposed human activities present dire threats to the springs on which the petitioned species depend. Most of the springs are small and unprotected, have been overlooked by land managers, and will require protection in order to conserve snails and other native aquatic biota (Hershler 1998). Hershler (1998) states:

> "[T]he typical habitats of Great Basin hydrobiids, very small springs that are often less than 1 m wide and 1 cm deep, are fragile, unprotected, and prone to extreme degradation owing to water development in the region, particularly livestock grazing."

Several researchers have reported anthropogenic disturbances to aquatic systems in desert ecosystems and the resultant decline in biodiversity. Sada and Vinyard (2002) reviewed the status of 135 distinct aquatic taxa endemic to the Great Basin and identified factors which had caused declines in their distribution and abundance. They found that half of the taxa they reviewed (68 species), had lost at least one population during the last 140 years. Seventy-eight taxa (58 %) experienced a major decline (a decrease in historical distribution or absolute abundance by at least one-half), and 15 became extinct. Of the 15 extinct species, 12 were fish, and three were mollusks. Most of the extinctions were caused by the introduction of nonnative species, water flow diversions, and groundwater use, with grazing and pollution causing a single extinction each (Ibid).

Among the taxa Sada and Vinyard (2002) reviewed, 67% had been negatively affected by water flow diversions, 58 % had been negatively affected by invasive species, 40% by grazing, 13% by groundwater pumping, and 2 % by recreation. They also found that nearly 60% of taxa were negatively affected by more than one factor. They state, "[S]ynergistic effects may affect status changes—e.g., the combined effects of degraded habitats and nonnative species on endemic taxa may be greater than the summed effect of individual threats (2002)."

Sada et al. (2001) noted several studies that cite water diversion, grazing, and nonnative species as major disturbance factors. The BLM's Resource Management Plan for the Las Vegas district (USDI BLM 1998) found that 40 percent of inventoried riparian spring areas were in poor condition, and no areas were considered to be in excellent condition (p. 3-21). They also found that approximately 94 percent of spring sources in the planning area were contaminated with coliform bacteria due to livestock grazing (USDI BLM 1998, p. 4-8). Sada and Nachlinger (1996, 1998) found that sixty percent of the 50 springs they surveyed in the Spring Mountains of southern Nevada were moderately to highly disturbed due to diversion, grazing, and recreation. They report that only 3/50 springs had no apparent use by humans or introduced animals. Sada et al. (2005) found that 78% of 45 study springs in the Spring Mountains were disturbed to some degree (16 highly disturbed, 9 moderately disturbed, 10 slightly disturbed). Fleishman et al. (2006) examined 63 springs in the Spring Mountains and classified 50 of them as disturbed (21 highly disturbed, 13 moderately disturbed, and 16 slightly disturbed). Many of the springs in the Spring Mountains have been excavated or developed, and water-diversion structures and invasive species are common (Fleishman et al. 2006).

To assess current ecological conditions and disturbance levels at springs of interest to the Southern Nevada Water Authority, BIO-WEST, Inc. conducted disturbance evaluations at 93 sites in 11 valleys of east-central Nevada and west-central Utah. They found that many springs have been degraded by diversions, grazing, nonnative species, recreation, and drought. Their report, an Ecological Evaluation of Selected Aquatic Ecosystems in the Biological Resources Study Area for the Southern Nevada Water Authority's Proposed Clark, Lincoln, and White Pine Counties Groundwater Development Project (henceforth Golden et al. 2007) was submitted in March 2007. They found that diversions and livestock-related damage were the most common disturbances, at least one of which was present at 96% of evaluated sites, and both of which were present at half of the sites. Nonnative species of vegetation, invertebrates, amphibians, or fish were present at over 63% of evaluated sites. Urban disturbances ("roads, recreation, dwellings and structures, and other human disturbances") were present at over a quarter of the sites. Roughly 19% of sites had been impacted by drought. They report that drought would likely have been listed as a disturbance factor at more sites if surveys had been conducted in 2004 rather than 2005 because 2005 had higher-than-average spring precipitation.

In addition to habitat loss and degradation due to spring diversion, groundwater pumping, grazing, and recreation, the invasion of non-native species, and altered flow conditions due to global climate change, the petitioned springsnails are inherently vulnerable to extinction due to their limited distributions and low dispersal ability (Hershler 1998, Hurt and Hedrick 2004).

A. Present or threatened destruction, modification, or curtailment of habitat or range

1. Groundwater Withdrawal

Groundwater withdrawal is an overarching and imminent threat for the petitioned springsnails. Springs “are an expression of groundwater function and influence” (BLM 2008 White Pine Energy Station FEIS, p. 3-13). Increasing human use of groundwater will have negative consequences on springs and the species which are dependent on them. Strayer (2006) states:

> “Humans in arid regions around the world are pumping water out of aquifers for agriculture and domestic use faster than it can be replenished . . . Groundwater withdrawals already have dried up many springs. Further withdrawals will dry up many more springs, aquifers, and small streams, resulting in species extinctions (e.g., Ponder 1986).”

Groundwater withdrawal can reduce spring discharge or dry springs up entirely (e.g. Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). The desiccation of springs obviously destroys springsnail habitat. Because springsnails have specific microhabitat requirements (Sada 2008), even reduced spring outflow can degrade or destroy springsnail habitat, resulting in population extirpation or worse, extinction.

Effects of Groundwater Pumping on Spring Discharge and Biota

The carbonate rock aquifer underlying most of southern Nevada is part of the Carbonate-Rock Province, a physiographic region comprising the eastern half of the Great Basin including southern Nevada, parts of eastern Nevada and western Utah, Death Valley California, and small areas in Arizona and Idaho (Harrill and Prudic 1998). Within the regional carbonate aquifer, groundwater is stored and conveyed through two primary systems-- shallow basin-fill deposits which are saturated and poorly consolidated, and the underlying fractured sedimentary carbonate (dolomite, limestone) or volcanic (basalt, tuff, rhyolite) rocks (Eakin 1966). In the shallow basin-fill deposits, groundwater flow generally corresponds with elevation (Eakin 1966). In the underlying carbonate-rock system, groundwater generally flows irrespective of local topography and hydrographic area boundaries, responding to regionally controlled hydraulic gradients driven by recharge and discharge areas (Harrill and Prudic 1998, USDI 2008 KSV FSEIS, p. 3-19). The carbonate rock aquifer is permeable enough to facilitate ground water flow at a regional scale. Regional flow systems are comprised of local basin fill aquifers underlain by the large regional aquifer that transmits groundwater from basin to basin, beneath topographic divides (Harrill and

Prudic 1998, Mayer and Congdon 2007). Water from the carbonate aquifer, along with local runoff, feeds local and regional aquatic systems.

Pumping water from local and regional aquifers will lead to declines in surface flows (Schaefer and Harrill 1995, Harrill and Prudic 1998, Bedinger and Harrill 2006, Congdon 2006, Deacon et al. 2007, Mayer and Congdon 2007). Patten et al. (2008) state:

> "These aquifers (the shallow basin-fill and deep regional aquifers) are primary drivers of spring hydrology and thus alteration of these aquifers and their associated water tables is also expected to alter surface flows (Fiero and Maxey 1970, Dudley and Larson 1976, Burk et al. 2005)."

The development of existing water rights and applications held by the Southern Nevada Water Authority (SNWA) and other users will have disastrous effects on the springs on which the petitioned springsnails depend for survival. Deacon et al. (2007) state:

> "The literature demonstrates that deep carbonate and shallow basin-fill aquifers are interconnected across the various basins likely to be affected by groundwater withdrawal, and that the approval of the SNWA applications for water rights is likely to reduce or eliminate many spring and wetland communities in the region, with consequent adverse impacts on the rich diversity of spring- and wetland-dependent endemic species."

The effects of groundwater pumping on spring discharge depend on the initial hydraulic head of the spring, the elevation of the spring orifice, and the proximity to pumping (Mayer and Congdon 2007). Darcy's Law states that flow through a porous medium is proportional to the hydraulic head differential or gradient (Fetter 1994). Groundwater pumping causes a drawdown cone, and as the drawdown cone extends, the hydraulic head differential at springs is reduced which causes a proportionate decrease in flow (Mayer and Congdon 2007).

Even relatively small decreases in groundwater level can reduce regional spring discharge (Mayer and Congdon 2007). Both small low-elevation springs close to pumping wells and high elevation springs are particularly sensitive to groundwater removal (Sada 2006b, Mayer and Congdon 2007). In small springs, even minor changes in discharge can greatly influence spring size and the integrity of aquatic communities (Sada 2006b).

Large-scale groundwater development projects in the aquifer will likely lead to groundwater overdraft which will have catastrophic ecological consequences. Zektser et al. (2005) state:

> "Groundwater overdraft develops when long-term groundwater extraction exceeds aquifer recharge, producing declining trends in aquifer storage and hydraulic head. In conjunction with overdraft, declines in surface-water levels and streamflow, reduction or elimination of vegetation, land subsidence, and seawater intrusion are well documented in many aquifers of the southwestern United States."

It is well known that excessive groundwater pumping can lead to spring drying and the loss of spring fauna (Minckley and Deacon 1968, Brune 1975, Williams et al. 1985, Johnson and Hubbs 1989 in Sada and Nachlinger 1996). The Nevada Wildlife Action Plan states:

> "In some basins, groundwater pumping has been found to depress spring flow and a small number of larger regional springs have demonstrated temporary or permanent dewatering as a result of groundwater development. Field studies have documented degraded habitat conditions, declines in sensitive plants and animal populations, and species extinctions" (Nevada Dept. of Wildlife 2006, p. 199).

There are numerous examples of groundwater pumping causing the failure of springs and the demise of the organisms dependent on them. The endemic Las Vegas dace (*Rhinichthys deaconi*) became extinct in 1957 when springs failed due to groundwater withdrawal (Harrill 1976, Miller 1984). In Pahrump Valley west of Las Vegas, Raycraft, Bennet's and Mase Springs dried in 1957, 1958, and 1975, respectively, resulting in extinction of the Pahrump poolfish (*Empetrichthys latos*) and extirpation of a population of the Spring Mountains springsnail (*Pyrgulopsis deaconi*) (Soltz and Naiman 1978, Deacon 1979, Harrill 1986, Hershler 1998). The effects of groundwater pumping on surface flows and species in Owens Valley and at Devil's Hole are well-known (Reisner 1993, Bedinger and Harrill 2006, Riggs and Deacon 2004, Deacon et al. 2007). Groundwater developments initiated in the 1960's led to reduced spring discharge at Ash Meadows (Dudley and Larson 1976, Dettinger et al. 1995). Pumping was curtailed in the early 1980's, but current projects continue to cause groundwater decline and reduced spring discharge at Ash Meadows (Riggs and Deacon 2004, Bedinger and Harrill 2006, Deacon et al. 2007). Groundwater pumping has also led to decreased surface flows in Moapa Valley (USDI 2006b). Sada and Vinyard (2002) found that 13% of evaluated endemic Great Basin aquatic taxa had declined due to groundwater pumping.

Groundwater withdrawal is acknowledged as a significant and ongoing threat to Nevada Wildlife:

> "[G]roundwater development has been a historic stressor on Nevada wildlife and habitats and continues to represent a significant ongoing threat. As demonstrated in areas such as Ash Meadows and Pahrump Valley in southern Nevada, excessive groundwater withdrawal can alter groundwater flow and recharge patterns, resulting in loss of connectivity between groundwater and surface water habitats and concurrent impacts to vegetative communities and surface flow of ground water from springs and seeps" (Nevada Department of Wildlife 2006, p. 200).

Deacon et al. (2007) report that ongoing groundwater development in southern Nevada and the subsequent decline in surface flows could adversely affect 20 federally listed species, and 137 other water-dependent endemic species. Forty-one of the petitioned springsnail species were identified by Deacon et al. (2007) as being threatened due to projected groundwater decline in the 78-basin area that would be affected by groundwater development currently proposed by the Southern Nevada Water Authority alone, not including existing or proposed groundwater development by other users. The additional petitioned species, *Pyrgulopsis* *serrata*, occurs in springs which are likely to be affected by groundwater pumping for the proposed White Pine Energy Station (USDI BLM 2008).

It is important to note that the petitioned species will be negatively affected not only by spring failure, but also by reduced flow or changes in water quality:

> "Any alteration in water flow or water quality of springs, including diversion or impoundment, and alteration in temperature, clarity, or mineral content of spring water, may result in direct loss of springsnails" (USDI FWS 2000, p. 5.41).

Reduced flow alters water quality parameters including temperature, dissolved oxygen, and conductivity, and affects sediment transport rates, channel morphology, vegetation, and invertebrate and phytoplankton production (USDI 2006b, p. 49). Because springsnails have very specific microhabitat requirements, reduced spring outflow due to groundwater pumping could lead to population decline or extirpation (Taylor 1985, Ponder et al. 1989, Sada and Nachlinger 1996, Hershler 1998, McCabe 1998, Myers and Resh 1999, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Sada and Vinyard 2002, Hurt 2004, Strayer 2006, Deacon 2007, Brown et al. 2008, Sada 2008). Deacon (2007) states:

> "Obviously, when springs dry, species dependent on them disappear. Effects of diminished flow can also be profound, though sometimes more subtle. For example, thermal endemic aquatic species typically require a relatively narrow temperature regime to maintain healthy populations. Reduced flow causes water to cool more rapidly, thus reducing habitat suitable for maintenance of already severely restricted populations."

Concerning the effects of reduced outflows on springsnails Deacon (2006) states:

> "Species in the genus *Pyrgulopsis* (36 petitioned species) are restricted to spring sources of permanent springs and a very short distance downstream. These springs have been flowing constantly for millennia. In addition, each species typically exhibits very specific preferences for microhabitat characteristics such as substrate, velocity, depth, etc, and they partition available habitats according to those microhabitat preferences (Hershler 1998, Hershler and Sada 2002). This makes their populations especially sensitive to reduced spring discharge."

Likewise, Hershler (2001) states, "Owing to their typical narrow distributions and small habitats, western congeners (of *Tryonia*, five petitioned species) are especially vulnerable to perturbations relating to water development."

Because of the high degree of endemism in Western springsnail populations, the failure of a single spring due to groundwater withdrawal or water diversion could lead to the extinction of a species. Hurt (2004) explains:

> "Habitat specificity and low dispersal capabilities have contributed to a high degree of endemism in this genus (*Pyrgulopsis*), with many species occurring only within a

> single spring or seep. Therefore, dewatering of a single springhead for human related activities can lead to the loss of an entire species (Landye 1981, Ponder & Colgan 2002)."

Fourteen of the petitioned springsnail species occur at only a single site, and there is no question that failure of the springs on which they depend will result in species' extinction. Eleven of the species are known from two sites, and only three of the petitioned species are found at more than ten locations. Even for those species which occur at more than one location, narrow environmental requirements and poor dispersal ability make recolonization highly unlikely if a population becomes extirpated (Ponder and Colgan 2002, Hurt 2004).

In addition to reduced or failed surface flow, groundwater development can be harmful for springsnails in other ways. Construction-related erosion, increased sedimentation, accidental chemical spills, and hydrostatic testing water discharges could lead to decreased water quality (USDI 2008 Kane Springs Valley FEIS p. ES-14). The Natural Resources Baseline Summary Report by ENSR Corporation for the Clark, Lincoln, and White Pine Counties Groundwater Development Project (2007b) identified the following potential ecological impacts of groundwater withdrawal and transport: increases in short-term suspended sedimentation, effects from hydrostatic testing and dust control water use, alterations in food-chain relationships, alterations in long-term community structure and species composition, reduction in habitat quality, and effects on biodiversity and species abundance (p. 4-1).

Groundwater pumping will have negative effects on plant communities, which will in turn affect springs. Patten et al. (2008) state, "As regional groundwater pumping drives reductions in spring discharge and local water tables, it will modify vegetation in the spring area." A drop in water levels will lead to the death of vegetation, which will lead to increased erosion and sedimentation. Loss of vegetation will also reduce spring shading and alter water temperature and dissolved oxygen content. Groundwater development will likely facilitate the spread of invasive species through several mechanisms. Pipeline construction provides establishment pathways for invasive vegetation (Charlet 2006). Altering flow regimes can accelerate the invasion of non-native species in moist environments such as springs (Eby et al. 2003). It can take hundreds of years for native desert vegetation to become reestablished following disturbance, if it recovers at all (Lathrop and Archbold 1980, Charlet 2006).

Increasing Groundwater Demand and Unsustainable Groundwater Withdrawal Rates

Threats to the petitioned species' habitat are increasing because of the increasing demand for groundwater. Southern Nevada is experiencing rapid human population growth. Las Vegas has become one of the fastest-growing metropolitan areas in the nation and water demand has reached current supply limits (Deacon et al. 2007). The city of Las Vegas, other cities and counties, and other users are relying on local aquifers and the regional carbonate rock aquifer to meet the growing demand for freshwater (Mayer and Congdon 2007). Municipalities began tapping the regional carbonate rock aquifer in 1986, and in 1998 pumping increased considerably (Mayer and Congdon 2007).The Southern Nevada Water Authority (SNWA) alone has applied for water rights for 200,000 acre-feet per year (afy) (246.7 million m^3) from the regional groundwater aquifer and for 330,000 afy total (SNWA 2004, Deacon et al.

2007). Satellite communities are applying for rights for an additional 870,487 afy (1.07 billion m^3). If all new permits were to be granted, groundwater would decline across 78 basins covering nearly 130,000 km^2 (Deacon et al. 2007). Mayer and Congdon (2007) conclude:

> “Our statistical results give strong inference that the carbonate rock aquifer and the regional springs are well connected and responding to changes in climate and pumping and that the system is reaching the limits of sustainability.”

Deacon et al. (2007) found that 35 basins in the Colorado flow system have already experienced groundwater decline, that existing water rights total 102% of perennial yield, and that current and applied for rights equal 271% of perennial yield, far exceeding the amount of available water. Existing rights exceed perennial yield in five of the eight major flow systems and in 65 of the 78 basins likely to be affected by groundwater pumping. As of February 2006 existing permits authorized withdrawal of 735,003 afy from the 78 basins. Permitted withdrawals are not evenly spaced across the landscape, and range from 0 to 1660% of the yield estimates for individual basins (Deacon et al. 2007).

Even if groundwater withdrawal were limited to the state’s estimate of perennial yield, the petitioned springsnails would still be threatened with extinction. The Nevada Division of Water Resources’ definition of perennial yield does not provide for the maintenance of wetlands, springs, stream flows, or the organisms which depend on them, nor does it maintain the groundwater table or subsurface interbasin flows (Deacon et al. 2007). There is also technical disagreement on perennial yield estimates for some local and regional aquifers (SNWA 2003, Deacon et al. 2007). Methods for determining perennial yield (i.e. Malmberg 1967) can include the drying up of springs, death of phreatophytes (deep-rooted plants), lowering of the groundwater table, land subsidence (sinking), and reductions in both shallow and deep interbasin subsurface flows. Further, permits are commonly issued for withdrawal in excess of perennial yield (Deacon et al. 2007). Deacon et al. (2007) state:

> ”These predictable consequences (spring drying, land subsidence, etc.) result directly from the issuance of permits equivalent to 100 percent of perennial yield. Unfortunately, despite the clear requirements of the law, permits commonly are issued for many times that amount. Clearly, several factors confound attempts to unambiguously quantify the extent of expected detrimental impacts. Predicting the final steady state of the groundwater system in response to massive groundwater removal is complicated by disagreement over recharge from precipitation, discharge from evapotranspiration, connectivity among aquifer components, and the time required to reach a new equilibrium. There is no question, however, that the state’s definition of, and methodology for determining, the quantity of water that legally may be withdrawn fails to envision the maintenance of natural systems. As a result, it is nearly impossible for the state engineer to issue groundwater permits in support of urban development while protecting existing water rights, including those concerning recreational resources and biodiversity.”

Because the Nevada Division of Water Resource's definition of perennial yield allows for the drying up of springs, the petitioned springsnails could be extirpated even if withdrawal was not permitted in excess of perennial yield. Without Endangered Species Act protection, the springs on which these species depend will likely be desiccated, and the springsnails will succumb to extinction.

Several groundwater models have been developed for basins that will be affected by groundwater removal including Schaefer and Harrill (1995), Principia Mathematica (1997 for SNWA), Durban (2006 for SNWA), Elliott et al. (2006), and Myers (2006). Except for the SNWA models, the results of other models were consistent with those of Schaefer and Harrill (1995), which projected groundwater level declines of about 0.3 to 488 m throughout 78 basins extending from Sevier Lake, Utah, to Death Valley, California (Deacon et al. 2007). The models suggest that a new steady state might be reached in 100 to 200 years with groundwater level declines of 15 to 152 m predominating in both shallow and deep aquifers. During the first century, flow at regional springs would decline by 2 to 14 percent, and would then continue to decline and eventually fail. The SNWA models differ from the other models primarily in that they assume higher levels of precipitation-induced recharge and evapotranspiration-induced discharge (Deacon et al. 2007).

The petitioned springsnails are threatened by the development of both existing and proposed water rights. Many of the valleys where the petitioned springsnails occur already have existing water rights in excess of annual yield. Specific existing and proposed groundwater projects which will affect the habitat of petitioned species are discussed by watershed in the Individual Species Account section, beginning on page 60.

Inadequacy of Mitigation Measures

Several proposed groundwater development projects have mitigation measures and stipulated agreements including monitoring facilities to evaluate the impacts of pumping (e.g. Stipulated Agreements for Spring Valley, Kane Springs Valley, and Delamar, Dry Lake, and Cave Valleys). The monitoring programs, however, are not adequate to protect the petitioned species from extirpation due to groundwater pumping for several reasons. The monitoring stations won't reveal changes in flow at all springs where the petitioned species occur, especially at small springs and low and high elevation springs which are especially sensitive to groundwater removal. Even at springs where discharge will be monitored, the standard for triggering mitigation measures might not match the physiological needs of the springsnails, meaning discharge could drop below a level adequate to support springsnail species before flow was low enough to prompt intervention. FWS cannot reasonably conclude that the stipulated agreements are adequate to protect springsnail habitat, because there is no mention of springsnails in the stipulated agreements. Monitoring is intended to assess "ecosystem health," but this term is not defined, and there is no trigger to stop pumping if effects to biota are manifested.

Springsnails will be harmed not only by cessation of flow, which will kill them outright, but also by reduced flow which will alter spring morphology and water quality. Springsnails have very specific microhabitat requirements (Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Deacon 2007, Sada 2008) and flow at springs where they occur is relatively constant with low temporal variability in discharge rate (Taylor 1985). Fluctuations in flow could thus be detrimental or fatal for the petitioned species (USDI 2000, p. 5.41). Further, even in the unlikely event that groundwater pumping is stopped, it is unknown how affected springs will respond or if flow will resume. If springsnail species are extirpated due to reduced flow, the after-the-fact cessation of groundwater pumping will not benefit species that have already been driven to extinction. Thus, the stipulated agreements are completely inadequate to protect the petitioned species.

Figure 2 (next page) shows the distribution of the petitioned springsnails in relation to the area of projected groundwater decline due to currently proposed Southern Nevada Water Authority (SNWA) withdrawal applications based on Deacon et al. 2007, Schaefer and Harrill 1995, and Harrill and Prudic 1998. Groundwater at many springs where petitioned species occur is expected to decline from 0.3 – 30 m, which could lead to the decline or cessation of springflow. This graphic is not comprehensive and is based on proposals from SNWA alone, not including existing and proposed rights from other users.

Figure 3 (page 32) shows existing and proposed water rights in valleys where the petitioned springsnails occur. Because of the connectivity of the regional carbonate aquifer and the influence of the regional aquifer on some local aquifers, spring discharge is expected to be negatively affected even in some valleys where pumping will not occur. The map is based on data from the Nevada Division of Water Resources Water Rights Database accessed in 2008 and January of 2009. (Note: This map should be considered a general overview because there are some internal inconsistencies in the database, and some recent data are not yet available from the database. For example, the totals for active water applications per valley available as pdf's from the database do not always equal the totals per valley available as Excel spreadsheets, and some recent applications which are reported on SNWA's website do not have total afy entered in the NDWR database).

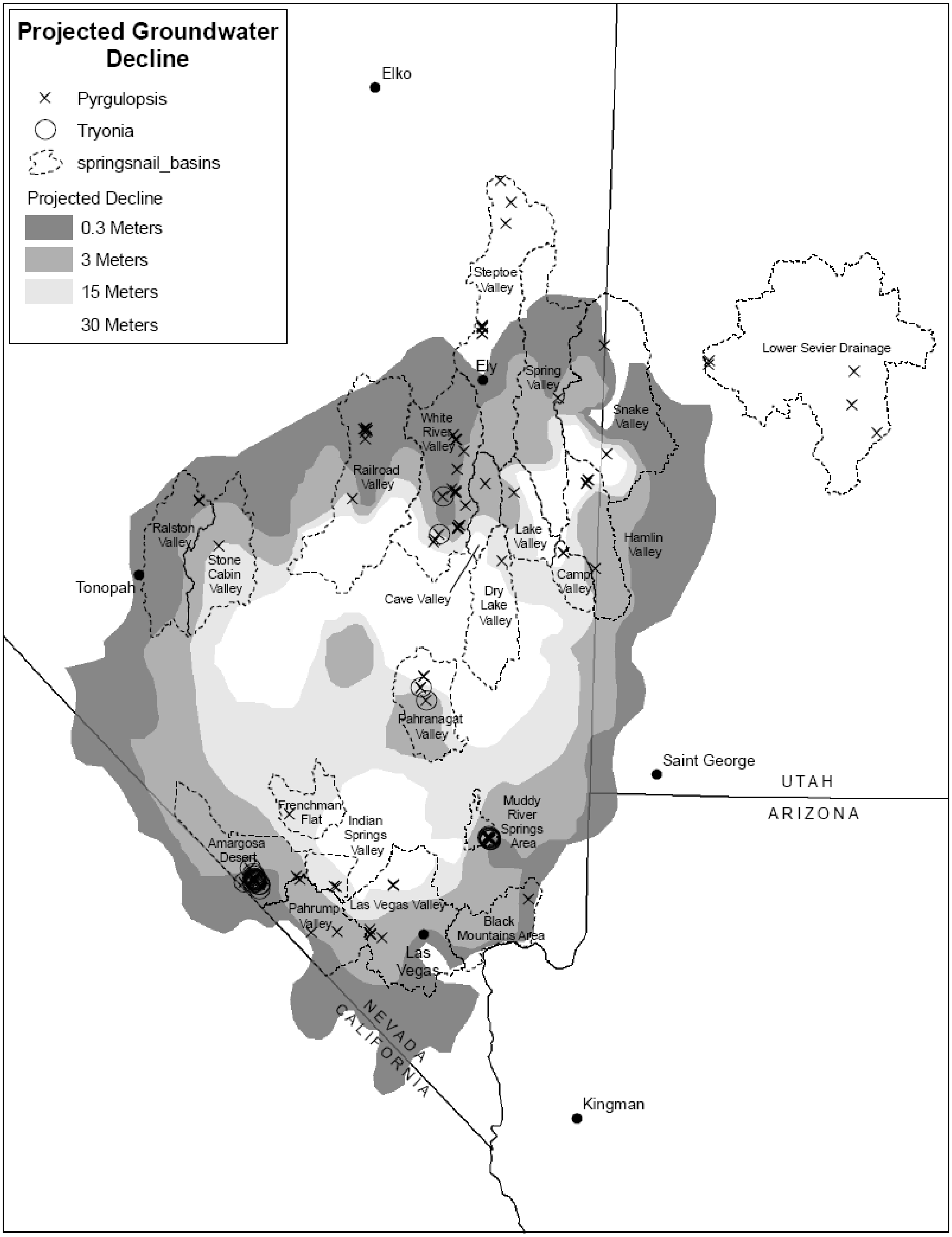

Figure 2. Distribution of petitioned species overlaid with area of projected groundwater decline due to proposals from the Southern Nevada Water Authority. Based on Deacon et al. 2007, Schaefer and Harrill 1995, and Harrill and Prudic 1998.

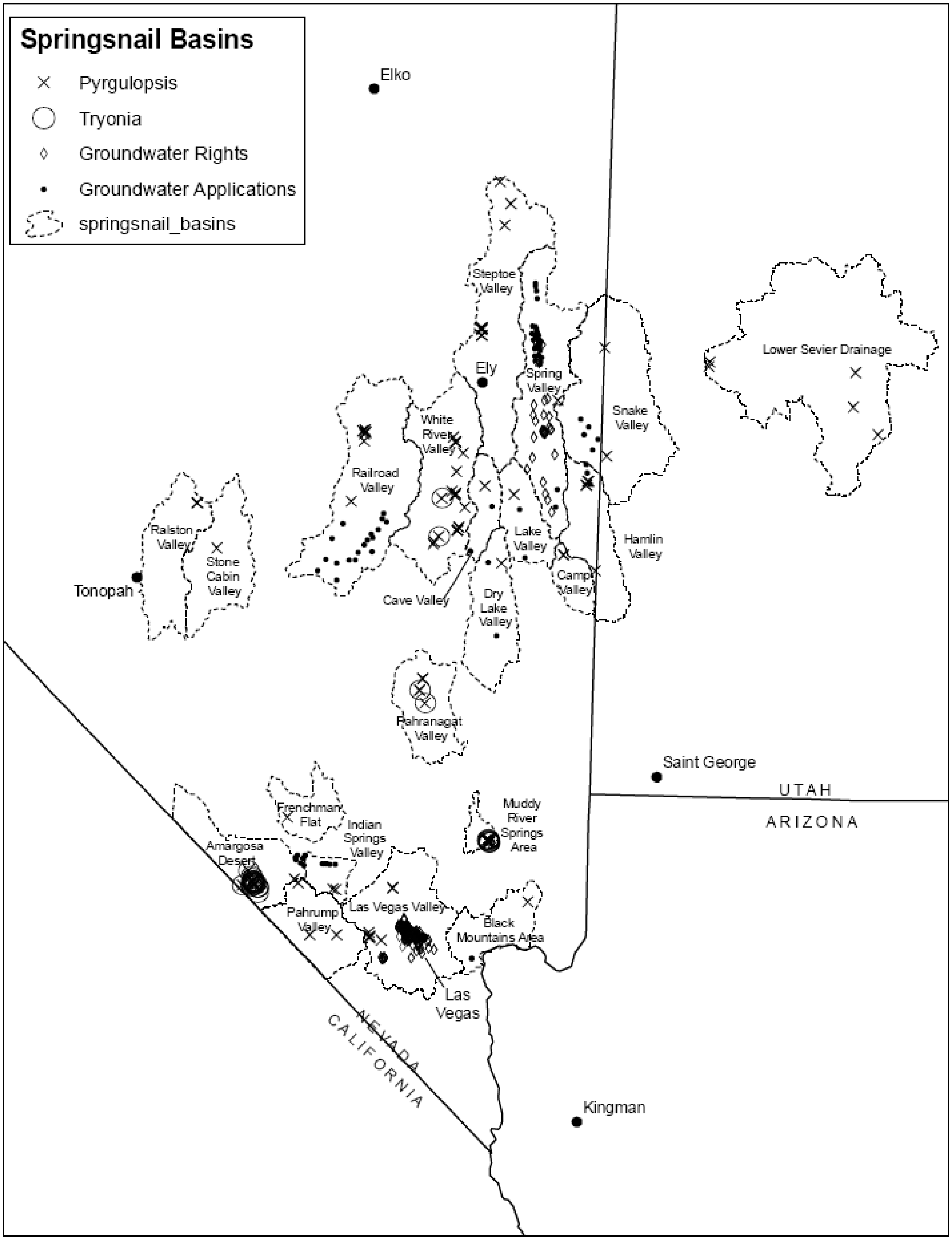

Figure 3. Distribution of petitioned species in relation to current groundwater rights and applications. Based on data from the Nevada Division of Water Resources Water Rights Database.

2. Spring Development and Diversion and Water Pollution

Spring development and diversion can alter flow regime and water quality parameters, lead to substrate disturbance and erosion, alter the structure and composition of vegetative cover, and can cause springs to dry up entirely, resulting in the loss of snail species (Shepard 1993, Frest and Johannes 1995, Frest 2002). Frest (2002) states:

> "Spring development generally results in loss of native freshwater mollusk species, particularly endemics. Effects include drying out of the original spring and spring meadow area; disruption of soil, rock, and vegetative cover; and increased stock visits, with accompanying trampling effects and accumulation of acidic manure and urine. Unless the source area is left intact and carefully protected, development can completely extirpate the native freshwater mollusks as well as reduce diversity in other animal and plant groups."

The development and diversion of springs is a primary cause of mollusk extirpation in western North America (Frest 2002). Springsnails have narrow physiological requirements and exhibit preferences for specific spring conditions (Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Hurt 2004, Sada 2008). Thus, springsnail populations can decline or become extirpated if spring conditions are modified:

> "Any alteration in water flow or water quality of springs, including diversion or impoundment, and alteration in temperature, clarity, or mineral content of spring water, may result in direct loss of springsnails" (USDI 2000, p. 5.41).

Because of the low dispersal ability and high endemism of *Pyrgulopsis*, the dewatering of a single springhead could result in the loss of an entire species (Landye 1981, Ponder and Colgan 2002, Hurt 2004).

Many springs that support desert wildlife species have been modified. The Nevada Wildlife Action Plan states:

> "A substantial number of springs on private and public lands have been historically altered by piping of outflows or the construction of spring head boxes. These practices eliminate or significantly modify spring pool and spring outflow habitats for wildlife and can eliminate important source water locations for use by resident wildlife species. More recent efforts to provide wildlife access to these modified spring systems are important, but have focused on terrestrial species needs with limited attention to restoring natural spring system functions to support spring-dependent endemic aquatic communities. Concerns exist that current protection and management attention is not sufficient to sustain spring ecological site integrity and long-term water production" (Nevada Dept. of Wildlife 2006, p. 199).

Water diversions already affect the habitat of many of the petitioned species. Sada and Vinyard (2002) found that 67% of evaluated endemic Great Basin aquatic taxa had declined due to water flow diversion and that most of the extinctions among these taxa were caused by the introduction of nonnative species, water flow diversions, and groundwater use. Sada (2008) found that springsnails were scarce or absent at approximately 85% of historically occupied springbrooks at Warm Springs because of reduced habitat quality and heterogeneity due to channelization, siltation, and diversion. He states:

> "[S]pringsnail abundance may be affected by any factor affecting water temperature (e.g., springbrook diversion, integrity of riparian vegetation), and the quality and heterogeneity of spring habitats. Human activities that reduce environmental heterogeneity (e.g., reduce discharge, channelize, or alter springbrook bank morphology and vegetation) are likely to reduce springsnail abundance or extirpate populations because they alter elements of the environment that define springsnail habitat" (Sada 2008, p. 69).

In the BLM Ely District planning area of Lincoln, White Pine, and Nye Counties where 11 of the petitioned species occur, over 150 spring development projects took place from 1958-2004 (USDI BLM 2007, p. 3.16-9). Golden et al. (2007) found that most of the aquatic systems they evaluated in Snake Valley were impacted by a current or historical water diversion structures. In the White River Valley, Golden et al. (2007) report that four springs that are home to *Pyrgulopsis sathos* and *P. marcida* are currently diverted for agricultural and livestock use. In the Pahranagat Valley, Ash Spring and Crystal Spring, home to the Grated *Tryonia* and Pahranagat Pebblesnail, have been highly modified for irrigation (Golden et al. 2007). Sada (2006b) found that of 44 springs surveyed for springsnails in Northern Steptoe Valley in 2005, 13 were moderately to highly disturbed due to spring diversion. Sada and Nachlinger (1996) report that diverted springs were the "most highly disturbed" type of degraded spring in the Spring Mountains, and that several springs there have been "completely destroyed by diversions" (p. 1). They report that two springsnail populations at Willow Spring and one at Grapevine Springs were probably extirpated due to diversion, channelization, and impoundment.

Anthropogenic changes in flow regimes such as spring diversion can accelerate the invasion of non-native species (Eby et al. 2003). Fleishman et al. (2006) found that species richness of native plants was lower at springs with high levels of diversion than at springs with moderate or no diversion. Likewise, native species plant cover was lowest at springs with higher levels of water diversion.

Golden et al. (2007) found that livestock-related damage and water diversion were the most common causes of disturbance at study springs in east-central Nevada and west-central Utah, at least one of which was present at 96% of evaluated sites, and both of which were present at half of the sites.

With the possible exception of the species which occur on National Wildlife Refuges, all of the petitioned species are threatened by current or historical spring development and diversion. Even in protected areas, surface flows can be affected by illegal diversions (USDI 2006b, p. 57). Because of the scarcity of water resources in the Great Basin and Mojave Deserts, springs are commonly diverted for livestock, recreational, wildlife, agricultural and other uses. The petitioned springsnails need Endangered Species Act protection to ensure their continued existence.

The petitioned species are threatened not only by spring diversion but also by water pollution. Springs environments can be polluted by direct impacts in the immediate vicinity of the spring, and also indirectly by activities that pollute the sources which feed the springs. Springs that are supplied by shallow aquifers can become polluted if spilled chemicals percolate from the surface through rock fractures or joints. Potential sources of pollution include refuse disposal, hazardous materials, injection fields, oil and gas development, and ungulate fecal material (Nevada Department of Wildlife 2006, p. 200).

3. Recreation

Recreational use of desert springs poses a serious threat to springsnails. Authorized or unauthorized recreation is a potential threat for all of the petitioned species. Golden et al. (2007) recorded recreation as a source of disturbance in Great Basin spring habitats, and Hershler (1998) identifies recreation as a source of disturbance for springsnails. Sada and Vinyard (2002) found that two percent of evaluated endemic aquatic Great Basin species had declined due to recreation. Sada and Nachlinger (1996) used multivariate analysis to assess the relationship between abiotic spring characteristics and the vulnerability of biodiversity and biotic function to human disturbance. They found that easy visitor access to springs was a significant explanatory variable, indicating that biodiversity is reduced and ecological functioning is modified when the public can easily access springs. Sada (2001) reported that public use has altered the physical and biological characteristics of Badwater Springs in Death Valley National Park, with effects similar to those caused by livestock use, resulting in reduced populations of endemic macroinvertebrates. Concerning the impacts of recreation on springs, the Nevada Wildlife Action Plan (2006) states:

> "Springs, particularly larger regional spring complexes, are also popular centers of human recreational activities. Although recreation can be managed to minimize effects on spring ecosystems in most cases, uncontrolled or poorly planned recreational use can have significant negative effects on spring habitats and biota . . . Recreational use impacts include bleach and soap added to the springs, soil compaction, removal of vegetation and resulting erosion from camping along the edges of springs, and manipulation of spring flow from installing tubs and water diversions" (Nevada Dept. of Wildlife 2006, p. 199-200).

Recreational use of springs is harmful to springsnails for many reasons. Users can directly kill organisms, simplify habitat structure, degrade water quality, and introduce nonnative species (Speight 1973, Liddle 1975, Shepard 1993, Sada and Nachlinger 1996, 1998, Rash 2001, Putnam and Botsford 2002, USDI 2003). Recreation can also result in increased frequency of wildfires (USDI 2000).

Frest and Johannes (1995) state, "In general, intense recreational usage will extirpate snail colonies" (p. 57). Recreation can contribute directly to springsnail mortality via crushing, desiccation, and collection. Visitors can crush snails by stepping on them or by rearranging rocks to construct dams and pools. When snails are attached to rocks and rocks are taken out of the water, snails dry out and die. Putnam and Botsford (2002) documented the deaths of 58 springsnail individuals at Red Springs (home to the petitioned species *P. deaconi*) outside Las Vegas due to visitors removing rocks from the water. Recreation can also result in unauthorized invertebrate collection (Rash 2001).

Recreation simplifies and degrades springsnail habitat due to vegetation trampling, soil compaction, and erosion. Sada and Nachlinger (1996) compare the impacts of human recreational use of springs to those caused by excessive grazing (p. 23). They state:

> "Biotic effects of recreation are similar to those for diversion and ungulate use. To facilitate recreational use of springs, riparian vegetation is typically removed or reduced, springbrooks are channelized to direct water around 'improvements' such as tables and parking areas, and trails are constructed. . . effects of trampling and riparian vegetation removal are similar to impacts caused by ungulates" (Sada and Nachlinger 1996, p. 23-24).

Rash (2001) discusses the effects of heavy spring visitation at Lost Creek Spring, where the petitioned species *Pyrgulopsis turbatrix* occurs:

> "Plant canopy (shade) removal contributes to elevated stream temperature. Stream siltation and turbidity increases in response to wading, bank trampling and accelerated surface run-off (due to lost soil and plant cover). Lost Creek Trail traverses the meadow on the fall-line of a moderate slope, atop soil that is loose and sandy. Wear-generated incisement of the trail has led to partial breaching and draining of the meadow's perched water table. Meadow plants exhibit decreased vigor along the trail, due to desiccation from either diminished soil moisture content or root exposure. Trampling, compaction, and erosion has already removed 4-10" of soil along portions of trail and in the streamside high-use areas. As the trailbed wears deeper and narrower more users will opt to walk alongside, in a pattern of ever-widening soil disturbance and vegetative loss. The longer such disturbance continues, the greater the probability of serious effects on the water quality and chemistry of Lost Creek Spring" (p. 4).

Recreation degrades water quality due to altered flow, altered temperature and sedimentation, and the introduction of pollutants. Springs are often modified or diverted to create favorable conditions for recreation. Diversions alter spring flow and water quality parameters such as temperature and dissolved oxygen concentration. Diversion can thus be harmful to springsnails because they are adapted to very specific microhabitat conditions (Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Hurt 2004, Deacon 2007, Sada 2008). Recreation can increase sedimentation by disturbing the substrate and because of bank erosion. Recreation can also degrade water quality by the introduction of sunscreen, personal-care products, and other chemicals and via sewage contamination (Rash 2001, USDI 2003, ORNHIC 2004). Visitors can also introduce exotic species to spring environments, such as the intentional release of unwanted pet fish or the inadvertent spread of invasive or pathogenic organisms on clothing and gear (Rash 2001).

The introduction of chemicals or nonnative species into spring environments could be disastrous for springsnails. For example, Rash (2001) states:

> "Unrestricted access into the Lost Creek Spring aquatic habitat will leave *Pyrgulopsis turbatrix* exposed to the risk of catastrophic stochastic population loss, such as could result from the introduction of a single water chemistry-altering substance or non-native predatory species" (p. 5).

The habitat of many of the petitioned species is known to have been degraded by recreation. In the Pahranagat Valley, Ash Spring and Crystal Spring, home to the Grated Tryonia (*T. clathrata*) and Pahranagat Pebblesnail (*P. merriami*), have been modified for recreational use (Golden et al. 2007). Sada and Nachlinger (1996, 1998) found that sixty percent of the 50 springs they surveyed in the Spring Mountains of southern Nevada were moderately to highly disturbed due to recreation, diversion, and/or grazing. They report that several Spring Mountains springs have been "heavily impacted" by recreation (1996, p. 1). Recreation at Willow Creek Spring, home to the petitioned species *Pyrgulopsis turbatrix*, for example, is preventing post-fire vegetation recovery. Sada and Nachlinger (1996) state:

> "Willow Creek Spring has been impacted by fire and heavy recreation. Fire removed riparian vegetation and heavy recreational use is preventing its recovery. Large areas of bare ground currently border the springbrook because of recreational vehicle use and camping" (p. 29).

Springsnail populations were eliminated at Willow Spring and Grapevine Springs following site modifications including diversion and the development of picnic sites (Sada and Nachlinger 1996, p. 17, 22); these populations have since been reestablished. Springsnail habitat at Red Spring, home to the petitioned species *P. deaconi*, has also been seriously degraded by recreation. BLM survey documents from the Red Rock Canyon National Conservation Area provided to the Center for Biological Diversity in response to a Freedom of Information Act request document recreational damage at Red Spring:

> "There is evidence that the stream flow was dammed, diverted by recreationists" (Patrick Putnam, March 1, 2002).

> "Many small rocks were recently removed from the spring at the source. An inspection of the rocks showed 58 spring snails were still attached to the rocks and had subsequently died due to desiccation" (Aug. 4, 2002, Patrick Putnam and Jed Botsford).

> "The spring channel was diverted due to damming by visitors. Rocks around the spring source were recently tagged by graffiti" (Patrick Putnam, May 3, 2003).

Before the construction of a boardwalk to reduce impacts, heavy recreational use led to habitat degradation at Lost Creek Spring, home to the Southeast Nevada Pyrg, *P. turbatrix*. Lost Creek Spring has a Children's Discovery Trail that is part of the Clark County School

District environmental education program. The trail was set up prior to BLM knowledge of *P. turbatrix* occurrence. Rash (2001) stated:

> "Extensive numbers of children are being regularly funneled into the core of the snail (*P. turbatrix*) habitat . . . Not only are large groups (15-30+) being continually pressed into a small portion of Lost Creek's riparian habitat but very often the educational purpose gives way to an ill-supervised romp, with the students being allowed to play and wade in the spring, just as if they were in an urban park. This group pressure is in addition to Lost Creek Spring's heavy volume of dispersed visitation. Visitor use impacts have thus far included: the release of non-native fish; vegetative trampling and destruction; unauthorized collecting of plants, amphibians, and invertebrates (especially by students); streambank degradation, and riparian terrace soil compaction and erosion" (Rash 2001, p. 4).

Similarly, an undated Restoration Plan for Lost Creek, submitted by Melissa Campbell to the BLM, states: "Heavy foot traffic at Lost Creek Spring has resulted in erosion, loss of vegetation, trail braiding, and general trash accumulation."

Recreational impacts are expected to increase with increased human population growth in southern Nevada:

> "As the human population of the county (Clark) increases, it is assumed that there will be a resultant increase in the amount of recreational and other uses of Bureau of Land Management, National Park Service, Forest Service, and Refuge lands" (USDI 2000, p. 5.1)

Human recreation at desert springs and associated infrastructure to support recreational use has many detrimental effects on springsnails and their habitat. The petitioned species thus need Endangered Species Act protection to ensure their survival.

4. Grazing

Grazing has been referred to as "the most widespread influence on native ecosystems of western North America" (Wagner 1978, Crumpacker 1984). Livestock grazing occurs on 70 percent of western lands including national forests, wildlife refuges, wilderness areas, and some national parks making it the most widespread land management practice in western North America (Fleischner 1994). Davis (1982) suggests that overgrazing is one of the most destructive forces in riparian ecosystems. A survey of peer-reviewed studies on the effects of grazing on stream and riparian ecosystems found that grazing negatively affects water quality and quantity, channel morphology, hydrology, soils, instream and streambank vegetation, and aquatic and riparian wildlife (Belsky et al. 1999). Grazing compacts soil, reduces infiltration rates and increases runoff and erosion (Brim Box and Mossa 1999). Grazing can reduce and eliminate streamside vegetation, alter plant species composition and diversity, modify the timing and volume of water flow, elevate water temperature and temperature fluctuation, and increase sediment loads, nutrients, and bacterial counts such as fecal coliform and fecal streptococci (reviewed in Boone Kauffman and Krueger 1984, Shepard

1993). Fleishman et al. (2006) found that native plant species richness was lower at springs with high grazing intensity than at springs with slight or no grazing. They also found that moderately grazed sites had more species of non-native plants than less heavily grazed sites (Ibid).

Grazing is detrimental to springsnails for many reasons including direct trampling, loss of vegetation, altered water chemistry and temperature, erosion and siltation, contamination from manure and urine, altered flow, and drying up of seeps and springs. Hurt (2004) states:

> "Slight changes in water chemistry or temperature, particularly contamination and trampling of vegetation resulting from livestock use, can quickly eliminate a (springsnail) population (p. 1173)."

The BLM's Resource Management Plan for the Las Vegas district (USDI BLM 1998) found that approximately 94 percent of spring sources in the planning area were contaminated with fecal coliform bacteria due to livestock grazing (USDI BLM 1998, p. 4-8).

Management activities such as rangeland improvement projects can have "major deleterious effects" on mollusk habitat (Frest 2002). Rangeland improvement typically involves piping water from natural springs to water troughs, which often results in spring destruction and the extirpation of native biota (Frest and Johannes 1995).

Hershler (1998) surveyed extensively for Great Basin springsnails (*Pyrgulopsis*) and he reports:

> "Relatively few of the collecting sites are in pristine condition, with livestock grazing being the predominant source of disturbance. Smaller, basin floor springs in particular were often profoundly disturbed by cattle, which modify the habitat both physically and chemically by trampling, removing aquatic and riparian vegetation, and depositing urine and feces. The resulting habitat often is largely unsuitable for *Pyrgulopsis*, although snails may persist in a small, upflow "refuge" of clean, flowing water which cows cannot reach."

Sada and Vinyard (2002) reviewed the status of and threats to 135 endemic Great Basin aquatic taxa and found that 40 % had been negatively affected by grazing, and that one species became extinct likely due to grazing. Golden et al. (2007) found that livestock-related damage and water diversion were the most common causes of disturbance at study springs in east-central Nevada and west-central Utah, and that at least one of these disturbances was present at 96 % of evaluated sites, and both of which were present at half of the sites. For example, they found that portions of every aquatic system they evaluated in Snake Valley had livestock impacts, with the exception of exclosed areas (Golden et al. 2007). Sada (2006b) found that of 46 sites surveyed for springsnails in Northern Steptoe Valley in 2005, 43 were moderately to highly disturbed by livestock.

Frest and Johannes (1995) identify grazing as a major factor causing mollusk extirpation (p. 54). They refer to grazing as “an extremely severe problem, especially in sensitive habitats.” They state:

> “We know of no instances in which moderate to heavy grazing can be said to have improved or allowed to remain stable either diversity or abundance of either terrestrial or aquatic mollusks, and literally thousands of sites at which reduction or extirpation has taken place” (p. 63).

They thus suggest, “To ensure survival of sensitive species, grazing should not be allowed at all at significant colony sites” (p. 64).

Springsnails and their habitat can be damaged not only by domestic livestock grazing, but also by feral horses and burros. The Nevada Wildlife Action Plan (Nevada Dept. of Wildlife 2006) states:

> “Improper grazing by cattle can cause significant damage by eliminating riparian vegetation and/or trampling (leading to topsoil loss during rainfall and snowmelt events, and to “sealing” of the spring in areas with high clay content). The same impacts can also occur with wild horse and burro use.”

Red Spring, home to the petitioned species *P. deaconi*, was degraded by burro use prior to the construction of fencing (USDI 2003, p. 38). BLM documents provided to the Center for Biological Diversity in response to a Freedom of Information Act request state:

> “There is a bad smell of burro urine throughout the upper end of (Red) Spring. Burros continue to use the spring source as a watering hole. Continued use at this site could lead to habitat degradation to springsnail habitat” (Patrick Putnam, April 18, 2002).

BLM management actions at Red Spring have since reduced burro use and the spring is recovering.

Thirty-two of the petitioned species occur on federal grazing allotments, as determined by using GIS to overlay springsnail location data from the Nevada Natural Heritage Program with BLM and FS grazing allotments (Table 3).

Table 3. Petitioned species which occur on federal grazing allotments. (Determined by using GIS to overlay springsnail location data from the Nevada Natural Heritage Program with grazing allotments).

Latin Name	Common Name	BLM Allotment(s)	FS Allotment
Pyrgulopsis aloba	Duckwater Pyrg	Duckwater	
Pyrgulopsis anatina	Southern Duckwater Pyrg	Duckwater	
Pyrgulopsis anguina	Longitudinal Gland Pyrg	Clay Springs, Hamlin Valley	
Pyrgulopsis avernalis	Moapa Pebblesnail	Arrow Canyon	
Pyrgulopsis breviloba	Flag Pyrg	Sunnyside, Wilson Creek	
Pyrgulopsis carinifera	Moapa Valley Pyrg	Arrow Canyon	
Pyrgulopsis coloradensis	Blue Point Pyrg	White basin	
Pyrgulopsis deaconi	Spring Mountains Pyrg	Spring Mountain, Wheeler Wash	
Pyrgulopsis gracilis	Emigrant Pyrg	Hardy Springs	
Pyrgulopsis isolata	Elongate-gland Springsnail	Carson Slough	
Pyrgulopsis landyei	Landyes Pyrg	Steptoe	
Pyrgulopsis lata	Butterfield Pyrg	Sunnyside	
Pyrgulopsis lockensis	Lockes Pyrg	Sand Springs West	
Pyrgulopsis marcida	Hardy Pyrg	Cave Valley Ranch, Hardy Springs, Sunnyside	
Pyrgulopsis merriami	Pahranagat pebblesnail	Forest Moon, Hardy Springs, Pahranagat East, Sunnyside	
Pyrgulopsis montana	Camp Valley Pyrg	Wilson Creek	
Pyrgulopsis neritella	Neritiform Steptoe Ranch Pyrg	Steptoe	
Pyrgulopsis orbiculata	Sub-globose Steptoe Ranch Pyrg	Steptoe	
Pyrgulopsis papillata	Big Warm Spring Pyrg	Duckwater	
Pyrgulopsis peculiaris	Bifid Duct Pyrg	Antelope, Tatow, D-x, Hamlin Valley	Scipio (Utah)
Pyrgulopsis planulata	Flat-topped Steptoe Pyrg	Heusser Mountain	
Pyrgulopsis sathos	White River Valley Pyrg	Forest Moon, Sunnyside	
Pyrgulopsis saxatilis	Sub-globose Snake Pyrg	Warm Creek	
Pyrgulopsis serrata	Northern Steptoe Pyrg	Currie, Indian Creek, Spruce	
Pyrgulopsis sterilis	Sterile Basin Pyrg	Ralston	Stone Cabin
Pyrgulopsis sublata	Lake Valley Pyrg	Geyser Ranch	
Pyrgulopsis sulcata	Southern Steptoe Pyrg	Heusser Mountain, Steptoe	
Pyrgulopsis turbatrix	Southeast Nevada Pyrg	Mount Sterling, Spring Mountain	
Pyrgulopsis villacampae	Duckwater Warm Springs Pyrg	Duckwater	
Tryonia clathrata	Grated Tryonia	Arrow Canyon, Hardy Springs, Pahranagat East, Sunnyside	
Tryonia monitorae	Monitor Tryonia	Potts	
Tryonia variegata	Amargosa Tryonia	Carson Slough	

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

Although very minor compared to other threats such as groundwater withdrawal and spring diversion, the improper collection of springsnails for scientific and educational purposes could potentially contribute to species decline, especially in conjunction with other factors. We recognize that sampling is critical for gaining information on species biology and that the threat posed by collection is currently minor compared to habitat degradation and loss. We advocate that steps be taken to prevent unauthorized collection, and that authorized collection be minimal.

Martinez and Sorensen (2007) evaluated the effects of sampling without replacement on aquatic organisms. They measured density and population size of *Heterelmis* sp. (riffle beetles) and *Pyrgulopsis morrisoni* (a springsnail) over four sampling periods during the course of a year at a spring in central Arizona. Their analysis showed a stark decline in the total population size of both *P. morrisoni* and *Heterelmis* sp. in response to sampling without replacement. They state, "We believe this decline was a direct consequence of removing a significant number of individuals from a relatively closed system." Encouragingly, *P. morrisoni* was locally abundant again during the following year. They suggest:

> "Spring ecosystems are affected by several anthropogenic stressors including livestock grazing, water consumption, water diversion, contaminants, recreation, exotic species, spring manipulation, and wildland fire (Williams et al. 1985, Shepard 1993, Myers and Resh 1999, Lang 2002, Sada et al. 2005). Ecological studies should not contribute additional stress. Isolated populations of endemic aquatic invertebrates may be resilient to transitory population declines. However, until more is known about fecundity, recruitment rates, and natural population fluctuations, it may be prudent to employ sampling methods that do not remove significant numbers of individuals" (Martinez and Sorensen 2007).

Unauthorized collection is a threat for those species which occur in high-recreation use areas. For example, Rash (2001) documents unauthorized collection of invertebrates at Lost Creek Spring, home to the petitioned species *P. turbatrix* (p. 4).

Some groundwater development projects include invertebrate sampling in the monitoring criteria. This sampling could pose a direct threat to the petitioned springsnails (and other endemic species) if it is conducted in an ecologically insensitive manner or if organisms are collected as part of the monitoring process. Because some of the petitioned species must be killed in order to be identified to the species level, even well-intentioned repeated surveys and monitoring could ultimately contribute to species decline.

C. Disease or predation:

Springsnails are key components of the food web, grazing on periphyton and detritus and in turn being consumed by other invertebrates, crayfish, fish, amphibians, reptiles, birds, and small mammals (Churchfield 1984, Hershler 1984, Taylor 1987, Myler 2000, Mladenka and Minshall 2001, Hurt 2004, Johnson et al. 2007, Brown et al. 2008). Although the petitioned species are naturally preyed upon, to the extent that these species have been reduced by other factors, natural predation could magnify the risk of extinction.

The invasion of exotic species increases the risk of both increased predation and disease introduction for springsnail populations.

D. Other natural or human caused factors:

Invasive Species

Species invasions are known to have contributed to the decline of native mollusks in the United States (Strayer 1999, Lydeard et al. 2004). The negative effects of invasive mussels are well-known, but freshwater snails and spring environments have received much less attention (Brown et al. 2008). Considerable numbers of non-native species have been introduced into spring environments, both intentionally and inadvertently (Hendrickson and Minckley 1984, Sada and Vinyard 2002). At least fifty nonnative fish taxa and several invertebrate taxa have been introduced into aquatic communities in the Great Basin (Sada and Vinyard 2002). Nonnative aquatic species were introduced to the Great Basin from other parts of North America and from Europe, Asia, Africa, and South America, and many of these introduced species are now widespread (Deacon and Williams 1984, Sigler and Sigler 1987, Sada and Vinyard 2002).

Various actions over the past two centuries have made desert ecosystems more vulnerable to invasion by nonnative species. For example, concerning Spring Valley in Nevada, Charlet (2006) states:

> "Ecosystems of Spring Valley, like most valleys in Nevada, are stressed (Brussard et al. 1999). Overgrazing, particularly during the late 1800s (Young and Sparks 1985, Charlet 2006), water diversions, and groundwater pumping have weakened the plant communities. The weakened state makes them susceptible to invasion by alien invasive weeds, especially cheatgrass (*Bromus tectorum*) in neutral soils and halogeton (*Halogeton glomeratus*) in more saline soils" (p. 17).

Sada and Vinyard (2002) found that 58% of evaluated endemic Great Basin aquatic taxa had declined due to invasion of nonnative species. Golden et al. (2007) found that non-native species of vegetation, invertebrates, amphibians, or fish were present at over 63% of springs evaluated for the Southern Nevada Water Authority's Clark, Lincoln, and White Pine County groundwater development project. Sada and Nachlinger (1996) found 33 exotic plant species and two exotic vertebrates in riparian areas in the Spring Mountains. The habitat of many of the petitioned species is known to have been degraded by exotic species. For example, Ash Spring and Crystal Spring, home to the Grated Tryonia and Pahranagat Pebblesnail, are known to have nonnative flora and fauna including nonnative fishes. Likewise, Apcar Spring, where the Moapa Pebblesnail, Moapa Valley Pyrg, and Grated Tryonia occur "is currently overgrown with non-native vegetation and requires stream restoration throughout the entire unit" (USDI 2006b, p. 57).

Invasive plants can harm native springsnails by displacing native vegetation and altering the physicochemical environment, microhabitat conditions, water quality, food availability, contaminant cycling, and ecological processes (Strayer 1999, Fleishman et al. 2006). Many invasive plant species are known to occur in the habitat of the petitioned species including Purple loosestrife (*Lythrum salicaria*), Red brome (*Bromus rubens),* Cheatgrass (*Bromus tectorum),* Mediterranean grass (*Schismus* sp*.),* Salt cedar (*Tamarix ramosissima),* Russian olive (*Elaeagnus angustifolia),* Russian knapweed (*Acroptilon repens),* Perennial pepperweed (*Lepidium latifolium),* Whitetop (*Lepidium draba)*, Redstem filaree (*Erodium cicutarium),* Sahara mustard (*Brassica tournefortii),* Canada thistle (*Cirsium arvense*), and Russian thistle (*Salsola tragus)* (Sada 1990, Nevada Dept. of Wildlife 2006, Golden et al. 2007, USDI 2008, KSV FEIS, p. 3-35).

Invasive animals can prey on native snails, compete with them directly and indirectly for resources such as food and space, act as vectors for disease and parasite introduction, and alter ecosystem function (Strayer 1999, Sada et al. 2005, Brown et al. 2008, Lysne et al. 2008). Several introduced invertebrate species are widespread in the Great Basin, including Asian clams *(Corbicula manilensis*), red-rimmed melania snails (*Melanoides tuberculata*), and crayfishes *(Procambarus* sp. and *Pacifastacus leniusculus*).The red-rimmed melania snail may contribute to declines in native springsnail populations, and is known to be present at some of the springs supporting petitioned species (Hershler and Sada 1987, Pointier et al. 1993, de Marco 1999, Golden et al. 2007). Other nonnative species known to be present at springs supporting petitioned species include bullfrogs (*Rana catesbeiana*), mosquitofish (*Gambusia affinis*), goldfish (*Carassius auratus)*, tilapia (*Tilapia* sp.), sailfin mollies (*Poecilia latipinna*), and introduced sport fish including rainbow trout (*Oncorhynchus mykiss*) and largemouth bass (*Micropterus salmoides*). (Hershler and Sada 1987, Sada 1990, USDI 2006b, Golden et al. 2007, BLM undated Red Rock Canyon survey documents). Feral horses and burros could also negatively impact springsnails by modifying spring vegetation and morphology (Sada et al. 2005). Sada (1990) reports that herds of wild horses altered spring morphology and impacted endemic plant and snail populations at Ash Meadows, where ten of the petitioned species occur.

Whether intentional or inadvertent, the introduction of exotic species into spring environments could have serious negative consequences for native springsnails. For example, Rash (2001) states:

> "Unrestricted access into the Lost Creek Spring aquatic habitat will leave *Pyrgulopsis turbatrix* exposed to the risk of catastrophic stochastic population loss, such as could result from the introduction of a single water chemistry-altering substance or non-native predatory species" (p. 5).

The Nevada Wildlife Action Plan states:

> "The introduction of nonnative aquatic organisms into spring and springbrook habitats, particularly the establishment of thermally tolerant invasive species into warm and thermal spring systems, has significantly impacted resident endemic species through competition and predation and represents the single greatest threat to a number of the aquatic species of conservation priority. The establishment of emergent invasive plant species such as cattails and Phragmites in spring pools and outflows has severely modified and altered some spring habitat and flow characteristics" (Nevada Dept. of Wildlife 2006, p. 199).

Concerning the threat of invasive species to Great Basin springsnails, Hershler (1998) states:

> "Exotic biota also may pose a serious threat to these populations (Great Basin springsnails), particularly crayfish, which have been widely introduced into the region's waters (Bouchard 1978, Johnson 1986) and, although omnivorous, often feed on small gastropods (Covich 1978, Vermeij and Covich 1978). An Asiatic gastropod, *Melanoides tuberculata*, now thrives in many of the warm springs of the Great Basin and may be displacing native prosobranch snails here and elsewhere in the West (Murray 1970, Williams et al. 1985), although rigorous documentation of this phenomenon and elucidation of its mechanism are lacking."

Anthropogenic changes in flow regimes can accelerate the invasion of non-native species in moist environments such as springs (Eby et al. 2003). Further, reductions in flow, such as those that could occur due to groundwater pumping projects, can magnify the negative effects of invasive species on aquatic organisms, especially in the small spring environments which are home to the petitioned species. Deacon (2007) states:

> "Reduction in flow reduces opportunities for niche partitioning. This means that fewer species will be able to coexist. The effect is especially problematic with respect to introduced species. Therefore, native species may be able to coexist with introduced species in relatively large habitats, but become increasingly vulnerable to extinction as habitat size diminishes."

Habitat disturbances, such as cattle grazing, foster the invasion of non-native vegetation. Fleishman et al. (2006) found that overall intensity of disturbance significantly affected species richness of native wetland plants. For example, in the Spring Mountains near Las Vegas, native plant cover and species richness of native plants decreased as intensity of disturbance increased (Ibid).

Freshwater gastropods and their habitats can be harmed by invasive species through both direct and indirect effects. Ironically, ecological restoration activities to control invasive species could also potential harm springsnails via pesticide contamination or direct crushing.

Global climate change is expected to accelerate the spread of invasive species (Field et al. 2007). For example, as the result of increased precipitation and atmospheric carbon dioxide during the growing season, invasive plants such as cheatgrass are expected to expand in southern Nevada (USDI 2008 KSV FEIS p. 4-51).

Global Climate Change

Global climate change poses a significant threat to the petitioned springsnails due to potential increased frequency and intensity of drought, altered precipitation patterns, shifting ecological zones, decreased groundwater levels and increasing demand for freshwater.

Both the frequency and intensity of drought in the United States is expected to increase due to climate change (Field et al. 2007, Cook et al. 2008). Drought has already become more frequent and intense in the western United States, and vulnerability to extended drought is increasing as limited water resources are over-allocated due to population growth, economic development, and increasing agricultural, municipal, and industrial uses (Field et al. 2007). Drought could reduce spring discharge, which would significantly threaten the petitioned species as water quality parameters change or worse, springs dry up entirely. Hurt (2004), states:

> "Spring outflows can vary greatly depending on levels of precipitation and groundwater pumping; these fluctuations are likely to have a large effect on springsnail numbers (Myers & Resh 1999)."

In addition, springsnails are dependent on very specific microhabitat conditions and it is predicted that climate change will cause changes in hydrology, water chemistry, riparian vegetation, and food availability for aquatic organisms (Strayer 2006, Sada 2008).

Climate change is expected to alter precipitation patterns in the western United States. Although total precipitation may actually increase in the desert, more precipitation will fall as rain instead of snow, reducing winter snowpack. Warmer temperatures will cause snow to melt earlier in the spring, and this earlier melting combined with decreased snowpack will diminish late spring and summer flows (Intergovernmental Panel on Climate Change 2001, Field et al. 2007). These changes in precipitation patterns could impact groundwater recharge which in turn could affect water levels at the springs on which the petitioned snails depend. For example, winter precipitation and late spring snowmelt, rather than summer precipitation, have been shown to be the principal sources of recharge in the fractured carbonate rock of the Spring Mountains (Winograd et al. 1998).

The changing climate will likely cause ecological zones to shift upward in latitude and altitude and species' persistence will depend upon, among other factors, their ability to disperse to suitable habitat (Peters and Darling 1985). Aquatic snails, however, have very poor dispersal abilities and are highly unlikely to be able to adjust their ranges (Frest and Johannes 1995, Hurt 2004). Strayer (2006) concludes:

> "Thus, we can expect climate change to endanger or extinguish many species of freshwater invertebrates in the coming century, especially those that disperse slowly and are not dispersed by humans."

Climate change is also expected to facilitate the spread of exotic species, as discussed in the previous section.

Inherent Vulnerability of Isolated Springsnail Populations

Springsnails have several inherent characteristics which magnify their risk of extinction. Isolated populations are vulnerable to extirpation due to limited gene flow and increased risk of extinction from stochastic demographic and natural events (Allee et al. 1949, Goodman 1987, Lacy 1987, Brussard and Gilpin 1989, Hanski et al. 1996). Most endemic springsnail species exist at only one to a few springs, and their populations tend to be highly concentrated, which increases the probability that a disturbance could lead to extirpation (Frest and Johannes 1993). Sada and Vinyard (2002) reviewed the status of endemic Great Basin aquatic taxa and found that all of the extinct taxa and the majority (68 %) of taxa experiencing major decline had narrow distributions, with less than five populations each. They conclude, "This indicates that taxa with limited distribution are acutely vulnerable to catastrophic changes in status."

Springsnails have very poor dispersal abilities, and are unable to relocate when faced with habitat degradation. In the event of population extirpation, rescue is unlikely to impossible. Further, because most springsnails live for only one year and reproduce only once, a single year of precluded recruitment could extirpate a population. Severe population crashes could be irreversible and maintaining existing populations is critical to ensure population survival (Frest and Johannes 1993, Lande 1993, Hanski et al. 1996, Taylor 2003).

E. Inadequacy of existing regulatory mechanisms:

None of the 42 petitioned springsnail species have legal protective status, and all of them are imperiled or critically imperiled (NatureServe 2008).

Federal Status

Twelve of the petitioned springsnail species were former Category 2 Candidate species for protection under the Endangered Species Act, but with the elimination of the Category 2 designation, the species lost their status (USDI 1994, 1996). The former candidate species are: *Pyrgulopsis crystalis*, *P. erythropoma*, *P. fairbanksensis*, *P. isolatus P. merriami, P. nanus, P. pisteri, Tryonia angulata, T. clathrata, T. elata, T. ericae,* and *T. variegata.* The former status of these species as Candidates verifies that FWS had substantial scientific information to justify their protection as threatened or endangered species. Since that time, the threats to these species, and the rest of the petitioned springsnails, have been magnified rather than alleviated.

Federal Land Designations

National Wildlife Refuges

Sixteen of the petitioned snail species occur on National Wildlife Refuges (NWR). The Desert National Wildlife Refuge Complex includes four refuges in southern Nevada including Ash Meadows NWR, Desert NWR, Moapa Valley NWR, and Pahranagat NWR.

Ash Meadows is located in the Amargosa Valley of southern Nye County and consists of over 24,000 acres of spring-fed wetlands and alkaline desert uplands which support one of the highest concentrations of endemic species in North America. Ten of the petitioned springsnails occur at Ash Meadows—*Pyrgulopsis crystalis, P. erythropoma, P. fairbanksensis, P. isolata, P. nanus, P. pisteri, Tryonia angulata, T. elata, T. ericae,* and *T. variegata.* The Desert NWR was established in 1936 and encompasses 1.5 million acres of the Mojave Desert. The Corn Creek Pyrg, *P. fausta*, and the Southeast Nevada Pyrg, *P. turbatrix*, occur at the Desert NWR. Moapa Valley NWR, 116 acres located in northeastern Clark County, was established to protect the endangered Moapa dace (*Moapa coriacea*), a small endemic fish present only in the headwaters of the Muddy River system. Three of the petitioned species occur at Moapa Valley NWR—*Pyrgulopsis avernalis, P. carinifera,* and *Tryonia clathrata.* Pahranagat NWR provides over 5,000 acres of habitat for migratory waterfowl in Lincoln County. *Pyrgulopsis merriami* and *Tryonia clathrata* occur at the refuge.

National Wildlife Refuges are managed by U.S. Fish and Wildlife Service. The southern Nevada refuges are managed under the Desert National Wildlife Refuge Comprehensive Conservation Plan (USDI FWS 2008). The species that occur on National Wildlife Refuges enjoy some degree of habitat protection because NWRs are managed primarily to conserve fish, wildlife, and plant resources. However, the species are still threatened with extinction for several reasons.

Springsnail conservation is generally not given high conservation priority, and even when it is identified as a priority, conservation actions are limited by available funding and staffing. For example, one of the management goals in the conservation plan for Ash Meadows National Wildlife Refuge is to restore and maintain viable populations of all endemic species (USDI FWS 2008, p. S-12). The plan acknowledges, however, that conservation plans provide guidance for planning and management decisions but do not constitute a commitment for staffing or funding (USDI FWS 2008, p. S- 2). The Desert National Wildlife Refuge Comprehensive Conservation Plan (USDI FWS 2008) states that current refuge budget and staffing levels are not adequate to implement preferred management actions (p. S-17). Due to lack of fiscal resources, the implementation of conservation actions that would benefit springsnails is uncertain.

Other factors also jeopardize springsnail populations on National Wildlife Refuge lands. Prior to refuge designation, aquatic habitats were degraded by recreation, spring diversion, grazing, development, and other activities. At Ash Meadows, for example, the conservation plan (USDI FWS 2008) states:

> "Many of the Refuge's seeps, springs, pools, and streams supporting sensitive species have been destroyed or altered by human activities over the last 100 years. Habitat alterations during agricultural, municipal, and mining development caused the extinction of one fish species, at least one snail species, and possibly an endemic mammal species" (p. S-11).

Aquatic habitats at Moapa Valley NWR were historically degraded by recreation, including swimming, and are still in the process of restoration (USDI FWS 2008). Invasive species that threaten springsnails are known to be present in aquatic refuge habitats including invasive snails, crayfish and fishes (e.g. USDI FWS 2008, p. 4-65). Although livestock grazing is now prohibited on lands in the Desert NWR Complex, grazing by feral horses and burros can also degrade springsnail habitat.

Federal land designations do not protect the petitioned springsnails from habitat degradation due to altered spring flow caused by climate change or groundwater pumping. Deacon et al. 2005 states:

> "Protection afforded by surface-land refuge designations may be inadequate to protect biodiversity and to counteract threats to aquifers posed by water withdrawal."

Massive groundwater withdrawal proposed by the Southern Nevada Water Authority (SNWA) and other users could jeopardize discharge at springs in the Desert NWR Complex, because spring discharge in the refuges is influenced by groundwater levels. The Desert National Wildlife Refuge Comprehensive Conservation Plan (USDI FWS 2008) states:

> "Each of the four refuges can be characterized by an interaction between springs discharging from the regional carbonate aquifer, groundwater stored in local alluvial aquifers, and surface flow as a result of spring discharge and precipitation. Groundwater originates as high-altitude winter precipitation in the higher mountain ranges (such as the Spring and Sheep Ranges) and can flow great distances through the carbonate rocks that make up the mountain ranges and underlie the valleys (Thomas et al. 1986). The major springs associated with the Desert Complex are part of several large regional groundwater flow systems, including the Death Valley regional groundwater flow system, which consists of multiple interconnected basins that transfer groundwater to and from adjacent basins (Bedinger and Harrill 2004) . . . For this reason, surface water resources within each of the four refuges can be affected by uses elsewhere within the same flow systems" (p. 4-8).

The SNWA, the U.S. Air Force, the Las Vegas Paiute Tribe, and other users all hold water rights that could affect spring discharge in the Desert NWR Complex (USDI FWS 2008). For example, the Moapa NWR is in the Muddy River watershed, where surface flows have been declining since the early 1960s, likely due to surface water diversions and nearby groundwater pumping (USDI FWS 2008, p. 4-74) and projects are ongoing that are known to be detrimental to habitat at the refuge. U.S. Fish and Wildlife Service (FWS) determined that the withdrawal of 16,100 afy of groundwater from the White River Flow system of the regional carbonate aquifer in Coyote Spring Valley and the California Wash is likely to adversely affect the endangered Moapa Dace (*Moapa coriacea*) at the Moapa NWR (USDI 2006b):

> "The Moapa dace will be directly affected by the proposed groundwater withdrawals since those actions are likely to affect the spring flows upon which the dace depends" (USDI 2006b, p. 44).

Three of the petitioned species occur in the same area as the dace—the Moapa Pebblesnail (*P. avernalis*), Moapa Valley Pyrg (*P. carinifera*), and Grated Tryonia (*Tryonia clathrata*). In response to the groundwater project, FWS issued a programmatic Biological Opinion and Memorandum of Agreement (MOA) to establish conservation measures for the dace (USDI 2006b). Action items identified in the MOA include restoration of dace habitat, eradication of non-native fish, development of a study to determine the effects of pumping on aquatic species in the Muddy River system, dedication of 460 afy of groundwater in perpetuity for the dace, and the development of a recovery program, among other measures. The MOA includes minimum in-stream flow levels at Moapa Valley National Wildlife Refuge (MVNWR) that would trigger conservation actions if surface flows drop below a certain level. These actions could provide some protection for the populations of *P. avernalis, P. carinifera,* and *T. clathrata* that occur in the MVNWR to the extent that protected locations and conditions that support the fish correspond to the needs of the three springsnail species. Still, these measures are not adequate to protect the springsnails because their entire range is not within refuge boundaries, it is unknown whether protecting flows for the fish will also protect flows for the snails or whether the level of flow sufficient to maintain habitat for the fish would also maintain microhabitat conditions suitable for the physiological requirements of the snails. Sada (2008) states, "[S]pringbrook restoration designed solely for Moapa dace may not provide sufficient heterogeneity for springsnails." Further, the loss of snails wouldn't trigger the conservation actions, and the snails could be extirpated before the actions are implemented.

National Wildlife Refuges can only provide refuge for springsnails if water remains in their springs. Thus, even the springsnail species which occur on NWR lands need the effective protection of the Endangered Species Act to safeguard surface water flows at the springs on which they depend for survival.

National Recreation and Conservation Areas

Three of the petitioned species occur in National Recreation or National Conservation Areas. The Blue Point Pyrg, *P. coloradensis*, occurs in the Lake Mead National Recreation Area which is administered by the National Park Service. Lake Mead is managed to "protect the natural environment and support the recreational interests of park visitors" (USDI NPS 2003 p. 3). The Lake Mead Management Plan Final Environmental Impact Statement (2003) does not discuss springsnails. *Pyrgulopsis deaconi* and *P. turbatrix* occur in the Spring Mountains National Recreation Area which is administered by the Forest Service. The Spring Mountains National Recreation Area is located just outside Las Vegas, and spring habitats there are particularly vulnerable to recreational impacts. The 1996 Spring Mountains National Recreation Area General Management Plan and 1998 Conservation Agreement between the Forest Service, Fish and Wildlife Service, and Nevada Dept. of Conservation and Natural Resources contain guidelines to promote the conservation of endemic and sensitive species at the ecosystem level and to maintain viable populations of all native species in their natural habitats in the Spring Mountains. These broad guidelines provide theoretical protection for springsnail species, but the implementation and effectiveness of actual tangible protections for springsnails is uncertain.

Pyrgulopsis deaconi and *P. turbatrix* also occur in the Red Rock Canyon National Conservation Area which is administered by the Bureau of Land Management. The Resource Management Plan for the Red Rock Canyon National Conservation Area was finalized in 2005 and describes management actions to conserve, protect, and enhance the endangered species, wilderness characteristics, unique geological, archeological, ecological, cultural, and recreation resources that are encompassed within the recreation area. Management prescriptions include protection of natural habitats including sensitive wildlife and plants and riparian areas, and population monitoring of Special Status Species. Red Rock Canyon is located just outside Las Vegas and receives over a million visitors per year, which poses a serious risk to these species as recreation tends to concentrate around spring environments. The Red Rock Canyon management plan includes actions to protect springsnail species from recreational impacts, including riparian area enhancement and fencing which, if enacted, could provide significant protection for these species from the impacts of recreation and grazing. However, the springs at which these species occur are still vulnerable to desiccation due to groundwater development outside of their protected area.

Federal Management Plans

Memorandum of Understanding Concerning the Conservation of Springsnails in the Great Basin

In 1998 the U.S. Forest Service, Bureau of Land Management, National Park Service, Geological Survey, Fish and Wildlife Service, the Smithsonian Institution, and The Nature Conservancy signed a Memorandum of Understanding Concerning the Conservation of Springsnails in the Great Basin (MOU). The purpose of the MOU was to facilitate cooperation and participation among the parties to conserve springsnails and their habitats on federal and Nature Conservancy land throughout the Great Basin. The signatories agreed to "work cooperatively to gather information and work towards the conservation of springsnails and their habitats." The MOU did not require the protection of springsnails or their habitat, and was subject to the availability of personnel and funding. The MOU expired in 2003.

Southern Nevada Public Land Management Act

The Southern Nevada Public Lands Management Act (SNPLMA) was enacted by Congress in 1998. It included the sale of 27,000 ac of scattered federal urban lands in Las Vegas Valley to fund the development and provisions of the Clark County Multi-Species Habitat Conservation Plan (CCMSHCP), the acquisition of environmentally sensitive property, and other measures. The provisions the Clark County MSHCP which pertain to springsnail conservation are discussed below under Regional Management Plans.

BLM Programs and Resource Management Plans

Special Status Species Program

Thirteen of the petitioned species are included in the Bureau of Land Management's Special Status Species Program-- *Pyrgulopsis aloba, P. anatina, P. deaconi, P. hamlinensis, P. landyei, P. orbiculata, P. papillata, P. peculiaris, P. saxatilis, P. sulcata, P. villacampae, Tryonia clathrata,* and *T. variegata.* The objective of the Special Status Species Program (SSSP) is to ensure that actions approved, authorized or funded by BLM do not contribute to the need to list species under the Endangered Species Act. The SSSP requires coordination with state and other federal agencies to achieve conservation goals of species, but does not require the selection of environmentally benign alternatives and does not provide any mandatory or enforceable protection for special status species or their habitat. Any protections afforded to species under the SSSP are at the discretion of the Line Officer (BLM Manual 6840). Thus, the provisions of the SSSP do not adequately protect the petitioned springsnail species.

Ely District Resource Management Plan

The BLM Ely District Resource Management Plan (RMP) and Environmental Impact Statement provides a framework for the management of lands under BLM jurisdiction in Lincoln and White Pine counties and a portion of Nye County in east-central Nevada. This management plan affects 10 of the petitioned species which potentially occur on BLM lands in the planning area—*Pyrgulopsis aloba, P. anatina, P. deaconi, P. landyei, P. orbiculata, P. papillata, P. peculiaris, P. sulcata, P. villacampae,* and *Tryonia clathrata* (USDI BLM 2007, Table E-1). The RMP provides broad management goals and guidelines but lacks specific, enforceable mechanisms to protect springsnail species.

In terms of the protection of water resources, the preferred alternative under the RMP calls for the achievement of the goals of the water resources program, including proper functioning condition of wetlands and riparian areas, and achievement of state water quality standards (USDI BLM 2007, p. ES-xiii). For aquatic invertebrates, the plan contains basic occurrence information for BLM Sensitive springsnail species, but acknowledges that systematic surveys, frequent sampling, and trend information are lacking (p. 3.7-11). The RMP states that "maintenance of habitat through protection of springs and their associated stream segments currently are part of management for native spring-dependent species" (p. 3.7-11). RMP management actions include conducting springsnail surveys prior to the development of any spring sources, but do not require that sites where springsnails are detected be protected (p. 2.4-18).

In terms of the threats specific management actions pose to springsnails, the RMP mentions threats in a very broad way and does not require specific actions to protect springsnail species. For example, the plan states that springsnails could be affected by: horse use and herd management areas, renewable energy development, vehicle use, mining, noxious weed treatment, transportation, recreation, grazing, wood-product harvesting, and mineral extraction (pp. 4.7-14, 21, 23, 34, 44, 54, 56, 57, 58, 68, 79), but does not discuss specific protections for springsnail species.

The RMP does restrict livestock grazing in certain areas which would afford springsnails in those areas some habitat protection (p. 4.7-30, 67). The plan also contains provisions to monitor rangeland health and conduct allotment evaluations and watershed analyses (p. 3.16-7). The RMP predicts that springsnail habitat will improve as the result of watershed assessments, grazing restrictions and habitat restoration:

> "[C}urrent trends in water bodies would continue until habitat restoration is implemented. Habitat for springsnails would improve at scattered spring locations throughout the planning area, with the timing of improvements depending on the schedule of the various watershed assessments and subsequent treatments" (4.7-60).

The RMP does not make protection of springsnail habitat a high priority action. Rather, springsnails are expected to benefit from actions taken to improve habitat for other species, with federally listed species having the highest priority for protective actions (p. 4.7-6). Springsnail habitat is not targeted for direct protection, such as would occur if the species were protected under the Endangered Species Act.

Rather than prohibiting degradation to Special Status springsnail habitat, the plan includes the mitigation goal of protecting two acres of comparable habitat for every one acre of habitat that is disturbed. The benefit to springsnails from this provision is questionable because of the high degree of endemism, extremely limited distribution, and poor dispersal capability of springsnail species. Degradation of even one acre of springsnail habitat could have dire consequences for the species that occurs there, and mitigation elsewhere would not benefit that particular species.

"Best management practices" are expected to avoid or minimize impacts to Special Status Species. The plan states:

> "The following beneficial impacts could result from these management actions: 1) maintain or increase population numbers by implementing recovery and habitat enhancement measures; 2) improve quality and increase quantity of habitat and population numbers as a result of the 2-to-1 mitigation ratio for disturbance to habitat for sensitive species; 3) improve water quality conditions involving turbidity levels by reducing or restricting surface disturbance" (p. 4.7-6).

These practices are not adequate to protect the petitioned species for several reasons. The recovery and habitat enhancement measures do not map and directly target springsnail habitat; rather, benefits to springsnails are expected to result indirectly as the result of enhancements for other species. The 2-1 mitigation ratio for habitat disturbance is unlikely to increase habitat quality and quantity for springsnails because of their extremely limited distribution. And, surface disturbance is not restricted or reduced in springsnail habitat specifically. The petitioned species need to be protected under the Endangered Species Act to effectively protect their habitat on BLM lands and on lands under other ownership.

Las Vegas District Resource Management Plan

The Bureau of Land Management Las Vegas District Resource Management Plan and Final Environmental Impact Statement (USDI BLM 1998) provides a framework for the management of lands under BLM jurisdiction in Clark and Southern Nye Counties. The plan does not discuss specific protections for springsnail species at all. Table B-2 contains a list of BLM Sensitive Species potentially occurring within the Las Vegas district, but none of the petitioned species are included on the list. It is unclear as to whether any petitioned species occur on BLM lands in the Las Vegas District, whether due to lack of occurrence of lack of data. Several species could potentially on BLM lands in the Las Vegas district including *Pyrgulopsis montana*, which occurs in the Meadow Valley Wash watershed, *P. fausta* and *P. turbatrix* which occur in the Las Vegas Wash, and *P. avernalis, P. carinifera*, and *Tryonia clathrata* which occur in the Muddy River system. The RMP states that *P. avernalis* occurs in Muddy River system, but does not mention *P. carinifera* or *T. clathrata* which are co-occurring species. The plan states that BLM has no management responsibility for the habitat of *P. avernalis* in the Muddy River system because it does not occur on lands under BLM jurisdiction (p. 3-41).

Although the RMP does not discuss springsnail conservation directly, several provisions are potentially applicable to springsnail conservation. In terms of riparian management, the plan states, "riparian enhancement actions would provide healthy riparian systems, providing habitat for a variety of wildlife species" (p. 4-18). The plan calls for riparian areas to be managed to maintain proper functioning condition and states that water quality is expected to improve as a result of protecting springs in allotments remaining open to livestock grazing and in herd management areas with horses and burro (p. 4-8). Grazing will continue to be authorized in the Muddy River area, but the installation of fencing is expected to reduce habitat contamination (p. 4-9). While these measures could protect springsnail habitat, they do not adequately protect the petitioned species due to lack of surveys and lack of directly targeting springsnail habitat for preservation. Further, the RMP cannot protect springs from habitat degradation due to groundwater development.

The groundwater system in Las Vegas Valley has been in overdraft since 1945, and all of the hydrographic basins wholly or partially within the Las Vegas BLM district have committed resources which exceed perennial yield (p. 3-17). Proposed groundwater development projects by the Southern Nevada Water Authority and other users will put more pressure on a system that already exceeds sustainable use, which could lead to spring failure of the habitat on which the petitioned species depend for survival.

State Land Designations

The Flag Pyrg, *P. breviloba*, occurs on the Wayne Kirch Wildlife Management Area (WMA). The primary management emphasis on WMAs is the protection of wetlands and migratory birds including the use of the areas as public hunting grounds. Springsnail conservation is not a direct goal of designated wildlife area management, and occurrence at this site does not adequately protect this species.

State Management Plans

Currently none of the petitioned springsnail species have state threatened or endangered status in Nevada or Utah.

Nevada Department of Wildlife

There are 58 springsnail species on the Species of Conservation Priority list of the Nevada Wildlife Action Plan including many of the petitioned species-- *Pyrgulopsis aloba, P. anatina, P. anguina, P. avernalis, P. breviloba, P. carinata, P. carinifera, P. crystalis, P. deaconi, P. erythropoma, P. fausta, P. fairbanksensis, P. gracilis, P. hubbsi, P. isolata, P. landyei, P. lata, P. lockensis, P. marcida, P. merriami, P. montana, P. nanus, P. neritella, P. orbiculata, P. papillata, P. peculiaris, P. pisteri, P. planulata, P. ruinosa, P. sathos, P. serrata, P. sterilis, P. sublata, P. sulcata, P. turbatrix, P. variegata, P. villacampae, Tryonia angulata, T. clathrata, T. elata, T. ericae,* and *T. variegata.*

Being a Species of Conservation Priority does not provide these springsnails with any tangible protections. The Nevada Wildlife Action Plan (Nevada Department of Wildlife (NDOW) 2006) is a guidance document for enhanced conservation, not a de facto regulatory document (p. 4). It does not contain mandatory or enforceable provisions to protect springsnails or their habitat. Further, there are no existing state conservation or monitoring plans for aquatic gastropods under the Wildlife Action Plan (NDOW 2006, p. 385).

Several objectives of the Wildlife Action Plan are pertinent to springsnail conservation. The Conservation Strategy objectives include maintaining healthy populations of aquatic Species of Conservation Priority, maintaining or restoring biological characteristics of special aquatic features, and no net loss of spring/springbrook-dependent Species of Conservation Priority. Actions include developing a public outreach program, managing invasive species, implementing existing recovery and conservation programs for spring dependent Species of Conservation Priority, and developing a regional Conservation Agreement and Strategy for isolated spring systems and spring dependent Species of Conservation (p. 201). If implemented, these objectives and actions would contribute to springsnail conservation, but their implementation and effectiveness are currently uncertain.

The Wildlife Action Plan is also inadequate to protect the petitioned springsnails because it cannot guarantee water rights for spring-dependent species. The Priority Research Needs of the plan include determining the impacts of groundwater withdrawals on a regional scale, evaluating groundwater interbasin connections and recharge intervals, and researching invertebrate adaptability to alterations in water level, water chemistry and other tolerance parameters. The prioritorization of these research needs indicates that the Department of Wildlife is aware of the potentially dire consequences of groundwater pumping for endemic aquatic species, but the Wildlife Action Plan does not have the regulatory authority to safeguard springflows.

Natural Heritage Programs

The Nevada and Utah Natural Heritage Programs maintain an inventory and database on the locations, biology, and conservation status of all threatened, endangered, and sensitive species and biological communities in Nevada and Utah and participate in and contribute to various species conservation strategies. The Natural Heritage Programs do not have any regulatory authority.

Utah Division of Wildlife Resources

The Utah Division of Wildlife Resources (UDWR) Comprehensive Wildlife Conservation Strategy (CWCS) was developed under the State Wildlife Grants program to restore and enhance wildlife populations and their habitat (Gorrell et al. 2005). The CWCS uses a three-tiered system to prioritize species based on conservation need. Four of the petitioned species, *Pyrgulopsis anguina, P. hamlinensis, P. peculiaris,* and *P. saxatilis*, are Tier II species. Tier II species are listed on the Utah Species of Concern List and lack federal status. The CWCS describes and prioritizes the most at risk species and habitat types in Utah, and identifies needed conservation actions. The Wildlife Conservation Strategy is not adequate to protect the petitioned species because it is not a regulatory document. Rather, the CWCS is a framework for conservation, the actual implementation of which is dependent on the cooperation of stakeholders and resource managers. The implementation and effectiveness of the strategy is thus uncertain, which the strategy acknowledges:

> "The voluntary nature of partner involvement in implementation does not ensure that partners will implement all of the conservation actions recommended in the CWCS. However, UDWR requested and received guidance from other resource management agencies and participation from the public and other stakeholders in the development of the CWCS. UDWR hopes that partners will be equally involved in implementing the plan's recommended conservation actions. How much of the CWCS is used by other agencies will be determined by their statutory requirements and within the permitted degree of discretion" (Gorrell et al. 2005, p. 6-76).

The Conservation Strategy discusses the threats to and needed conservation actions for four of the petitioned species. The Bifid Duct Pyrg (*P. peculiaris*) is affected by overgrazing, irrigation, and habitat degradation. Recommended conservation actions include: determine population status and trends, remove agricultural water downstream of habitat, and provide enclosures (Gorrell et al. 2005). The Hamlin Valley Pyrg (*P. hamlinensis*) is known from only one location and is negatively affected by livestock overgrazing. Conservation actions include determining population status and trends and providing enclosures. The Longitudinal Gland Pyrg (*P. anguina*) is negatively affected by grazing and irrigation. Conservation actions include protecting significant areas and providing enclosures. Conservation actions for the Sub-globose Snake Pyrg (*P. saxatilis*) include providing enclosures, determining population status and trends, and searching for additional sites (Gorrell et al. 2005). If implemented, these measures could provide protection for these species from the detrimental effects of livestock grazing, but are not adequate to protect the springsnails from other threats.

Utah Natural Resources Conservation Service

The Utah Natural Resources Conservation Service Action Plan (2006) "identifies conservation targets, major threats, and conservation actions for each target, and discusses opportunities for NRCS programs to help implement conservation actions" (p. 1). The Action Plan does not mention springsnails or the conservation of spring habitats.

State Engineer Approval and Perennial Yield

An overarching threat to the majority of the petitioned species is diminished or failed spring flow due to groundwater development. Although models vary, it is widely accepted that groundwater removal will adversely affect spring discharge (Schaefer and Harrill 1995, Myers and Resh 1999, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007). Several of the valleys where petitioned species occur already have existing water rights that exceed perennial yield, with more applications pending. Although groundwater applications must be approved by the State Engineer, permits are commonly issued for withdrawal in excess of perennial yield. Further, even if withdrawal was limited to perennial yield, the Nevada Division of Water Resources' definition of perennial yield does not provide for the maintenance of springs (Deacon et al. 2007).

Groundwater Development Stipulated Agreements

Stipulated Agreements for Spring Valley, Kane Springs Valley, and Delamar, Dry Lake, and Cave Valleys require monitoring to evaluate the impacts of pumping. The monitoring programs, however, are not adequate to protect the petitioned species from extirpation for several reasons. First and foremost, specific protections for springsnails are not included in the stipulated agreements. Because springsnails have very specific microhabitat requirements (Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008), and flow at springs where they occur is relatively constant with low temporal variability in discharge rate (Taylor 1985), populations are likely to be negatively affected not only by spring failure, but also by reduced flow and altered water quality.

Monitoring is intended to assess "ecosystem health," but this term is not defined, and there are no mechanisms to stop pumping if effects to biota are manifested. The monitoring stations won't reveal changes in flow at all springs where the petitioned species occur. Even at springs where discharge will be monitored, the standard for triggering mitigation measures does not necessarily correspond to the physiological needs of the springsnails, meaning discharge could drop below a level adequate to support springsnail species before flow was low enough to prompt intervention. Further, even if groundwater pumping were to be stopped, which is unlikely, it is unknown how affected springs will respond or if flow will resume. If springsnail species are extirpated due to reduced flow, the after-the-fact cessation of groundwater pumping will not benefit species that have already been driven to extinction.

Regional Management Plans

Clark County Multi-Species Habitat Conservation Plan

The Clark County Multi-Species Habitat Conservation Plan (MSHCP) provides a 30-year incidental take permit pursuant to section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (Act) to Clark County, the Cities of Las Vegas, North Las Vegas, Henderson, Boulder City, and Mesquite, and the Nevada Department of Transportation for two federally-listed threatened and endangered species, and 76 non-listed species of concern in the event these species become listed under the Act during the term of the permit. The permit authorizes the incidental take of the 78 species in connection with economic growth and development of up to 145,000 acres of non-Federal lands in Clark County. The Multispecies Plan is the direct outgrowth of provisions of the Desert Conservation Plan. The Southern Nevada Water Authority is a member of the Clark County Desert Conservation Plan Implementation and Monitoring Committee.

To minimize and mitigate the impacts of take of species, the Applicants propose to impose a $550-per-acre development fee and maintain an endowment fund that will provide up to $4.1 million per biennial period to fund conservation measures for covered species and to administer the Multispecies Plan. The plan includes measures to implement a public information and education program; purchase grazing allotments and interest in real property and water; maintain and manage allotments, land, and water rights which have been acquired; participate in and fund local habitat rehabilitation and enhancement programs; and develop and implement an adaptive management process that allows for responses to new information. Implementation of the conservation measures in the Multispecies Plan is a cooperative effort among the Applicants, Fish and Wildlife Service, Bureau of Land Management, U.S. Forest Service, National Park Service, Nevada Division of Wildlife, and other Federal and State land managers and regulators.

The MSHCP pertains to several of the petitioned species. *Pyrgulopsis deaconi* and *P. turbatrix* are covered species under the plan. *Pyrgulopsis avernalis, P. carinifera,* and *Tryonia clathrata* are Evaluation Species, and *P. fausta* and *P. coloradensis* are Watch List Species. Evaluation Species are species which could be added to the list of covered species once additional information and management prescriptions become available. Watch List Species are species for which adequate information is not available to assess population range, current status, or conservation potential or that are not considered to be at risk during the planning horizon of the MSHCP (Clark County 2000, p. 2-61).

The plan lists threats to the Spring Mountains Pyrg, *Pyrgulopsis deaconi*, as habitat degradation and modification resulting from concentrated recreation, degradation by wild horse and burro grazing and trampling, spring diversion and modification, and spring outflow diversion. The two extant springs where this species occurs are managed by the BLM and USFS to minimize the impacts of recreational activities. Existing and proposed conservation actions for this species include environmental education programs, riparian protection, restoration, and enhancement; and reestablishment of extirpated populations, and the development and implementation of a plan to monitor springsnail populations and habitats

(Clark County 2000, p. B-178). The MSHCP does not develop or mandate any new conservation measures for *P. deaconi*, but instead relies on existing management: "Implementation of existing management . . . should provide adequate conservation for this species" (p. B-178). However, there is no specific management plan in place for the Spring Mountains Pyrg (*P. deaconi*) or Southeast Nevada Springsnail (*P. turbatrix*) within the permit area. *Pyrgulopsis turbatrix* is managed under the general direction and sensitive species management guidelines of the Red Rock Canyon National Conservation Area General Management Plan and the Bureau of Land Management's Resource Management Plan (discussed above under Federal plans). *Pyrgulopsis deaconi* is managed under the Spring Mountains National Recreation Area General Management Plan and Conservation Agreement. These plans identify ecosystem and species-specific conservation actions, but do not provide the species with any regulatory protection.

The plan lists the threats to *P. turbatrix* as: reduction of population resulting from commercial collection, habitat modification and degradation from commercial collection, concentrated recreation, increased use of pesticides and herbicides, wild horse and burro grazing and trampling, and spring diversion and modification. Just as for the Spring Mountains Pyrg, the plan does not create or mandate any habitat protections for springsnails, rather it relies on existing management. Further, the conservation actions in the plan are recommended not required. Recommended conservation actions include public information and education, adaptive management including research, monitoring for trends, and inventories to assess the status of habitats and species, and land use policies and actions including habitat restoration and enhancement measures. Protective measure *may* include use restrictions and regulatory restrictions (p. 2-9). The spring species covered by the HCP are expected to benefit from general public education and information programs, the purchase, maintenance, and management of grazing allotments and water rights, funding of local rehabilitation and enhancement projects, funding or assistance in inventory, monitoring, and management activities, and increased interagency coordination of conservation activities.

The Clark County MSHCP is inadequate to protect the seven petitioned species which occur on lands under its provisions because it does not create or contain mandatory or enforceable regulations for springsnail conservation, and it does not address the threat posed to these species by spring fluctuation or failure due to groundwater development.

Concerning water development, the Biological Opinion on the MSHCP (USDI FWS 2000) states:

> "Future acquisition of water rights is not considered a federal action, and therefore not subject to Section 7 consultation. This action is reasonably certain to occur at an escalating rate as the population of Clark County continues to grow. Additional acquisition of water rights may result in depletion of ground water and/or instream flows, and may seriously impact listed covered species that are dependent on water from ground and or surface sources" (p. 6.1).

The protective measures for springsnails in the MSHCP are focused on recreation and grazing and will not protect the species habitat from degradation due to groundwater development.

In sum, there are no existing regulatory mechanisms that adequately protect the petitioned springsnails. Without the effective protection of the Endangered Species Act, these species are very likely to become extinct.

VI. Individual Species Accounts

This section provides information on the taxonomy, description, range, habitat requirements, status, known threats, and land management of the petitioned springsnails. The species' descriptions are not diagnostic; for full diagnostic characteristics, please refer to the primary literature (Hershler and Sada 1987, Hershler 1998, 1999, 2001). In terms of common names for the genus *Pyrgulopsis*, springsnail and pyrg are used interchangeably e.g., "Ash Meadows Springsnail" or "Ash Meadows Pyrg." Accounts are arranged alphabetically by valley location and then by species Latin name within each valley. Species that occur in more than one valley are described in the first alphabetical valley of occurrence.

For more detailed discussion of the effects of specific threats on springsnails, please refer to the Threats section above, beginning on page 21.

AMARGOSA DESERT

Ten of the petitioned species occur in the Amargosa Basin including *Pyrgulopsis crystalis, P. erythropoma, P. fairbanksensis, P. isolata, P. pisteri, P. nanus, Tryonia angulata, T. elata, T. ericae,* and *T. variegata.*

SPECIES

1. *Pyrgulopsis crystalis* Crystal Springsnail

Taxonomy. Family Hydrobiidae. Hershler and Sada 1987. Spelling in Federal Register is *cristalis*.

Description. The Crystal Springsnail is a small-sized snail with a globose-neritiform shell. The spire is very short and the aperture is broad and enlarged. The penis is simple with narrow filament and a large glandular ridge. It is 1.8 – 2.6 mm in height and has 3.0 – 3.5 whorls. The shell is colorless, transparent, and thin, and the periostracum is very light brown.

Range. The Crystal Springsnail is known only from Crystal Pool in Ash Meadows, Nye County, Nevada, Upper Amargosa watershed (Hershler 1994).

Habitat Requirements. Crystal Spring is a large, low-elevation spring where this species is "only found clinging to travertine walls of chasm-like orifices in the deepest (greater than 4 m) part of the spring" (Hershler and Sada 1987, p. 802).

Status. The Crystal Springsnail is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). The springsnail was once a Category 2 Candidate species (USDI FWS 1994), but was subsequently dropped as a Candidate due to the elimination of the Category 2 designation (USDI FWS 1996). It is on the Nevada Natural Heritage Program At-Risk Tracking List. The species occurs at only a single site and Hershler and Sada (1987) report that it is rare at this site. Existing regulatory mechanisms are completely inadequate to protect this species.

2. *Pyrgulopsis erythropoma* Ash Meadows Pebblesnail

Taxonomy. Family Hydrobiidae. Pilsbry 1899

Description. The Ash Meadows Pebblesnail is 1.6 – 2.4 mm in height and has three to four whorls. This snail is small-sized with a very short-spired globose-turbinate shell. The penis is simple with a small glandular ridge near the base on the dorsal surface (Hershler and Sada 1987).

Range. This springsnail is restricted to the Ash Meadows area of Nye County, Nevada, Upper Amargosa watershed, where it occurs at six springs, all within 0.5 km of each other, including King's Pool and Point of Rocks Springs.

Habitat Requirements. Sada (1990) describes the pyrg's habitat as rocky substrate in flowing thermal water. Hershler and Sada (1987) report that this species is found on stones and travertine in swift currents.

Status. The Ash Meadows Pyrg is ranked as critically imperiled globally and in Nevada meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). The species was proposed for listing as Threatened in 1976 (USDI 1976), but the proposal was withdrawn in 1979 because the USFWS failed to finalize the listing rule within two years (USDI FWS 1979). The pyrg was designated as a Category 1 Candidate species in 1984, meaning the USFWS had sufficient information to support listing the snail under the ESA (USDI FWS 1984). The snail was later downgraded to a Category 2 Candidate species (USDI FWS 1994), but was later dropped as a Candidate altogether due to the elimination of the Category 2 designation (USDI FWS 1996). This species is on the Nevada Natural Heritage Program At-Risk Tracking List. Existing regulatory mechanisms do not provide this species with any tangible protection.

3. *Pyrgulopsis fairbanksensis* Fairbanks Springsnail

Taxonomy. Family Hydrobiidae. Hershler and Sada 1987

Description. The Fairbanks Springsnail has 3 – 4 whorls, and a height of 2.5 – 3.4 mm. It is a moderate-sized snail with a very short-spired, globose-turbinate shell with a thickened inner lip. The penis has a small lobe with a single glandular ventral ridge.

Range. The Fairbanks Springsnail is known only from Fairbanks Spring in the Ash Meadows area of Nye County, Nevada, Upper Amargosa watershed (Hershler 1994).

Habitat Requirements. Sada (1990) reports this species' habitat to be "soft substrates in thermal springs." Hershler and Sada (1987) report that the snail is found in a large, low-elevation spring on travertine at the spring orifice.

Status. The Fairbanks Springsnail is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) NatureServe 2008). This snail was once a Category 2 Candidate species (USDI FWS 1994), but was later dropped as a Candidate due to the elimination of the Category 2 designation (USDI FWS 1996). It is on the Nevada Natural Heritage Program At-Risk Tracking List. The Fairbanks Springsnail is not adequately protected by any existing regulatory mechanisms.

4. *Pyrgulopsis isolatus* Elongate-gland Springsnail

Taxonomy. Family Hydrobiidae. Hershler and Sada 1987

Description. The Elongate-gland Springsnail is a large-sized snail with a broadly conical shell that has a moderate spire. The penis is enlarged and rectangular with an enlarged lobe that has an elongate glandular distal ridge. The shell is 2.6 – 3.1 mm high, and there are 3.75 – 4.25 whorls. The shell is colorless and transparent and the periostracum is light brown.

Range. The Elongate-gland springsnail is known only from the spring at Clay Pits, in the Ash Meadows area of Nye County, Nevada, Upper Amargosa watershed (Hershler 1994).

Habitat Requirements. This springsnail is locally common on soft substrates in its thermal habitat. It can be found on outflows from the marsh (Hershler and Sada 1987).

Status. The Elongate-gland Springsnail is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It was once a Category 2 Candidate species (USDI FWS 1994), but lost its candidate status due to the elimination of the Category 2 designation (USDI FWS 1996). It is on the Nevada Natural Heritage Program At-Risk Tracking List. Existing regulatory mechanisms are not sufficient to protect this species.

5. *Pyrgulopsis nanus* Distal-gland Springsnail

Taxonomy. Family Hydrobiidae. Hershler and Sada 1987

Description. The Distal-gland Springsnail is a small-sized snail with a globose, short-spired shell. The penis has short filament and the penial lobe is large with a glandular ridge along the distal edge. It is 1.5 – 2.4 mm in height and has 3 – 4 whorls.

Range. The Distal-gland Springsnail is known only from the Ash Meadows area of Nye County, Nevada, Upper Amargosa watershed (Hershler 1994). It is found at four small springbrooks that are within 10 km of each other: Five Springs, Mary Scott Spring, Collins Ranch Spring, and a spring north of Collins Ranch Spring (Hershler and Sada 1987).

Habitat Requirements. Sada (1990) reports that this species uses soft substrates in thermal springs. Hershler and Sada (1987) report that this snail is locally common in the upper segments of streams on soft sediment and loose travertine.

Status. The Distal-gland springsnail is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It was once a Category 2 Candidate species (USDI FWS 1994), but was subsequently dropped as a Candidate altogether due to the elimination of the Category 2 designation (USDI FWS 1996). It is on the Nevada Natural Heritage Program At-Risk Tracking List. This snail is completely unprotected by existing regulatory mechanisms.

6. *Pyrgulopsis pisteri* Median-gland Springsnail or Median-gland Nevada Pyrg

Taxonomy. Family Hydrobiidae. Hershler and Sada 1987

Description. The Median-gland Springsnail is a small-sized snail with a globose shell with a short spire. The penis is simple and non-tapering with a glandular ridge positioned ventrally. The shell is 1.8 – 2.7 mm high and has 3.25 – 4.5 whorls. The shell is colorless and transparent and the periostracum is light brown and very thin.

Range. The Median-gland Nevada Pyrg is known only from the Ash Meadows area in Nye County, Nevada, Upper Amargosa watershed (Hershler 1994). It is found at North Scruggs Spring, Marsh Spring, and an observation pond below School Spring, all within 2 km of each other (Hershler and Sada 1987).

Habitat Requirements. This springsnail is found in the outflows of thermal springs on travertine, aquatic macrophytes, or soft substrates (Hershler and Sada 1987, Sada 1990).

Status. The Median-gland Nevada Pyrg is critically imperiled meaning that this species is at very high risk of extinction (G1 S1 (NV) (NatureServe 2008). In 1984, the snail was designated a Category 1 Candidate species, then under the name "*Fluminicola sp*." (USDI FWS 1984). In 1994 this snail was designated as a Category 2 Candidate species (USDI FWS 1994), but lost its status with elimination of the Category 2 program (USDI FWS 1996). Existing regulatory mechanisms do not afford this species with any protection.

7. *Tryonia angulata* Sportinggoods Tryonia

Taxonomy. Family Cochliopidae. Hershler and Sada 1987

Description. The Sportinggoods *Tryonia* is a fairly large-sized snail with an elongate conic shell. The shell height is 2.7 – 4.0 mm and it is about twice as tall as it is wide with 5 – 7 whorls. The penis has three papillae on the inner curvature, two of which are distal. The shell is colorless and transparent and the periostracum is light brown (Hershler and Sada 1987).

This species is distinguished from other congeners by the flattening of the teleoconch whorls immediately below the suture (Hershler 2001).

Range. *Tryonia angulata* is found at Fairbanks Spring, Big Spring, and Crystal Pool at Ash Meadows in Nye County Nevada, Upper Amargosa watershed (Hershler and Sada 1987).

Habitat Requirements. This species is found on soft substrates in three large thermal low-elevation limnocrenes (Sada 1990, Hershler and Sada 1987).

Status. The Sportinggoods Tryonia is critically imperiled meaning that it is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). In 1984, the snail was designated a category 1 Candidate species (USDI FWS 1984). It was later designated a category 2 Candidate species (USDI FWS 1994d), but with the elimination of the category 2 designation, the snail lost its Candidate status (USDI FWS 1996).

8. *Tryonia elata* Point of Rocks Tryonia

Taxonomy. Family Cochliopidae. Hershler and Sada 1987

Description. The Point of Rocks Tryonia has a small- to medium-sized, narrow-conic shell (0.29 cm length). The penial ornament consists of two distal and one basal papillae along the inner edge. It is distinguished from its congeners by the combination of its small size and narrow-conic shell and because the brood pouch lacks a posteriorly folded component (Hershler 2001).

Range. The Point of Rocks Tryonia is found only at two localities at Point of Rocks Springs in the Ash Meadows area of Nye County, Nevada, Upper Amargosa watershed (Hershler and Sada 1987).

Habitat Requirements. This species is found on a travertine (a form of limestone) mound at two small springs. It is locally common in the silted stream outflows.

Status. The Point of Rocks Tryonia is critically imperiled meaning it as at very high risk of extinction (G1S1 (NV)) (NatureServe 2008). This snail was once a Category 1 Candidate species, meaning the USFWS had sufficient information to support ESA listing (USDI FWS 1984). The Point of Rocks Tryonia was later designated a Category 2 Candidate species (USDI FWS 1994d), but with the elimination of the category 2 designation, the snail lost its Candidate status (USDI FWS 1996). The Point of Rocks Tryonia currently lacks protective status.

9. *Tryonia ericae* Minute Tryonia

Taxonomy. Family Cochliopidae. Hershler and Sada 1987

Description. The Minute Tryonia is a small springsnail that is distinguished by its small size (0.19 cm length) and conical shell with impressed sutures and frequently thickened aperture.

It is also unique in that the female sperm tube and brood pouch are fused instead of opening separately (Hershler 2001). The penial ornament consists of two distal and one basal to medial papillae along the inner edge (Hershler 2001).

Range. The Minute Tryonia is known only from the Ash Meadows area of Nye County, Nevada, Upper Amargosa watershed, where it occurs at North Scruggs Spring and a spring north of Collins Ranch Spring (Hershler and Sada 1987).

Habitat Requirements. This springsnail is found on macrophytes, in stream outflows, on travertine bits, and on mats of algae at two small low-elevation springs (Hershler and Sada 1987).

Status. The Minute Tryonia is critically imperiled meaning that it is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). *Tryonia ericae* was once a Category 1 Candidate species, meaning the USFWS had sufficient information to support listing the Minute Tryonia under the ESA (USDI FWS 1984). This species was later designated a Category 2 Candidate species (USDI FWS 1994d), but with the elimination of the Category 2 designation, the snail lost its Candidate status (USDI FWS 1996). Existing regulatory mechanisms are completely inadequate to protect this springsnail.

10. Tryonia variegata Amargosa Tryonia

Taxonomy. Family Cochliopidae. Hershler and Sada 1987

Description. The shell of the Amargosa Tryonia is 2.8 -7.5 mm in height and is conic to elongate-conic in shape. There are 5.25 – 9.75 whorls. The penial ornament has two or three distal and one basal papillae on the inner edge and occasional basal papilla on the outer edge. It is distinguished from other congeners by its narrow, smooth, medium to large shell with evenly rounded whorls (Hershler and Sada 1987, Hershler 2001).

Range. The Amargosa Tryonia is known from at least 21 sites**.** *Tryonia variegata* occurs at nineteen small springs at Ash Meadows and at two to a few springs at Shoshone and Tecopa, California in the Upper Amargosa River Basin. In Nye County, Nevada, the species is found at Five Springs, Chalk Spring, Mary Scott Spring, North and South Scruggs Spring, Marsh Spring, North and South Indian Spring, School Spring and the observation pond below School Spring, Devils Hole, Collins Ranch Spring and a spring north of Collins Ranch Spring, a spring south of Clay Pits, two springs near Crystal Reservoir, and Point of Rocks Springs. In Inyo County, California the species occurs at Shoshone Spring and a spring by Grimshaw Lake (Hershler and Sada 1987).

Habitat Requirements. The Amargosa Tryonia is locally abundant in detritus-covered areas, on macrophytes, or on travertine (a calcium-carbonate rock) blocks in spring pools. It is also found on travertine or soft sediment along the sides of upper segments of thermal stream outflows (Hershler and Sada 1987).

Status. NatureServe (2008) ranks the Amargosa Tryonia as imperiled globally and in Nevada and critically imperiled in California (G2 S2 (NV) S1 (CA)). The species was once a Category 2 Candidate species (USDI FWS 1994), but with the elimination of the Category 2 designation, the snail lost its Candidate status (USDI FWS1996). It is a Nevada BLM Special Status Species. The species is not adequately protected by any existing regulatory mechanisms.

THREATS

Loss and Degradation of Spring Habitat due to Groundwater Development

Groundwater withdrawal is an ongoing and increasing threat to the springsnails at Ash Meadows. It is known that past groundwater removal lowered spring discharge at the meadows. Dudley and Larsen (1976) evaluated the effects of groundwater withdrawal from 1969-1972 on spring discharge at Ash Meadows and found that flow at Fairbanks Spring was reduced by 10%, flow at Collins Spring was reduced by half, and flow at Jack Rabbit Spring temporarily ceased in response to pumping. Pumping was stopped in the early 1980's and the groundwater table rose through 1987, but in 1988 the water table began to decline again and this decline has continued (Dettinger et al.1995, Riggs and Deacon 2004). The decline appears to be related to groundwater withdrawal for irrigation at the Amargosa farms area 25-30 km northeast of Devil's Hole (Bedinger and Harrill 2006, Deacon et al. 2007).

Ash Meadows is adjacent to Devil's Hole where water rights to support the Devil's Hole Pupfish (*Cyprinodon diabolis*) were upheld by the U.S. Supreme Court (United States v. Cappaert 1976). Protected water rights for the fish are not adequate to protect the petitioned springsnails for several reasons. First, even with protected rights, the water level at Devil's Hole is declining (Dettinger et al.1995, Riggs and Deacon 2004, Bedinger and Harrill 2006, Deacon et al. 2007), and is likely to continue to decline. Groundwater level is expected to decline from 0.3 to 3 m at locations at Ash Meadows where the petitioned springsnails occur (Figure 2; Deacon et al. 2007, Schaefer and Harrill 1995, Harrill and Prudic 1998). Schaefer and Harrill (1995) predicted a decrease in flow of 2% for the Ash Meadows complex in response to groundwater pumping. Second, water level sufficient to maintain the pupfish population is not necessarily adequate to meet the physiological needs of springsnails, which have very specific microhabitat requirements and depend on a stable physicochemical environment with low disturbance and consistent flow (Ponder et al. 1989, Sada and Nachlinger 1996, Hershler 1998, McCabe 1998, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008; see General Habitat Requirements, above, p. 16).

Finally, spring flow at Ash Meadows will be negatively affected by pumping in other parts of the aquifers which feed the springs. Patten et al. (2008) state:

> "[G]roundwater pumping from aquifers that support Ash Meadows springs could lower the shallow water table at Ash Meadows and/or reduce discharge at many of the springs."

Spring flow at Ash Meadows generates from the local basin-fill aquifer which is recharged by deep aquifers to the north, from Pahranagat Valley to the northeast, and from snowmelt in the Spring Mountains (Winograd and Friedman 1972, Osmond and Cowart 1982, Thomas et al.1996). It is thought that from the Spring Mountains the flow runs underground to the general vicinity of Indian Springs Valley, then turns toward Frenchman Flat, picking up additional flow from the Sheep Range, the White River system, and Pahranagat Valley before discharging at Ash Meadows (Winograd and Thordarson 1975, Dettinger et al. 1995, Winograd et al. 1998, Riggs and Deacon 2004).

Proposed SNWA wells in the northeastern portion of the Ash Meadows flow system in Indian Springs, Three Lakes, and Tikaboo valleys are likely to adversely affect spring discharge at Ash Meadows (Riggs and Deacon 2004, Deacon et al. 2007). In 2005 the Nevada State Engineer approved SNWA permits for 10,605 afy of groundwater to be pumped to Las Vegas from Tikaboo and Three Lakes Valleys. SNWA holds applications for 16,000 afy of groundwater in Indian Springs Valley (SNWA website). Groundwater is expected to decline by 30 m in Indian Springs Valley from proposed withdrawals (Deacon et al. 2007, Schaefer and Harrill 1995, Harrill and Prudic 1998). The Nevada Water Resources Database reports that the perennial yield of Indian Springs Valley is 500 afy, but there are already 1,380 existing afy of certified and permitted rights. The database reports that SNWA holds 30,407 afy of ready for action protested applications in Indian Springs Valley.

Thomas et al. (1996) found that groundwater discharging at Ash Meadows springs is 40% Pahranagat Valley water. The yield of Pahranagat Valley is 25,000 afy, but there are 31,816 afy of active records for this valley (Nevada Division of Water Resources (NDWR) Database 2009). Pahranagat Valley is in the region of influence for SNWA's Kane Springs Valley Groundwater Development Project and is in the biological resources study area for SNWA's Clark, Lincoln, and White Pine Counties Groundwater Development Project. Groundwater is expected to decline from 0.3-30 m in Pahranagat Valley as the result of proposed withdrawals by SNWA (Deacon et al. 2007, Schaefer and Harrill 1995, Harrill and Prudic 1998). Flow in Pahranagat Valley springs is expected to decrease by 14% (Schaefer and Harrill 1995, Patten et al. 2008). Groundwater could decline in Pahranagat and connected valleys due to proposals by other users in addition to SNWA. For example, Silver State Land Company LLC holds six separate ready for action protested applications for 20,400 afy each in Pahranagat Valley (NDWR 2009).

Ash Meadows itself is located in the Amargosa Basin. As of January 16, 2009, there were 609 active water rights records for the Amargosa Basin (Basin #230) including certified and/or permitted rights held by Mud Camp Mining Company, Rockview Farms, Rockview Dairies, Geneerco, Inc., Stewart Equipment Auctioneers, and others. The perennial yield of Amargosa Basin is 24,000 afy (combined yield for basins 225-230), but there are 24,489 afy of permitted and/or certified rights and 27,937 afy of active water records, including ready for action and ready for action protested applications from Hidden Ridge, LLC and others.

Water rights are commonly granted in excess of perennial yield, but even if withdrawals were limited to perennial yield, the definition of perennial yield allows for the drying up of springs. Existing and proposed groundwater withdrawals pose a real and serious threat to the springs at Ash Meadows on which the petitioned springsnails depend for survival.

Global Climate Change

Springflow is dependent on groundwater recharge which is dependent on precipitation. Global climate change is expected to alter precipitation patterns in the western United States (Field et al. 2007, Cook et al. 2008). Thomas et al. (1996) estimated that 60% of the groundwater discharging at Ash Meadows originates from the Spring Mountains. This water is directly tied to precipitation, and spring flow at Ash Meadows will thus be directly affected by alterations in precipitation. The frequency and intensity of drought is expected to increase, and more precipitation is expected to fall as rain rather than as snow, which will decrease snowpack. Drought will obviously cause decreased springflows, which will negatively affect springsnails. Decreased snowpack will result in decreased groundwater recharge and will lower surface flows in summer, both of which are detrimental for springsnails. Decreased precipitation, in conjunction with increased groundwater withdrawal, is a serious threat for springsnail habitat.

Invasive Species

The establishment of invasive species in spring habitats can significantly impact resident endemic species through both competition and predation and poses a serious threat for native aquatic species (Nevada Dept. of Wildlife 2006). Invasive plants can harm native springsnails by displacing native vegetation and altering the physicochemical environment, microhabitat conditions, spring outflows, water quality, food availability, contaminant cycling, and ecological processes (Strayer 1999, Fleishman et al. 2006, Nevada Dept. of Wildlife 2006). Invasive animals can prey on native snails, compete with them directly and indirectly for resources such as food and space, act as vectors for disease and parasite introduction, and alter ecosystem function (Strayer 1999, Sada et al. 2005, Brown et al. 2008, Lysne et al. 2008).

Several exotic species are established at Ash Meadows including bullfrogs (*Rana catesbeiana*), mosquitofish (*Gambusia affinis*), sailfin mollies (*Poecilia latipinna*), redrim melania snails (*Melanoides tuberculata*), crayfish (*Procambarus clarki*), and salt cedar (*Tamarisk* sp.) (Hershler and Sada 1987). Hershler (1998) reports that exotic biota may pose a serious threat to native springsnails, particularly crayfish, which feed on small gastropods, and *Melanoides tuberculata,* which may be displacing native snails.

For more detailed discussion of the impacts of invasive species on springsnails, please refer to the Invasive Species section, under Threats, on page 43.

LAND MANAGEMENT

Ash Meadows is a National Wildlife Refuge and is managed by U.S. Fish and Wildlife Service. In addition to Ash Meadows National Wildlife Refuge, *Tryonia variegata* occurs on BLM and private lands, and at Saratoga Springs in Death Valley National Park.

CAVE VALLEY

SPECIES

11. Hardy Pyrg *Pyrgulopsis marcida*

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Hardy Pyrg is a small to medium-sized snail with an ovate to elongate conic shell. Its height is 1.6 - 3.9 mm, and it has 3.5 - 4.75 whorls, and a tan periostracum. It has a medium-large penis with medium length filament and lobe, and a very small or absent penial gland.

Range. The Hardy Pyrg is known only from seven springs in the Cave and White River Valley watersheds in Nye, Lincoln, and White Pine Counties, Nevada (Hershler 1998, Golden et al. 2007). In the White River Valley in Nye County it occurs in Hardy Springs, Emigrant Springs, and Butterfield Springs. In Lincoln County it occurs at Silver Springs and at the unnamed springs at Parker Station in Cave Valley. In White Pine County it occurs at Ruppo's Boghole in the White River Valley. It also occurs at Arnoldson Spring in the White River Valley (Golden et al. 2007).

Habitat Requirements. Water temperature at springs where this species occurs ranges from 13-23º C. Hardy Spring is a small rheocrene with a maximum depth of 50 cm and a temperature of 14º C. The unnamed spring at Parker Station is a helocrene with a maximum depth of 100 cm, a temperature of 14º C, and approximately 95 % emergent vegetative cover (Golden et al. 2007). Watercress (*Rorippa* sp.) is present at both of these sites (Sada 2005). Butterfield Spring is a small rheocrene with a maximum depth of 1 cm and a temperature of 17º C (Golden et al. 2007). Emigrant Spring is a small rheocrene with a maximum depth of 2 cm and a temperature of 18º C (Golden et al. 2007). Ruppo's Boghole is a rheocrene with a maximum depth of 100 cm and a temperature of 13º C. Silver Spring is a rheocrene with a maximum depth of 1 cm and temperature of 15º C. Arnoldson Spring is a rheocrene with a maximum depth of 86 cm and a temperature of 23º C with vegetation including Spikerush (*Eleocharis sp*.), Kentucky Bluegrass (*Poa portensis*), and Aster (*Symphyothrichum* sp.) (Golden et al. 2007).

Status. The Hardy Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. There are no existing regulatory mechanisms that adequately protect this species.

THREATS

The Hardy Pyrg is threatened by spring fluctuation or failure due to groundwater development. Groundwater removal can decrease spring flow or lead to spring desiccation (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). Springsnails have specific microhabitat requirements and fluctuations in spring flow and resultant effects on water quality can contribute to population decline or extirpation (Taylor 1985, Ponder et al. 1989, Sada and Nachlinger 1996, Hershler 1998, McCabe 1998, Myers and Resh 1999, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Sada and Vinyard 2002, Hurt 2004, Strayer 2006, Deacon 2007, Brown et al. 2008, Sada 2008). The Hardy Pyrg occurs only in Cave and White River Valleys.

In Cave Valley, groundwater is expected to decline by up to 30 m in Cave Valley as the result of proposed withdrawals (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007). There is a projected groundwater decline of 3 m in Cave Valley where *P. marcida* occurs (Figure 2). The perennial yield of Cave Valley (Hydrographic Basin #180) is 5000 afy. In July 2008 the Nevada State Engineer granted the Southern Nevada Water Authority rights to remove 18,755 acre-feet of groundwater annually from Delamar, Dry Lake and Cave valleys for the Clark, Lincoln, and White Pine Counties Groundwater Development Project (CLWP GDP). As of January 15, 2009 there were 17,713 afy of active water records for Cave Valley in the Nevada Water Rights Database, which does not appear to have been updated to include the SNWA rights granted in July 2008 for the CLWP GDP. According to the database, the Southern Nevada Water Authority holds 8,722 afy of permitted rights, and the Lincoln County Water District has applied for rights to 10,420 afy which are ready for action protested. As the yield of Cave Valley is reported as 5000 afy, it is apparent that granted groundwater rights already exist in excess of available water. The SNWA applications were granted subject to a stipulated agreement, but this agreement is not adequate to protect *P. marcida* because the agreement does not mention springsnails and there is no mechanism to stop pumping even if effects to biota are detected. Myers (2007) predicts that SNWA pumping in Cave, Dry Lake, and Delamar Valleys will completely desiccate springs in Cave Valley (Myers 2007).

In White River Valley, there 40,675 afy of active water records, including 29,894 permitted and certified afy. The perennial yield of White River Valley is 37,000 afy, which is less than the number of active records. Water rights are often granted in excess of yield, and the definition of perennial yield allows for the drying up of springs. White River Valley is in the biological resources study area for the Southern Nevada Water Authority's Clark, Lincoln, and White Pine Counties Groundwater Development Project (Golden et al. 2007). Springs in White River Valley are expected to be negatively influenced first by pumping by Vidler Water Company and then by SNWA pumping (Deacon et al. 2007). Groundwater is projected to decline from 0.3-30 m in White River Valley (Deacon et al. 2007, Schaefer and Harrill 1995, and Harrill and Prudic 1998). Myers (2007) estimates that SNWA pumping in Cave, Dry Lake, and Delamar Valleys will cause springflow in southern White River Valley to decline by half within 15 years, and to eventually fail.

Reduced or failed spring flow due to groundwater withdrawal is an overarching threat to *P. marcida*, and the species is also threatened by spring diversion, livestock grazing, invasive species, global climate change, and potentially by recreation. Spring development and diversion are common in the Great Basin, and at least one of the springs where this species occurs has a known diversion, entering a piped irrigation system downstream of the spring head (Golden et al. 2007). Golden et al. (2007) report that four springs that are home to *Pyrgulopsis sathos* and *P. marcida* are currently diverted for agricultural and livestock use. At least one of the springs where this species occurs is known to have been "highly disturbed" by cattle and possibly excavated at one time (Sada 2005). This species occurs on three BLM grazing allotments-- Cave Valley Ranch, Hardy Springs, and Sunnyside. The invasive snail *Melanoides tuberculata* is one of the most dominant taxa at Arnoldson Spring (Golden et al. 2007) and may have negative affects on native springsnails (Hershler and Sada 1987, Pointier et al. 1993, de Marco 1999). The Hardy Pyrg is also threatened by global climate change, which is expected to alter regional precipitation patterns and could lead to fluctuations and reductions in spring discharge and increased drought (Field et al. 2007).Golden et al. (2007) report that at least one of the springs where this species occurs is already known to have been disturbed due to drought.

LAND MANAGEMENT

Arnoldson Spring, Butterfield Spring, Emigrant Spring, Hardy Spring, Ruppo's Boghole, Silver Spring, and the unnamed springs at Parker Station are privately owned.

<u>DRY LAKE VALLEY</u>

SPECIES

12. Flag Pyrg *Pyrgulopsis breviloba*

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Flag Pyrg is a small snail with a low trochoid shell. It is 1.2 - 2.2 mm in height, has 2.75 - 3.75 whorls, and a thick light brown periostracum. The penis is large with medium length filament and a very short lobe, and the penial ornament is a very small terminal gland.

Range. The Flag Pyrg is found at Meloy Spring in Dry Lake Valley in Lincoln County, and at Flag Springs in the White River Valley in Nye County (Hershler 1998).

Habitat Requirements. North Flag Springs is a rheocrene with a maximum depth of 76 cm and a temperature of 16 - 18º C (Golden et al. 2007). Middle Flag Springs is a rheocrene with a maximum depth of 20 cm and a temperature of 20º C. South Flag Springs is a limnocrene with a maximum depth of 40 cm and a temperature of 22 - 23º C. Meloy Spring is a rheocrene with a maximum depth of 2 cm, a maximum wetted width of 1 m, and a temperature of 14º C. Vegetation at Flag Springs includes Rush (*Juncus sp*.), Bulrush (*Schoenoplectus* and *Scirpus sp*.), Spikerush (*Eleocharis sp*.), and Water Cress (*Rorripa* sp.) (Golden et al. 2007).

Status. The Flag Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program

At-Risk Tracking List. There are no existing regulatory mechanisms in place to protect this species.

THREATS

The Flag Pyrg is threatened by groundwater withdrawal which could cause decreased spring discharge or spring failure (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). Springsnails are dependent on consistent spring flow and water quality conditions and populations can be negatively affected by alterations in aquatic conditions (Ponder et al. 1989, Myers and Resh 1999, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Sada and Vinyard 2002, Hurt 2004, Deacon 2006, Strayer 2006, Deacon 2007, Sada 2008). The Flag Pyrg only occurs in Dry Lake Valley and White River Valley.
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In Dry Lake Valley, there is a projected 15 m decline in groundwater where *P. breviloba* occurs (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007). The perennial yield of Dry Lake Valley (Hydrographic Basin #181) is 12,700 afy, but there are 21,881 afy of active records for this basin. SNWA holds 11,584 afy of permitted rights in Dry Lake Valley, and in 2008 SNWA was granted permits for 18,755 afy of groundwater from Cave, Dry Lake, and Delamar Valleys. The Lincoln County Water District filed applications for groundwater withdrawal from Dry Lake Valley in December 2008, but the amounts were not available in the Nevada Water Rights database as of January 15, 2009.

In White River Valley, there are 40,675 afy of active water records, including 29,894 permitted and certified afy. The perennial yield of White River Valley is 37,000 afy, which is less than the number of active records. Water rights are often granted in excess of yield, and the definition of perennial yield allows for the drying up of springs. White River Valley is in the biological resources study area for the Southern Nevada Water Authority's Clark, Lincoln, and White Pine Counties Groundwater Development Project (Golden et al. 2007). Springs in White River Valley are expected to be negatively influenced first by pumping by Vidler Water Company and then by SNWA pumping (Deacon et al. 2007). Groundwater is projected to decline from 0.3-30 m in White River Valley (Deacon et al. 2007, Schaefer and Harrill 1995, and Harrill and Prudic 1998). Myers (2007) estimates that SNWA pumping in Cave, Dry Lake, and Delamar Valleys will cause springflow in southern White River Valley to decline by half within 15 years, and to eventually fail.

The Flag Pyrg is also threatened by spring development, domestic livestock grazing, invasive species, and global climate change (Hershler 1998, Sada and Vinyard 2002). Livestock are known to be present at one spring complex where this species occurs (Golden et al. 2007). Golden et al. (2007) classified Middle Flag Spring as highly disturbed based on its proximity to the main housing area of the Kirch Wildlife Management Area, because it had been moved from its historic channel, and because it is near a road. South Flag Springs was characterized as moderately disturbed due to livestock use, diversion, and the presence of a residence. They characterized North Flag Springs as slightly disturbed due to livestock use and the presence of a residence. This species occurs on the Sunnyside and Wilson Creek BLM grazing allotments. The Flag Pyrg is also threatened by global climate change which could affect spring discharge due to changing precipitation patterns (Field et al. 2007). Persistent drought or decreased snowpack could reduce spring recharge and discharge and negatively affect *P. breviloba* populations. In addition, the species' limited distribution makes the snail more vulnerable to extinction.

LAND MANAGEMENT

Flag Springs comprises three springs draining to Sunnyside Creek, located within the Wayne Kirch Wildlife Management Area. Flag Springs and Sunnyside Creek are managed by the Nevada Department of Wildlife. Meloy Spring is privately owned.

DUCKWATER (RAILROAD) VALLEY

SPECIES

Five of the petitioned species occur in Duckwater (Railroad) Valley including *Pyrgulopsis aloba, P. anatina, P. lockensis, P. papillata,* and *P. villacampae.*

13. *Pyrgulopsis aloba* Duckwater Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Duckwater Pyrg is a small snail with a sub-globose to ovate-conic shell, a height of 1.0 - 1.9 mm, 2.5 - 4.0 whorls, and a light brown-tan periostracum. It has a medium-sized penis with medium length filament and no lobe or penial ornament.

Range. The Duckwater Pyrg is known from two unnamed springs northwest and east-southeast of Duckwater, Duckwater Valley (Railroad Valley) Nye Co., Nevada (Hershler 1998).

Habitat Requirements. One of the springs where this species occurs is a small rheocrene.

Status. The Duckwater Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is included in the Nevada BLM's Special Status Species Program, but this program is discretionary and provides no tangible protection for the species or its habitat. This snail is not adequately protected by any existing regulatory mechanisms.

14. *Pyrgulopsis anatina* Southern Duckwater Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Southern Duckwater Pyrg is a medium-sized snail with a broadly to ovately-conic shell. Its height is 2.3-2.9 mm, and it has 4.25-4.75 whorls. The periostracum is tan. It has a medium-sized penis with medium-length filament and lobe. The penial ornament is a small terminal gland, and the penial gland is medium-sized.

Range. The Southern Duckwater Pyrg is known only from a single spring southeast of Old Collins Spring in the Duckwater Valley in Nye County, Nevada, Railroad Valley watershed (Hershler 1998).

Habitat Requirements. The spring where this species occurs is a small rheocrene.

Status. The Southern Duckwater Pyrg is critically imperiled, meaning the species is at very high risk of extinction (G1S1 (NV)) (NatureServe 2008). It is included in the Nevada BLM's Special Status Species Program, but this does not provide the springsnail with any substantive protection. It completely lacks meaningful protective status.

15. *Pyrgulopsis lockensis* Lockes Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. Lockes Pyrg is a small snail with a sub-globose to ovate-conic shell, a tan periostracum, a height of 1.6 - 1.9 mm, and 3.25 - 4.5 whorls. The penis is large with very short filament and no lobe or penial ornament.

Range. This springsnail occurs at only a single spring in Lockes, Duckwater (Railroad) Valley, Nye Co., Nevada (Hershler 1998).

Habitat Requirements. The spring where Lockes Pyrg occurs is a large, thermal (30º C) limnocrene.

Status. Lockes Pyrg is critically imperiled (G1 S1 (NV)) meaning this species is at very high risk of extinction (NatureServe 2008). This springsnail is on the Nevada Natural Heritage Program At-Risk Tracking List. This species is not protected by any existing regulatory mechanisms.

16. *Pyrgulopsis papillata* Big Warm Spring Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Big Warm Spring Pyrg is a small snail with a sub-globose shell. It is 1.8 - 2.2 mm in height and has 3.25 - 3.75 whorls and a light tan periostracum. The penis is large with a very short filament and lacks a lobe or penial ornament.

Range. The Big Warm Spring Pyrg is known only from Big Warm Spring and Little Warm Spring in the Duckwater Valley of Nye County, Nevada (Hershler 1998).

Habitat Requirements. One of the springs where this species occurs is a large thermal (31ºC) limnocrene which flows into a canal system and which has bladderwort (*Utricularia*) in the spring pool.

Status. The Big Warm Spring Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is included in the Nevada BLM's Special Status Species Program. This species occurs at only two sites and is not adequately protected by any existing regulatory mechanisms.

17. *Pyrgulopsis villacampae* Duckwater Warm Springs Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Duckwater Warm Springs Pyrg is a medium-sized snail with a trochiform-neritiform shell. It has a height of 2.5 - 3.7 mm, 3.5 - 4.5 whorls, and a tan periostracum. The penis is large with medium length filament and lobe. The penial ornament is a medium-sized terminal gland. The penial gland and ventral gland are large.

Range. The Duckwater Warm Springs Pyrg is known only from Big Warm Spring and Little Warm Spring in the Duckwater Valley of Nye County, Nevada, Railroad Valley watershed (Hershler 1998).

Habitat Requirements. This springsnail is found among rocks in deep (1 m) thermal spring outflows.

Status. The Duckwater Warm Springs Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is included in the Nevada BLM's Special Status Species Program, but this discretionary program does not provide the species with legal protective status.

THREATS

The overarching threat to the petitioned springsnail species in Duckwater Valley is groundwater withdrawal which could lead to reductions or fluctuations in springflow and alter the consistent microhabitat conditions on which these species depend for survival. It is well established that springflow can be negatively affected by groundwater withdrawal (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008) and that springsnails can be negatively affected by alterations and reductions in springflow (Ponder et al. 1989, Myers and Resh 1999, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Sada and Vinyard 2002, Hurt 2004, Deacon 2006, Strayer 2006, Deacon 2007, Sada 2008). Proposed Southern Nevada Water Authority (SNWA) wells in Nye County are expected to negatively affect spring discharge in Railroad Valley (Deacon et al. 2007). There is a projected 0.3 – 3m decline in the groundwater table where these species occur (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al.

2007). The perennial yield of Southern Railroad Valley is 2,800 afy, but there are 3,908 certified and permitted afy for this valley (Nevada Division of Water Resources Database (NDWR) 2009). The yield of Northern Railroad Valley is 75,000 afy, but there are 143,684 afy of active records for this valley, including 116,432 afy of ready for action applications. The SNWA holds 95,568 afy of ready for action protested applications, and the Great Basin Land Company holds 15,360 afy of ready for action protested applications (NDWR 2009). Water rights are commonly granted in excess of perennial yield, and even if water rights were to be limited to the level of perennial yield, the definition of perennial yield allows for the drying up of springs. Because all of the petitioned species in Duckwater Valley occur at only 1 -2 springs each, these species could be driven to extinction if groundwater withdrawal desiccates the springs where they occur.

Pyrgulopsis aloba, P. anatina, P. lockensis, P. papillata, and *P. villacampae* are also threatened by spring development, domestic livestock grazing, and potentially by recreation and invasive species, which are common disturbances to Great Basin springs (Hershler 1998, Sada and Vinyard 2002). Thermal springs have a greater risk of being negatively impacted by recreational use (Hershler 1998). Big Warm Spring has apparently been impacted by the development of a diversion (Hershler 1998). All of these species overlap with BLM grazing allotments. In addition, global climate change is a potential threat to these species because it is predicted that regional precipitation patterns will be altered, which will likely affect spring recharge and discharge and could lead to inconsistent or decreased spring flows (Field et al. 2007).

LAND MANAGEMENT

Pyrgulopsis aloba, P. papillata, and *P. villacampae* are found on the Duckwater Indian Reservation. The spring where *P. lockensis* occurs is privately owned. Land management for *P. anatina* is unknown.

HAMLIN VALLEY

SPECIES

18. Hamlin Valley Pyrg *Pyrgulopsis hamlinensis*

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Hamlin Valley Pyrg is a small snail with a narrow conic shell, a light tan periostracum, a height of 1.6 - 2.0 mm, and 4.25 - 5.0 whorls. It has a small to medium sized penis with medium length filament and a short to medium length lobe. The penial ornament is a medium-sized terminal gland.

Range. The Hamlin Valley Pyrg occurs at an unnamed springs east of White Rock Cabin Springs in Hamlin Valley, Beaver County, Utah (Hershler 1998).

Habitat Requirements. The single spring where this species occurs is a small high elevation (2180 m) rheocrene with a temperature of 16° C, relatively low conductivity, and a rocky substrate (Hershler 1994, Hershler 1998).

Status. The Hamlin Valley Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (UT)) (NatureServe 2008). It is a State of Utah Wildlife Species of Concern. Existing regulatory mechanisms are completely inadequate to protect this species.

THREATS

The Hamlin Valley Pyrg is threatened primarily by groundwater withdrawal and livestock grazing, and is also potentially threatened by spring diversion, recreation, and global climate change. Groundwater withdrawal leads to decreased or failed spring discharge (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). Reductions and alterations in spring discharge are harmful for springsnails (Ponder et al. 1989, Myers and Resh 1999, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Sada and Vinyard 2002, Hurt 2004, Deacon 2006, Strayer 2006, Deacon 2007, Sada 2008). Springflow in Hamlin Valley is likely to be negatively affected by groundwater withdrawal for the Southern Nevada Water Authority's Clark, Lincoln, and White Pine Counties Groundwater Development Project. Groundwater withdrawal in Spring and Snake Valleys could decrease groundwater level and surface flows in Hamlin Valley (Congdon 2006). Spring development and diversion could alter water conditions or lead to spring failure (Hershler 1995, 1998). The spring where this species occurs is near a residence and is known to have been impacted by livestock grazing (Gorrell et al. 2005, Hershler 1998). Oliver and Bosworth III (1999) report:

> "Given that this species occurs, so far as is known, nowhere else, the known threat of trampling by cattle together with the potential threats suggested by the proximity of a residence must be considered serious threats that jeopardize the continued survival of the species" (p. 27).

Recreation and other sources of water pollution also potentially threaten this species (State of Utah 2007). Concerning threats to this species, the State of Utah (2007) reports:

> "A lack of proactive water, agricultural, petroleum exploration, and recreation management may lead to reduced populations of this species . . . The singular distribution of the Hamlin Valley Pyrg renders this species especially susceptible to any habitat loss or degradation from recreation or water contamination."

The Hamlin Valley Pyrg is also threatened by global climate change which is expected to alter regional precipitation patterns and could lead to decreased spring discharge (Field et al. 2007).

LAND MANAGEMENT
Unknown.

INDIAN SPRINGS VALLEY

SPECIES

19. *Pyrgulopsis turbatrix* Southeast Nevada Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Southeast Nevada Pyrg is a medium-sized snail with a narrow conic to turriform shell, a height of 2.1-3.6 mm, 4.25-5.5 whorls, and a light tan-brown periostracum. The penis is large with medium length filament and lobe, and the penial ornament is a small terminal gland. The penial gland is small to absent.

Range. The Southeast Nevada Pyrg is known from ten to eleven sites, but may no longer be extant at all of them. In Indian Springs Valley it occurs at Willow Spring and Cold Creek Spring. In the Las Vegas Valley in Clark County it occurs at La Madre Spring, Lost Creek Spring, Willow Spring, and at Lost Canyon Spring in Red Rock Wash. In Nye County it occurs at Horseshutem Springs in the Pahrump Valley and at Grapevine Springs in the Amargosa Flat and at Cane Spring in the Frenchman Flat Basin. The Clark County Multispecies Habitat Conservation Plan reports that there are five extant and one extirpated populations of this species (Clark County 2000).

Habitat Requirements. The Southeast Nevada Pyrg requires permanently flowing, highly oxygenated, unpolluted water with high mineral content (USDI 2000). Sada and Nachlinger (1996) recorded habitat variables at springs where this species occurs. Lost Creek Spring has an elevation of 4480 ft, a length of 1000 m, a depth of 15 cm, a width of 200 cm, a temperature of 15º C, and 100 % emergent vegetative cover (Sada and Nachlinger 1996). Water cress (*Rorippa nasturtium-aquaticum*) is dominant at Lost Creek Spring and at Grapevine Spring. Grapevine Spring is 4400 ft in elevation, with a length of 80 m, a width of 100 cm, a depth of 7 cm, and is 18.5º C with 100% emergent vegetative cover (Sada and Nachlinger 1996). Willow Spring is 4510 ft in elevation, is 50 m long, 30 cm wide, and 4 cm deep, with a temperature of 17 º C (Sada and Nachlinger 1996). La Madre Spring has an elevation of 5550 ft, and is 2000 m long, 50 cm wide, and 5 cm deep with a temperature of 12.9 º C, and 100% emergent vegetative cover (Sada and Nachlinger 1996). La Madre Spring has a silt/cobble/sand substrate and is lined by cattails (*Typha latifolia*) on the eastern edge (BLM Red Rock Canyon survey documents). Horseshutem Spring is 4850 ft in elevation, and is 400 m long, 300 cm wide, 2 cm deep, and is 17.1º C with 40 % emergent vegetative cover.

Status. The Southeast Nevada Pyrg is imperiled meaning it as at high risk of extinction (G2 S2 (NV)) (NatureServe 2008). It is a covered species in the Clark County Multiple Species Habitat Conservation Plan (2000) and is a Nevada BLM Sensitive Species. It lacks meaningful protective status

THREATS

The Southeast Nevada Pyrg is threatened by spring fluctuation or failure due to groundwater development. Springsnails are dependent on consistent spring flow conditions (Ponder et al. 1989, Myers and Resh 1999, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Sada and Vinyard 2002, Hurt 2004, Deacon 2006, Strayer 2006, Deacon 2007, Sada 2008) and groundwater pumping can lead to diminished or failed spring flow (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008).

In Indian Springs Valley, there is a projected groundwater decline of 15 m where *P. turbatrix* occurs (Deacon et al. 2007, Schaefer and Harrill 1995, Harrill and Prudic 1998). There are 17,401 afy of active water records for Indian Springs Valley, but the perennial yield of the valley is only 500 afy, which is less than 1,380 afy of already existing certified and permitted rights (Nevada Division of Water Resources (NDWR) 2009). According to the Nevada Division of Water Resources Water Rights Database, the Southern Nevada Water Authority holds 30,407 afy of ready for action protested applications in Indian Springs Valley. SNWA's website reports holding 16,000 afy of applications in this valley.

In Frenchman Flat, there is a projected 15 m groundwater decline where *P. turbatrix* occurs (Deacon et al. 2007, Schaefer and Harrill 1995, Harrill and Prudic 1998). In Pahrump Valley, groundwater is expected to decline by 3 m where *P. turbatrix* occurs (Ibid). The perennial yield of Pahrump Valley is 12,000 afy, but there are 53,641 afy of permitted, vested, and certified rights (NDWR 2009). Excessive groundwater pumping already contributed to the extirpation of a population of *P. deaconi* in Pahrump Valley (Hershler 1998). It is likely that springsnail populations in Pahrump Valley that are susceptible to groundwater pumping impacts have already been eradicated, with remaining springs being supplied by recharge from the Spring Mountains (Thomas et al. 1996). In Las Vegas Valley, groundwater is expected to decline by 30 m (Deacon et al. 2007, Schaefer and Harrill 1995, Harrill and Prudic 1998). The perennial yield of Las Vegas Valley is 25,000 afy, but there are 93,992 afy of active water records, 77,729 afy of which are vested, permitted, or certified (NDWR 2009).

The Southeast Nevada Pyrg faces several threats in addition to groundwater pumping. The Clark County Multispecies Habitat Conservation Plan (2000) identifies ecosystem level threats to this species as: reduction of population resulting from commercial collection, habitat modification and degradation from commercial collection, concentrated recreation, increased use of pesticides and herbicides, wild horse and burro grazing and trampling, and spring diversion and modification. This species' type locality has been highly impacted by cattle and water diversion (Hershler 1998, p. 53).

Some of the springs where this species occurs are known to have been heavily impacted by recreation and by grazing:

> “The greatest threat to the Southeast Nevada Springsnail is ground disturbance from recreational and ungulate use of the springs. Misuse and overuse of the areas have created large areas of bare ground that border the springbrooks. This condition could accelerate erosion and alter the physical condition of the spring including water quality and temperature. Spring habitat degradation has also facilitated weed growth resulting in further degradation of the water quality and the site in general” (USDI 2000, p. 3.39).

Sada and Nachlinger (1996) identify spring diversion, recreation, grazing, and exotic species as threats to this species in the Spring Mountains. They describe Willow Spring as being “highly disturbed” by diversion and recreation:

> “Willow Spring has been modified for visitor use so that little natural character remains to aquatic and riparian systems. Impoundment and channelization of the springbrook, and placement of trails and concrete in the riparian zone, eliminated riparian vegetation and caused extirpation of two undescribed springsnail species that are endemic to the Spring Mountains area” (p. 29, II-5).

BLM survey documents describe Willow Spring as “highly disturbed” due to recreation, picnicking, diversion, and burro use. Willow Spring is rated nonfunctional in BLM survey documents because it is developed and piped to pools (Norman and McFadden 1998). According to BLM documents, a population of *P. turbatrix* may have been extirpated at Willow Spring circa 1992-1993 when water was impounded for the development of a recreational site (Rash 2001, p. 1). This site was later fenced and flow was restored (Putnam 2002 in BLM Red Rock Canyon documents). Willow Spring has since been rehabilitated.

Grapevine Springs have been “seriously impacted” by grazing and diversion (Sada and Nachlinger 1996). The Grapevine Spring complex is “highly disturbed from excavation, diversion, wild horse and burro use, and exotic plant introductions and has led to extirpation of an undescribed springsnail at one spring” (Sada and Nachlinger 1996, p. IV-3).

The riparian zone at Lost Creek Spring is “heavily used by the public” (Sada and Nachlinger 1995 in BLM survey documents). The stream banks “were bare in most places due to human foot traffic and a dense overstory of Gooding willow” (Norman and Rash in BLM survey documents). In 2001 the Environmental Assessment for the redesignation of Red Rock Canyon from a Recreation Area to a Conservation Area included closing trails and building a boardwalk at Lost Creek Spring to protect *P. turbatrix*. A 2002 survey states that the boardwalk and fencing were effective in keeping the majority of people off the stream banks (Putnam).

At Lost Creek Spring, collection presents a threat to this species. Rash (2001) states that unauthorized invertebrate collection, especially by students, occurs at Lost Creek Spring (p. 4). Lost Creek Spring has a Childrens Discovery Trail that is part of the Clark County School District environmental education program. The trail was set up prior to BLM knowledge of *P. turbatrix*:

> “Extensive numbers of children are being regularly funneled into the core of the snail habitat . . . Not only are large groups (15-30+) being continually pressed into a small portion of Lost Creek’s riparian habitat but very often but very often the educational purpose gives way to an ill-supervised romp, with the students being allowed to play and wade in the spring, just as if they were in an urban park. This group pressure is in addition to Lost Creek Spring’s heavy volume of dispersed visitation. Visitor use impacts have thus far included: the release of non-native fish; vegetative trampling and destruction; unauthorized collecting of plants, amphibians, and invertebrates (especially by students); streambank degradation, and riparian terrace soil compaction and erosion” (Rash 2001, p. 4).

The La Madre Spring area is heavily used by hikers. BLM Red Rock Canyon survey documents describe La Madre Spring as “slightly disturbed” due to damming and diversion, and state that the spring is “used heavily by recreationists (Burz. and Schafer 1979)” and “highly used by hikers” (Sada and Nachlinger 1995). The area around the dam “shows heavy soil impact by recreational hikers” (Putnam 2002). Exotic goldfish were reported at La Madre Spring in 2003 (Putnam, BLM Red Rock Canyon Survey documents).

Horseshutem Spring is highly disturbed by diversion and grazing by horse/burro/elk and cattle (Sada and Nachlinger 1996, p. II-6). Flow at Horseshutem spring is piped to a trough for horse and burro use in the Johnnie Herd Management Area.

Grapevine Spring is also diverted:

> “A portion of another population was reported lost at privately owned Grapevine Spring (Nye County), when a 1995 pipeline installed at one of the three source springs resulted in the ‘aquatic habitat . . . completely eliminated for water delivery to troughs.’ According to Jack Norman, LVFO hydrologist, this trespass line (on BLM land) supplies a residence, not a stock trough” (Rash 2001, p. 1).

Recreational impacts are expected to increase with increased human population growth in southern Nevada:

> “As the human population of the county (Clark) increases, it is assumed that there will be a resultant increase in the amount of recreational and other uses of Bureau of Land Management, National Park Service, Forest Service, and Refuge lands” (USDI 2000, p. 5.1)

Exotic plant species are present at Lost Creek Spring, Willow Spring, Willow Creek Spring, Cold Creek Spring, La Madre Spring, Grapevine Spring, and Horseshutem Springs (Sada and Nachlinger 1996).

Pyrgulopsis turbatrix occurs on the BLM Mountain grazing allotment.

In addition to spring diversion, recreation, grazing, and invasive species, the Southeast Nevada Pyrg is threatened by global climate change. Climate change is expected to alter regional precipitation patterns which could negatively affect spring recharge and discharge (Field et al. 2007). For example, the spring where this species occurs in Pahrump Valley is dependent on recharge from the Spring Mountains, and spring flow could decrease in response to diminished snowpack.

LAND MANAGEMENT

Lost Creek Spring, Willow Spring, and La Madre Spring are in the Red Rock Canyon National Conservation Area and are managed by the Bureau of Land Management. Grapevine Spring and Horseshutem Spring are privately owned. Willow Creek Spring and Cold Creek Spring are managed by the U.S. Forest Service. Cane Spring is on the Nevada Test Site and is managed by the Department of Energy.

LAKE MEAD (BLACK MOUNTAINS)

SPECIES

20. *Pyrgulopsis coloradensis* Blue Point Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Blue Point Pyrg is a small snail with a low trochoid to ovate-conic elongate shell, a height of 1.2 - 1.6 mm, 2.75 - 3.5 whorls, and a tight tan periostracum. The penis is medium-sized and smooth with blade-like simple tapering and no penial ornament or lobe (Hershler 1998).
.
Range. This species is found only at Blue Point Spring in Clark County, Nevada, in the Lake Mead watershed.

Habitat Requirements. Blue Point Spring is a small thermal (30º C) rheocrene.

Status. The Blue Point Pyrg is ranked by NatureServe as possibly extinct (GH SH (NV)) because it had not been detected since 1992 (NatureServe 2008). This species was redetected in 2006 (USNM 1098622), but then was not found in a later survey in 2008 (Hershler, pers. comm.). This species merits emergency listing.

THREATS

The Blue Point Pyrg is highly vulnerable to extinction because of its occurrence at a single location and obviously decreased population size. It was thought to be extinct, rediscovered, and then was undetectable again at a later date. It is threatened by predation from introduced convict cichlids (*Amatitlania niigrofacsciata*) which are believed to have played a large role in its decline. Because this species occurs in a thermal spring in a National Recreation Area near a major metropolitan area, it is vulnerable to recreational impacts. The Blue Point Pyrg is potentially threatened by livestock grazing. Grazing is authorized but not currently active on two allotments within the Lake Mead National Recreation Area. The Blue Point Pyrg is also threatened by global climate change which is predicted to alter regional precipitation patterns and could negatively affect spring recharge and discharge (Field et al. 2007). The groundwater which supports spring flow in the Lake Mead NRA is mostly derived from the local aquifer and shallow-basin fill aquifers which are supported by precipitation (Pohlmann et al. 1998).

The Blue Point Pyrg is also threatened by groundwater withdrawal. Groundwater withdrawal can lead to decreased or failed spring discharge (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). Decreased spring discharge is harmful for springsnails because they exhibit very specific habitat preferences and are dependent on consistent microhabitat conditions (Taylor 1985, Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008, Brown et al. 2008). Some springs in the Lake Mead NRA are fed by groundwater from the regional aquifer (Prudic et al. 1995). Patten et al. (2008) state:

> "This aquifer (regional) is being considered for urban use, which, if developed, may directly influence spring discharge and associated shallow groundwater in Lake Mead NRA."

Springflow at Blue Point spring is likely to be negatively affected by groundwater pumping for the Lincoln County Water District's (LCWD) Kane Springs Valley (KSV) Groundwater Development Project which would withdraw 5,000 afy from the regional aquifer for use in the Coyote Springs Investment development area (USDI 2008 KSV FSEIS). Spring discharge at Blue Point Spring contains 42-53% groundwater from the regional aquifer (USDI 2008 KSV FSEIS p. 3-27). The LCWD has submitted applications for up to 17,000 afy from the Kane Springs Valley Hydrographic Basin. Other groundwater development projects which could contribute to the cumulative impacts of the Kane Springs Valley project include the build out of the Coyote Spring Investment development area and associated water rights development in southern Lincoln County, pumping of existing undeveloped Coyote Spring Valley groundwater rights by the Nevada Power Company, and additional groundwater pumping by the Moapa Valley Water District in Upper Moapa Valley (KSV FEIS p. 4-64). The Southern Nevada Water Authority also holds applications for groundwater development in the regional aquifer which supports flow at Blue Point Springs. Even though groundwater development projects contain monitoring criteria and mitigation measures for certain surface waters if flows decline, the flow levels that would trigger mitigation are often so low that springsnails could be harmed before intervention could occur. Even with proposed mitigations, both direct and indirect effects to springsnail habitat may occur due to decreased surface flows resulting from groundwater pumping (KSV FSEIS p. 4-19 - 4-20). There is a projected 0.3 m groundwater decline in the Lake Mead watershed where *P. coloradensis* occurs (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007). The perennial yield of the Lake Mead basin is 1300 afy, but there are 7,217 afy of permitted and certified rights (Nevada Division of Water Resources 2009).

Groundwater development projects directly threaten the springflow on which the Blue Point Pyrg depends for survival. *Pyrgulopsis coloradensis* should be immediately protected under the ESA due to the threats this springsnail faces from drastically decreased population size, predation from invasive cichlids, and decreased springflow due to groundwater development.

LAND MANAGEMENT

Blue Point Spring is in the Lake Mead National Recreation Area, which is administered by the National Park Service. Lake Mead is administered by the U.S. Bureau of Reclamation.

LAKE VALLEY

SPECIES

21. Lake Valley Pyrg *Pyrgulopsis sublata*

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Lake Valley Pyrg is a medium-sized snail with a broadly to ovately conic shell, a tan periostracum, a height of 2.2 - 2.7 mm, and 4.5 - 5.0 whorls. The penis is large with short filament and lobe, and the penial ornament is a large terminal gland.

Range. This springsnail occurs only at Wambolt Springs in the Lake Valley watershed in Lincoln Co., NV.
Habitat Requirements. Hershler (1998) characterizes Wambolt Springs as a shallow broad (8m) helocrene. Golden et al. (2007) characterize Wambolt Springs as a limnocrene with a maximum depth of 10 cm, a temperature of 14 - 18º C, and vegetation including watercress (*Rorippa* sp.) and Mare's tail (*Hippurus* sp.). The wet areas around Wambolt Springs are dominated by spikerush (*Eleocharis* sp.) and Nebraska sedge (*Carex nebrascensis).*

Status. The Lake Valley Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. This springsnail is not adequately protected by any existing regulatory mechanisms.

THREATS

The Lake Valley Pyrg is threatened by groundwater development. Groundwater pumping can lead to reduced or failed spring discharge (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). Because springsnails are dependent on consistent microhabitat conditions, decreased springflow can have negative affects on springsnail populations (Taylor 1985, Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008, Brown et al. 2008).The perennial yield of Lake Valley is 12,000 afy, but there are 21,869 afy of certified and permitted rights, and 41,130 afy of active records for the Lake Valley hydrographic basin (NDWR 2009). The majority of water permits and applications in Lake Valley are held by Tuffy Ranch Properties, LLC and by Geyser Ranch, LLC. Springflow in Lake Valley is also threatened by proposed groundwater pumping for Southern Nevada Water Authority's Clark, Lincoln, and White Pine County Groundwater Development Project. There is a projected 3 meter decline in the groundwater table where *P. sublata* occurs (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007).

The Lake Valley Pyrg is inherently vulnerable to extinction because it occurs at only one spring complex. The single site where this species occurs is known to have been disturbed by livestock grazing and water diversion (Hershler 1998, Golden et al. 2007). Golden et al. (2007) report that this species is possibly declining. Global climate change also threatens the Lake Valley Pyrg because spring discharge and recharge is likely to be reduced by altered regional precipitation patterns (Field et al. 2007).

LAND MANAGEMENT

Wambolt Springs is privately owned.

<u>LAS VEGAS VALLEY</u>

SPECIES

22. *Pyrgulopsis deaconi* Spring Mountains Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Spring Mountains Pyrg is a small snail with a sub-globose shell. Its height is 1.5-1.9 mm, and it has 3.5-3.75 whorls. The penis is large with medium length filament and a short lobe. The periostracum is light tan.

Range. This species is restricted to the Spring Mountains of Nevada in drainages of Las Vegas and Pahrump Valleys in Clark and Nye Counties. In the Las Vegas Valley in Clark County it occurs at Red Spring and Willow Spring. In the Pahrump Valley in Clark County it occurs at Kiup Spring. In the Pahrump Valley in Nye County it did occur at a spring at Manse Ranch, but has been extirpated from that site. The Clark County Multi Species Habitat Conservation Plan (2000) reports that there are two extant and one extirpated populations of this snail.

Habitat Requirements. The Spring Mountains Pyrg depends on artesian spring ecosystems with permanent flowing, unpolluted, highly oxygenated waters with high mineral content (USDI 2000). The type locality for this species is a small rheocrene (Hershler 1998). Sada and Nachlinger (1996) recorded the following habitat variables at Red Spring: elevation 3620 ft, length 150 m, width 100 cm, depth 7 cm, temperature 20º C, emergent vegetative cover 100%. Sada and Nachlinger (1996) recorded the following habitat variables at Willow Spring: elevation 4510 ft, length 50 m, width 30 cm, depth 4 cm, temperature 17 º C.

Status. The Spring Mountains Pyrg is critically imperiled meaning it is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is a covered species in the Clark County Multi Species Habitat Conservation Plan, and is a BLM Nevada Sensitive Species. It lacks meaningful protective status.

23. *Pyrgulopsis fausta* Corn Creek Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Corn Creek Pyrg is 1.4 - 1.7 mm in height and has 3.25 - 3.75 whorls and a light tan periostracum. It is distinguished from other species by a very large penial gland and a uniquely elongate ventral gland that crosses the entire width of the penis and extends along the inner edge of the penis distally.

Range. This springsnail is known only from Corn Creek Springs, Las Vegas Wash, Clark County, Nevada (Hershler 1998).

Habitat Requirements. Corn Creek Springs is a small thermal spring system with a temperature of approximately 23º C (Hershler 1998).

Status. The Corn Creek Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. This snail lacks legal protective status.

19. Pyrgulopsis turbatrix also occurs in Las Vegas Valley. *P. turbatrix* is described in the Indian Springs Valley section, above, beginning on p. 78.

THREATS

The Spring Mountains Pyrg, Corn Creek Pyrg, and Southeast Nevada Pyrg are threatened by habitat degradation, spring diversion, invasive species, recreation, global climate change, and potentially by groundwater extraction.

The Corn Creek Pyrg occurs only at Corn Creek Springs, where the main spring has been modified by a cement –lined outflow (Hershler 1998). Invasive species are known to occur at Corn Creek including goldfish (*Carassius auratus*) and crayfish (*Procambarus* sp.) (USDI FWS 2008, p. 4-65).

The Spring Mountains Pyrg and Southeast Nevada Pyrg occur in the Spring Mountains where the majority of springs have experienced habitat disturbance. Fleishman et al. (2006) examined 63 springs in the Spring Mountains and classified 79% of them as disturbed. Many of the springs in the Spring Mountains have been excavated or developed, and water-diversion structures and invasive species are common. In addition, many of the springs have been affected by stochastic phenomena including fire, floods, and avalanches (Fleishman et al. 2006). Sada et al. (2005) examined 45 springs in the Spring Mountains and classified 78%

of them as disturbed to some degree. Exotic plant species are known to be present at Kiup, Red and Willow Springs (Sada and Nachlinger 1996, 1998).

Sada and Nachlinger (1996) identify spring diversion, recreation, grazing, and exotic species as threats to *P. deaconi* in the Spring Mountains. The Clark County Multi Species Habitat Conservation Plan (2000) reports threats to *P. deaconi* as: habitat degradation and modification resulting from concentrated recreation, degradation by wild horse and burro grazing and trampling, spring diversion and modification, and spring outflow diversion. Hershler (1998) reports that *P. deaconi's* type locality has been moderately impacted by recreational activities (p. 25).

BLM survey documents describe Willow Spring as "highly disturbed" due to recreation, picnicking, diversion, and burro use. At one point Willow Spring was rated as nonfunctional because it is developed and piped to pools (Norman and McFadden 1998). Concerning Willow Spring, Sada and Nachlinger (1996) state:

> "Willow Spring has been modified for visitor use so that little natural character remains to aquatic and riparian systems. Impoundment and channelization of the springbrook, and placement of trails and concrete in the riparian zone, eliminated riparian vegetation and caused extirpation of two undescribed springsnail species that are endemic to the Spring Mountains area" (p. 29).

Red Spring is heavily used by the public. Sada and Nachlinger (1996) describe it as being moderately disturbed by recreation (p. 30, II-5). BLM survey documents describe Red Spring as moderately disturbed due to recreation and burro use. A BLM survey document dated April 22, 1998 states that the spring is in a developed recreation site and heavy recreational use is occurring. Recreational disturbance was also reported in 2002 and 2003:

> "There is evidence that the stream flow was dammed and diverted by recreationists" (Patrick Putnam March 1, 2002 Red Springs Analysis and recommendations).

> "The current habitat conditions of the springsnail are subject to degradation due to people recreating directly in the spring source. This activity can cause fluctuations in water chemistry and trampling of both vegetation and the snail itself" (BLM 2003, p. 38).

The BLM has since made habitat improvements at Red and Willow Springs, and they are now recovering.

Because of their proximity to the city of Las Vegas, all of these species are potentially threatened by recreation. Recreational impacts are expected to increase with increased human population growth in southern Nevada:

> "As the human population of the county (Clark) increases, it is assumed that there will be a resultant increase in the amount of recreational and other uses of Bureau of

> Land Management, National Park Service, Forest Service, and Refuge lands" (USDI 2000, p. 5.1)

In Las Vegas Valley, *P. fausta* is potentially threatened by groundwater development. Groundwater is expected to decline by 30 m in Las Vegas Valley (Deacon et al. 2007, Schaefer and Harrill 1995, Harrill and Prudic 1998). The yield of Las Vegas Valley is 25,000 afy, but there are 93,992 afy of active water records, 77,729 afy of which are vested, permitted, or certified (NDWR 2009). Historically, groundwater extraction and tapping of artesian wells dried up local springs and lowered the water table by 100 m in some areas in Las Vegas Valley (Pavleko et al.1999). It is possible that springs susceptible to groundwater withdrawal have already been desiccated. Most of the groundwater in Las Vegas Valley is from the Spring Mountains, which is precipitation dependent (Thomas et al. 1996). Global climate change thus poses a threat to *P. deaconi*, *P. fausta*, and *P. turbatrix* populations in Las Vegas Valley because climate change could lead to decreased precipitation and decreased spring recharge and discharge (Field et al. 2007).

In Pahrump Valley, groundwater is expected to decline by 3 m where *P. turbatrix* occurs (Deacon et al. 2007, Schaefer and Harrill 1995, Harrill and Prudic 1998). The yield of Pahrump Valley is 12,000 afy, but there are 53,641 afy of permitted, vested, and certified rights (NDWR 2009). Excessive groundwater pumping already contributed to the extirpation of a population of *P. deaconi* in Pahrump Valley (Hershler 1998). It is likely that springsnail populations in Pahrump Valley that are susceptible to groundwater pumping impacts have already been eradicated, with remaining springs being supplied by recharge from the Spring Mountains, making them susceptible to decreased springflow due to global climate change (Thomas et al. 1996, Field et al. 2007).

LAND MANAGEMENT

Red Spring and Willow Spring are in the Red Rock Canyon National Conservation Area and are managed by the Bureau of Land Management. Kiup Spring is managed by the U.S. Forest Service. Corn Creek Springs is in the Desert National Wildlife Refuge Complex and is managed by the U.S. Fish and Wildlife Service.

<u>MEADOW VALLEY WASH (CAMP VALLEY)</u>

SPECIES

24. *Pyrgulopsis montana* Camp Valley Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Camp Valley Pyrg is medium-sized with a sub-globose to ovate-conic shell that is slightly broad with a simple whorl outline. It is 2.1 - 3.0 mm in height, and has 3.25 - 4.0 whorls and a light brown periostracum. The penis is small with medium-length filament and a short lobe. The penial ornament is a small terminal gland.

Range. This springsnail is known only from an unnamed spring in the upper Camp Valley of Lincoln County, Nevada in the Meadow Valley Wash (Hershler 1998).
Habitat Requirements. The spring where this species occurs is a small montane rheocrene (Hershler 1998).

Status. The Camp Valley Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. This snail has no legal protective status.

THREATS

The Camp Valley Pyrg is threatened by reduced springflow due to groundwater development. It is well established that groundwater extraction can negatively influence spring discharge (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). Springsnails can be negatively affected by alterations and reductions in springflow (Ponder et al. 1989, Myers and Resh 1999, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Sada and Vinyard 2002, Hurt 2004, Deacon 2006, Strayer 2006, Deacon 2007, Sada 2008).

The Camp Valley Pyrg occurs at only a single spring, and this site is in the region of influence for the Lincoln County Water District's (LCWD) Kane Springs Valley (KSV) Groundwater Development Project which would withdraw 5,000 afy from the regional aquifer for use in the Coyote Springs Investment development area (USDI 2008 KSV FSEIS). The flow in Meadow Valley Wash contains 38% groundwater from the regional aquifer (USDI 2008 KSV FSEIS p. 3-27). Myers (2007) predicts that springflow in Meadow Valley Wash will decline due to pumping by the Southern Nevada Water Authority in Cave, Dry Lake, and Delamar Valleys. The Camp Valley Pyrg is also potentially threatened by pumping for the Lincoln County Land Act Groundwater Development and Utility Right-of-Way Project (Deacon et al. 2007, USDI 2008 Lincoln Co. Land Act GDP DEIS). In addition, the Moapa Valley Water District holds 7,860 afy of ready for action or ready for action protested applications for this basin. Groundwater is projected to decline by 30 m in Camp Valley where the Camp Valley Pyrg occurs (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007). The Nevada Division of Water Resources reports the combined perennial yield of Lower Meadow Valley Wash (Basin #205) and basins 198-205 to be 25000 afy, so the yield for Lower Meadow Valley Wash alone is less than this. There are 31,741 afy of active records for Lower Meadow Valley Wash, 23,473 afy of which are permitted and certified (NDWR 2009).

This Camp Valley Pyrg is intrinsically vulnerable to extinction because of its existence at only one location. The single spring where the Camp Valley Pyrg occurs is known to have been heavily impacted by livestock grazing (Hershler 1998). The Camp Valley Pyrg is also threatened by global climate change which will likely negatively affect spring discharge and recharge due to altered regional precipitation patterns (Field et al. 2007).

LAND MANAGEMENT
The single spring where this species occurs is privately owned.

MUDDY RIVER SPRINGS AREA (UPPER MOAPA)

SPECIES

25. *Pyrgulopsis avernalis* Moapa Pebblesnail

Taxonomy. Family Hydrobiidae. Pilsbry 1935. This species was transferred from *Fluminicola* (Pilsbry 1935).

Description. The Moapa Pebblesnail is a medium-sized snail with a globose-trochoid shell. The penis is large with short filament and lacks a lobe. The penial ornament is a large ventral gland.

Range. This snail occurs in the Muddy River watershed in Clark County, Nevada, in the Moapa Valley at Moapa Springs, Apcar Springs, Cardy Lamb Spring, Muddy Spring, and springs west of Muddy Spring (Hershler 1998).

Habitat Requirements. Sada (2008) conducted detailed analyses in this species' habitat at Warm Springs and found that *P. avernalis* was more associated with gravel substrate, higher current velocities, and warmer water temperatures than other snail species at Warm Springs. Discharge and temperature at individual springs where this species occurs ranges from 10 – 200 l/min and from 24.5 $^{-}$ 31.8^{o} C, respectively. Spring brooks are bordered by ash (*Fraxinus velutina*), mesquite (*Prosopis* sp.), non-native salt cedar (*Tamarisk* sp.), and fan palm (*Washingtonia filifera*) interspersed with grasses (mostly *Distichlis spicata*) and perennial herbs. The Moapa Pebblesnail occupies a wide diversity of depths, but prefers depths from 30 cm to 40 cm. It also occupies a wide variety of current velocities, but prefers velocities > 50 cm/sec and strongly prefers velocities of approximately 70 - 110 cm/sec. This snail avoids currents < 40 cm/sec and is found most often where currents are swift and smaller substrates are scarce. The species prefers gravel, avoids cobble, and strongly avoids fines, sand, and coarse particulate organic matter. It occupies the warmest water temperatures in the spring province, preferring temperatures near 32^{o} C, and avoiding cooler water (Sada 2008).

Status. The Moapa Pebblesnail is critically imperiled meaning this species is at very high risk of extinction (G1G2 S1S2 (NV)) (NatureServe 2008).The snail does not have any protective status.

26. *Pyrgulopsis carinifera* Moapa Valley Pyrg

Taxonomy. Family Hydrobiidae. Pilsbry 1935

Description. The Moapa Valley Pyrg is a medium-sized snail with a trochoid shell. Its penis is medium-sized with medium length filament and lobe. The penial ornament is a large, fragmented terminal gland.

Range. The Moapa Valley Pyrg occurs in Clark County, Nevada, in the Upper Muddy River watershed at Apcar Springs, Muddy Spring, springs west of Muddy Spring, and at a spring in Moapa Valley National Wildlife Refuge.

Habitat Requirements. Sada (2008) gathered detailed information on this species' habitat at Warm Springs. Discharge and temperature at individual springs where this species occurs ranges from 10 – 200 l/min and from 24.5 - 31.8° C, respectively. Spring brooks are bordered by ash (*Fraxinus velutina*), mesquite (*Prosopis* sp.), non-native salt cedar (*Tamarisk* sp.), and fan palm (*Washingtonia filifera*) interspersed with grasses (mostly *Distichlis spicata*) and perennial herbs. He found that the Moapa Valley Pyrg is associated with moderate current velocities and incised, unarmored banks (Sada 2008). This snail occupies a diversity of depths but prefers habitats less than 10 cm deep and avoids depths greater than 30 cm. It occupies both slow and fast currents, and prefers mean water column velocities from 30 to 40 cm/sec. Similar to *P. avernalis*, it prefers gravel, avoids sand and coarse particulate organic matter, and strongly avoids fines and cobbles. It also strongly preferred temperatures near 32° C and avoids cooler water (Sada 2008).

Status. The Moapa Valley Pyrg is critically imperiled, meaning this snail is at very high risk of extinction (G1S1 (NV)) (NatureServe 2008). It completely lacks protective status.

27. Grated Tryonia *Tryonia clathrata*

Taxonomy. Family Cochliopidae. Stimpson 1865

Description. The Grated Tryonia has a medium to large-sized conical shell, a height of 2.9 - 7.0 mm, and 5.75 - 8.75 whorls. The penial ornament consists of 4 medial to proximal and 1 basal papillae along the inner edge with occasional basal papilla arising from near mid-line (rather than from penis edge). It is distinguished from other congeners by its strong collabral shell sculpture, ellipsoidal operculum, and more numerous papillae on the inner edge of the penis (Hershler 2001).

Range. The Grated Tryonia is found at eleven to thirteen sites in the Muddy River, White River, and Pahranagat Valleys. It occurs in Clark County, Nevada at Oasis Spring, a spring west of Oasis Spring, Muddy Spring, springs west of Muddy Spring, Cardy Lamb Spring, Apcar Springs, a spring in Moapa Valley Water District, and a spring in the Moapa Valley National Wildlife Refuge. It occurs in the Pahranagat Valley in Lincoln County at Warm Spring, Ash Springs, and Crystal Spring. The species occurs in Nye County at Moorman Spring and Hot Creek Spring.

Habitat Requirements. The Grated Tryonia appears to prefer warmer waters than other springsnail species with which it co-occurs. Sada (2008) found that *Tryonia clathrata* was most common along spring brook banks where it preferred shallow (< 5 cm deep), slow moving (< 20 cm/sec) water while avoiding deeper, swiftly flowing waters. In terms of substrate, Sada (2008) found that this species preferred sand, fines, and coarse particulate organic matter, and strongly avoided gravel and cobbles. This species can also be found on algae and detritus (USDOI 2008 KSV FEIS).

Golden et al. (2007) characterized several of the springs where the Grated Tryonia occurs. Hot Creek Spring is a limnocrene with a maximum depth of 488 cm, a temperature of 31º C, and vegetation including Bulrush (*Schoenoplectus* sp.) and Muskgrass (*Chara vulgaris*). Moorman Spring is a rheocrene with a maximum depth of 50 cm and a temperature of 35º C. Ash Spring is a limnocrene with a maximum depth of 150 cm, a temperature of 34º C, and vegetation that includes Horsehair algae (*Chlorophyceae* sp.), Spikerush (*Eleocharis* sp.), and Yerba mansa (*Anemopsis* sp.*)*. Crystal Spring is a limnocrene with a maximum depth of 152 cm and a temperature of 27º C with vegetation including Saltgrass (*Distichlis spicata*). Discharge and temperature at individual springs ranged from 10 – 200 l/min, and 24.5º - 31.8º C, respectively.

Sada (2008) reported habitat characteristics for Warm Springs in Clark County. He found that the water temperature at the spring sources is approximately 32º C with discharge from individual springs ranging from approximately 0.0028 to 0.17 m^3/sec. The spring brooks are bordered by ash (*Fraxinus velutina*), mesquite (*Prosopis* sp.), non-native salt cedar (*Tamarisk* sp.), and fan palm (*Washingtonia filifera*) interspersed with grasses (mostly *Distichlis spicata*) and perennial herbs.

Status. The Grated Tryonia is imperiled and is declining (G2 S2 (NV)) (NatureServe 2008). It is a Former Category 2 Candidate Species but lost its Candidate status when the Category 2 designation was eliminated (USDI FWS 1996). It is on the Nevada Natural Heritage Program At-Risk Tracking List. The Grated Tryonia is included in the Nevada BLM's Special Status Species Program, but this program does not provide the species or its habitat any substantial protection.

THREATS

Pyrgulopsis avernalis, P. carinifera, and *Tryonia clathrata* are threatened by decreased spring discharge due to groundwater development, and by water diversions, recreation, invasive species, and global climate change.

The overarching threat to the Moapa Pebblesnail, Moapa Valley Pyrg, and Grated Tryonia is groundwater development. Groundwater is already declining in the Muddy River Springs Area, and this decline is expected to increase as the result of currently proposed withdrawals. Groundwater has been and continues to be extracted from both the shallow alluvial aquifer and the deeper carbonate rock aquifer in the Muddy River Springs Area. Water has been removed from the alluvial aquifer since the 1940's, and municipalities began extracting water from the carbonate aquifer in the 1980's, with development increasing significantly in 1998. Mayer and Congdon (2007) found that there has been a statistically significant fourfold increase in groundwater removal from the regional carbonate aquifer since 1998, with extraction averaging 8870 m^3/d from 1998 -2005 (p. 9). Withdrawal from the alluvial aquifer has also increased, averaging 17,750 m^3/d from 1998-2005 (Ibid). Well data indicate that the groundwater level in the carbonate aquifer in the Muddy River Springs Area shows a multiyear decrease beginning in 1998 that corresponds to the fourfold increase in extraction from the carbonate aquifer that simultaneously occurred in the Muddy River Springs Area (Mayer and Congdon 2007). Mayer and Congdon (2007) found that groundwater levels at Muddy River Springs are responsive to both climate and pumping influences, but that groundwater removal is primarily responsible for decreasing groundwater levels. They state:

> "We infer from these results that the long-term decline in carbonate levels beginning in 1998 is a result of the increased carbonate pumping that began at the same time" (Mayer and Congdon 2007, p. 11).

Groundwater is projected to decline from 3-30 m in the Muddy River Springs Area (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007).The perennial yield of the Muddy River Springs Area (Upper Moapa) basin (hydrographic basin #219) is estimated to be 100 – 36,000 afy, and there are 15,085 permitted and certified afy for this basin (Nevada Division of Water Resources Database 2009). Groundwater levels in this basin will be negatively affected by withdrawals from connected basins.

Groundwater removal from the alluvial and carbonate aquifers has direct negative influences on springflow at Muddy River Springs. Spring discharge emanates from the regional carbonate aquifer (Eakin 1966, Prudic et al. 1993, Thomas et al. 1996, Mayer and Congdon 2007, p. 4). Mayer and Congdon (2007) state:

> "Relatively small changes in carbonate water levels are observed to cause corresponding changes in regional spring discharge . . . Our statistical results give strong inference that the carbonate rock aquifer and the regional springs are well connected and responding to changes in climate and pumping and that the system is reaching the limits of sustainability" (p. 15).

Surface flows have been declining in the Muddy River watershed since the early 1960s, likely due to surface water diversions and nearby groundwater pumping (USDI FWS 2008, p. 4-74). Because the carbonate aquifer has high transmissivity and a uniform potentiometric surface, even springs distant from pump locations can be negatively affected by pumping (Mayer and Congdon 2007, p. 9). It is established that historical and current groundwater removal has led to decreased spring discharge at Muddy River Springs, and springflow will continue to be negatively affected by additional groundwater removal. Flow at Apcar Spring, where *Pyrgulopsis avernalis*, *P. carinifera*, and *Tryonia clathrata* occur, is known to be declining (USDI 2006b, p. 40).

Surface flows in the Muddy River watershed are likely to be negatively affected by the Kane Springs Valley Groundwater Development Project, pumping in Coyote Spring Valley, pumping in Cave, Dry Lake, and Delamar Valleys, and pumping by Vidler Water Company (USDI 2006b, Deacon et al. 2007, Myers 2007). U.S. Fish and Wildlife Service determined that the withdrawal of 16,100 afy of groundwater from the White River Flow system of the regional carbonate aquifer in Coyote Spring Valley and the California Wash will have adverse affects on surface flows in the Moapa Valley National Wildlife Refuge, which was established to protect the Moapa dace (*Moapa coriacea)*, and where populations of *Pyrgulopsis avernalis, P. carinifera*, and *Tryonia clathrata* also occur. FWS (2006b) states:

> "The Moapa dace will be directly affected by the proposed groundwater withdrawals since those actions are likely to affect the spring flows upon which the dace depends" (USDI 2006b, p. 44).

Groundwater development projects include mitigation measures to protect the dace, but these measures are not adequate to protect the petitioned springsnails because springsnails have different microhabitat requirements than dace. Sada (2008) states:

> "Springsnail preference for relatively shallow habitats with diverse substrate composition suggests that springbrook restoration designed solely for Moapa dace may not provide sufficient heterogeneity for springsnails" (Sada 2008, p. 70).

Even if monitoring wells detected a decline in groundwater, and even if pumping were actually ceased in response to monitoring data, the level of decline necessary to trigger mitigations might not be sufficient to protect springsnail habitat, and populations could drastically decline or be extirpated in the interim. Measures intended to protect the dace cannot be considered adequate to protect the springsnails.

Sada (2008) conducted detailed studies of springsnail ecology at Warm Springs in the Muddy River Springs Area and found that each springsnail species exhibits specific habitat preferences, that springsnail abundance is correlated with habitat variables, and that human alterations to the spring systems, including diversion and decreased surface flows, negatively affect springsnail abundance:

> "Studies at Warm Springs provide quantitative evidence that springsnail abundance may be affected by any factor affecting water temperature (e.g., springbrook diversion, integrity of riparian vegetation), and the quality and heterogeneity of spring habitats. Human activities that reduce environmental heterogeneity (e.g., reduce discharge, channelize, or alter springbrook bank morphology and vegetation) are likely to reduce springsnail abundance or extirpate populations because they alter elements of the environment that define springsnail habitat. Effects of reduced habitat quality and heterogeneity by channelization, siltation, and diversion on springsnail abundance are apparent at Warm Springs where springsnails are scarce or absent from approximately 85 percent of historically occupied springbrooks" (Sada 2008, p. 69).

Available data clearly provide substantial information that groundwater pumping is and will continue to negatively affect springflow at the Muddy River Springs Area (Mayer and Congdon 2007), and that this alteration in springflow directly threatens springsnail populations (Sada 2008), warranting Endangered Species Act protection for *Pyrgulopsis avernalis, P. carinifera*, and *Tryonia clathrata.* The more detailed studies which are available for this particular basin and its species are also applicable to other basins in that groundwater withdrawal decreases springflow, and decreased springflow negatively affects springsnail populations.

Pyrgulopsis avernalis and *P. carinifera* occur only at Muddy River Springs. *Tryonia clathrata* also occurs in Pahranagat Valley and White River Valley (discussed in detail below in the sections for the respective valleys). Flows in Pahranagat Valley and White River Valley could decline due to pumping for the Kane Springs Valley Groundwater Development Project, pumping by Vidler Water Company, and withdrawal for the Clark, Lincoln, and White Pine Counties Groundwater Development Project and the Lincoln County Land Act Groundwater Development and Utility Right-of-Way Project (Deacon et al. 2007, ENSR 2007, USDI 2008 Lincoln Co. Land Act GDP DEIS).

In addition to the threat of groundwater withdrawal, these species are threatened by habitat degradation due to surface diversions, recreational impacts, invasive species, and global climate change. At Warm Springs, 85 percent of historically occupied springbrooks no longer support springsnail populations (Sada 2008). Sada (2008) states:

> "[S]prings have been altered for recreation and diversion, channelization, and siltation from agriculture, and non-native fishes and aquatic invertebrates have been introduced (Scoppettone,1993)" (p. 70).

Habitat degradation has been extensive:

> "Spring orifices and outflow streams have been dug out, lined with concrete and/or gravel, mechanically and/or chemically treated to eliminate aquatic vegetation, and chlorinated to create private and public swimming pools. Several springs are capped and piped directly from the orifices for municipal use, desiccating associated outflow streams. Chlorination and agricultural activities in the Warm Springs have decreased in recent years, but some spring outflow springs continue to flow through culverts and/or dirt and cement irrigation ditches" (USDI 2006b, p. 28).

Degradation is ongoing. At least three Moapa spring habitats were recently destroyed by diverting spring discharge into pipes. There is a known irrigation diversion at Crystal Spring where *T. clathrata* occurs (Golden et al. 2007). Golden et al. (2007) noted that sensitive aquatic species have been extirpated at Ash Spring and Crystal Spring and that recreation has degraded these springs. Springs in the Moapa Valley National Wildlife Refuge have been degraded by recreational activities and diversions (USDI FWS 2008). Although Moapa Valley National Wildlife Refuge is currently closed to the public, aquatic habitats there have been degraded by previous recreational activities including swimming (USDI FWS 2008), and unauthorized recreation remains a threat.

Invasive species are a potential threat to *P. avernalis, P. carinifera,* and *T. clathrata.* Invasive flora and fauna have degraded habitats in the Muddy River system (USDI 2006b). Nonnative fish species, including Tilapia, are known to be present (USDI 2006b). The oriental snail *Melanoides turberculatum* is present at the springs which support the petitioned species (Sada 2008). Apcar Spring is in an area that "is currently overgrown with non-native vegetation and requires stream restoration throughout the entire unit" (USDI 2006b, p. 57).

Nonnative species are known to be present at Hot Creek Spring in the White River Valley and at Crystal Spring in the Pahranagat Valley where the Grated Tryonia occurs (Golden et al. 2007). Nonnative species of fishes, frogs, invertebrates and plants are "pervasive throughout many of the aquatic systems of interest in the Pahranagat Valley" (Golden et al. 2007).

Spring discharge at Muddy River Springs emanates from the regional carbonate aquifer (Mayer and Congdon 2007) which is recharged principally by winter precipitation and late spring snowmelt (Winnograd et al. 1998). Global climate change thus threatens these springsnail species because of the likelihood of reduced snowpack due to higher average temperatures and altered precipitation patterns (Field et al. 2007).

LAND MANAGEMENT

Pyrgulopsis avernalis, *P. carinifera*, and *Tryonia clathrata* occur in the Moapa Valley National Wildlife Refuge and at privately owned springs. *Tryonia clathrata* occurs at Hot Creek Spring which is managed by the Nevada Department of Wildlife, at Moorman Spring and Crystal Springs, which are privately owned, and at Ash Spring, which Golden et al. (2007) list the ownership of as BLM/Private.

PAHRANAGAT VALLEY

SPECIES

28. Hubbs Pyrg *Pyrgulopsis hubbsi*

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Hubbs Pyrg is a medium-sized to large springsnail with a globose to low-conical somewhat squat shell and a thick, light brown periostracum. It is 2.5 - 3.8 mm in height and has 3.25 - 3.75 whorls. Its penis is medium-sized with a long filament and short lobe and lacks a ventral gland. The penial ornament is a dot-like terminal gland.

Range. The Hubbs Pyrg is known only from Hiko Spring and Crystal Spring in the Pahranagat Valley of Lincoln County, Nevada (Hershler 1998). The species could possibly be extirpated at Hiko Spring; Golden et al. (2007) did not find any springsnails during surveys at the spring.

Habitat Requirements. Hershler (1998) describes Hiko Spring as a large, thermal (27º C) rheocrene. Golden et al. (2007) describe Hiko Spring as a limnocrene with a maximum depth of 273 cm, a temperature of 19 - 26º C, and vegetation that includes Spikerush (*Eleocharis sp*.), Bulrush (*Schoenoplectus* sp.), and Horsehair algae (*Chlorophyceae* sp.). Crystal Spring is a limnocrene with a maximum depth of 152 cm and a temperature of 27º C with vegetation that includes Saltgrass (*Distichlis spicata*).

Status. The Hubbs Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. Existing regulatory mechanisms do not provide this species with any protection.

29. *Pyrgulopsis merriami* Pahranagat Pebblesnail

Taxonomy. Family Hydrobiidae. Pilsbry and Beecher 1892. This snail was previously known as *Fluminicola merriami* (Hershler 1994), but was later transferred to the genus *Pyrgulopsis* and is considered a valid taxon (Hershler 1994, Turgeon et al. 1998).

Description. The Pahranagat Pebblesnail is medium-sized with a globose shell. Its penis is large with short filament and medium length lobe. The penial gland is large and trifid and the ventral gland is large.

Range. The Pahranagat Pebblesnail is known from four Nevada springs. It occurs at Ash Spring in the Pahranagat Valley in Lincoln County (Hershler 1994). In the White River Valley in Nye County it occurs at Hot Creek Spring, Moon River Spring, and Moorman Spring (Hershler 1998).

Habitat Requirements. The Pahranagat Pebblesnail uses thermal springs. Hot Creek Spring is a limnocrene with a maximum depth of 488 cm, a temperature of 31º C, and vegetation including Bulrush (*Schoenoplectus* sp.) and Muskgrass (*Chara vulgaris*). Moon River Spring is a rheocrene with a maximum depth of 3 cm and a temperature of 32º C. Moorman Spring is a rheocrene with a maximum depth of 50 cm and a temperature of 35º C. Ash Spring is a limnocrene with a maximum depth of 150 cm, a temperature of 34º C, and vegetation that includes Horsehair algae (*Chlorophyceae* sp.), Spikerush (*Eleocharis* sp.), and Yerba mansa (*Anemopsis* sp.).

Status. The Pahranagat Pebblesnail is critically imperiled, meaning this species is at very high risk of extinction (G1 S1 (NV) NatureServe 2008). This snail was proposed for listing as Threatened under the ESA in 1976 (USDI FWS 1976), but the proposal was withdrawn in 1979 because the USFWS failed to finalize the rule within two years (USDI FWS 1979). The snail was later designated a Category 2 Candidate species (USDI FWS 1994), but was subsequently dropped as a Candidate altogether due to the elimination of the Category 2 designation (USDI FWS 1996). This species completely lacks protective status.

27. Grated Tryonia *Tryonia clathrata*. The Grated Tryonia occurs in Pahranagat Valley in Lincoln County at Warm Spring, Ash Springs, and Crystal Spring. *Tryonia clathrata* is described in the Muddy River Springs section, above, p. 91.

THREATS

Pyrgulopsis hubbsi, *P. merriami*, and *Tryonia clathrata* are threatened by groundwater development, spring diversion, nonnative species, recreation, grazing, drought, and global climate change.

It is well established that groundwater extraction can lead to decreased spring discharge or spring failure ((Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). Springsnail populations are obviously extirpated when springs fail, but even reduced spring discharge can cause springsnail populations to decline because springsnails exhibit very specific habitat preferences and are dependent on consistent microhabitat conditions (Taylor 1985, Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008, Brown et al. 2008). Springflow in Pahranagat Valley is fed by the regional carbonate aquifer where large-scale groundwater extraction is planned.

In Pahranagat Valley, multiple groundwater development projects threaten the Hubbs Pyrg, Pahranagat Pebblesnail, and Grated Tryonia including the Southern Nevada Water Authority's Clark, Lincoln, and White Pine County Groundwater Development Project, the Lincoln County Land Act Groundwater Development and Utility Right-of-Way Project, the Lincoln County Water District's (LCWD) Kane Springs Valley (KSV) Groundwater Development Project, and pumping by Vidler Water Company (Deacon et al. 2007, ENSR 2007, USDI 2008 KSV FSEIS, USDI 2008 Lincoln Co. Land Act GDP DEIS). Myers (2007) predicts that springflow in Pahranagat Valley will decline as the result of SNWA pumping in Cave, Dry Lake, and Delamar Valleys. Deacon et al. (2007) specifically identify Ash, Crystal, and Hiko Springs, where these three species occur, as springs that are likely to be adversely affected by pumping by Vidler and SNWA. Schaefer and Harrill (1995) predict a decrease in flow of 14% for Pahranagat Valley springs. There is a projected 3-30 m decline in groundwater where these species occur in Pahranagat Valley (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007). The perennial yield of Pahranagat valley is 25,000 afy, but there are 31,816 total active records for this basin (NDWR 2009).

The Hubbs Pyrg occurs only in Pahranagat Valley where it is threatened by groundwater development, and in addition, faces multiple other threats. This species is highly vulnerable to extinction because it occurs at only two sites, appears to be declining at one of these sites, and may already be extirpated at the other (Golden et al. 2007). The Hubbs Pyrg warrants emergency listing. Golden et al. (2007) state:

> "While Hiko Spring is the type location and survey results from 1992 (Sada 2005) show that the Hubbs springsnail was abundant at Hiko Spring, these springsnails were not found in Hiko Spring during subsequent surveys in 2000 or our surveys in September 2006. Therefore, the Hubbs springsnail appears to be extirpated in this system."

This springsnail also appears to be declining at Crystal Spring. Golden et al. (2007) report:

> "In addition, we found that the Hubbs springsnail was scarce in Crystal Spring. We sampled 31 different locations in various spring heads, pools, and spring brooks, and only found springsnails, which were scarce, at one of those locations. EcoAnalysts identified only one springsnail (Hydrobiidae) in their 300 organism subsample of our qualitative macroinvertebrate sample from Crystal Spring. Survey results from 1992

listed in Sada (2005a) showed that the Hubbs springsnail was abundant at Crystal Spring, but it was found to be scarce and only present at a single location in Crystal Spring during subsequent surveys (D.W. Sada 2005)."

Threats to the Hubbs Pyrg, in addition to groundwater development, include spring diversion, nonnative species, recreation, grazing, drought, presence of a residence, and global climate change (Hershler 1998, Sada and Vinyard 2002, Deacon et al. 2007, Golden et al. 2007, Field et al. 2007). Golden et al. (2007) describe the disturbance level at Hiko Spring as high due to diversion, nonnative species, recreation, grazing, drought, and presence of a residence. The disturbance level at Crystal Spring, where both *P. hubbsi* and *T. clathrata* occur, is also high due to spring diversion, recreation, and nonnative species (Golden et al. 2007). Crystal Spring discharges into a bermed pond that drains into a piped irrigation outflow.

Other threats to the Pahranagat Pebblesnail include spring development, domestic livestock grazing, recreation, and invasive species (USDI FWS 1976, 1998, Hershler 1994, 1995, Golden et al. 2007). Nonnative fishes, frogs, invertebrates, and plants are pervasive throughout many aquatic systems in the Pahranagat Valley (Golden et al. 2007). Hot Creek Spring has been disturbed by recreation and nonnative species (Golden et al. 2007). Ash Spring, where both *P. merriami* and *T. clathrata* occur, has been highly disturbed by diversion, nonnative species, and recreation (Golden et al. 2007). The public portion of Ash Spring is a recreational area where flows have been diverted for swimming and bathing (Ibid). Global climate change is a threat for these three springsnail species because alterations in regional precipitation patterns and reduced snowpack could negatively affect spring recharge and discharge (Field et al. 2007).

The Hubbs Pyrg occurs only in Pahranagat Valley. The Pahranagat Pebblesnail and Grated Tryonia also occur in White River Valley, and the Grated Tryonia occurs in Muddy River Springs. Threats to these species in White River Valley and Muddy River Valley are discussed by valley on pages 111 and 90, respectively.

LAND MANAGEMENT

Hot Creek Spring is managed by the Nevada Department of Wildlife. Ash Spring is managed by the BLM. Crystal Spring, Hiko Springs, Moon River Spring, and Moorman Spring are privately owned.

RALSTON and STONE CABIN VALLEYS

SPECIES

30. *Pyrgulopsis sterilis* Sterile Basin Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Sterile Basin Pyrg is a medium to large-sized snail with an ovate to narrow conic shell. Its height is 2.2-4.0 mm, and it has 3.75-5.25 whorls and a dark brown periostracum. The penis is medium-sized with medium length filament and lobe. The penial ornament consists of small terminal and penial glands.

Range. The Sterile Basin Pyrg occurs in Nye County at a spring at Hunts Canyon Ranch in the Ralston Valley and at Sidehill Spring in Stone Cabin Valley.

Habitat Requirements. One of the springs where this species occurs is a small rheocrene.

Status. The Sterile Basin Pyrg is critically imperiled meaning it is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It completely lacks protective status.

THREATS

The Sterile Basin Pyrg is threatened by reduced spring discharge or spring failure due to groundwater development. Groundwater is projected to decline from 0.3-3 m in Ralston Valley, and from 3-15 m in Stone Cabin Valley (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007). The perennial yield of Ralston Valley is 6,000 afy and there are 5,939 active records for this basin (NDWR 2009). The Nye County Board of Commissioners and MGC Resources, Inc. hold Ready for Action or Ready for Action Protested applications in Ralston Valley (Ibid). The perennial yield of Stone Cabin Valley is 2000 afy, but there are 16,653 total active records for this basin, including 11,533 afy of permitted, vested, and certified rights, which far exceeds the yield (NDWR 2009).

Groundwater withdrawal can cause reduced spring output or spring desiccation (Fiero and Maxey 1970, Dudley and Larson 1976, Hendrickson and Minckley 1984, Schaefer and Harrill 1995, Myers and Resh 1999, Mudd 2000, Burk et al. 2005, Zektser et al. 2005, Bedinger and Harrill 2006, Strayer 2006, Deacon et al. 2007, Mayer and Congdon 2007, Patten et al. 2008). Spring failure would lead to extinction for this species, but this springsnail could also face population decline due to reduced spring discharge because springsnail populations exhibit very specific habitat preferences and are dependent on consistent springflow and microhabitat conditions (Taylor 1985, Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008, Brown et al. 2008).

The Sterile Basin Pyrg is intrinsically vulnerable to extinction because of its occurrence at only two sites. Livestock grazing and spring development threaten this species because one of its localities is "in the middle of a pasture on a private ranch" (Hershler 1998, p. 54). Global climate change is also a threat to *P. sterilis* because altered regional precipitation patterns and reduced snowpack could contribute to reduced springflows (Field et al. 2007).

LAND MANAGEMENT

The two springs where *Pyrgulopsis sterilis* occurs are privately owned.

SNAKE and SPRING VALLEYS

SPECIES

31. *Pyrgulopsis anguina* Longitudinal Gland Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Longitudinal Gland Pyrg is a medium-sized snail with a sub-globose to ovate conic shell and a tan-green periostracum. Its height is1.7 - 2.4 mm and its penis is large with short filament and short lobe.

Range. This springsnail is known from Big Springs and an unnamed spring north of Big Springs in Snake Valley in White Pine County, Nevada and from Clay Spring in Snake Valley in Millard County, Utah (Hershler 1998).

Habitat Requirements. Hershler (1994) described the habitat of this species as warm, flowing springs with intermediate conductivity and a temperature of 16 - 17° C. One of the springs is a shallow 4 m wide rheocrene. Aquatic vegetation at the springs includes watercress (*Rorippa nasturtium-aquaticum*), Baltic Rush (*Juncus balticus*), and muskgrass (*Chara vulgaris)* (Golden et al. 2007).

Status. The Longitudinal Gland Pyrg is critically imperiled meaning that it is at very high risk of becoming extinct (G1 S1 (NV) S1 (UT)) (NatureServe 2008). It is a State of Utah Wildlife Species of Concern (2007). This pyrg is not adequately protected by any existing regulatory mechanisms.

32. *Pyrgulopsis peculiaris* Bifid Duct Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Bifid Duct Pyrg is a medium-sized snail with an ovate to narrow conic shell. The penis is large with a medium length lobe and filament, and the penial ornament is a medium-large fragmented terminal gland. It has a small penial gland, an additional four to seven dorsal glands, and two large ventral glands. It is 1.7-3.0 mm in height with a light tan periostracum (Hershler 1998).

Range. This species is known from 6 sites in Millard County, Utah, and two sites in White Pine County, Nevada. In White Pine County *Pyrgulopsis peculiaris* occurs at an unnamed spring at Big Springs Creek in Snake Valley and at Turnley Spring in Spring Valley, but it may be extirpated at Turnley Spring (Golden et al. 2007). In Millard County this snail occurs at a spring in Maple Grove, and at Church Spring and T Spring at South Fork Chalk Creek in Pahvant Valley. It also occurs in the Sevier River drainage (Big Spring, Oak Creek, spring above Swasey Spring, Whirlwind Valley; Antelope Spring, House Range).

Habitat Requirements. The spring at Maple Grove in Round Valley is a small montane rheocrene. Another site where the species occurs, Turnley Spring, is a 42-cm maximum depth rheocrene, with a temperature between 14-18° C (Golden et al. 2007). Seven known inhabited sites are rheocrenes with temperatures ranging from 9-13° C, moderate to high conductivity (317 - 622 micromhos/cm), and elevations from 6,150 to 7,470 ft. (Hershler 1994, State of Utah 2007). Vegetation at springs inhabited by the Bifid Duct Pyrg includes water cress (*Nasturtium officinale*, *Rorippa nasturtium-aquaticum*), Baltic Rush (*Juncus balticus*), and water parsnip (*Berula bess)*.

Status. NatureServe (2008) ranks the Bifid Duct Pyrg as globally imperiled, and critically imperiled in Nevada and Utah (G2 S1 (NV) S1S2 (UT)). It is included in the Nevada BLM's Special Status Species Program. It is a State of Utah Wildlife Species of Concern. There are eight known locations for this species, although it might be extirpated at one of these sites (Golden et al. 2007). This springsnail does not have any substantive protective status.

33. *Pyrgulopsis saxatilis* Sub-Globose Snake Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Sub-Globose Snake Pyrg is a small snail with a sub-globose shell. Its height and width are 1.0-1.4 mm and it has 3.5-4.0 whorls. The periostracum is eroded or absent. It has a large penis with short filament and short lobe. The penial ornament consists of a small terminal gland and large ventral gland.

Range. The Sub-Globose Snake Pyrg is found in the Snake Valley in Millard County, Utah at a single spring complex which includes Warm Springs, Gandy Warm Springs, and Gandy Warm Creek (Hershler 1998, Golden et al. 2007).

Habitat Requirements. This species is found in a series of large, thermal (26.9º C) rheocrenes issuing from the side of a hill. The springs have moderate conductivity, and an elevation of 1500 m (5,080 ft). Saxatilis means "found among rocks" and refers to the rocky habitat of this species.

Status. The Sub-Globose Snake Pyrg is critically imperiled meaning it is at very high risk of extinction (G1 S1 (UT)) (NatureServe 2008). It is a Utah Species of Concern but completely lacks meaningful protective status.

THREATS

The overarching threat to *Pyrgulopsis anguina*, *P. peculiaris* and *P. saxatilis* is groundwater withdrawal (Deacon 2006, Elliott et al. 2006, Myers 2006, Deacon et al. 2007, Patten et al. 2008). *Pyrgulopsis anguina* and *P. saxatilis* occur only in Snake Valley. The perennial yield of Snake Valley is estimated to be 25,000 afy, but there are 65,949 afy of active records for this basin (NDWR 2009). The Southern Nevada Water Authority holds applications for 50,679 afy in Snake Valley. Groundwater is projected to decline between 0.3-30 m in Snake Valley (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007). Concerning the effects of proposed SNWA withdrawals on the petitioned springsnail species in Snake Valley, Deacon (2006) states:

> "In Snake Valley *Pyrgulopsis peculiaris* and *Pyrgulopsis anguina* are restricted to Big Springs and two nearby springs, all within an area identified by Elliott et al. (2006) as "likely susceptible to groundwater withdrawal." Reduction in spring discharge therefore may adversely affect the only habitat from which *Pyrgulopsis anguina* is known, and one of the few habitats occupied by *Pyrgulopsis peculiaris*. Warm Spring in the Utah portion of Snake Valley, the only known habitat of *Pyrgulopsis saxatilis*, may also be adversely affected by the proposed project."

SNWA applications in Snake Valley have yet to be approved because the Lincoln County Land Act requires that Utah and Nevada agree on the appropriation of groundwater from this valley and the states have yet to come to agreement. In terms of habitat destruction, springsnail habitat will be degraded by withdrawal regardless of how the water is ultimately appropriated.

SNWA has already been granted water rights for the withdrawal of 40,000 afy of groundwater (and up to 60,000 afy after ten years) in adjacent Spring Valley. Springsnail habitat in Spring Valley, where *P. peculiaris* occurs, will be directly negatively affected by this withdrawal, and in addition, surface flows in Snake Valley could decline due to hydrological connectivity. The pumping of groundwater from Spring Valley is expected to produce a drawdown cone that will affect surface flows in Spring Valley and adjacent valleys. Congdon (2006) states:

> "[I]t is clear that significant drawdown will occur as a result of pumping of the proposed magnitude . . . [T]he model (Schaefer and Harrill 1995) clearly shows a cone of depression for the carbonate and the alluvial aquifers that could reasonably be expected to develop due to proposed pumping in Spring Valley. Water table levels in the alluvial aquifer could decline by 200 feet or more following 200 years of pumping at the proposed rates. If pumping of this magnitude takes place for long enough, springs, creeks, ponds, and wetlands in Spring Valley have the potential to be dried up or experience reduced flow if and when the potentiometric surface falls below spring orifices or the surface elevation of wetlands, streams and ponds. . .Elliott, et al (2006, page 44) postulate that water resources in southern Snake Valley would likely be affected by large scale water withdrawal from Spring Valley" (pp. 2-4).

The perennial yield of Spring Valley is estimated to be 80,000 afy, and there are already 84,878 afy of permitted and certified rights for this basin, and 166,212 afy total active records (NDWR 2009). Groundwater level is projected to decline from 0.3-30 m in Spring Valley (Schaefer and Harrill 1995, Harrill and Prudic 1998, Deacon et al. 2007). Following 75 years of pumping, the aquifer in Spring Valley could decline by as much as 60 m (in Patten et al. 2008; at http://www.water.nv.gov/hearings/spring%20valley%20hearings).

Groundwater pumping in Spring Valley is expected to have devastating effects on biotic communities. Charlet (2006) states:

> "The general trend of the ecosystems during the proposed action will be to simplify the vertical structure of the vegetation, reduce the biodiversity of the communities, transform wetlands into xeric sites, and dramatically reduce the amount of palatable forage in the valley."

The Spring Valley population of the Bifid Duct Pyrg is likely to be extirpated as the result of groundwater withdrawal. Deacon (2006) states:

> "The report by Myers (2006) indicates that the proposed SNWA groundwater project will result in drawdown of the water table at Sacramento Pass (Spring Valley, Turnley Spring) within 20 years. The drawdown of the water table is likely to be severe enough to cause the springs at Sacramento Pass to fail. As a consequence, the critically imperiled Bifid Duct Pyrg population at Turnley Spring in Spring Valley is likely to disappear within 20 years of implementation of the proposed SNWA project."

Groundwater withdrawal in Spring Valley is subject to a stipulated agreement, but the provisions of this agreement are not adequate to protect springsnails. Springsnails are not mentioned in the agreement. Monitoring provisions are intended to assess "ecosystem health," but this term is not defined, and there is no trigger to stop pumping if effects to biota are manifested. Springsnail populations could be extirpated before reduced springflow was detected, and even if reduced flow were detected, and provisions were in place to stop pumping, these species could be driven to extinction before pumping was stopped. Not only spring desiccation, but also reduced flow is harmful to springsnail populations. Springsnails are dependent on consistent microhabitat conditions and fluctuations in water level can lead to population decline (Taylor 1985, Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008, Brown et al. 2008).

The area of projected groundwater decline from SNWA water development could extend from Death Valley, California to Sevier Lake, Utah (Deacon et al. 2007). This potentially threatens *P. peculiaris* populations in the Sevier drainage.

In addition to groundwater withdrawal, *P. anguina*, *P. peculiaris,* and *P. saxatilis* face a host of other threats including spring diversion, domestic livestock grazing, nonnative species, agricultural development and irrigation, and global climate change (Hershler 1998, Oliver and Bosworth III 1999, Sada and Vinyard 2002, Gorrell et al. 2005, Field et al. 2007, Golden et al. 2007, State of Utah 2007).

Pyrgulopsis anguina occurs at only two springs, both of which have been disturbed by livestock (Hershler 1998, Golden et al. 2007). Golden et al. (2007) report that Big Springs is highly disturbed due to grazing, channelization, presence of a residence, "multiple other human impacts," drought, and nonnative species. Clay Spring is also highly disturbed due to water diversion and grazing (Golden et al 2007). The State of Utah (2007) describes habitat conditions for *P. anguina* at Clay Spring:

> "The spring now issues from an artificial structure, a box, and its flow is mostly diverted to an irrigation ditch. Boxing and diversion of the spring artificially limit usable habitat for this species, reducing available water and suitable substrate habitat. Trampling of snails by livestock and degradation of critically important water quality through livestock use are threats to population viability of this species."

Pyrgulopsis anguina is also threatened by agricultural development. The State of Utah (2007) reports:

> "The limited distribution of the Longitudinal Gland Pyrg makes it susceptible to habitat loss and degradation in an area experiencing increased agricultural development . . . A lack of proactive agricultural and water management may lead to reduced populations of this species."

Pyrgulopsis peculiaris is threatened by the same factors as *P. anguina* (Gorrell et al. 2005, Hershler 1998, Oliver and Bosworth III 1999, Sada and Vinyard 2002, Deacon et al. 2007, Golden et al. 2007). The Utah Comprehensive Wildlife Conservation Strategy reports that the Bifid Duct Pyrg is negatively affected by habitat degradation, overgrazing, and water diversion for agricultural irrigation (Gorrell et al. 2005). Golden et al. (2007) found that most of the aquatic systems they evaluated in Snake Valley were impacted by a current or historical water diversion structures. Five of the six Utah springs where *P. peculiaris* occurs are reported as slightly to moderately disturbed due to flow diversion, livestock, and recreational use (Hershler 1994, Oliver and Bosworth III 1999). The State of Utah (2007) reports:

> "The very limited distribution of this species, together with documented disturbances of occupied sites—trampling and degradation of water quality and aquatic substrates by livestock, water diversion, and recreational activities—threaten the continued existence of this species in Utah . . . The limited distribution of the Bifid Duct Pyrg makes it susceptible to habitat loss and degradation in an area experiencing continuing impacts to the aquatic habitat . . . A lack of proactive water, agricultural, petroleum, and recreation management may lead to reduced populations of this species."

Both of the springs in Nevada where the Bifid Duct Pyrg occurs are disturbed. Golden et al. (2007) characterize Big Springs as highly disturbed due to water diversion, livestock grazing, presence of a residence, "multiple other human impacts," drought, and nonnative species. They characterize the disturbance level at Turnley Springs as moderate due to water diversion, roads, and livestock. The spring head at Turnley Spring was boxed during the 1990's, and Golden et al. (2007) were unable to find the Bifid Duct Pyrg at this known site in August 2006. If the species has been extirpated at Turnley Spring, then it only has one remaining location in Nevada.

The Sub-Globose Snake Pyrg, *Pyrgulopsis saxatilis,* is also threatened by habitat degradation. The spring complex where this species occurs has been degraded by recreation (Hershler 1994, Gorrell et al. 2005). Golden et al. (2007) report moderate disturbance at

Gandy Warm Springs due to livestock, recreation, and nonnative species. The State of Utah reports:

> "The limited distribution of the Sub-globose Snake Pyrg makes it susceptible to habitat loss and degradation in an area susceptible to development . . . A lack of proactive water, agricultural, petroleum, and recreation management may lead to reduced populations of this species" (Oliver and Bosworth III 1999).

The Sub-Globose Snake Pyrg is inherently vulnerable to extinction due to its occurrence at only a single spring complex.

Global climate change is also a threat for the Bifid Duct Pyrg, Longitudinal Gland Pyrg, and Sub-Globose Snake Pyrg. Climate change is expected to alter regional precipitation patterns and lead to reduced snow pack which could negatively affect the springflow on which these species depend, especially in conjunction with groundwater withdrawal and surface diversions (Field et al. 2007).

LAND MANAGEMENT

The Warm Springs complex where *P. saxatilis* occurs is managed by the BLM. All of the springs where *P. anguina* occurs are privately owned. For *P. peculiaris*, Turnley Spring is managed by the Nevada Bureau of Land Management. Antelope Spring and the unnamed spring above Swasey Spring are managed by the Utah BLM. The spring at Big Springs Creek is privately owned. Management at the other sites is unknown.

STEPTOE VALLEY

Six of the petitioned species occur in Steptoe Valley—*Pyrgulopsis landyei, P. neritella, P. orbiculata, P. planulata, P. serrata,* and *P. sulcata.*

34. *Pyrgulopsis landyei* Landyes Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. Landyes Pyrg is a small snail with a broadly conical shell, a tan periostracum, and a height of 1.3 - 1.7 mm. It has a large penis with medium length filament and lobe, and the penial ornament is a large fragmented terminal gland.

Range. Landyes Pyrg is known only from a spring north-northwest of Steptoe Ranch in White Pine County, Nevada (Hershler 1998).

Habitat Requirements. The spring where this species occurs is small rheocrene.

Status. Landyes Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. There are no existing regulatory mechanisms that protect this species.

35. *Pyrgulopsis neritella* Neritiform Steptoe Ranch Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Neritiform Steptoe Ranch Pyrg is a small snail with an apically eroded neritiform shell. The periostracum is light brown, the height is 1.1-1.7 mm, and there are about 3.5 whorls. It has a small penis with long filament and lacks a lobe.

Range. Hershler (1998) reports that this pyrg occurs at two springs north of Steptoe Ranch in the Steptoe Valley of White Pine County, Nevada.

Habitat Requirements. This species occurs in a thermal (23º C) rheocrene.

Status. The Neritiform Steptoe Ranch Pyrg is critically imperiled meaning this snail is at very high risk of extinction (G1S1 (NV)) (NatureServe 2008). It completely lacks protective status.

36. *Pyrgulopsis orbiculata* Sub-Globose Steptoe Ranch Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Sub-Globose Steptoe Ranch Pyrg is a small snail with a globose shell. Its height is 1.1-1.3 mm, and it has 3.75-4.25 whorls. The periostracum is tan. It has a small bladelike penis with long filament and lacks a lobe or penial ornament.

Range. This pyrg is restricted to two springs in the Steptoe Valley of White Pine County, Nevada (Hershler 1998). It occurs at a spring at Steptoe Ranch and at a spring north-northwest of Steptoe Ranch.

Habitat Requirements. One of the springs where this species occurs is a small rheocrene.

Status. The Sub-Globose Steptoe Ranch Pyrg is critically imperiled, meaning it is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is included in the Nevada BLM's Special Status Species Program, but lacks substantial protective status.

37. Flat-topped Steptoe Pyrg *Pyrgulopsis planulata*

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Flat-topped Steptoe Pyrg is a small snail with a highly eroded shell apex. The rest of the shell is sub-globular to discoidal. It is 1.1 - 1.4 mm in height and has 2.0 - 3.0 whorls and a tan periostracum. The penis is medium-sized with medium length filament and a very short lobe. The penial ornament is a small terminal gland.

Range. The Flat-topped Steptoe Pyrg occurs only at a spring northwest of Clark Spring in the Steptoe Valley of White Pine County, Nevada (Hershler 1998).

Habitat Requirements. This snail occurs in a small thermal (23.3º C) rheocrene.

Status. The Flat-topped Steptoe Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. This pyrg is not adequately protected by any existing regulatory mechanisms.

38. *Pyrgulopsis serrata* Northern Steptoe Pyrg

Taxonomy. Family Hydrobiidae. Hershler1998

Description. The Northern Steptoe Pyrg is a medium-sized snail with an ovate to narrow conic shell, and a medium-sized penis with medium length filament and lobe. The penial ornament consists of small terminal and penial glands. The periostracum is tan.

Range. The Northern Steptoe Pyrg occurs at Twin Springs and springs south of Currie in Steptoe Valley in Elko County, Nevada, and at Indian Ranch Spring and Indian Creek in Steptoe Valley in White Pine County (Hershler 1998). This snail also occurs at ten springs in the Northern Steptoe Valley (Sada 2006b).

Habitat Requirements. One of the springs where this springsnail occurs is a shallow broad rheocrene on a forested slope (Hershler 1998). Sada (2006b) found that most of the springs where this species occurs in the Northern Steptoe Valley are helocrenes with generally longer and narrower springbrooks and greater discharge than the average of other springs in the vicinity. Aquatic vegetation at the springs includes species of *Carex* and *Juncus*.

Status. The Northern Steptoe Pyrg is critically imperiled, meaning that it is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). This snail completely lacks protective status.

39. *Pyrgulopsis sulcata* Southern Steptoe Pyrg

Taxonomy. Family Hydrobiidae. Hershler1998

Description. The Southern Steptoe Pyrg is a small snail with a low trochoid to ovate-conic shell and a light tan periostracum. It has a medium-sized bladelike penis with medium length filament and lacks a penial ornament or lobe.

Range. The Southern Steptoe Pyrg is restricted to two spring complexes in the Steptoe Valley of White Pine County, Nevada-- springs north of Grass Springs and a spring northwest of Clark Spring (Hershler 1998).

Habitat Requirements. One of the springs where this springsnail occurs is a small marshy rheocrene.

Status. The Southern Steptoe Pyrg is critically imperiled, meaning that it is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). This snail is included in the Nevada BLM's Special Status Species Program, but lacks meaningful protective status.

THREATS

Pyrgulopsis landyei, *P. neritella*, *P. orbiculata*, *P. planulata*, *P. serrata,* and *P. sulcata* are threatened primarily by spring diversions and livestock grazing. *Pyrgulopsis serrata* is threatened by groundwater withdrawal for the White Pine Energy Station (Sada 2006b, USDI BLM 2008 White Pine FEIS), and the other species are potentially threatened by cumulative groundwater withdrawals. All six of these springsnails are potentially threatened by invasive species, recreation, and global climate change, and are inherently at high risk of extinction due to their limited distribution (Hershler 1998, Sada and Vinyard 2002, Field et al. 2007).

Sada (2006b) found that of 46 sites surveyed for springsnails in Northern Steptoe Valley in 2005, 13 were moderately to highly disturbed due to spring diversion, and 43 were moderately to highly disturbed by livestock. He reports that all of the surveyed springs were disturbed by either livestock or diversion, and that nine of the springs were so severely degraded that their natural morphology was indiscernible. He states:

> "Although these types of cultural disturbance are typical of those affecting springs throughout northern Nevada, the incidence and severity of disturbance observed in Steptoe Valley is proportionally greater than disturbances observed by Sada et al. (1992) during springsnail surveys of approximately 500 springs in northern Nevada."

The springs where *P. landyei*, *P. neritella*, *P. orbiculata*, *P. planulata,* and *P. sulcata* occur are known to have been degraded by water diversions and livestock use (Hershler 1998, Sada 2006b). The springsnails in Steptoe Valley are immediately threatened by habitat degradation due to spring diversion and livestock grazing, the effects of which are likely to be magnified by groundwater withdrawal, as stated in the Final Environmental Impact Statement for the White Pine Energy Station:

> "[C]ontinued livestock grazing may contribute to adverse effects on endemic springsnail populations that rely on the isolated springs. Livestock grazing can reduce water quality and lead to a reduction in the health of spring function and vegetative structure. Further water diversion in Steptoe Valley may lead to additional adverse effects to endemic springsnail populations" (USDI BLM 2008, p. 4-286).

It is acknowledged that groundwater withdrawal directly threatens *P. serrata* (Sada 2006b, USDI BLM 2008 White Pine FEIS), but groundwater withdrawal is also a threat for the other springsnail species in Steptoe Valley because the groundwater in this basin is over allocated. The perennial yield of the Steptoe hydrographic basin is 70,000 afy, but there are 97,199 afy of existing permitted, certified, and vested rights and 108,741 afy of total active rights for this basin including Ready for Action applications held by Nevada Power Company, Sierra Pacific Power Company, and Blue Diamond Oil Corporation (NDWR 2009). The White Pine Energy Station FEIS states, "The groundwater in the basin fill deposits of Steptoe Valley is over allocated by the Nevada Division of Water Resources. The amount of committed resources is 78,531 afy" (USDI BLM 2008, p. 3-48). The White Pine Energy Station will withdraw 5000 afy, the rights for which were acquired in 1983.

Groundwater pumping is expected to reduce springflow in Steptoe Valley. Concerning the threat posed to *P. serrata* by groundwater extraction for the White Pine Energy Station, the FEIS states:

> "One species of special status aquatic springsnail (the Northern Steptoe Springsnail) occurs in ten springs in Steptoe Valley, including three of the 12 springs that are in areas where there is a risk of more than 2 feet of ground water drawdown. Drawdown could cause reduced flows and water levels at these springs, which could eliminate populations of this species, which have extremely restricted distributions" (USDI BLM 2008, p. 4-89).

The threat posed to *P. serrata* by groundwater extraction is magnified by the already degraded quality of the springs:

> "Reduced spring discharge flows caused by Station water pumping could eliminate or reduce local springsnail populations. Loss of even one spring that supports springsnails could be substantial, particularly because Steptoe Valley springs are in degraded condition and susceptible to loss of biotic diversity" (USDI BLM 2008, p. 4-66).

Springsnails could also be harmed due to contamination of groundwater and degraded water quality due to leaching from the solid waste disposal facility and/or the evaporation pond associated with the plant (USDI BLM 2008 White Pine FEIS).

Groundwater withdrawal for the energy station contains a monitoring plan to avoid harm to aquatic species, including springsnails. The provisions of this plan should not preclude protection of these species under the Endangered Species Act for several reasons. First, the primary threats to the springsnail species in Steptoe Valley are spring diversion and livestock grazing, and the provisions of the monitoring plan cannot address these impacts. Second, the monitoring plan is not adequate to protect the springsnails from decreased springflow due to groundwater withdrawal because it is full of loopholes which would allow pumping to continue even if adverse affects are detected. For example, the FEIS states:

> "If the monitoring program indicates that the discharge from known springs may experience a potentially adverse reduction *as a direct response* to continued pumping by the Station *and it is determined that the production well is the cause* of that potential impact, action would be taken *to adjust the amount and pattern of pumping* in advance of spring discharge being adversely affected. One form of mitigation would involve modifications to the operation of the water supply wells to control the location and timing of, and to minimize, ground water level declines. Examples of possible changes in pumping strategy include pumping from different wells (perhaps those farthest from affected springs) and varying the amount of water being pumped from each well (reduce pumping rates nearest affected springs) *in order to meet overall project needs* while avoiding the potential for adverse Station effects" (USDI BLM 2008, p. 4-22, emphasis added).

The monitoring provisions do not state that pumping will be stopped if adverse affects are detected, only that pumping will be modified, which may or may not restore spring levels. Further, pumping will be modified only if it is determined that decreased springflow is both a direct response to pumping by the station *and* if it is determined that the production well is the cause. This language is discretionary and subjective and provides the opportunity to attribute decreased springflow to climate or to groundwater extraction by other users.

The spring habitats of *Pyrgulopsis landyei, P. neritella, P. orbiculata, P. planulata, P. serrata*, and *P. sulcata* have been degraded by water diversion and livestock grazing, groundwater in Steptoe Valley is over allocated, and springflow will diminish as already acquired water rights are developed. Springsnail populations decline when their habitat is degraded because springsnails are dependent on consistent springflow and microhabitat conditions (Taylor 1985, Ponder et al. 1989, O'Brian and Blinn 1999, Mlandeka and Minshall 2001, Sada 2008, Brown et al. 2008). These six species merit Endangered Species Act protection to ensure their survival.

LAND MANAGEMENT

Pyrgulopsis neritella occurs on a private ranch. Most of the springs where *P. serrata* occurs are privately owned, but at least one is managed by the BLM. The springs north of Grass Springs where *Pyrgulopsis sulcata* occurs are privately owned. Management of the other springs is unknown.

WHITE RIVER VALLEY

SPECIES

Seven of the petitioned species occur in White River Valley—*Pyrgulopsis breviloba, P. gracilis, P. lata, P. marcida, P. merriami, P. sathos,* and *Tryonia clathrata. Pyrgulopsis breviloba* is described in the Dry Lake Valley section (p. 71). *P. marcida* is described in the Cave Valley section (p. 69). *P. merriami* is described in the Pahranagat Valley section (p. 97). *Tryonia clathrata* is described in the Muddy River section (p. 91).

40. Emigrant Pyrg *Pyrgulopsis gracilis*

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Emigrant Pyrg is a small snail with a broad to narrow conic shell and a tan, brown, or reddish periostracum. Its height is 1.6 - 1.9 mm, and it has up to 4.0 whorls. Its penis is medium-sized with a long filament and short or absent lobe. The penial ornament is a small terminal gland and the penial gland is large.

Range. This springsnail occurs only at Emigrant Spring, White River Valley, Nye County, Nevada (Hershler 1998).

Habitat Requirements. Emigrant Spring is a small rheocrene with a maximum depth of 2 cm and a temperature of 18º C (Golden et al. 2007).

Status. The Emigrant Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. The Emigrant Pyrg is not adequately protected by any existing regulatory mechanisms.

41. Pyrgulopsis lata Butterfield Pyrg

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The Butterfield Pyrg is a small snail with an ovate to narrow-conic shell and a light brown periostracum. It is 1.6 - 2.1 mm in height, and has 3.75 - 4.25 whorls. The penis is large with a short filament and short lobe, and the penial ornament is a small fragmented terminal gland.

Range. The Butterfield Pyrg is known only from Butterfield Springs in the White River Valley of Nye County, Nevada (Hershler 1998).

Habitat Requirements. Butterfield Spring is a small rheocrene with a maximum depth of 1 cm and a temperature of 17º C (Golden et al. 2007).

Status. The Butterfield Pyrg is critically imperiled meaning this species is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It is on the Nevada Natural Heritage Program At-Risk Tracking List. This species occurs at only one site and is not protected by any existing regulatory mechanisms.

42. White River Valley Pyrg *Pyrgulopsis sathos*

Taxonomy. Family Hydrobiidae. Hershler 1998

Description. The White River Valley Pyrg has an ovate to narrow-conic shell and a tan to brown periostracum. Its height is 1.4 - 4.6mm, and it has 3.25-5.25 whorls. The penis is medium-sized with long filament and a short lobe. The penial ornament consists of small terminal and ventral glands.

Range. The White River Valley Pyrg is known from five to six springs in the White River watershed of Nye, Lincoln, and White Pine counties in Nevada (Hershler 1998). It occurs at Flag Springs in Nye County, at Camp Spring in Lincoln County, and at Arnoldson Spring, Preston Big Spring, and a spring in Lund in White Pine County (Hershler 1998). Golden et al. (2007) report this species from Nicholas Spring.

Habitat Requirements. One of the springs where this species occurs is a large rheocrene where snails are found on hard substrate in a pool just below the spring source (Hershler 1998).

Golden et al. (2007) recorded habitat variables at several sites where this species occurs. Arnoldson Spring is a rheocrene with a maximum depth of 86 cm, a temperature of 23º C, and vegetation which includes Spikerush (*Eleocharis* sp.), Kentucky Bluegrass (*Poa portensis*), and Aster (*Symphyothrichum* sp.) (Golden et al. 2007). Camp Spring is a rheocrene with a maximum depth of 3 cm and a temperature of 19º C. North Flag Springs is a rheocrene with a maximum depth of 76 cm and a temperature of 16-18º C (Golden et al. 2007). Middle Flag Springs is a rheocrene with a maximum depth of 20 cm and a temperature of 20º C. South Flag Springs is a limnocrene with a maximum depth of 40 cm and a temperature of 22-23º C. Vegetation at Flag Springs includes Rush (*Juncus* sp.), Bulrush (*Schoenoplectus* and *Scirpus* sp.), Spikerush (*Eleocharis* sp.), and Water Cress (*Rorripa* sp.) (Golden et al. 2007). Lund Spring is a limnocrene with a maximum depth of 92 cm, a temperature of 18º C, and vegetation including Watercress (*Rorippa* sp.) and Reedgrass (*Phragmites* sp.) (Golden et al. 2007). Nicholas Spring is a rheocrene with a maximum depth of 37 cm, a temperature of 22º C, and vegetation including Watercress (*Rorippa* sp.). Preston Big Spring is a limnocrene with a maximum depth of 46 cm, a temperature of 21-22º C, and vegetation including Rush (*Juncus* sp.) and Bulrush (*Schoenoplectus* sp.).

Status. The White River Valley Pyrg is critically imperiled meaning it is at very high risk of extinction (G1 S1 (NV)) (NatureServe 2008). It completely lacks protective status.

THREATS

The overarching threat to the seven petitioned springsnail species which occur in White River Valley is groundwater development. Springs in White River Valley are expected to be negatively influenced first by pumping by Vidler Water Company and then by Southern Nevada Water Authority pumping (Deacon et al. 2007). Groundwater is projected to decline from 0.3-30 m in White River Valley (Deacon et al. 2007, Schaefer and Harrill 1995, and Harrill and Prudic 1998). Myers (2007) estimates that SNWA pumping in Cave, Dry Lake, and Delamar Valleys will cause springflow in southern White River Valley to decline by half within 15 years, and to eventually fail. Springflow in White River Valley could decline due to pumping in adjacent valleys and in White River Valley itself. In White River Valley, there are 40,675 afy of active water records, including 29,894 afy of permitted and certified rights. The perennial yield of White River Valley is 37,000 afy, which is less than the number of active records. Water rights are often granted in excess of perennial yield, and the definition of perennial yield allows for the drying up of springs. Deacon et al. (2007) specifically identify some of the springs where petitioned species occur as likely to be adversely affected by withdrawal by Vidler and SNWA including Preston Big Spring and Lund Spring (*P. sathos*), Moorman Spring (*P. merriami*, *T. clathrata*), and Flag Spring (*P. breviloba*).

Because springsnails are dependent on consistent springflow and microhabitat conditions, reduced spring discharge can lead to springsnail population decline (Taylor 1985, Ponder et al. 1989, Sada and Nachlinger 1996, Hershler 1998, McCabe 1998, Myers and Resh 1999, O'Brian and Blinn 1999, Hershler 2001, Mlandeka and Minshall 2001, Sada and Vinyard 2002, Hurt 2004, Strayer 2006, Deacon 2007, Brown et al. 2008, Sada 2008).

In addition to the threat of groundwater development, *Pyrgulopsis breviloba, P. gracilis, P. lata, P. marcida, P. merriami, P. sathos,* and *Tryonia clathrata* are threatened by spring development, domestic livestock grazing, drought, invasive species, and potentially recreational activities (Hershler 1998, Sada and Vinyard 2002, Golden et al. 2007). Arnoldson, Flag, Lund, Nicholas, and Preston Big Springs have water diversions (Golden et al. 2007). Middle Flag Spring has been moved from its historic channel. All seven of these species occur on BLM grazing allotments, and Flag Spring and Lund Spring are known to have been impacted by livestock (Golden et al. 2007). Residences are present at Arnoldson, Flag, Lund, and Nicholas Spring, and the main housing area of the Kirch Wildlife Management Area is close to Middle Flag Spring (Ibid). *Pyrgulopsis gracilis* is threatened by road maintenance and/or runoff because it occurs near a state highway (Hershler 1998).

Invasive species are present at springs throughout White River Valley and have been recorded at Arnoldson Spring, Lund Spring, Nicholas Spring, and Preston Big Spring (Golden et al. 2007). The invasive snail *Melanoides tuberculata* is known to be present at Arnoldson Spring, Nicholas Spring, and Preston Big Spring. At Arnoldson Spring, *M. tuberculata* is one of the three most-dominant taxa (Golden et al. 2007).

The limited distribution of these species makes them inherently vulnerable to extinction. In addition, these springsnails are threatened by global climate change which could cause reduced spring discharge due to altered regional precipitation patterns and reduce snowpack (Field et al. 2007).

LAND MANAGEMENT

Emigrant Spring, Butterfield Spring, Arnoldson Spring, Camp Spring, Lund Spring, Preston Big Spring, and Nicholas Spring are privately owned. Flag Springs is managed by the Nevada Department of Wildlife.

VII. RECOMMENDATIONS FOR PROTECTION AND RECOVERY

Protecting these 42 springsnail species as threatened or endangered is an essential step towards ensuring their survival. Following listing, we support several actions to ensure the conservation of these species. The Endangered Species Act requires conservation efforts to facilitate recovery in its definition of conserve as seen below:

> “The terms ‘conserve,’ ‘conserving,’ and ‘conservation’ mean to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary. Such methods and procedures include, but are not limited to, all activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation, and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking (16 U.S.C. § 1532 (3)).

In the context of protection as threatened or endangered species with critical habitat designation, the following measures are recommended by the Center for Biological Diversity for springsnail protection and recovery:

Protect Spring Flow

- Dedicate surface and groundwater resources to ensure the persistence of endemic aquatic species. Enforceable measures should be put in place to protect spring discharge at all sites where petitioned species occur. Spring discharge should be secured at a level that is sufficient to maintain the ecological integrity of the springs including biodiversity preservation, the maintenance of aquatic vegetation, and high water quality.

- Develop a monitoring program capable of detecting altered spring discharge before sensitive aquatic species are impacted. Monitoring should include not just wells but also on-site visits to evaluate spring discharge, aquatic vegetation, and aquatic invertebrates. Small low-elevation springs located close to pumping wells and small high-elevation springs should be monitored, and monitoring should occur often enough to detect impacts before species are extirpated. Enforceable measures should be put in place to stop groundwater pumping if spring flow declines. Monitoring and sampling should be conducted in an ecologically sensitive manner that does not contribute to the decline of springsnails or other species

- Minimize diversion disturbance by leaving the spring source, and as much of the springbrook as is necessary to support biodiversity, free-flowing and free from structures such as springboxes, impoundments, channelization, and pipes. The length of springbrook to be protected should be determined by surveys; 50 m has been suggested as an approximate guideline (Sada and Nachlinger 1996). At larger springs, greater lengths of the springbrook should be protected, including all areas supporting the petitioned species.

- Protect the riparian zones surrounding springs.

Protect Springs from Habitat Degradation due to Grazing and Recreation

- Consider reducing or eliminating livestock use in spring ecosystems. Cooperate with landowners to reduce grazing impacts on springs. Consider erecting exclosures around the spring source and sensitive portions of the springbrook. Exercise caution in erecting exclosures and manage exclosed vegetation so that vegetative overgrowth does not contribute to reduced springflow.

- Protect springs from recreational developments and recreation. Recreational impacts can be similar those of grazing and protective measures should be put in place for springsnail species including fencing of sensitive areas.

Manage Invasive Species

- Actively manage invasive species in spring habitats to protect native springsnails from competition, predation, and other stresses induced by exotic organisms. Introduced convict cichlids (*Amatitlania niigrofacsciata*) should be immediately removed from Blue Point Spring to protect *P. coloradensis*.

- Manage restoration projects in spring habitats in a manner that is not detrimental to springsnails, which could be harmed by pesticide use and trampling.

The following sources contain information on the protection of springsnail habitat: Sada and Nachlinger 1996, 1998, Sada et al. 2001, Sada 2008, 2006b, Golden et al. 2007.

VIII. REQUEST FOR CRITICAL HABITAT DESIGNATION

We request and strongly recommend that all known locations for all petitioned springsnail species be designated as critical habitat concurrent with species' listing.

As required by the Endangered Species Act, the Secretary shall designate critical habitat concurrent with determination that a species is endangered or threatened (16 U.S.C. 1533(a)(3A)). Critical habitat is defined by Section 3 of the ESA as:

(i) the specific areas within the geographical area occupied by the species,
at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and

(ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species.16 U.S.C. §1532(5).

Because the survival of the petitioned springsnails is entirely dependent on the continuation of water flow at their springs, critical habitat designation should include water rights to ensure adequate surface flows.

IX. CONCLUSION

The 42 species of springsnails presented in this petition undoubtedly merit protection under the Endangered Species Act. Thirty-eight of the species are critically imperiled, three are imperiled, and one is possibly extinct. None of them have substantive legal protective status, and all of them are faced with an array of threats that could push them into extinction.

The diversification of springsnails across the Great Basin and Mojave ecosytems indicates that the springs which support the petitioned species have been flowing continuously for thousands to millions of years:

> Springsnails are "restricted to waters of unquestioned permanence and stability . . . thus, presence of a substantial population of hydrobiid snails at a locality is a direct measure of permanence. The habitat may well have persisted for millennia if this animal group is present" (Silvey and Williams 1996, p. 1).

It would be tragic if short-sighted anthropogenic practices erased the radiation of this exceptional group of organisms. Protecting the petitioned species will safeguard not only the species themselves but also the ecological integrity of spring ecosystems. Desert springs and their riparian areas provide habitat for endemic invertebrate fauna and also for amphibians and reptiles, resident and migratory birds, and mammals. The Nevada Wildlife Action Plan states:

> "In addition to springs' critical role in the survival and conservation of endemic aquatic species, they also play a very important role for other wildlife species. Nevada, which has the lowest annual rainfall in the U.S., has limited surface water resources, particularly during drought. Springs provide a vital water source between infrequent surface waters, providing water availability and food resources for a wide range of Nevada's wildlife, from bighorn sheep, elk, and deer; to birds and bats. The broad distribution of functional spring and spring outflow systems of all types across Nevada's landscape is an important element in maintaining Nevada's wildlife diversity" (Nevada Dept. of Wildlife 2006, p. 198).

The purpose of the Endangered Species Act is to ensure the survival of the diversity of life which contributes to the greatness of the natural history of the United States. Springsnails play a critical role in spring ecology, are indicators of spring health, and are amazing organisms in their own right. Without Endangered Species Act protection, the 42 petitioned springsnail species, an irreplaceable part of American heritage, could be lost forever.

As human population continues to grow, demands for groundwater will increase, as will other stressors facing aquatic desert ecosystems such as water diversion, livestock grazing, and recreation. These unique species urgently need Endangered Species Act protection and critical habitat designation to safeguard their habitat in perpetuity.

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February 17, 2009

To Whom It May Concern,

This letter is submitted in support of the petition by the Center for Biological Diversity (CBD) to list 42 species of freshwater snails under the United States Endangered Species Act. Given the restricted ranges, specific habitat requirements, and eminent threats to the very survival of these snails, we believe that listing action is warranted under the US Endangered Species Act. Our organization, the Freshwater Mollusk Conservation Society (FMCS), is a non-profit entity whose mission includes education, research, and protection of freshwater mollusks, North America's most imperiled group of animals. Our membership includes individuals affiliated with state and federal government, academia, as well as amateur collectors and citizen scientists.

The current count of known freshwater snail extinctions in the United States stands at 42; within the hydrobiid family, almost ¾ of the fauna is considered to be at-risk, a staggering total. Much of this high degree of imperilment stems from endemic western United States springsnail species. In the case of the hydrobiid springsnails being petitioned by CBD, all of the species are restricted to a single system or a small number of spring systems; without protection of their groundwater habitats, these species are at critical risk of extinction. The groundwater resources that are being targeted for pumping are largely to support the explosive growth of the Las Vegas metro area. Not only do these projects jeopardize the very existence of these springsnails but also threaten regional wetlands and isolated groundwater-dependent waterbodies. Additionally, several of these species will require action to reduce habitat disturbance and degradation due to existing intensive recreation impacts.

The FMCS requests that you give strong consideration to the CDB petition and act to list the species in the package. Without the intervention of the US Department of the Interior on this issue, we will likely stand witness to more species' extinctions due to the lack of adequate consideration for our nation's biodiversity.

Thank you for all considerations.

Sincerely,

Steven Ahlstedt

Steven Ahlstedt, President

Freshwater Mollusk Conservation Society