Rare Species of Prescott National Forest: Invertebrates

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AN INTRODUCTION TO THE HYDROBIIDAE SPRINGSNAILS OF THE PRESCOTT NATIONAL FOREST REGION (http://en.wikipedia.org/wiki/Hydrobiidae)

Hydrobiidae are known as the mudsnails and springsnails, and are a large cosmopolitan family of very small freshwater and brackish water snails. These snails have an operculum, and are in the aquatic gastropod mollusks in the clade Littorinimorpha. The fossil record of this family extends back to the Early Carboniferous Period. Hydrobiidae is the largest family within the superfamily Rissooidea. Nearly 400 genera have been assigned to this family, and probably more than 1,000 species. This family was originally named by Troschel in 1857, as the group Hydrobiae. Troschel was not certain of their rank, and he placed them in the Taenioglossata: Ctenobranchiata between the Lithoglyphi and Ancyloti. Over the years there have been numerous attempts to give an adequate and more finely divided classification.

The North American Hydrobiidae springsnails are generally small to minute snails, with a shell height often less than 3 mm. The dextrally (right)-coiled shells are smooth (except for growth lines conforming to the shape of the outer lip) and are usually rather nondescript. The shell offers few clear characteristics to taxonomists trying to classify species within this family. This difficulty is compounded by a high degree of intraspecific variation. Species descriptions often have to be based on the characteristics of the operculum, radula and penis. Within the family, the springsnails (*Pyrgulopsis* and *Trionia*) are particularly diverse and prone to endemism in springs in the Basin and Range geologic province of western North America.

The ctenidium (a comblike respiratory apparatus) exists along most of the length of the pallial cavity and this gill consists of 10 to 200 triangular filaments. The osphradium is an olfactory organ linked with the respiration organ, and is usually relatively small. The taenioglossate radula consists of more than fifty rows of teeth. The central tooth is trapezoidal. The lateral teeth have few to numerous cusps. The marginal teeth are usually with numerous cusps.

Most species in this family live in freshwater (lakes, ponds, rivers, streams), but some are found in brackish water or at the borders between freshwater and brackish water. A few species occur in marine settings on sandy or muddy bottoms between algae and sea grass.

Hydrobiid snails usually have both male and female individuals, but very rarely reproduction may be parthenogenic or caused by internal fertilization. Females lay eggs in single capsules on the leaves or stems of water plants, but sometimes they produce eggs that are hatched within the pallial gonoduct of the body. In such species the young are born

alive. Species that inhabit estuaries sometimes produce veliger larvae. These small snails feed on algae, diatoms and detritus.

Hydrobiid snails in the American Southwest are often found in great abundance at the sources of springs. Feeding on biofilm and algae, these species often play important micro-ecological roles in springs ecosystem function. The high level of hydrobiid endemism at springs, coupled with threats of groundwater pumping that reduce or eliminate springs, has elicited conservation attention in this family.

VERDE RIM SPRINGSNAIL
Pyrgulopsis glandulosa Hershler and Landye 1988

Figure 1: Verde Rim Springsnail (*Pyrgulopsis glandulosa*), Nelson Place Spring, Yavapai County, Arizona, with mm marks (photo by L.E. Stevens).

Taxonomy

Mollusca
Gastropoda
Neotaenioglossa
Hydrobiidae
Pyrgulopsis
P. glandulosa Hershler and Landye 1988

Description

General Description: A small aquatic snail with a dextral (right-upwards) curving conical shell. The shell is amber colored when the snail is alive, and is transparent or bleached white after death. The periostracum is a thin chitin layer that covers the shell, and is light brown. The shell length slightly exceeds its width. VRS shell whorls vary from 3.5 to 4.0 and are convex, with impressed sutures. Mature snail shells are 1/8 in (2.0-2.8 mm) long. The snout is thick, relatively wide, with terminal fleshy lips. VRS have narrow cephalic tentacles that are less than twice as long as the snout and are expanded at the tips. Upon dissection, the ventral penial surface has two accessory crests and the dorsal surface has at least two elongated ridges. The posterior end of the foot is rounded. Egg capsules are likely hemispherical to spherical, as with other *Pyrgulopsis*.

Similar Species: All *Pyrgulopsis* snails in Arizona are indistinguishable in the field, and must be carefully preserved and dissected for proper identification. **"**Based on penial morphology, this species is most similar to *P. montezumensis*, which also occurs in Verde River drainage, but differs in having a larger penis." (AGFD 2003).

Range

Overall Range: Nelson Place Spring is the only known locality for this species (Landye 1981; Fig. 2). The Arizona Game and Fish Department (2003) reports that the locality consists of "…two springs, separated by 150 meters, that form the headwaters of Sycamore Creek, Yavapai County, central Arizona." Nelson Place Springs lies at about 1605-1610 m and consists of 3 springs complexes, each separated by a few tens of meters. Neither the upper nor the small lowermost springs appear to support VRS; however, a site visit in September 2010 revealed a large, healthy population of VRS at the main (middle) springs complex. Nelson Place Springs was once a popular stopping place for travelers between Phoenix and the high plateaus of northern Arizona. The site appears to have been restored, with the removal of housing structures and roads, and the overall site has been fenced. The only remaining signs of human presence are catalpa and Lombardy poplar trees, and a water drain structure, none of which appear to negatively affect the snail habitat at the middle springs source.

Known Localities and Distribution of Specimens: Prior to our visit in September 2010, VRS had not, to our knowledge been observed since its original collection in the 1970s by

Landye (J. Landye, retired USFWS, personal communication 2010). The specimens collected by Landye are housed in the Smithsonian Institution in Washington, DC.

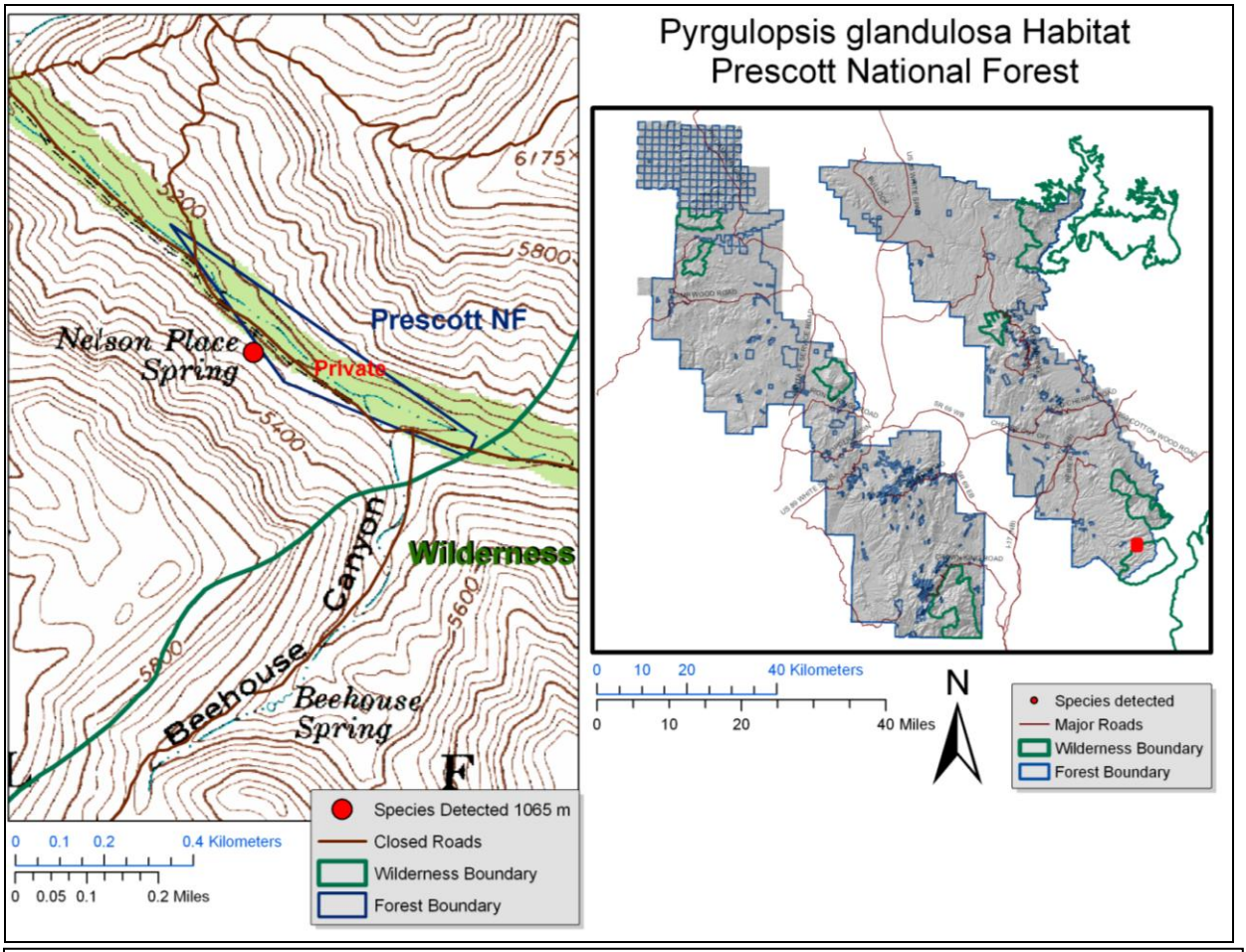

Figure 2: Verde Rim Springsnail distribution in Arizona. Roads, Forest Service and Wilderness boundary data from Prescott National Forest geodatabase. Raster layers provided by USGS. Projection NAD83.

Habitat Requirements

As with many *Pyrgulopsis* species, VRS is narrowly endemic to the source of the main Nelson Place Springs (Fig. 3). At that site the snail occurs in association with rocks, logs, and other firm substrata in the uppermost 20 m of the spring outflow, which lies on the Prescott National Forest. Also, like other *Pyrgulopsis*, it appears to prefer the roots of non-native watercress *(Nasturtium officinale).* Water temperature of the spring during the site visit was 68°F (20°C).

Figure 3: Nelson Place main spring, September 2010 (photo by L. E. Stevens).

Ecology and Life History

Details of the ecology and life history of this *Pyrgulopsis* are likely similar to other members of the genus that are springs source-specialists; however, no specific information is available on VRS ecology and life history.

"Most hydrobioids are oviparous, with females depositing small egg capsules, either singly or (rarely) in strings, on the substrate. A small number of hydrobioids are ovoviviparous, in which female's brood of shelled young hatch in the pallial gonoduct. Copulation in hydrobioids is usually via an anterior opening to the glandular oviduct. The ventral channel may be traversed at least in part by the penis, but it is more likely that the penis only enters the anterior-most section. (Hershler and Ponder, 1998)" (AGFD 2003).

Behavior

Likely similar to other *Pyrgulopsis*, VRS is tightly tied to the spring source and firm substrata and aquatic vegetation. It is primarily nocturnal, and stays beneath rocks or in

the shallow hyporheic zone and substratum during the day. There is some evidence of negative phototaxy in *P. glandulosa*, as they appear to move away from light. The attraction of this species to non-native watercress has not been studied. Although individuals are commonly found in watercress roots, it is uncertain whether the roots are used as a food source.

Conservation Status

VRS is listed by NatureServe as a G1 (globally imperiled) species, and is listed by the State of Arizona as an S1 species (imperiled in the state; NatureServe 2007). In addition, it is listed as a USDA Forest Service Region 3 Regional Forester's sensitive species, and the USFWS is concerned about this springsnail.

Threats

General threats: Ungulate grazing, planned and wild fires, recreation impacts, and global climate changes are the primary threats to this snail. A monitoring program that includes a periodic check on the abundance of the snail appears warranted.

National Forest Service habitat modifying activities: The primary Forest Service management activities that may influence the VRS habitat at Nelson Place Springs are listed in Table 1. VRS habitat stewardship issues include non-native species and recreation management issues. Although several non-native trees and other plants occur at the site, removal of non-native trees may negatively affect the VRS population. Crayfish exist in the nearby creek, and occasional monitoring may reveal incursions into the springs area, which may be somewhat protected by the placement of the drainpipe. Increased recreational use intensity may introduce additional disturbance and non-native species, and monitoring also can provide management with information on present use levels and new non-native species introductions.

Table 1: Common general and specific Forest Service management practices, potential impacts, and mitigation actions for use on non-wilderness lands.

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical cutting of juniper with lop and scatter to 18 to 24 inches from the ground	Wood chip cover of riparian habitats	Designate stream buffer zone; avoid chipping near spring or riparian habitats
Brush control	Mechanical removal of oaks, manzanita, and other brushy vegetation as a fuel reduction project near WUI	Exposure of aquatic habitats, heating water during daytime	Designate stream buffer zone; avoid concentrating slash near spring or riparian habitats

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical treatment of chaparral (mastication)	Exposure of riparian habitats	Designate stream buffer zone; avoid concentrating slash
Construction	Drainage or stream crossings by trails or roads with insertion of proper culverts to allow for water flow	Erosion, soil compaction	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; minimize road and trail impacts on spring and riparian habitats
Construction	Road construction	Soil erosion and sedimentation to springs and stream drainages.	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; schedule road construction work to minimize VRS population and riparian habitat impacts, including potential dispersal
Forest management	Prescribed burning	Increased soil temperature during fire, ash and sediment inflow into aquatic/riparian habitats	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; conduct prescribed fires to minimize seasonal impacts on VRS and its habitat
Forest management	Timber harvest using thinning in Ponderosa Pine	Soil erosion and sedimentation inflow into aquatic/riparian habitats; heavy equipment impacts	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; designate stream buffer zone.
Forest management	Underburning using prescribed fire in Ponderosa Pine	Increased soil temperature during fire, ash and sediment inflow into aquatic/riparian habitats	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; conduct prescribed fires to minimize seasonal impacts on VRS and its habitat
Livestock management	Fencing to exclude livestock	Fencing may exclude livestock from sensitive areas, such as springs and stream-riparian zones	Assess and manage fencing needs to meet desired goals

General Activity	Management Action	Impacts	Mitigation Actions
Livestock management	Livestock grazing management	Vegetation removal, streambank trampling reduced water quality from animal waste products.	Resource monitoring, vegetation utilization levels; livestock grazing exclusion from habitat
Pest control	Non-native invasive plant species treatment (either mechanically or via herbicide)	Reduction or elimination of vegetation may increase soil erosion and sedimentation to springs and stream drainages	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages
Pest control	Release of biological control insects and pathogens.	Predation, competition, disease transmission to native taxa	Control non-native fauna as feasible, using integrated pest control methods
Fisheries management	Electroshocking fish as a monitoring activity	No effect on VRS.	Not applicable to VRS
Water resources management	Spring or stream capture and diversion	Reduction or elimination of surface flows and reduction of soil moisture	Assess and mitigate spring and streamflow alterations
Water supplies management	Spring and stream monitoring	Resource conditions may dwindle or disappear without regular monitoring	Inflow stream flow water rights

Mitigation of Management Practices

General maintenance and monitoring activities should include consideration of minimizing impacts springs habitats (Table 1).

Restoration Opportunities

Nelson Place Springs was once a popular stopping place for travelers between Phoenix and the high plateaus of northern Arizona. The site appears to have been restored, with the removal of housing structures and roads, and the only signs of human presence are catalpa and Lombardy poplar trees, and a water drain structure, none of which affect the snail habitat. Occasional monitoring of this population will help inform Prescott Forest managers as to changes in the habitat and snail population status.

Research Questions

1) What are *P. glandulosa* population dynamics and responses to recreation, fires, and wildlife use at the springs?
2) Does *P. glandulosa* occur at other springs in the vicinity?
3) What are the water quality limitations on this snail species?
4) What are the implications of global climate change on this species?

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BROWN SPRINGSNAIL
Pyrgulopsis solus Hershler and Landye 1988

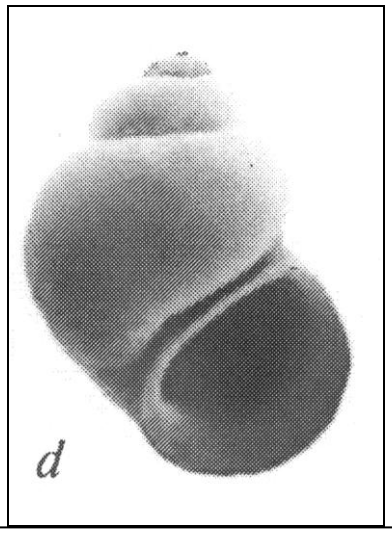

Figure 1: Brown Springsnail (*Pyrgulopsis solus*) holotype specimen from Smithsonian Institution (USNM 859045), Brown Spring, Yavapai County, Arizona (Hershler and Landye 1988:28).

Taxonomy

Mollusca
- Gastropoda
  - Neotaenioglossa
    - Hydrobiidae
      - *Pyrgulopsis*
        - *P. solus* Hershler and Landye 1988

Description

General Description: Brown springsnail (BSS) is a small aquatic snail with a dextral (right-upwards) curving conical shell. BSS shells are "…ovate and small with shell height (height from top of shell to bottom of shell) 1.4 to 2.0 mm. Body whorl relatively large (83% of shell height) with 3.5 to 4.0 moderately convex whorls. Inner lip is moderately thickened, fused to or slightly separated from body whorl. Pigment on head/foot may be absent, or range from very light to dark dusting on all surfaces. All hydrobioids have a foot with a rounded posterior end" (AGFD 2003). The penial filament is darkly pigmented. Although the penis is small, it has an enlarged bifurcate lobe, with an elongate glandular ridge along lobe's edge and a smaller ridge on ventral surface. The squat penis of this species is unique among southwestern *Pyrgulopsis* (AGFD 2003). Egg capsules are likely hemispherical to spherical, as with other *Pyrgulopsis*.

In general, "the hydrobioid digestive system is typical of style-bearing neotaenioglossans. The mouth opens to a short oral area containing a pair of dorsolateral

chitinous jaws composed of small, simple rodlets, immediately behind which is a well-developed buccal mass (situated within the snout). A pair of simple, unbranched, tubular salivary glands opens anterodorsally to the buccal cavity and (almost always) pass posteriorly over the nerve ring, rarely stopping short of the ring, but never passing through it in hydrobioids" (Hershler and Ponder 1998; AGFD 2003).

Hydrobioids have taenioglossate radulae (seven teeth per row). "…comprising numerous rows of cuspate teeth, each of which includes a typically squarish or trapezoidal central tooth flanked on each side by lateral, inner marginal, and outer marginal teeth. Teeth near the anterior end of the radula are often worn or broken, whereas the proximal portion of the ribbon has several to many rows of poorly differentiated or incompletely formed teeth. (Hershler and Ponder, 1998)"

Similar Species: All *Pyrgulopsis* snails in Arizona are indistinguishable in the field, and must be carefully preserved and dissected for proper identification.

Range

Overall Range: Brown Spring is the only known locality for this species (AGFD 2003; Fig. 2). It lies on private land on the south side of the Verde River, about 15 miles (23 km) downstream from Camp Verde. Brown Spring emerges approximately 100 m up on the hillslope near Coldwater Creek, and discharges into the Verde River. However, if BSS is similar to most other *Pyrgulopsis*, it likely only occurs near the spring source. Other springs in the area should be examined to determine whether any populations of this species exist on Prescott National Forest land.

Known Localities and Distribution of Specimens: BSS have not, to our knowledge, been observed since its original collection by Landye (J. Landye, USFS Retired, oral communication 2010). The specimens collected by Landye and described by Hershler and Landye (1988) are housed in the Smithsonian Institution in Washington, DC.

Habitat Requirements

As with many *Pyrgulopsis* species, BSS is presently known only to be narrowly endemic to a single springs ecosystem. *Pyrgulopsis* habitat is usually a matrix of rocks, logs, and other firm substrata in the uppermost spring outflow, and including the shallow, rocky hyporheic zone. However, Brown Spring lies on private land, and is not under the jurisdiction of Prescott National Forest. An inventory of regional springs would help establish whether this species exists on Forest Service land, and the survey should include Coldwater springs and headwaters of Gap Creek.

Ecology and Life History

Details of the ecology and life history of BSS are likely similar to other members of the genus that are springs source-specialists; however, no information is available on BSS ecology and life history.

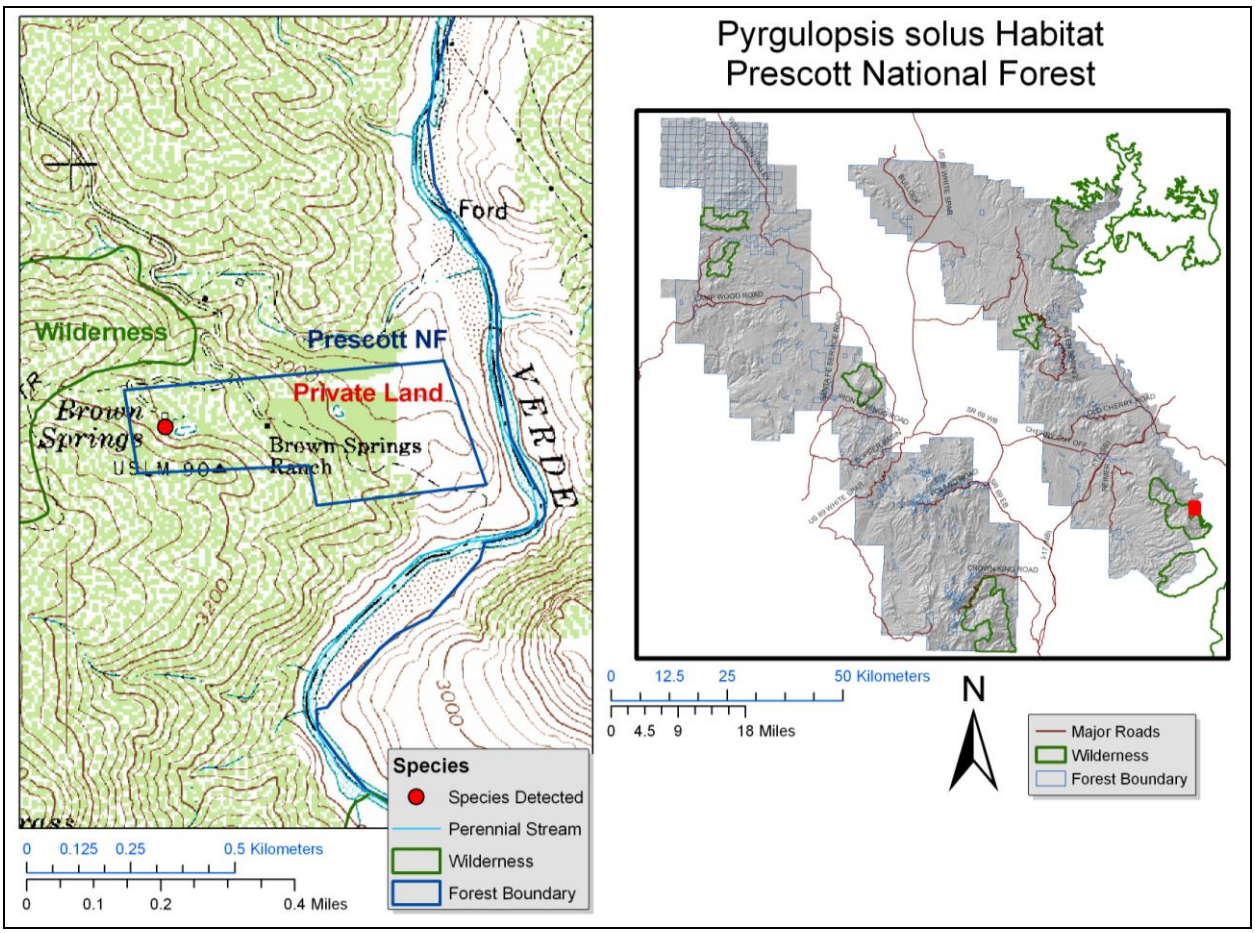

Figure 2: Brown Springsnail occurrence in Prescott National Forest. Boundary data from Prescott National Forest geodatabase; raster layers from USGS.

Behavior

Likely similar to other *Pyrgulopsis*, BSS is probably closely affiliated with the spring source, and likely occurred on firm substrata and aquatic vegetation. Related taxa are primarily nocturnal, remaining beneath rocks or in the shallow hyporheic zone and substratum during the daylight hours.

According to the Arizona Game and Fish Department (2003), "most hydrobioids are oviparous, with females depositing small egg capsules, either singly or (rarely) in strings, on the substrate. A small number of hydrobioids are ovoviviparous, in which female's brood shelled young in the pallial gonoduct. Hydrobioid egg capsules are typically hemispherical to spherical. Copulation in hydrobioids is usually via an anterior opening to the glandular oviduct. The ventral channel may be traversed at least in part by the penis, but it is more likely that the penis only enters the anterior most section (Hershler and Ponder, 1998)."

Conservation Status

The Brown Springsnail is a USDA Forest Service Region 3 Regional Forester's sensitive species, and the U.S. Fish and Wildlife Service is concerned about this springsnail. It is listed by NatureServe as a G1 (globally imperiled) species, and is listed by the State of Arizona as an S1 species (imperiled in the state; NatureServe 2007).

Threats

General threats: Local and regional groundwater pumping and diversion, ungulate grazing, planned and wild fires, recreation impacts, and global climate changes are the primary threats to this snail. There is a water diversion from Brown Springs to FS lands; however, this species is not presently known to occur on Prescott National Forest.

National Forest Service Habitat Modifying Activities: Forest Service management activities may influence the BSS and its habitat, if any BSS are found to exist on Prescott National Forest land (Table 1).

Table 1: Common general and specific Forest Service management practices, impacts, and mitigation actions for Brown Springsnail, if any are discovered on Prescott National Forest land. No vegetation treatments, timber harvest, road construction, or water diversions are undertaken on lands designated or managed as wilderness.

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical cutting of juniper with lop and scatter to 18 to 24 inches from the ground	Wood chip cover of riparian habitats	Designate stream buffer zone; avoid chipping near spring or riparian habitats
Brush control	Mechanical removal of oaks, manzanita, and other brushy vegetation as a fuel reduction project near WUI	Exposure of aquatic habitats, heating water during daytime	Designate stream buffer zone; avoid concentrating slash near spring or riparian habitats
Brush control	Mechanical treatment of chaparral (mastication)	Exposure of riparian habitats	Designate stream buffer zone; avoid concentrating slash
Construction	Drainage or stream crossings by trails or roads with insertion of proper culverts to allow for water flow	Erosion, soil compaction	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; minimize road and trail impacts on spring and riparian habitats

General Activity	Management Action	Impacts	Mitigation Actions
Construction	Road construction	Soil erosion and sedimentation to springs and stream drainages.	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; schedule road construction work to minimize BSS population and riparian habitat impacts, including potential dispersal
Forest management	Prescribed burning	Increased soil temperature during fire, ash and sediment inflow into aquatic/riparian habitats	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; conduct prescribed fires to minimize seasonal impacts on BSS and its habitat
Forest management	Timber harvest using thinning in Ponderosa Pine	Soil erosion and sedimentation inflow into aquatic/riparian habitats; heavy equipment impacts	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; designate stream buffer zone.
Forest management	Underburning using prescribed fire in Ponderosa Pine	Increased soil temperature during fire, ash and sediment inflow into aquatic/riparian habitats	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; conduct prescribed fires to minimize seasonal impacts on BSS and its habitat
Livestock management	Fencing to exclude livestock	Fencing may exclude livestock from sensitive areas, such as springs and stream-riparian zones	Assess and manage fencing needs to meet desired goals
Livestock management	Livestock grazing management	Vegetation removal, streambank trampling reduced water quality from animal waste products.	Resource monitoring, vegetation utilization levels; livestock grazing exclusion from habitat

General Activity	Management Action	Impacts	Mitigation Actions
Pest control	Non-native invasive plant species treatment (either mechanically or via herbicide)	Reduction or elimination of vegetation may increase soil erosion and sedimentation to springs and stream drainages	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages
Pest control	Release of biological control insects and pathogens.	Predation, competition, disease transmission to native taxa	Control non-native fauna as feasible, using integrated pest control methods
Fisheries management	Electroshocking fish as a monitoring activity	No effect on BSS.	Not applicable to BSS
Water resources management	Spring or stream capture and diversion	Reduction or elimination of surface flows and reduction of soil moisture	Assess and mitigate spring and streamflow alterations
Water supplies management	Spring and stream monitoring	Resource conditions may dwindle or disappear without regular monitoring	Inflow stream flow water rights

Mitigation of Management Practices

Mitigation of management practices will benefit from a *Pyrgulopsis* inventory of nearby springs, and will benefit from minimizing impacts on adjacent lands around Brown Spring (Table 1).

Restoration Opportunities

Brown Spring management is not in the purview of the National Forest Service; however, a *Pyrgulopsis* inventory at springs in the vicinity of Brown Springs will help inform Prescott Forest managers as to whether or not BSS is a stewardship responsibility of the Forest Service.

Research Questions

1) Are there *P. solus* populations on Prescott National Forest land?
2) What are *P. solus* population dynamics and responses to recreation, fires, and wildlife use at the springs?
3) What are the water quality limitations on this snail species?
4) What are the implications of global climate change on this species?

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TIGER BEETLES (COLEOPTERA: CICINDELIDAE) OF THE PRESCOTT NATIONAL FOREST REGION

Tiger beetles are small (3/8-1 in,12-25 mm) ground-dwelling beetles that are active and often colorful predators. Tiger beetles are closely related to, and sometimes included in, the large family of ground beetles (Carabidae). Tiger beetles recently have become much better known, due to the publication of Pearson et al. (2005) *Field Guide to the Tiger Beetles of the United States and Canada* (Oxford University Press, Oxford). There are four genera of tiger beetles in North America north of Mexico: giant tiger beetles (*Amblycheila*), night-stalking tiger beetles (*Omus*), big-headed tiger beetles (*Tetracha*), and common tiger beetles (*Cicindela*), of which all but *Omus* occur in northern Arizona (Stevens and Huber 2004). The genus *Cicindela* has been subdivided into 11 subgenera, including *Cicindela, Tribonia, Cicindelidia, Habroscelidomopha, Eunota, Microthylax, Opilidia, Brasilia, Cylindera, Dromochorus,* and *Ellipsomorpha*.

Adult tiger beetles are commonly black, bronze, green, or blue, with cream colored maculations (markings) on their elytra (first pair of wings), and have large mandibles. Most adult tiger beetles are diurnal, but some, such as *Amblycheila* and *Tetracha* are nocturnal. Diurnal species fly up or chase down soft-bodied invertebrate prey, and often are strongly territorial. While many species have 1-2 generation per year, quite a few species have 2-3 yr life cycles.

Larval tiger beetles also are predatory, and have massive heads and mandibles, and a distinctive dorsal hump on top of the fifth abdominal segment. The larvae dig a sometimes deep (>1 ft, 35 cm) vertical burrow. They rest at the top of the burrow with their heads flat to the ground, lunging out to grab passing invertebrate prey. They are highly sensitive to vibrations of large animals, quickly retreat deeply into their burrows when disturbed. The larvae have not received as much scientific attention as the adults, and often have not been described.

MARICOPA TIGER BEETLE – *Cicindela oregona maricopa* Leng 1902

Figure 1: Maricopa Tiger Beetle (*Cicindela oregona maricopa* Leng 1902). Photo by Lawrence Stevens.

Taxonomy

Arthropoda
- Hexapoda
  - Coleoptera
    - Cicindelidae
      - *Cicindela oregona*
        - *C. o. maricopa* Leng 1902

Description

Larvae: Larvae of the Maricopa Tiger Beetle (MTB) have not been specifically described, but are likely similar to those of other members of this subgenus. MTB larvae are elongate and pale with a dark head. The head is flattened and the large mandibles are slightly recurved upwards. The head and prothorax are fused to form a circular plate, and are held perpendicular to the body. A pronounced tergal hump on the fifth abdominal segment bears anteriorly curved spines (Brock and Prchal 2001, Pearson and Vogler 2001, Pearson et al. 2005).

Adults: Adult MTB are medium-sized, showy, metallic blue-green tiger beetles with white- or cream-colored maculations (elytral white colored patches). The head contains large mandibles with large tooth-like dentition, and relatively long filiform antennae. MTB was first described as a variety (Leng 1902), and no type specimen was designated. Dahl's (1941) designated lectotype has the head and pronotum metallic green, but its elytra and undersides are dull dark violet. The elytra of most living adult MTB grade from metallic green and blue to violet along the length of the elytra (Fig. 1).

Similar Taxa

Adult MTB are distinct from other tiger beetles in their range, being moderately large, brightly metallic blue-green colored, and diurnal, as compared to other regional Cicindelidae. While they somewhat similar to *Tetracha carolina*, MTB are diurnal. MTB are much larger than *Cicindela marutha*, another bright metallic blue-green tiger beetle that occurs in MTB's range. Intergrades and hybrids of MTB with the other three subspecies have been reported (AGFD 2002).

Range

***Regional*:** *Cicindela oregona* is widely distributed across the western United States, from Arizona northward into Canada. The subspecies *C. o. maricopa* is broadly distributed in riparian and moist fine sand habitats across western Utah and most of Arizona. It occurs from southern Utah southward to Cochise County in Arizona, with Arizona collections reported from Cochise, Coconino, Gila, Graham, Greenlee, Maricopa, Mohave, Navajo, Pima, Pinal, and Yavapai counties (Brock and Prchal 2001, AGFD 2002, Stevens and Huber 2004). MTB overlaps in range with *C.o. oregona* to the north, *C.o. guttifera* to the northeast, and *C.o. navajoensis* to the east (Pearson et al. 2005).

MTB occurs from at least 1,092 - 6,940 ft (330 - 2,117 m) in Arizona and southern Utah (AGFD 2002, Stevens and Huber 2004). Despite the broad areal and elevational range of MTB, it is almost wholly confined to moist sandy riparian habitats along perennial streams, and thus its actual habitat is relatively small.

Prescott National Forest: *C. oregona* is widely distributed in the Great Basin, Colorado Plateau, and western North America, but MTB is more narrowly restricted to perennial stream riparian habitats in northern Arizona and southern Utah (Fig. 2). MTB inhabits alluvial perennial stream margins. The potential range of MTB on Prescott National Forest

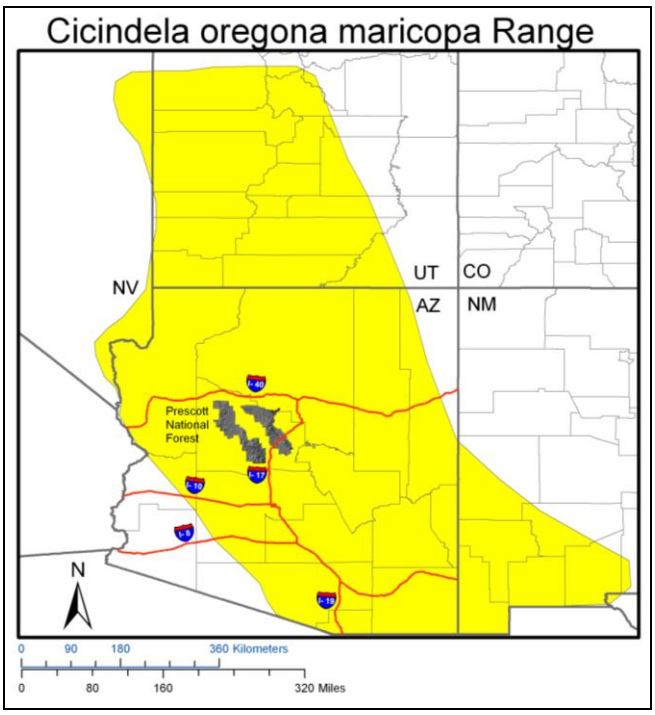

Figure 2: Regional range map of *Cicindela oregona maricopa* in the American Southwest.

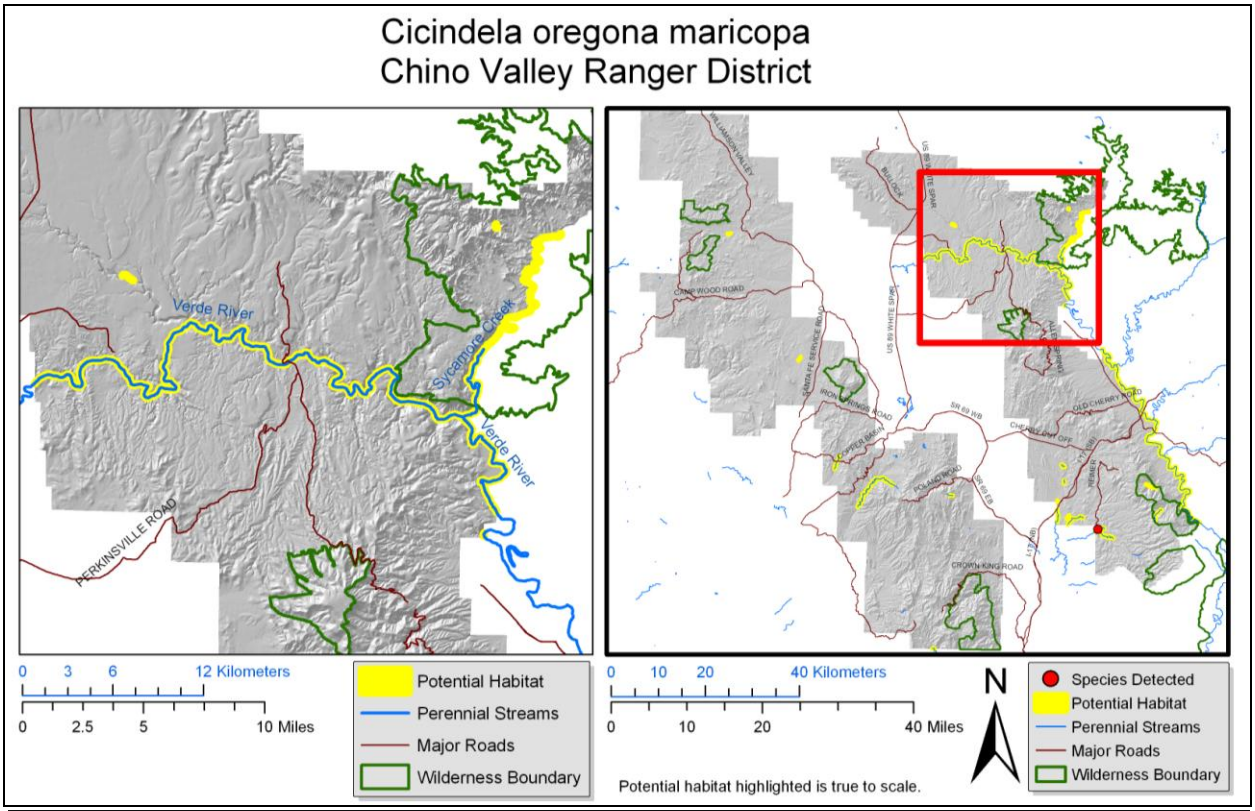

Figure 3: *Cicindela oregona maricopa* potential habitat and occurrence in the Chino Valley Ranger District of Prescott National Forest.

is inadequately resolved, with available habitat limited by naturally arid conditions and the few perennial streams. Mapping information of MTB range on the Forest is preliminary (Figures 3 and 4).

The range of sites at which MTB has been detected include: numerous localities in southern Utah, throughout Grand Canyon, and south to Cochise County, a range that encompasses much of Prescott National Forest; however, few specimens have been collected on Prescott National Forest to date. This is likely due to the lack of collecting and the paucity of stream-riparian habitat in this arid forest.

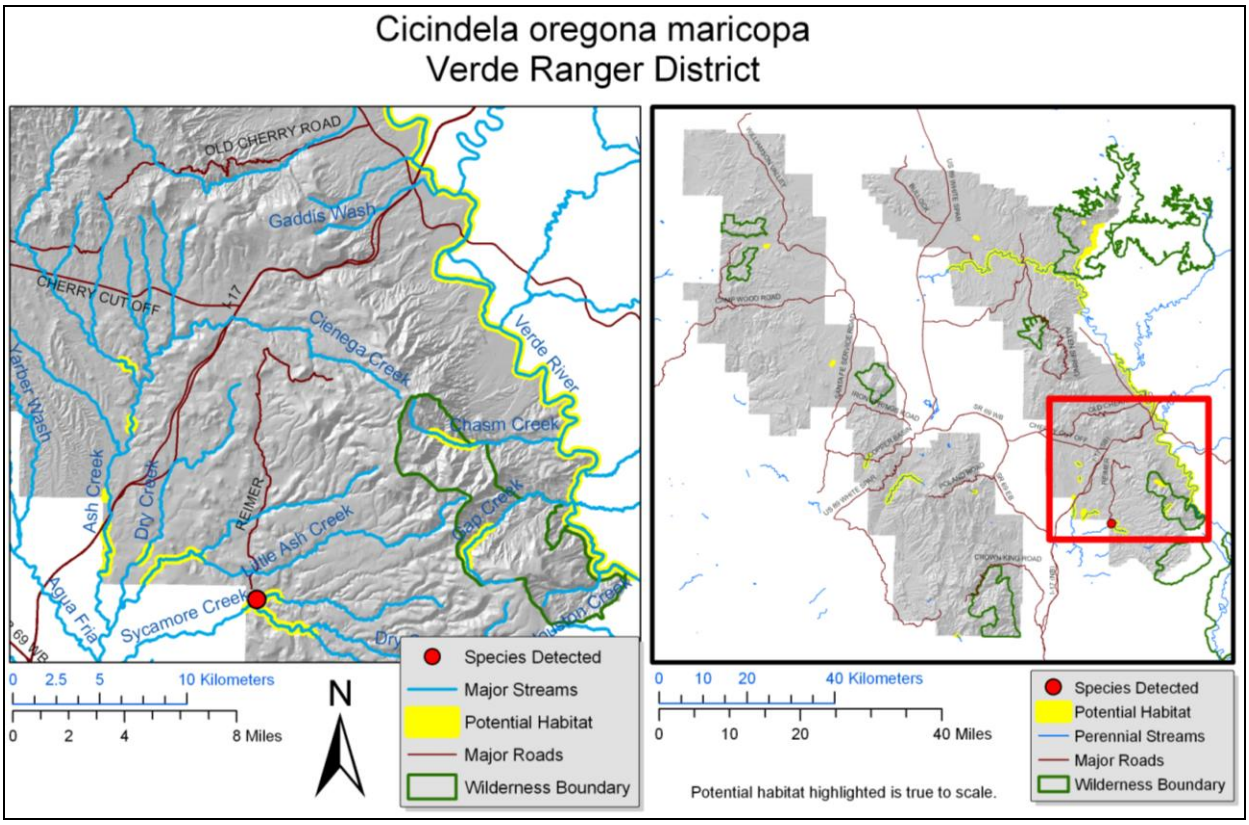

Figure 4: *Cicindela oregona maricopa* range and occurrence in the Verde Ranger District of Prescott National Forest.

Habitat Requirements

MTB occupies and is restricted to open or sparsely-covered silty sand banks of perennial, alluvial streams, springs, and ponds at low-middle elevations in central and northern Arizona, and southern Utah. Larvae burrow into these sediment deposits, and adults use the habitats for foraging, courting, and reproduction.

Ecology and Life History

Both larvae and adults are predaceous, and feed on soft-bodied insects. Larvae sit and wait for prey to approach their burrows, sensing vibrations in the soil. They quickly lunge out grab the unsuspecting prey with their heavy mandibles, subdue the prey and eat it. Larvae are active during April and May, pupate in early summer, and emerge in a second generation in late summer and autumn, likely producing offspring that overwinter in larval or pupal stages.

MTB has two generations per year at lower elevations in the Southwest, emerging in spring and again in late summer-early autumn. Early and late adult activity dates are 27 March and 14 October, respectively (N =56 specimens examined).

Behavior

MTB eggs are laid in the soil. The larvae live in vertical burrows, where they rest with their heads at the top of the burrow, flat against the ground. There they wait for soft-bodied prey to pass by. They are extremely sensitive to vibration, detecting prey from several inches away. They withdraw into the ground when they detect large animals approaching (e.g., livestock, large game, and entomologists).

Adults are active during warm days in spring and late summer, and maintain an upright, "alert" posture when resting, with head up and abdomen lowered, ready for fight or flight... They run, rest, display, and hunt on moist, open, silty sand alluvial deposits along perennial streams during sunny portions of the day. They fly a short distance when approached within about 5 ft (1.5 m). When hunting, adult MTB chase down, or leap out or up to grapple terrestrial or slow-flying prey.

Conservation Status

The MTB is listed as a G5 species, globally secure but potentially rare at its range edges. BISON (http://www.bison-m.org/reports.aspx?rtype=13&category=%2719%27, accessed 15 Oct 2010) states that MTB is a U.S. Fish and Wildlife Service Species of Concern, and that the State of Arizona lists it as an S3 species, Uncommon or Restricted in the state. However, MTB is the most common tiger beetle at low elevations in its range, and several experts over the past decade have reported to the Forest Service that MTB is not a significant conservation priority (e.g., Pearson and Wismann 1995, Brock and Prchal 2001). We reiterate that claim here: Because MTB is restricted to middle and lower elevation riparian ecosystems, it does not much occur on National Forest lands, which lie in middle to upper elevations. While MTB may be rare on PNF and other National Forest lands on the southern Colorado, it is relatively abundant in non-Forest Service, lower elevation riparian habitats, and it remains relatively abundant throughout its range. It appears that its habitat requirements and fidelity to perennial stream shorelines keep it a species of concern to the Forest Service.

Threats

General threats: Threats to MTB are primarily related to the quality and status of its habitat (Table 1). Flow diversion, decreased flood intensity, streamside sand and gravel mining,

and invasion of stream riparian habitat by non-indigenous weeds, shrubs or trees likely are detrimental to this taxon, as MTB require open, moist, sunny streamside habitat.

With regard to threats to this taxon, Brock and Prchal (2001) referred to "…short term and potentially long term impact(s) of sand and gravel operations on the ability of this species to survive and recolonize... Sand and gravel operations below dams present a double whammy because deposition of sand and gravel is severely reduced by dams. ...dams not only trap sediment, but act to regulate stream flow and hence to eliminate (reduce) stream bank erosion." They also state that "Cattle generally do not damage the adults, but continually trample the larval burrows. This impact results in severe reductions in both larvae and adults and soon the potential for re-colonization is eliminated and species is in trouble."

Other threats include grazing and other bank-disturbing activities, but some such activities may help ensure sufficient open, moist habitat is seasonally (spring and autumn) available. The responses of MTB to riparian fires are not known and deserve attention. Vegetation expansion into floodplains may be associated with flow regulation and global climate change, and may limit habitat availability.

National Forest Service Habitat-modifying Activities: Several National Forest management activities may modify the habitat of MTB (Table 1). Most potential impacts can be mitigated with prior planning, use of Best Management Practices, and followed by impact monitoring.

Mitigation of Management Practices

Forest Service management practices may affect MTB and its habitat on the Prescott National Forest, but more detailed information is needed to predict this beetle's responses to habitat modification or mitigation activities to learn whether management actions can be effectively mitigated. Due consideration should be given to the potential impacts of livestock and wildlife grazing, sand and gravel mining, road construction, hiking, off-road vehicle recreation, and other managed activities along perennial streams and other potential MTB habitats.

Restoration/Conservation Opportunities

MTB is widely distributed in Arizona and is likely to occur in suitable riparian habitats on the Prescott National Forest. Riparian habitat restoration is likely to promote MTB population expansion, and translocation of MTB into restored habitats may be effective, particularly along lower elevation streams. Monitoring also is needed, and timed visual searches along transects parallel to the channel should be conducted during sunny portions of the day.

Table 1: General and specific Forest Service management activities, potential impacts, and mitigation strategies. No vegetation treatments, timber harvest, road construction, or water diversions are undertaken on lands designated or managed as wilderness.

General Activity	Management Action	Impacts	Mitigation Actions
Brush control	Mechanical cutting of juniper with lop and scatter to 18 to 24 inches from the ground	Wood chip cover of riparian habitats	Designate stream buffer zone; avoid chipping near riparian habitats
Brush control	Mechanical removal of oaks, manzanita, and other brushy vegetation as a fuel reduction project near WUI	Exposure of aquatic habitats, heating water during daytime	Designate stream buffer zone; avoid concentrating slash near riparian habitats
Brush control	Mechanical treatment of chaparral (mastication)	Exposure of riparian habitats	Designate stream buffer zone; avoid concentrating slash
Construction	Drainage or stream crossings by trails or roads with insertion of proper culverts to allow for water flow	Erosion, soil compaction	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; minimize road and trail impacts on riparian habitats
Construction	Road construction	Soil erosion and sedimentation to stream drainages.	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; schedule road construction work to minimize MTB population and riparian habitat impacts, including potential dispersal
Forest management	Prescribed burning	Increased soil temperature during fire, ash and sediment inflow into aquatic/riparian habitats	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; conduct prescribed fires to minimize seasonal impacts on MTB and its habitat

General Activity	Management Action	Impacts	Mitigation Actions
Forest management	Timber harvest using thinning in Ponderosa Pine	Soil erosion and sedimentation inflow into aquatic/riparian habitats; heavy equipment impacts	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; designate stream buffer zone.
Forest management	Underburning using prescribed fire in Ponderosa Pine	Increased soil temperature during fire, ash and sediment inflow into aquatic/riparian habitats	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages; conduct prescribed fires to minimize seasonal impacts on MTB and its habitat
Livestock management	Fencing to exclude livestock	Fencing may exclude livestock from sensitive areas, such as stream-riparian zones	Assess and manage fencing needs to meet desired goals
Livestock management	Livestock grazing management	Vegetation removal, streambank trampling reduced water quality from animal waste products.	Resource monitoring, vegetation utilization levels; livestock grazing exclusion from habitat
Pest control	Non-native invasive plant species treatment (either mechanically or via herbicide)	Reduction or elimination of vegetation may increase soil erosion and sedimentation to stream drainages	Apply Best Management Practices to reduce soil erosion and sedimentation to drainages
Pest control	Release of biological control insects and pathogens.	Predation, competition, disease transmission to native taxa	Control non-native fauna as feasible, using integrated pest control methods
Fisheries management	Electroshocking fish as a monitoring activity	No effect on MTB.	Not applicable to MTB

General Activity	Management Action	Impacts	Mitigation Actions
Water resources management	Spring or stream capture and diversion	Reduction or elimination of surface flows and reduction of soil moisture	Assess and mitigate streamflow alterations
Water supplies management	Spring and stream monitoring	Resource conditions may dwindle or disappear without regular monitoring	Inflow stream flow water rights

Research Questions

1) What is the distribution and status of MTB on Prescott National Forest?
2) What are MTB population dynamics, particularly in relation to fire frequency and other major anthropogenic impacts?
3) What are the implications of local habitat alterations on MTB?
4) What are the implications of global climate change on MTB?
5) Can MTB populations be reintroduced into restored habitats from which they have been extirpated?

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