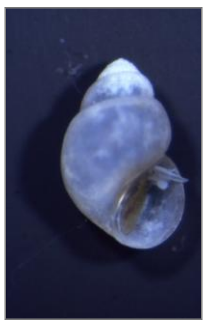
Roswell springsnail (*Pyrgulopsis roswellensis*)
Koster's springsnail *(Juturnia kosteri)*
Noel's amphipod (*Gammarus desperatus*)
Pecos assiminea (*Assiminea pecos*)

5-Year Review:
Summary and Evaluation



Roswell springsnail

Koster's springsnail

Noel's amphipod

Pecos assiminea

Photos by Brian Lang, New Mexico Department of Game and Fish

U.S. Fish and Wildlife Service
New Mexico Ecological Services Field Office
Albuquerque, New Mexico

5-YEAR REVIEW

Roswell springsnail (*Pyrgulopsis roswellensis*), Koster's springsnail (*Juturnia kosteri*), Noel's amphipod (*Gammarus desperatus*), Pecos assiminea (*Assiminea pecos*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Region: Region 2 (Southwest) Regional Office
Susan Jacobson, Chief Threatened and Endangered Species, 505-248-6641;
Wendy Brown, Recovery Coordinator, 505-248-6664;
Maggie Dwire, Recovery Biologist, 505-248-6666.

Lead Field Office: New Mexico Ecological Services Field Office
Susan Oetker, Fish and Wildlife Biologist, 505-761-4761.

Cooperating Offices: Jeff Sanchez, Biologist, Bitter Lake National Wildlife Refuge, 575-622-6755;
Brian Lang, Invertebrate Biologist, New Mexico Department of Game and Fish, 505-476-8108.

1.2 Methodology used to complete the review

This review was conducted through public review notification and a comprehensive review of all documents regarding the Roswell springsnail, Koster's springsnail, Noel's amphipod, and Pecos assiminea (four invertebrates) that were available to the U.S. Fish and Wildlife Service's (Service) New Mexico Ecological Services Field Office (NMESFO). The Federal Register (FR) notice (74 FR 6917) announcing this review was published on February 11, 2009, and solicited new information about species biology, habitat conditions, conservation measures implemented, threats, trends, and significant portion of the range from other agencies, both Federal and State, non-governmental organizations, academia, and the general public. No new information was received from this solicitation. The primary source of information used in this analysis was the August 9, 2005, final listing rule (70 FR 46304), the June 22, 2010, proposed rule to revise critical habitat (75 FR 35375), unpublished reports, and personal communication with Brian Lang, Invertebrate Biologist with the New Mexico Department of Game and Fish (NMDGF).

1.3 Background

The purpose of this 5-year review is to ensure that these species have the appropriate level of protection under the Endangered Species Act. The review documents a determination by the Service whether the status of the four invertebrates has changed since the time of its listing. The review also provides updated information on the current threats, ongoing conservation efforts, and the priority needs for future conservation actions.

1.3.1 FR Notice citation announcing initiation of this review: 74 FR 6917; February 11, 2009.

1.3.2 Listing history:

Original listing
FR notice: 70 FR 46304
Date listed: August 9, 2005
Entities listed: Species, *Pyrgulopsis roswellensis, Juturnia kosteri, Gammarus desperatus, Assiminea pecos*
Classification: Endangered

1.3.3 Associated Rulemakings: None.

1.3.4 Review History: This is the first 5-year review for these species since listing in 2005. Their status is listed as “stable” in the Recovery Data Call every year since 2005.

1.3.5 Species Recovery Priority Number at start of review: 5.
This number indicates species with a high degree of threat and low recovery potential.

1.3.6 Recovery Plan or Outline: The State of New Mexico has a recovery plan (NMGFD 2005) that has helped guide conservation efforts, but the Service does not yet have a final, approved recovery plan.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) Policy

2.1.1 Is the species under review a vertebrate? No. The four species are invertebrates, thus the DPS policy does not apply.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan? Although the State of New Mexico has a recovery plan (NMGFD 2005) for the four species, the Service does not yet have a final, approved recovery plan.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

All four invertebrate species are associated with aquifer-fed spring systems in desert grasslands of the Pecos River basin in southeast New Mexico and west Texas. This basin has abundant “karst” topography (landscape created by groundwater dissolving sedimentary rock), such as sinkholes, caverns, springs, and underground springs, which have created unique settings harboring diverse assemblages of plants and animals. The isolated limestone and gypsum springs, seeps, and wetlands located in and around Roswell, New Mexico, and Pecos and Reeves counties, Texas, provide the last known habitats in the world for several endemic (native) species of fish, plants, mollusks, and crustaceans. These species include the Roswell springsnail and Koster's springsnail of the freshwater snail family Hydrobiidae, Pecos assiminea of the snail family Assimineidae, and Noel's amphipod (a crustacean of the family Gammaridae) (NMDGF 2005).

The snails are fairly small; Koster's springsnail is the largest of the three snails and is about 4 to 4.5 millimeters (mm) (0.16 to 0.18 inches [in]) long. The Roswell springsnail is 3 to 3.5 mm (0.12 to 0.14 in) long. Pecos assiminea is the smallest of the three, with a shell length of 1.55 to 1.87 mm (0.06 to 0.07 in) long (Taylor 1987). The Roswell springsnail and Koster's springsnail have lifespans of 9 to 15 months and reproduce several times during the spring through fall breeding season (Taylor 187; Pennak 1989). No information exists on frequency of breeding, fecundity, or other aspects of reproduction of Pecos assiminea (NMDGF 2005). All three snails feed on algae, bacteria, and decaying organic material (NMDGF 1988). They will also incidentally ingest small invertebrates while grazing on algae and detritus (dead or partially decayed plant materials or animals).

Male Noel's amphipods are slightly larger than females, and individuals range from 8.5 to 14.8 mm (0.33 to 0.58 in) long (Cole 1981, 1985). Because they are light-sensitive, these bottom-dwelling amphipods are active mostly at night and feed on algae, submergent vegetation, and decaying organic matter (Holsinger 1976; Pennak 1989). Most amphipods complete their life cycle in one year and breed from February to October, depending on water temperature (Pennak 1978).

The Roswell springsnail and Koster's springsnail are aquatic species, distributed in five geographically separate populations in isolated limestone and gypsum springs, seeps, and wetlands on Bitter Lake National Wildlife Refuge (Refuge). As with other snails in the family Hydrobiidae, the Roswell springsnail and Koster's springsnail are completely aquatic but can survive in seepage areas, as long as flows are perennial and within the species' physiological tolerance limits (NMDGF 2005). The Roswell springsnail and Koster's springsnail are currently known only from the Middle Tract of Bitter Lake National Wildlife Refuge (Refuge) and a nearby complex of springs owned by the City of Roswell, Chaves County, New Mexico. The core population of Roswell springsnail is in the Sago Springs Complex and Bitter Creek on the Refuge. Roswell springsnail occurred at densities ranging from 1,125/m^2 (104/ft^2) to 27,924/m^2 (2,595/ft^2) at Sago Spring and only 64/m^2 (6/ft^2) to 512/m^2 (47/ft^2) at Bitter Creek in 1995 and 1996 (Lang 2002). The Sago Springs Complex is approximately 1,000 feet (ft) (304 meters [m]) long, half of which flows underground with aboveground flow in the upper reaches restricted to sinkholes. Bitter Creek is six times longer than the Sago Springs Complex and has a total length of 1.1 miles (mi) (1.8 kilometers [km]). Roswell springsnail formerly occurred on private land at North Spring east of Roswell but has since been extirpated (NMDGF 2005).

Koster's springsnail is most abundant in the deep organic substrates (material on the bottom of the stream) of Bitter Creek and its headwaters on the Refuge (NMDGF 2005); it also occurs at the Sago Springs Complex, but in lower numbers: it ranged from 704/m^2 (65/ft^2) to 89,472/m^2 (8,315/ft^2) in Bitter Creek in 1995 and 1996; while at Sago Spring it ranged from 51/m^2 (5/ft^2) to 75/m^2 (7/ft^2)(Lang 2002). Koster's springsnail also occurs in Lake St. Francis, the southwestern corner of Impoundment 15, Hunter Marsh, spring-ditches of Impoundments 6 and 7, and several springs adjacent to the Refuge owned by the City of Roswell (NMDGF 2005, Sanchez 2009, B. Lang, NMDGF, pers. comm. 2010). The species has not been found in recent times along the western boundary of the spring run originating from the saline waters of Bitter Lake, bordering Impoundment 3 on the Refuge (NMDGF 2005), and it was recently extirpated from North Spring (NMDGF 2005). Fossil records indicate that at least one or more of these snail species was historically found at Berrendo Spring, North Spring, and South Spring River, and along the Pecos River (NMDGF 1999). This evidence suggests an apparent historical decline in the numbers, range, and distribution of the Koster's and Roswell springsnails.

The Pecos assiminea is a minute marsh snail (from 1.36 to 2.16 mm [0.05 to 0.08 in] shell length) that seldom occurs immersed in water but prefers a humid microhabitat created by wet mud or beneath vegetation mats, typically within about 1 in (2 to 3 centimeters [cm]) of running water. Pecos assiminea is presently known from a total of six sites: four sites on the Refuge, from a large population at Diamond Y Spring and its associated drainage in Pecos County, Texas, and at East Sandia Spring, in Reeves County, Texas. Populations of Pecos assiminea occur sporadically along Bitter Creek, in a dense population around the perimeter of Sinkhole 31 within the Sago Springs Complex, on the western perimeter of Impoundment 7, in the extreme southwest corner of Impoundment 15, and in several springs adjacent to the Refuge owned by the City of Roswell (NMDGF 2005). Critical habitat is currently designated for the Pecos assiminea at the Texas sites.

Noel's amphipod is a small freshwater shrimp in the family Gammaridae that inhabits shallow, cool, well-oxygenated waters of streams, ponds, ditches, sloughs, and springs (Holsinger 1976, Pennak 1989). Noel's amphipod is currently known from five sites at the Refuge: Sago Springs Complex, Bitter Creek and its headwater springs, Unit 6 spring-ditch, Unit 7 spring-ditch, and Hunter Marsh (NMDGF 2005, Sanchez 2009). Furthermore, a population in several spring vents along the Rio Hondo on the South Tract of the Refuge was recently confirmed as Noel's amphipod (Berg 2010). It is also found in several springs just outside the Refuge boundary on property owned by the City of Roswell (G. Warrick, pers. comm., 2005). The species was extirpated from Lander Springbrook between 1951 and 1960, and the North Spring population was lost between 1978 and 1988 (NMDGF 2005). The extirpations were attributed to regional groundwater depletions and habitat alterations (spring channelization), respectively (Cole 1985). Amphipods can occur in high densities; Noel's amphipod populations have ranged from 64/m^2 (6/ft^2) to 8,768/m^2 (815/ft^2) at Bitter Creek and 20/m^2 (2/ft^2)

to 575/m^2 (53/ft^2) at Sago Spring (NMDGF 2005).

2.3.1.1 New information on the species' biology and life history:

When these four species were listed in 2005, a full analysis of their status was completed. Given the recent listing history, within the five-year period since listing there has been very little new information on the species' biology and life history.

2.3.1.2 Abundance, population trends, demographic features, or demographic trends:

Since 2005 when the four species were listed as endangered, several collections have been made at the Refuge. Abundance and range of the species has been similar to past levels (NMDGF 2007, 2008), except for Noel's amphipod, which has declined within Bitter Creek, likely due to the Sandhill Fire of 2000 (NMDGF 2005, 2007, 2008). For all four species, habitat and population levels at the other sites have been stable (NMDGF 2007, 2008).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

There is little new genetic information on these species. A study examining the taxonomic relationships among closely related gammarid populations in the Pecos River Valley of New Mexico using molecular genetic techniques has suggested that Noel's amphipod on the Refuge may in fact be two separate species, but further investigation is needed (Seidel *et al*. 2009). Recent genetic and morphologic studies confirmed that a population of amphipod along the Rio Hondo on the South Tract of the Refuge is Noel's amphipod (Berg 2010).

2.3.1.4 Taxonomic classification or changes in nomenclature:

No change; all four invertebrates are classified as species.

2.3.1.5 Spatial distribution, trends in spatial distribution, or historic range:
In 2009, new populations of Noel's amphipod, Koster's springsnail, and Pecos assiminea were discovered in Hunter Marsh (NMDGF 2010). Because habitat is suitable and the Roswell springsnail usually co-occurs with Koster's springsnail, Roswell springsnail is expected to occur at these new sites as well (NMDGF 2010). During the summer of 2010, a new locality of Noel's amphipod was discovered in several spring vents along the Rio Hondo on the South Tract of the Refuge (Berg 2010). These vents are found along the banks of approximately 100 m (328 ft) of the river but are not regularly inundated with river water.

2.3.1.6 Habitat or ecosystem conditions:

Habitat conditions have not changed since the species were listed. All four species occur in or near isolated springs, seeps, and wetlands within the karst topography of southeast New Mexico and southwest Texas.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification, or curtailment of its habitat or range:

Reduction of Water in Springs

These four invertebrates depend on water for survival. Therefore, the loss or alteration of spring habitat continues to be the main threat to each of the four invertebrates. The scattered distribution of springs makes them aquatic islands of unique habitat in an arid-land matrix (Myers and Resh 1999). Members of the snail family Hydrobiidae (including Roswell and Koster's springsnails) are susceptible to extirpation or extinction because they often occur in isolated desert springs (Hershler 1989, Hershler and Pratt 1990, Hershler 1994, Lydeard *et al.* 2004). There is evidence these habitats have been historically reduced or eliminated by aquifer depletion (Jones and Balleau 1996). The lowering of water tables through aquifer withdrawals for irrigation and municipal use has degraded desert spring habitats, which the three snails and Noel's amphipod depend upon for survival. At least two historic sites for the invertebrates (South Spring, Lander Spring) are currently dry due to aquifer depletion (Cole 1981, Jones and Balleau 1996), and Berrendo Spring, historical habitat for the Roswell springsnail, is currently at 12 percent of the 1880s flow. However, during the mid-1970s, the areas currently occupied by the species continued to flow, even though groundwater pumping was at its highest rate and the area was experiencing extreme drought (McCord *et al.* 2007). This suggests these springs and seeps may be somewhat resilient to reduced water levels.

The primary threat to Pecos assiminea in Texas is the potential failure of spring flow due to excessive groundwater pumping or drought or both, which would result in total habitat loss for the species. Diamond Y Spring is the last major spring still flowing in Pecos County, Texas (Veni 1991). Pumping of the regional aquifer system for agricultural production of crops has resulted in the drying of most other springs in this region (Brune 1981). Other springs that have already failed include Comanche Springs, which was once a large spring in Fort Stockton, Texas, about 18 mi (29.0 km) from Diamond Y Spring. Comanche Springs flowed at more than 142 cubic feet per second (cfs) (4.0 cubic meters per second [cms]) (Scudday 1977, Brune 1981) and undoubtedly provided habitat for rare species of fish and invertebrates, including springsnails. The spring ceased flowing by 1962 (Brune 1981) except for brief periods (Small and Ozuna 1993). Leon Springs, located upstream of Diamond Y Spring in the Leon Creek watershed, was measured at 18 cfs (0.5 cms) in the 1930s and was also known to contain rare fish, but ceased flowing in the 1950s following significant irrigation pumping (Brune 1981). There have been no continuous records of spring flow discharge at Diamond Y Spring by which to determine trends in flow.

East Sandia Spring in Reeves County, Texas, discharges at an elevation of 3,205 ft (977 m) from alluvial sand and gravel (Schuster 1997). Brune (1981) noted that flows from East Sandia Spring were declining. East Sandia Spring may be very susceptible to over pumping in the area of the local aquifer that supports the spring. Measured discharges in 1995 and 1996 ranged from 0.45 to 4.07 cfs (0.013 to 0.11 cms) (Schuster 1997). The small outflow channel from East Sandia Spring has not been significantly modified, and water flows into an irrigation system approximately 328 to 656 ft (100 to 200 m) after surfacing.

Water Contamination

Water contamination, particularly from oil and gas operations, is a significant threat for these four invertebrates. In order to assess the potential for contamination, a study was completed in September 1999 to delineate the area that serves as sources of water for the springs on the Refuge (Balleau Groundwater, Inc. 1999). This study reported that the sources of water that will reach the Refuge's springs include a broad area beginning west of Roswell near Eightmile Draw, extending to the northeast to Salt Creek, and southeast to the Refuge. This area represents possible pathways from which contaminants may enter the groundwater that feeds the springs on the Refuge. This broad area sits within a portion of the Roswell Basin and contains a mosaic of Federal, State, City, and private lands with multiple land uses including expanding urban development.

There are 378 natural gas and oil wells in the 12-township area encompassing the source-water capture zone for the Middle Tract of the Refuge that are potential sources of contamination (Go-Tech 2010). The Bureau of Land Management (BLM) designated an area for protection of habitat from potential groundwater contamination by oil and gas well drilling operations (BLM 2002). This area, referred to as the habitat protection zone, includes a portion of the source-water capture area for the springs in the northern part of the Middle Tract of the Refuge, where the four invertebrate species occur. There are 17 oil and gas leases currently within this habitat protection zone. A lease does not necessarily represent a well; a lease may have approval for drilling but no wells, or it may have one or more wells. This habitat protection zone encompasses 12,585 acres (ac) (5,093 hectares [ha]) of the Federal mineral estate within the water resource area for the Refuge (Service 2005a). Twenty natural gas wells currently exist on these leases. The BLM has estimated a maximum potential development of 66 additional wells within the habitat protection zone, according to well spacing requirements established by the New Mexico Oil Conservation Division (New Mexico Statutes Annotated 1978, Chapter 70, Article 2).

There are numerous examples in which oil and gas operations have met regulatory standards within karst lands in New Mexico and other states but these measures failed to protect groundwater resources and prevent aquifer drawdown (McCord *et al*. 2007). To clean the aquifer would be extremely difficult should it become contaminated by oil, chemicals, or excess nutrients, such as nitrates. In most cases, contamination of an underground aquifer by agricultural, industrial, or domestic sources is treated only at the source. When a contamination site is discovered, the source of the contamination is treated, but rarely do remediation efforts pump water from the aquifer and treat it before returning it to the aquifer. This is largely because these techniques are very costly and difficult to apply (S. McGrath, New Mexico Environment Department, pers. comm., 2001). Because these invertebrate species are sensitive to contaminants, efforts to clean up pollution after the aquifer has been contaminated may not be sufficient to protect these species and the aquatic habitat on which they depend.

Currently there are two active gas wells on the Middle Tract of the Refuge that are upstream (within the underground watershed) of occupied habitat for the four invertebrates. In 2006, Yates Petroleum applied for two additional gas wells, one of which would have been just upstream of occupied habitat for the four invertebrates. The applications have since been withdrawn, although the potential for oil and gas development remains.

The Diamond Y Springs Complex is within an active oil and gas extraction field. At this time, there are still many active wells and pipelines located within close proximity (~330 ft [100 m]) of the surface waters at the springs. In addition, a natural gas refinery is located within 0.5 mi (0.8 km) upstream of Diamond Y Spring. There are also old brine pits associated with previous drilling that can contribute salt and other mineral pollutants to the groundwater and are near surface waters. In addition, oil and gas pipelines cross the spring outflow channels and marshes where the species occurs, creating a constant potential for contamination from pollutants from leaks or spills. These activities pose a threat to the habitat of the Pecos assiminea by creating the potential for pollutants to enter underground aquifers that contribute to spring flow or by point sources from spills and leaks of petroleum products on the surface.

As an example of the likelihood of a spill occurring, in 1992 approximately 10,600 barrels (1,685 cubic meters) of crude oil were released from a 6-in (15.2 cm) pipeline that traverses Leon Creek above its confluence with Diamond Y Draw. The oil was from a pipeline that ruptured several hundred feet away from the Leon Creek channel. The site itself is about 1 mi (1.6 km) overland from Diamond Y Spring. The distance that surface runoff of oil residues must travel is about 2 mi (3.2 km) down Leon Creek to reach Diamond Y Draw. The pipeline was operated at the time of the spill by the Texas-New Mexico Pipeline Company, but ownership has since been transferred to several other companies. The Texas Railroad Commission has been responsible for overseeing cleanup of the spill site. Remediation of the site initially involved aboveground land farming of contaminated soil and rock strata to allow microbial degradation. In recent years, remediation efforts have focused on vacuuming oil residues from the surface of groundwater exposed by trenches dug at the spill site. No impacts on the rare fauna of Diamond Y Springs Complex have been observed; however, no specific monitoring of the effects of the spill was undertaken (Service 2005a).

Fire

Fire suppression efforts on the Refuge are largely restricted to established roads due to the safety hazards of transporting equipment over karst terrain. This severely limits the ability to quickly suppress fires that threaten fragile aquatic habitats on the Refuge. On March 5, 2000, the Sandhill Fire burned 1,000 ac (405 ha) of the western portion of the Refuge, including portions of Bitter Creek. The fire burned through Dragonfly Spring, a spring that feeds Bitter Creek, occupied habitat for Noel's amphipod and Koster's springsnail. The fire eliminated vegetation shading the spring and generated a substantial amount of ash in the spring system (Lang 2002, NMDGF 2005). This resulted in the formation of dense algal mats, increased water temperature fluctuations, increased maximum water temperatures, and decreased dissolved oxygen levels (Lang 2002). The pre-fire dominant vegetation of submerged aquatic plants and mixed native grasses within the burned area has also been replaced by the invasive common reed (*Phragmites australis*) (NMDGF 2005, 2008). Following the fire at Dragonfly Spring, a dramatic reduction in Noel's amphipod was observed, and Koster's springsnail presently occurs at lower densities than were observed prior to the fire (Lang 2002, NMDGF 2006a).

Removal of vegetative cover by burning in habitats occupied by Pecos assiminea may be an important factor in decline or loss of populations (Taylor 1987, NMDGF 2005). It is likely that Pecos assiminea may survive fire or other vegetation reduction if sufficient litter and ground cover remain to sustain appropriate soil moisture and humidity at a microhabitat scale (NMDGF 2005, Service 2004). Complete combustion of vegetation and litter, high soil temperatures during fire, or extensive vegetation removal resulting in soil and litter drying may create unsuitable habitat conditions and loss of populations (NMDGF 2005). Pecos assiminea was discovered at Dragonfly Spring following the burning of habitat there during the Sandhill Fire (NMDGF 2005); it had not been found there previously. Season of burning, intensity of the fire, and frequency of fire likely determine the magnitude of the fire's effects on Pecos assiminea population persistence and abundance (NMDGF 2005), as the species has been found to persist in areas following fires (Lang 2002). Pecos assiminea is relatively vulnerable to fires because the assiminea resides at or near the surface of the water and on moist soils.

The effects of wildfire to these four invertebrate species could be catastrophic and pose a threat to at least the Roswell and Koster's springsnails and Noel's amphipod. As such, strategically timed prescribed burns throughout their range significantly reduce fuel loads, limiting the risk of detrimental wildfires.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Roswell springsnail, Koster's springsnail, Pecos assiminea, and Noel's amphipod may occasionally be collected as specimens for scientific study, but these uses have a negligible effect on total population numbers. These species are currently not known to be of commercial value, and overutilization has not been documented. However, as their rarity becomes known, they may become more attractive to collectors. Although scientific collecting is not presently identified as a threat, unregulated collecting by private and institutional collectors could pose a threat to these locally restricted populations. We are aware of overcollection being a potential threat with other snails (*e.g.*, armored snail (*Pyrgulopsis* (*Marstonia*) *pachyta*) (65 FR 10033, February 25, 2000); Bruneau hot springsnail (*P. bruneauensis*) (58 FR 5938, January 25, 1993); and Socorro springsnail (*P. neomexicana*) and Alamosa springsnail (*Tryonia alamosae*) (56 FR 49646, September 30, 1991), due to their rarity, restricted distribution, and generally well known locations. Due to the small number of localities for the four invertebrates, these species are vulnerable to unrestricted collection, vandalism, or other disturbance. There is no documentation of collection as a significant threat to any of the species. Therefore, we believe that collection of the animals is a minor but present threat.

2.3.2.3 Disease or predation:

<u>Predation</u>

Springsnails and amphipods are a food source for other aquatic animals. Juvenile springsnails appear vulnerable to a variety of predators. Damselflies (Zygoptera) and dragonflies (Anisoptera) have been observed feeding upon snails in the wild (Mladenka 1992). Damselflies and dragonflies are native and abundant on the Refuge and their aquatic larvae most likely prey upon both the springsnails and Noel's amphipod. Springsnails are vulnerable to predation by fish (Kennedy 1977; Winemiller and Anderson 1997). Mladenka (1992) found that guppies would feed on springsnails in the laboratory. Nonnative fish present on the Refuge (primarily common carp, *Cyprinus carpio*) most likely also prey upon the springsnails and Noel's amphipod when they occur in the same habitats. The extent to which predation from nonnative fish affects population size of the three aquatic invertebrates is not known. Predation pressure on the semiaquatic Pecos assiminea is also unknown. However, if the decollate snail (*Rumina decollata*), a nonnative predatory snail, becomes established on the Refuge, the potential exists for it to prey on Pecos assiminea.

The decollate snail was introduced to the United States in the early 1800s in South Carolina and spread westward (Selander and Kaufman 1973). It was reported in

Arizona in 1952 and California in 1966 but was well established by the time it was discovered (Selander and Kaufman 1973). It is common in Texas (Selander and Kaufman 1973) and has been reported from the Roswell area in New Mexico (Lang 2005b). It inhabits gardens and agricultural areas and is primarily terrestrial, but has also invaded riparian and other native habitats (Selander and Kaufman 1973). It is used in California as a biological control agent against the brown garden snail (*Helix aspera*) (Cowie 2001). It will consume native snails (Cowie 2001) as well as vegetation (Dundee 1984). For these reasons, the decollate snail is a potential threat to Pecos assiminea.

<u>Predation and competition</u>

Nonnative aquatic species such as crayfish, fish, and aquatic snails are also a potential threat to the four invertebrates. There are three native and three nonnnative species of crayfish in New Mexico, but their distributions do not overlap with that of the four invertebrates (Hobbs 1991; B. Lang, NMDGF, pers. comm., 2010). Crayfish are typically opportunistic generalists (they will eat anything and everything) (Hobbs 1991) and their predation on invertebrates is well documented (Hobbs 1991; Lodge *et al.* 1994; Charlebois and Lamberti 1996; Strayer *et al.* 1999). Additionally, because they also feed on organic debris and vegetation and reduce algal biomass (Charlebois and Lamberti 1996), they could potentially compete with Roswell springsnail, Koster's springsnail, and Noel's amphipod for food resources. Currently nonnative crayfish are not present on the Refuge or the sites in Texas. Diamond Y Springs Complex does have an undescribed native crayfish that we do not believe to be a concern for Pecos assiminea. However, crayfish have created major problems in aquatic systems in Arizona, and there is no physiological reason why some species of crayfish could not survive in the habitats that now support the four invertebrates. Eradication of crayfish once they are established is extremely difficult (Hyatt 2004). Should crayfish become established in habitats occupied by the four invertebrates, crayfish would pose a potential threat via predation and competition.

Nonnative fish have had a major impact on native aquatic fauna in the southwest (Minckley and Douglas 1991; Desert Fishes Team 2003). Communities of animals evolved together and developed adaptations to deal with competition and predation from other members of the community (Meffe *et al.* 1994). When a nonnative species is introduced into this community, the native members often do not have defenses against predation or they may be less successful competitors. As a result, the nonnative species can have a major impact on native populations (Minckley and Douglas 1991; Meffe *et al.* 1994). Common carp, a nonnative species, is known to co-occur with the three aquatic invertebrates on the Refuge. Native to Asia, common carp was introduced into the United States in 1831, has become widely distributed (Sublette *et al.* 1990), and is present on the Refuge in habitats occupied by the invertebrates. It is an omnivore that feeds on aquatic invertebrates, fish eggs, algae, plants, and organic matter (Sublette *et al.* 1990). In addition, through spawning and feeding behavior it uproots vegetation and increases turbidity (Sublette *et al.* 1990). Because of its non-discriminatory diet and habitat disturbance, the introduced common carp could have an impact on the three aquatic invertebrate species.

Mosquitofish (*Gambusia affinis*) is also present in some of the spring systems on the Refuge, but it is not known if it is native to the area or not. The species is native to portions of New Mexico, but it has also been widely introduced to control mosquitoes (Sublette *et al.* 1990). However, it has negatively affected or extirpated many native species of fish and invertebrates (*e.g.*, through predation or hybridization) (Meffe *et al.* 1994). It is not known if mosquitofish are affecting the three species of aquatic invertebrates.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

The four invertebrates are federally and State listed as endangered (70 FR 46304, August 9, 2005; NMDGF 2006). Critical habitat was designated for the Pecos assiminea in 2005 concurrent with the listing rule. Since that time the Service has proposed new critical habitat for the Roswell and Koster's springsnails and Noel's amphipod, as well as revised critical habitat for the Pecos assiminea (75 FR 35375, June 22, 2010). Currently, the Service is amending this proposal to reflect the addition of more recent data from the summer of 2010 on the distribution of Noel's amphipod. All research activities are regulated by permits issued by the Service and New Mexico Department of Game and Fish. As described below, it is anticipated the climate change will have a significant impact on the water resources of the southwestern U.S.; however, there are no regulatory mechanisms that address climate change. Based on these existing regulations, the lack of regulatory mechanisms does not pose a threat to the four invertebrate species.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

<u>Introduced Species</u>

Introduced species are one of the most serious threats to native aquatic species (Williams *et al.* 1989, Lodge *et al.* 2000). Because the distribution of the four invertebrates is so limited and their habitat is so restricted, introduction of certain nonnative species into their habitat could be devastating. Building upon the list of nonnative aquatic species, such as crayfish, fish, and aquatic snails, discussed under Predation and competition in section 2.3.2.3, below is a discussion of additional nonnative plants and animals that could negatively impact the four invertebrates.

Plants
Several invasive terrestrial plant species that may affect the invertebrates are present on the Refuge, including saltcedar (*Tamarix* spp.), common reed, and Russian thistle (tumbleweed) (*Salsola* spp.). Control and removal of nonnative vegetation is a factor responsible for localized extirpations of populations of

Pecos assiminea in Mexico and New Mexico (Taylor 1987), but uncontrolled nonnative vegetation invasion is also likely detrimental to the species. Saltcedar, found on the Refuge and at Diamond Y Spring Complex and East Sandia Spring, threatens spring habitats primarily through displacement of native plants, shading and/or cooling of spring runs, and from the chemical composition of the leaves and sap that drop to the ground and into the springs. Saltcedar leaves that fall to the ground and into the water increase the salinity of the system, as their leaves contain salt glands (DiTomaso 1998).

Additionally, dense stands of common reed choke the stream channel, slowing water velocity and creating more pool-like habitat; this habitat is less suitable for Roswell and Koster's springsnails, which prefer flowing water. Finally, Russian thistle (tumbleweed) can create problems in spring systems by being blown into the channel, slowing flow and overloading the system with organic material (Service 2005b). The specific and limited habitat of the four invertebrates is vulnerable to invasion by these introduced plants, posing the potential for habitat degradation by a moderate threat to the four invertebrates.

Mollusks

Nonnative mollusks have affected the distribution and abundance of native mollusks in the United States. Of particular concern for three of the invertebrates (Noel's amphipod, Roswell springsnail, and Koster's springsnail) is the red-rim melania (*Melanoides tuberculatus*), a snail that can reach tremendous population sizes and has been found in isolated springs in the west. The red-rim melania has caused the decline and local extirpation of native snail species, and it is considered a threat to endemic aquatic snails that occupy springs and streams in the Bonneville Basin of Utah (Rader *et al.* 2003). It is easily transported on fishing boats and gear or aquatic plants, and because it reproduces asexually (individuals can develop from unfertilized eggs), a single individual is capable of founding a new population. It has become established in isolated desert spring ecosystems such as Ash Meadows, Nevada, and Cuatro Cienegas, Mexico, and within the last 15 years, the red-rim melania has become established in Diamond Y Springs Complex (Echelle 2001). It has become the most abundant snail in the upper watercourse of the Diamond Y Springs Complex (Echelle 2001). In many locations, this exotic snail is so numerous that it dominates the substrate in the small stream channel. The effect the species is having on native snails is not known; however, because it is aquatic it probably has less effect on Pecos assiminea than on the other endemic aquatic snails present in the spring.

Snails

The New Zealand mudsnail (*Potamopyrgus antipodarum*) is also a potential threat to the endemic aquatic snails on the Refuge and the spring systems in Texas. It was discovered in the Snake River, Idaho, in the mid-1980s and has quickly spread to every Western state except New Mexico (Montana State University 2010). Like the red-rim melania, the New Zealand mudsnail has an operculum (a lid to close off the shell opening), can withstand periods of drying up to eight days (thereby facilitating transport) and can reproduce either sexually or asexually. Thus, new populations can be established with transport of a single individual. In addition, the New Zealand mudsnail is tiny (3 mm [0.12 in] in height), is easily overlooked on gear or shoes, and can be transported unknowingly by people visiting various recreational sites. Considering its current rate of expansion and the availability of suitable habitat, it is highly likely that the New Zealand mudsnail will soon be discovered in New Mexico.

The New Zealand mudsnail tolerates a wide range of habitats, including brackish water. Densities are usually highest in systems with high primary productivity, constant temperatures, and constant flow (typical of spring systems). It has reached densities exceeding 500,000 per square meter (46,400 per square foot) (Richards *et al.* 2001) to the detriment of native invertebrates. Not only can it dominate the invertebrate assemblage (97 percent of invertebrate biomass), it can also eat nearly all of the algae and diatoms growing on the substrate, altering ecosystem function at the base of the food web (food is no longer available for native animals) (Hall *et al.* 2003). If the New Zealand mudsnail is introduced into the spring systems harboring the four invertebrates, control would most likely be impossible because the snails are so small and because any chemical treatment would also affect the native species. The impact could be devastating.

Trematodes

Infestation by trematodes (a flatworm or fluke, phylum Platyhelminthes) was noted by Taylor (1987) in populations of Koster's springsnail at Sago Spring on the Refuge. Digenetic trematodes (trematodes in the order Digenera) are parasitic and have the most complicated life histories in the animal kingdom involving two to four intermediate (vertebrate and/or invertebrate) hosts (Hickman *et al.* 1974). The first larval stage of the trematode nearly always uses a mollusk (snail or bivalve) as the first intermediate host (Hickman *et al.* 1974). Larval trematode parasites reduce or completely inhibit snail reproduction through castration (Minchella *et al.*1985). The effect of the trematodes on the springsnail population is not known.

Population Dynamics

Several biological traits have been identified as putting a species at risk of extinction (McKinney 1997, O'Grady *et al.* 2004). Some of these characteristics include having a localized range, limited mobility, and fragmented habitat (Noss *et al*. 2006, Fagan *et al*. 2002). The four invertebrate species each have all of these characteristics. Having a small, localized range means that any perturbation (e.g., drought, water contamination) can eliminate the species. Having a high number of individuals at a site provides no protection against extinction. Noel (1954) noted that Noel's amphipod in Lander Spring, New Mexico was the most abundant animal present when she did her research. The species was extirpated from that site when the spring dried up (Cole 1985). Extremely limited dispersal capability effectively eliminated the ability of the amphipod to find and disperse to other suitable habitats or to move out of habitat that becomes unsuitable. Consequently, the amphipod and snails are unable to avoid pollution or other unfavorable changes to their habitat. Severe drought or wildfire, groundwater pollution and spring contamination, or spring development (impoundment, dredging, piping) could result in the extirpation or extinction of the species.

Climate Change

The seeps and springs currently occupied by the four invertebrates have been perennial even through times of drought and increased groundwater pumping (such as in the 1970s), suggesting that these springs are relatively resilient to drought. However, climate change may test that resiliency. The Southwest may be entering a period of prolonged drought (McCabe *et al*. 2004, Seager *et al*. 2007). Seager *et al*. (2007) show that there is a broad consensus among climate models that the southwest will get drier in the twenty-first century and that the transition to a more arid climate is already under way. Only 1 of 19 models examined showed a trend toward a wetter climate in the southwest (Seager *et al*. 2007). An increase in average mean air temperature of just under 1˚C (1.8 ˚F) has already been documented in New Mexico since 1976 (Lenart 2007). Udall and Bates (2007) found that multiple independent data sets confirm widespread warming in the west.

In consultation with leading scientists from the Southwest, the New Mexico Office of the State Engineer prepared a report for the Governor (New Mexico Office of the State Engineer 2006) which made the following observations about the impact of climate change in New Mexico:

(1) warming trends in the American southwest exceed global averages by about 50 percent;
(2) models suggest that even moderate increases in precipitation would not offset the negative impacts to the water supply caused by increased temperature;
(3) temperature increases in the southwest are predicted to continue to be greater than the global average; and
(4) the intensity, frequency, and duration of drought may increase.

Increased air temperatures lead to higher evaporation rates, which may reduce the amount of runoff, groundwater recharge, and consequently spring discharge. Increased temperatures across the southwest may also increase the extent of area influenced by drought (Lenart 2003), decreasing groundwater recharge regionally, thereby reducing spring discharge. Prolonged drought leading to diminishment or drying of the spring would have a negative impact on the four invertebrates. Springs would not have to dry out completely to have an adverse effect. Decreased spring flow could lead to a decrease in the amount of suitable habitat, increased water temperature fluctuations, lower dissolved oxygen levels, and an increase in salinity (MacRae *et al*. 2001). In addition, as water becomes increasingly scarce, conflict over its use becomes more intense. Human and cattle consumption of water would be expected to increase during drought. Any of these factors, alone or in combination, could lead to either the reduction or extirpation of the populations. Thus, climate change is a significant threat to these four invertebrate species into the foreseeable future.

2.4 Synthesis

The Roswell springsnail, Koster's springsnail, Noel's amphipod, and Pecos assiminea are rare species that survive in only isolated locations in Chaves County, New Mexico, and Pecos and Reeves counties, Texas. Population numbers are unknown, although the species has remained stable at occupied sites. The effects of climate change, including widespread drought, decreased spring discharge, or a change in water chemistry could eliminate the species. Water contamination, particularly from oil and gas activities, catastrophic wildfire, and competition and predation from introduced species are additional threats to the species. A recovery plan has not yet been developed for these species. Because these species only occur in isolated locations where they could easily be extirpated by biological or environmental threats, we recommend that the Roswell springsnail, Koster's springsnail, Noel's amphipod, and Pecos assiminea remain listed as endangered.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
  ____ *Extinction*
  ____ *Recovery*
  ____ *Original data for classification in error*
__x_ No change is needed

3.2 New Recovery Priority Number: No change, remain as 5 for all four species.

Brief Rationale: The threats remain high, but intensive management is needed and the threats are not alleviated easily. Therefore, the recovery potential for the four species is low.

3.3 Listing and Reclassification Priority Number: Not applicable.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

(a) Develop a recovery plan for these species. The State of New Mexico has a recovery plan that has helped guide conservation efforts; however, a recovery plan with measurable objectives and criteria needs to be developed by the Service to provide delisting goals.

(b) Continue investigation of Noel's amphipod population genetics to determine the species' status on the Refuge.

(c) Continue investigation of the effects of fire on the Pecos assiminea to determine methods of burning an occupied area while protecting the population.

(d) Secure conservation on additional lands surrounding occupied habitat to protect water quality and improve land management practices.

(e) Continue to manage Refuge lands to reduce invasive plants.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Roswell springsnail (*Pyrgulopsis roswellensis*), Koster's springsnail (*Juturnia kosteri*), Noel's amphipod (*Gammarus desperatus*), and Pecos assiminea (*Assiminea pecos*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: Not applicable

Review Conducted By: Susan Oetker, U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve Wally Murphy Date 9/17/10

REGIONAL OFFICE APPROVAL:

Acting **Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service, Region 2**

Approve Steven M. Chambers Date 12/28/10