SURVEY DATA FOR WET CANYON TALUSSNAIL (*SONORELLA MACROPHALLUS*) AND OTHER PINALEÑO MOUNTAIN LAND SNAILS, 2001-2016

Jeff A. Sorensen, Invertebrate Wildlife Program Manager
Terrestrial Wildlife Branch, Wildlife Management Division
Arizona Game and Fish Department

and

Alex J. Martinez
Ecology and Evolutionary Biology Internship Program
University of Arizona

Technical Report #295
Nongame and Endangered Wildlife Program
Terrestrial Wildlife Branch Chief: Josh Avey
Arizona Game and Fish Department
5000 West Carefree Highway
Phoenix, Arizona 85086

December 6, 2016

CIVIL RIGHTS AND DIVERSITY COMPLIANCE

The Arizona Game and Fish Commission receives federal financial assistance in Sport Fish and Wildlife Restoration. Under Title VI of the 1964 Civil Rights Act, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, Title IX of the Education Amendments of 1972, the U.S. Department of the Interior prohibits discrimination on the basis of race, color, religion, national origin, age, sex, or disability. If you believe you have been discriminated against in any program, activity, or facility as described above, or if you desire further information please write to:

Arizona Game and Fish Department
Office of the Deputy Director, DOHQ
5000 West Carefree Highway
Phoenix, Arizona 85086

and

U.S. Fish and Wildlife Service
Wildlife and Sport Fish Restoration Program
Attention: Civil Rights Coordinator for Public Access
4401 North Fairfax Drive, Room 300
Arlington, Virginia 22203

AMERICANS WITH DISABILITIES ACT COMPLIANCE

The Arizona Game and Fish Department complies with all provisions of the Americans with Disabilities Act. This document is available in alternative format by contacting the Arizona Game and Fish Department, Office of the Deputy Director at the address listed above or by calling (602) 943-3000 or TTY 1-800-367-8939.

ARIZONA GAME AND FISH DEPARTMENT MISSION

To conserve Arizona's diverse wildlife resources and manage for safe, compatible outdoor recreation opportunities for current and future generations.

RECOMMENDED CITATION

Sorensen, J.A. and A.J. Martinez. 2016. Survey Data for Wet Canyon Talussnail (*Sonorella macrophallus*) and Other Pinaleño Mountain Land Snails, 2001-2016. Nongame and Endangered Wildlife Program Technical Report #295. Arizona Game and Fish Department, Phoenix, Arizona.

ACKNOWLEDGMENTS

We thank the following individuals for their contributions in the field: Paul Barrett, Darren Bolen, Anne Casey, Cat Crawford, Michael Demlong, Larry Jones, Alicia Jontz, Rebekah Karsch, Lance Koch, Thetis Gamberg, Tim Grosch, Clay Nelson, Tom Skinner, Kristin Terpening, Ross Timmons, Brian Wooldridge, and numerous interns and technicians over the years. Logistical and administrative support was provided by: Angela Barclay, Debra Bills, Cat Crawford, Mike Demlong, Larry Jones, and Mike Martinez. Cover image by Jeff Sorensen.

PROJECT FUNDING

Funding for this project was provided by: Arizona Game and Fish Department's Heritage Fund, Game and Fish Fund, E5 Section 6 funding, and State Wildlife Grants.

EXECUTIVE SUMMARY

The Wet Canyon talussnail (Helminthoglyptidae: *Sonorella macropallus* Fairbanks and Reeder), is one of several landsnails found along eastern drainages of Mount Graham of the Pinaleño Mountains, in Graham County, Arizona. Surveys and genetic analysis demonstrated that the Wet Canyon talussnail also occurs in Twilight Canyon, and two unnamed drainages on Mount Graham.

To ensure the long-term viability of the Wet Canyon talussnails and their habitat, a conservation agreement was developed and completed in 1999. Signatories to that conservation agreement included the Coronado National Forest, the United States Fish and Wildlife Service, and the Arizona Game and Fish Department. That original agreement expired in December 2004, but the signatories plan to update and renew the conservation agreement with the inclusion of additional native land snails found within the Pinaleño Mountains.

Initial surveys in the early 2000s were conducted seasonally (spring through autumn) in various weather conditions to determine the current distribution, relative abundance, and activity periods of the Wet Canyon talussnail and other land snails within its range. Most active snails were observed during or immediately following heavy rain.

In late June 2004, the Gibson and Nuttall wildfires burned across several drainages in the eastern Pinaleño Mountains, including Wet Canyon. An interagency survey conducted in late July 2004, found a total of 25 live and 209 dead talussnails in Wet Canyon. The survey crew also noted heavy siltation along the drainage.

Over the past 16 years, the Department has conducted 14 talussnail surveys in the Pinaleño Mountains. Since the initial Department survey in August 2001, over 512 live talussnails and possibly as many as 49 mountainsnails have been observed in the Pinaleño Mountains by survey crews. Nearly 62% (n=317) of those talussnails observed were from surveys after the 2004 Gibson-Nuttall Fire, and 100% of the mountainsnails observed.

The Catch-Per-Unit-Effort estimates (snail counts divided by total search time) were similar in range both before and after the 2004 Gibson-Nuttall Fire, although the pre-fire surveys that had active snails observed (3 of 5 surveys) had an average CPUE estimate of 0.84 snails per 10-min search, compared to the post-fire surveys (6 of 9 surveys) that had an average CPUE estimate of 0.66 snails per 10-min search. Although, the averaged CPUE estimate from the four post-fire surveys that had “ideal, wet weather conditions” to observe active snails (in 2004, 2011, 2013, and 2016), the average CPUE estimate is 0.80, which is very similar to the pre-fire averaged CPUE estimate of 0.84.

Based on these survey results over a 16-year timeframe, it appears that the averaged relative abundance of the talussnail and mountainsnail populations in Wet Canyon and vicinity are essentially unchanged following the 2004 Gibson-Nuttall Fire. Fire certainly impacts these species and their habitats, but these effects may be temporal. The land snail populations in the eastern Pinaleño Mountains survived a major wildfire and severe post-fire impacts, but even after a decade has passed since that fire, they appear to be stable with robust relative abundance and distribution.

TABLE OF CONTENTS

SURVEY DATA FOR WET CANYON TALUSSNAIL (*SONORELLA MACROPHALLUS*) AND OTHER PINALEÑO MOUNTAIN LAND SNAILS, 2001-2016

Jeff A. Sorensen and Alex J. Martinez

INTRODUCTION

In 1999, the Arizona Game and Fish Department (AGFD) partnered with the U.S. Fish and Wildlife Service (USFWS) and the U.S. Forest Service (USFS) Coronado National Forest to develop a conservation agreement to ensure the long-term viability of the Wet Canyon talussnail (Helminthoglyptidae: *Sonorella macrophallus* Fairbanks and Reeder) and its habitat (USFS *et al*. 1999). The Wet Canyon Talussnail Conservation Agreement was finalized in December 1999. In collaboration with the USFS, AGFD conducted an initial reconnaissance visit to Wet Canyon in 2001 and subsequent seasonal surveys to gather baseline data on the natural history, distribution, and relative abundance of talussnails. AGFD summarized the baseline survey data for Wet Canyon talussnail and other land snails observed in a 2002 report by Jontz *et al*. (2002). Two years later, the conservation agreement expired at the end of 2004. USFS, USFWS, and AGFD are in the process of updating and renewing the agreement to include four species of talussnails (including Wet Canyon talussnail), one mountainsnail species (genus *Oreohelix*), and two species of snaggletooth snails (genus *Gastrocopta*) that reside in the Pinaleño Mountains (AGFD 2016a).

Previously, it was believed that there was only one known population of Wet Canyon talussnail on Mount Graham—in a one mile section of the Wet Canyon drainage, adjacent to the Arcadia campground (Hoffman 1990; USFS *et al*. 1999). AGFD-led surveys in the early 2000s had detected talussnails in two unnamed drainages on Mount Graham as well as in Twilight Canyon, which neighbors Wet Canyon (AGFD 2015; Jontz *et al*. 2002). These talussnails were later genetically analyzed and Wet Canyon talussnail was verified along with other conspecifics—Mimic talussnail (*S. imitator*) and Pinaleño talussnail (*S. grahamensis*) on the eastern end of the Pinaleño Mountains (Weaver *et al*. 2010). Due to their similar size (17-20mm in shell diameter), appearance, and cryptic nature, species of *Sonorella* are difficult to key to species in the field (Hoffman 1990; AGFD 2016b).

DISTRIBUTION AND STATUS

Sonorella species are found in Arizona, southern New Mexico, western Texas, northwest Chihauaha, Mexico and northeast Sonora, Mexico in habitats ranging from arid low elevation foothills to wooded canyons at elevations of 2438 to 3048 m (8000 to 10,000 ft) (Pilsbry 1939).

Wet Canyon talussnail were only known from a one-mile section of Wet Canyon above Highway 366 as described by Hoffman (1990), but genetic testing of specimens in a neighboring canyon, Twilight Canyon, and other unnamed drainages on the eastern slope of the Pinaleño Mountains, confirmed they had a greater range (Weaver *et al*. 2010). Initial AGFD surveys documented that talussnails occurred throughout a 1.5-mile section of Wet Canyon above and below the intersection with Highway 366 (Jontz *et al*. 2002). Talussnails have also been discovered in

neighboring drainages to Wet Canyon at elevations of 1845 to 2104 m (6053 to 6903 ft) (Jontz *et al*. 2002; AGFD 2015). Wet Canyon talussnail is documented in at least seven locations in the southeastern part of the Pinaleño Mountains (Weaver *et al*. 2010).

In 1989, Hoffman searched known and presumed *Sonorella* habitat in the Pinaleño, Santa Teresa, Dos Cabesa, Galiuro, Winchester, and Peloncillo mountains without discovering additional Wet Canyon talussnail populations (Hoffman 1990). Hoffman reported numerous locations of Pinaleño talussnail, Mimic talussnail, Clark Peak talussnail (*Sonorella christenseni*), and Pinaleño mountainsnail (*Oreohelix grahamensis*) in the Pinaleño Mountains in his 1990 report. The Pinaleño talussnail is known from four locations near Heliograph Peak, the Mimic talussnail from at least 19 localities in the central and eastern parts of the Pinaleño Mountains, the Clark Peak talussnail in at least six localities between West Peak and Clark Peak in the northwestern part of the Pinaleño Mountains, and the Pinaleño mountainsnail is known from at least 20 localities throughout the Pinaleño Mountains (Hoffman 1990). Figures 1-4 show the localities of Pinaleño Mountain land snails as documented by Hoffman (1990), Weaver *et al*. (2010), AGFD, and USFS.

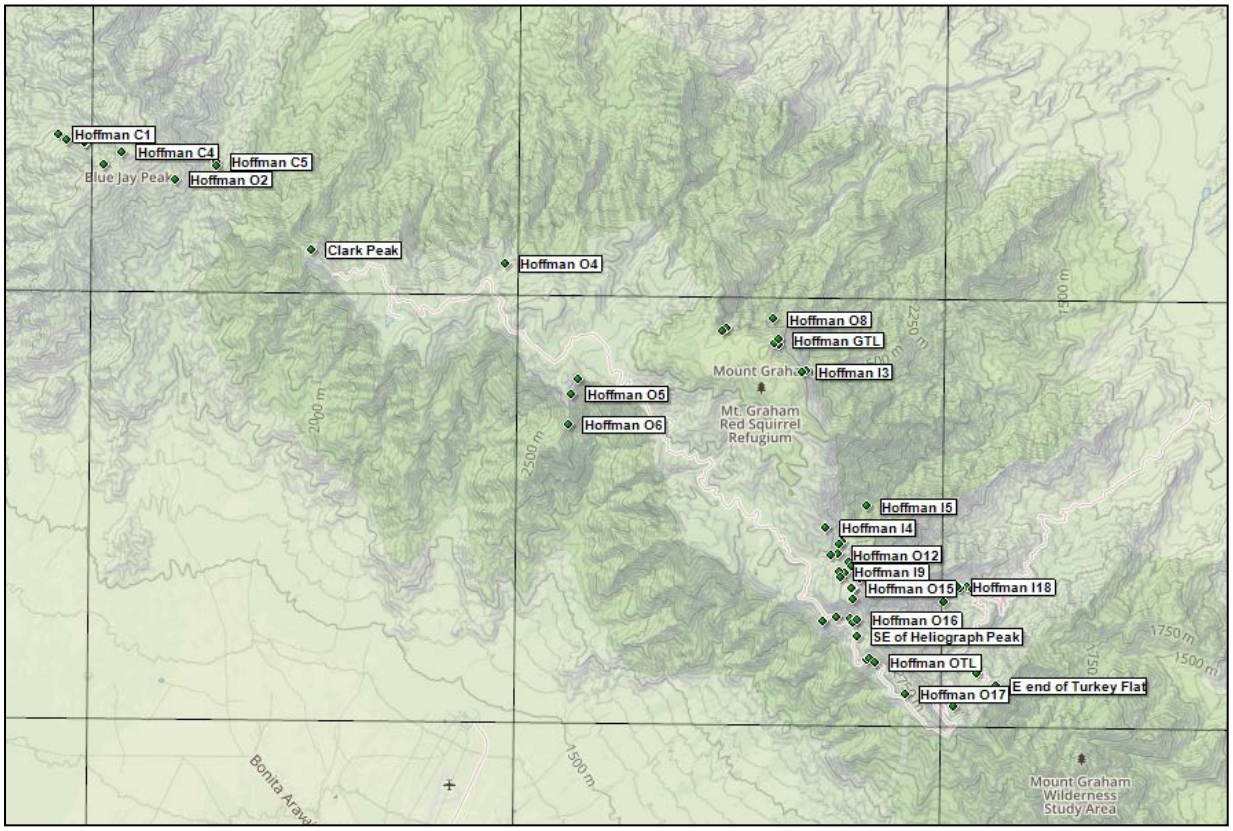

Figure 1. Overview map of Pinaleño land snail localities as of September 2016. All localities are on the Coronado National Forest, Arizona. The "Hoffman" waypoints indicate the species and population number: "C"=*Sonorella christenseni*, "O"=*Oreohelix grahamensis*, "I"=*S. imitator*, "G"=*S. grahamensis*, and "TL"=type locality. Due to the scale of the map, not all the waypoints are labelled. None of the *S. macrophallus* populations are labelled, but they occur near "Hoffman O15", "Hoffman I18", "E end of Turkey Flat", "Hoffman O17", and "Hoffman OTL".

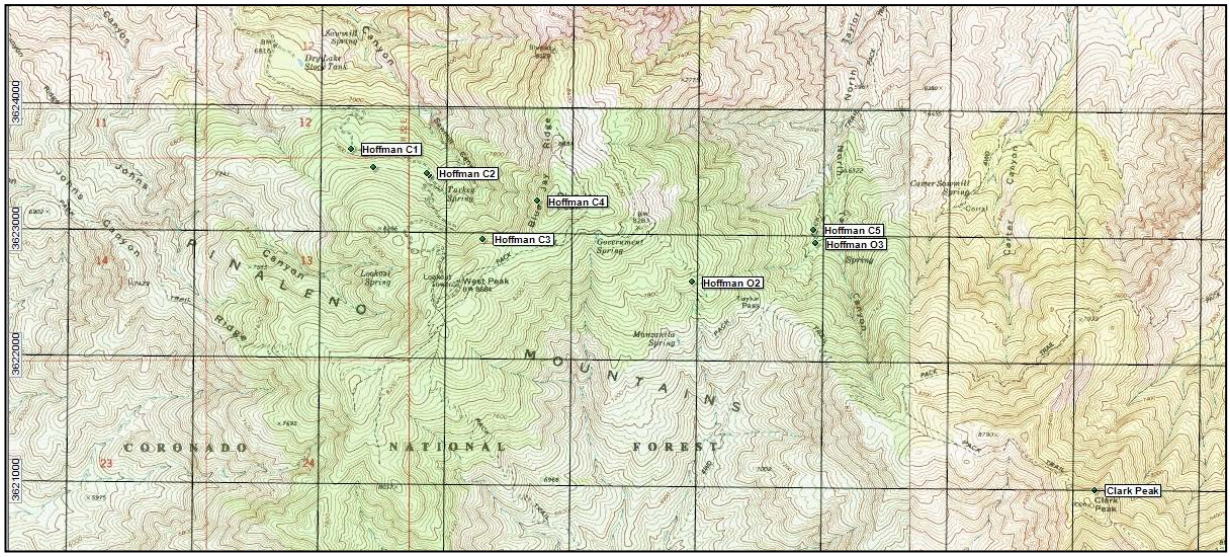

Figure 2. Map of land snail localities in the northwestern part of the Pinaleño Mountains, West Peak to Clark Peak, as of September 2016. In July 2016, a USFS biologist found a *Sonorella* shell at the locality between "Hoffman C1" and "Hoffman C2", northwest of West Peak.

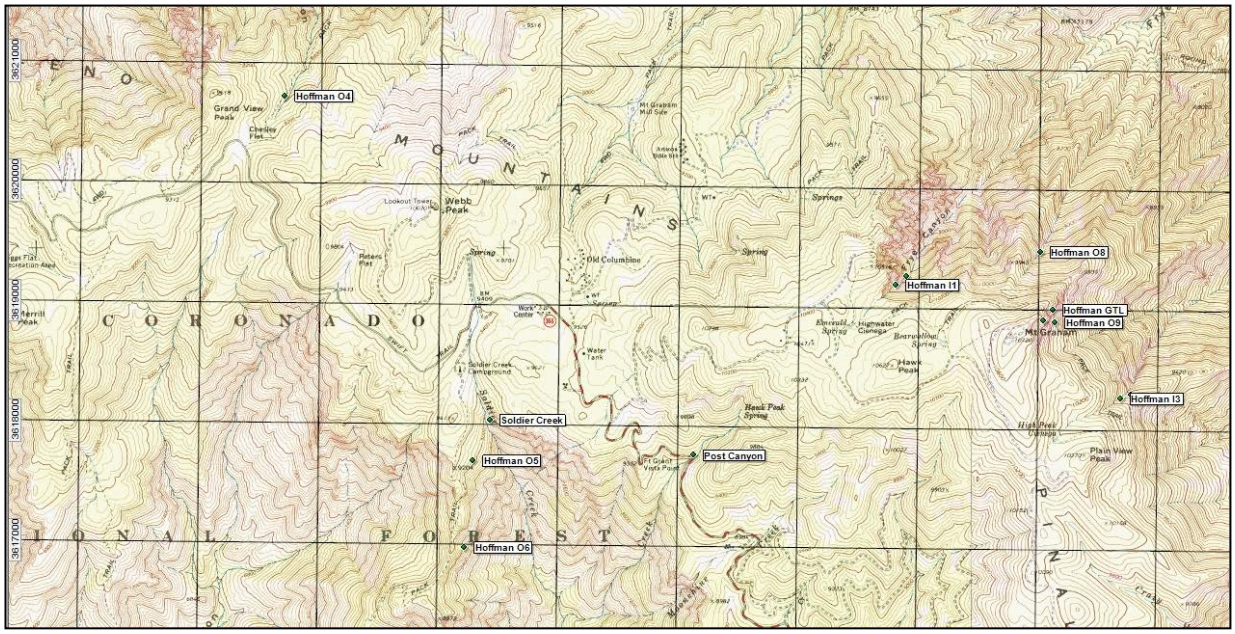

Figure 3. Map of land snail localities in the central part of the Pinaleño Mountains, Grand View Peak to Plain View Peak, including Soldier Creek and Post Canyon, as of September 2016.

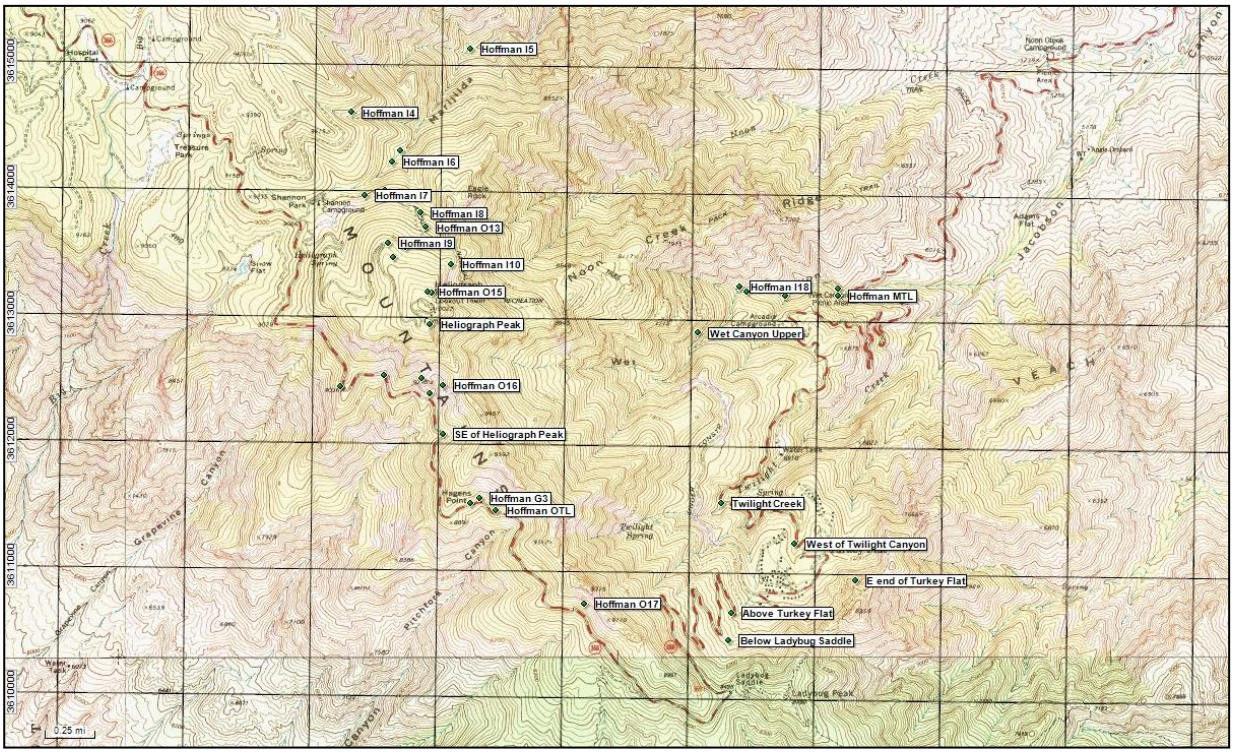

Figure 4. Map of land snail localities in the southeastern part of the Pinaleño Mountains, Marijilda Canyon to Wet Canyon and Turkey Flat, as of September 2016.

In June 2007, Forest Guardians (now WildEarth Guardians) petitioned the USFWS to list the Wet Canyon talussnail, Pinaleño talussnail, mimic talussnail, Clark Peak talussnail, and Pinaleño mountainsnail as threatened or endangered with critical habitat under the Endangered Species Act (ESA). The USFWS issued a positive 90-day finding that the petition presented substantial scientific information indicating that listing the Wet Canyon talussnail and Pinaleño talussnail may be warranted (USFWS 2009). The 2007 petition did not provide substantial information on the other species, and the USFWS determined they were not warranted for listing under ESA (USFWS 2009). The Wet Canyon talussnail and Pinaleño talussnail are identified as species for further evaluation by the USFWS as part of a joint effort to address data and conservation needs of potentially at-risk native species through coordination with the Western Association of Fish and Wildlife Agencies.

Wet Canyon talussnail is identified as a Tier 1A Species of Greatest Conservation Need (SGCN) in Arizona's SWAP (AGFD 2012). Tier 1A includes, in part, those species that are closed season (as identified by Arizona Game and Fish Commission Order), currently listed under the ESA as endangered or threatened, including those populations considered essential or nonessential experimental under section 10(j) of the ESA, are candidates for listing, or are covered under an existing conservation agreement. The USFS identified the Wet Canyon talussnail, Pinaleño talussnail, mimic talussnail, Clark Peak talussnail, and Pinaleño mountainsnail as sensitive species in their 2013 Southwest Regional Forester's Sensitive Species Animals list (USFS 2013).

In September 2016, the other species of talussnails, the mountainsnail, and two snaggletooth snails in the Pinaleño Mountains were included as closed season species in the approved Arizona Game and Fish Commission Order 42, in anticipation of the new multi-species conservation agreement being finalized before the end of the year. The talussnail and mountainsnail species were already identified as Tier 1B SGCN in Arizona's SWAP (AGFD 2012), but will be elevated to Tier 1A with the next amendment to the SWAP.

TAXONOMY

There are over 65 described species in the genus *Sonorella* (Turgeon *et al*. 1998). Taxonomic classification is based on analysis of the soft body parts, specifically the reproductive organs. Talussnails are classified in the order Stylommatophora and the family Helminthoglyptidae (Pilsbry 1939). The genus *Sonorella* was described by H.A. Pilsbry in 1900 (Pilsbry 1939; Bequaert and Miller 1973). The Pinaleño mountainsnail was originally described by Greg and Miller (1974) from specimens collected from the Pinaleño Mountains. Each of the *Sonorella* species in the Pinaleño Mountains and the mountainsnail are considered valid species by the Integrated Taxonomic Information System (the USFS taxonomic standard), Turgeon *et al*. (1998; the malacologists taxonomic standard), and confirmed to be genetically distinct by Weaver *et al*. (2010).

HABITAT

Wet Canyon talussnails and their conspecifics are restricted to wet mountain slopes with a dense overstory canopy that contain talus slopes with deep, soil free crevices where they can escape exposure to direct sunlight, high temperatures and low humidity which leads to both the environment and the snails drying out. Talussnails require the calcium carbonate found in limestone rocks to neutralize the carbonic acid produced by the snail as a result of respiration during estivation (Hoffman 1990).

Flora associated with Wet Canyon talussnail habitat includes: ponderosa pine (*Pinus ponderosa*), Gamble's Oak (*Quercus gambelii*), deer grass (*Muhlenbergia rigens*), monkey flower (*Mimulus* sp.), nettle (*Urtica gracilis*), velvet ash (*Fraxinus velutina*), Arizona walnut (*Juglans major*), and spruce (*Picea* sp.) (AGFD 2016b; Jontz *et al*. 2002).

NATURAL HISTORY

The Wet Canyon talussnail is a hermaphroditic land snail that spends a large portion of its life in estivation attached to rock by a mucus and calcium seal. Talussnails may remain in estivation for multiple years if conditions favorable for foraging and mating are not present. Talussnail activity is dependent on the frequency and duration of wet weather. Their life span is estimated to be six years, reaching sexual maturity at 2-3 years of age (Hoffman 1990).

When *Sonorella* mate, both snails are typically inseminated. Fertilization and production of eggs takes several days. Each snail may lay a clutch or two of 30-40 eggs each summer. Talussnails

are capable of self-fertilization, but will only resort to such methods when they fail to meet a conspecific for several years (Hoffman 1990). In contrast, *Oreohelix* is ovoviviparous, and give live birth to 5-6 offspring, usually once each summer (Hoffman 1990).

THREATS

The primary threat to land snail populations on the Pinaleño Mountains is the threat of stand-replacement wildfire. Large "crown" wildfires in the drainages in which land snails occur could be potentially devastating to the snail populations due to extreme temperatures, loss of tree canopy and local moisture and temperature levels related to those canopies, and siltation from post-fire flooding and landslides that may fill in interstitial spaces of talus habitat.

METHODS

Between August 2001 and July 2004, seasonal monitoring surveys by AGFD and USFS biologists were conducted to determine the distribution, relative abundance, and activity periods of talussnails. Surveys consisted of searching several drainages and the associated talus slopes for live talussnails or evidence that snails were using the area (i.e. shells and slime trails) when live snails could not be located. In addition to searching for snails, a thermohygrometer reading was taken to determine the relative humidity (%) and air temperature (°C) at specific sites within the snail's habitat. These readings were primarily taken when live snails were sighted. The snail's level of activity and behavior, if active, were also noted. Weather conditions were recorded on all surveys in order to develop a correlation between the weather and periods of snail activity. During the baseline surveys, the location of each live snail, or group of snails, was recorded using Global Positioning System (GPS) receivers when it was possible to access satellites. Surveys over the past 12 years have relied on timed counts of land snails observed from known locations in Wet Canyon and Twilight Canyon, with opportunistic searches of other areas throughout the Pinaleño Mountains. Appendix A describes the current survey protocol.

Two HOBO® H8 Data Loggers were placed in Wet Canyon in May 2002. These data loggers recorded ambient air temperature (°C) and relative humidity (%) every 30 minutes. One logger was secured 0.5 m inside a talus crevice and one was placed outside of the talus to record the difference between environmental conditions in the talus interstitial area and on the exposed surface. In May 2003, a third data logger was installed in the Wet Canyon drainage outside and away from the talus, in the shade, near the rain gauge. Unfortunately, due to excessive leaf litter and downed trees, the data loggers had only been successfully relocated twice.

RESULTS

Over the past 16 years, AGFD has conducted 14 talussnail surveys in the Pinaleño Mountains (AGFD 2015; AGFD 2016c). Since the initial AGFD survey in August 2001, over 512 live talussnails and possibly as many as 49 mountainsnails have been observed in the Pinaleño Mountains by survey crews. Nearly 62% (n=317) of those talussnails observed were from surveys after the 2004 Gibson-Nuttall Fire, and 100% of the mountainsnails observed. Table 1

provides a summary of Catch-Per-Unit-Effort estimates of Pinaleño land snails in occupied areas for AGFD-led surveys 2001-2016.

Table 1. AGFD data from Pinaleño Mountains land snail surveys 2001-2016. "WC" is the abbreviation for Wet Canyon, and "nc" = not collected. Numbers of snails tallied below represent live snails observed. Air temperature and relative humidity (RH) are reported when readings were recorded in the field notes.

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
07/27/2016	Upper WC (Above Trail)	13	0	120	1.08
07/27/2016	Upper WC (Below Trail)	23	0	120	1.92
07/27/2016	Lower WC (Bridge Area)	1	0	80	0.12
07/27/2016	Twilight Canyon	7	0	240	0.29
07/27/2016	Heliograph Peak Area	0	(6 possible)	60	1.00
	Cumulative Totals:	**44**	**6**	**620**	**0.81**

Notes: Weather was warm (Temp=21.9°C) and humid (RH=72%) at the start of the survey, with a light rain the night prior. One *Oreohelix* shell found in Upper WC (Below Trail) and two *Oreohelix* shells found in Twilight Canyon—these were taken as voucher specimens. A *Sonorella* shell—a recent mortality with good pigmentation was found in a narrow crevice within a boulder pile at Heliograph Peak, but we were unable to retrieve that shell as a specimen. Six possible *Oreohelix* live snails were <5 mm in diameter and found under rocks at Heliograph Spring; four of those snails at Heliograph Spring were taken as voucher specimens. Survey crew: Lance Koch and Rebekah Karsch (USFS), Gabrielle Blanchette and Jeff Sorensen (AGFD).

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
08/05/2015	Upper WC (Above Trail)	9	0	180	0.50
08/05/2015	Upper WC (Below Trail)	12	0	90	1.33
08/05/2015	Lower WC (Bridge Area)	4	0	120	0.33
08/05/2015	Twilight Canyon	1	4	240	0.21
08/05/2015	E end of Turkey Flat	0	0	60	0.0
	Cumulative Totals:	**26**	**4**	**690**	**0.43**

Notes: Weather was warm (Temp==21.5°C) and slightly humid (RH=55%) at the start of the survey, and last rained maybe two days prior. Seven *Sonorella* shells and two *Oreohelix* shells were found in Twilight Canyon—these were taken as voucher specimens. A *Sonorella* shell was also found in Lower WC (Bridge Area) and kept as a voucher. Two large slugs (*Limax flavus*, introduced species) were found under the Highway 366 Bridge in Lower WC; these were taken as voucher specimens. One of the live (mature) *Sonorella* found in Lower WC was estivating on the underside of the Highway 366 Bridge. Survey crew: Cat Crawford (USFWS), Kristin Terpening, Rachel Fadlovich, and Jeff Sorensen (AGFD).

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
07/16/2013	Upper WC (Above Trail)	5	0	180	0.28
07/16/2013	Upper WC (Below Trail)	6	0	90	0.67
07/17/2013	Lower WC (Bridge Area)	15	0	160	0.94
07/16/2013	Twilight Canyon	53	0	150	3.53
07/16/2013	E end of Turkey Flat	6	0	60	1.00
07/16/2013	Post Creek	2	0	50	0.40
07/16/2013	Clark Peak Area	1	0	75	0.13
	Cumulative Totals:	**88**	**0**	**765**	**1.15**

Notes: Weather was warm (Temp=16.3°C), damp, and humid (RH=90%), with a soaking rain the night prior and misty conditions in the morning of the survey. This was an ideal weather condition to find active land snails. Survey crew: Steve Skiba, Justin Nelson, and Jeff Sorensen (AGFD).

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
08/10/2011	Upper WC (Above Trail)	29	0	360	0.81
08/10/2011	Upper WC (Below Trail)	11	0	200	0.55
08/11/2011	Lower WC (Bridge Area)	2	0	120	0.17
08/11/2011	Twilight Canyon	59	0	240	2.46
	Cumulative Totals:	**101**	**0**	**920**	**1.10**
Notes: Weather was warm (Temp=22.2°C) and humid (RH=70%), with a soaking rain less than an hour before the survey that afternoon. This was an ideal weather condition to find active land snails. Survey crew: Anne Casey (USFS), Tim Grosch, Sheridan Paulus, Grant Pearce, and Jeff Sorensen (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
08/12/2009	Upper WC (Below Trail)	0	0	~20	0
	Cumulative Totals:	**0**	**0**	**~20**	**0**
Notes: Weather was hot, dry, with no recent rain. Two shells were found in Upper WC (Below Trail)—one was likely an *Oreohelix* based on its description in the field notes. Survey crew: Amy Bailey (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
07/08/2008	Upper WC (Above Trail)	9	0	135	0.67
07/08/2008	Upper WC (Below Trail)	19	2	480	0.44
07/08/2008	Lower WC (Bridge Area)	3	0	360	0.08
	Cumulative Totals:	**31**	**2**	**975**	**0.34**
Notes: Weather was cool and humid, and had a soaking rain two nights prior to the morning survey. Found two *Sonorella* shells and two *Oreohelix* shells in Upper WC (Above Trail), and five *Sonorella* shells in Upper WC (Below Trail). During the search of Lower WC we searched approximately a mile down drainage to Angle Orchard, but found no other *Sonorella* or *Oreohelix* much past the Highway 366 Bridge. Survey crew: James Fowler and Ben Spatola (USFS), Amy Bailey and Jeff Sorensen (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
11/08/2006	Upper WC (Above Trail)	0	0	~20	0
11/08/2006	Upper WC (Below Trail)	0	0	~25	0
11/08/2006	Lower WC (Bridge Area)	0	0	30	0
	Cumulative Totals:	**0**	**0**	**75**	**0**
Notes: Weather was cool and dry, with no recent rain. Two shells (genus unverified) were found in Upper WC (Below Trail) and one shell (genus unverified) was found in Lower WC (Bridge Area). Survey crew: Ross Timmons (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
10/01/2005	Waypoint 62*	0	0	nc	-
10/01/2005	Heliograph Spring Area	0	(8 possible)	nc	-
10/01/2005	Spring S of Webb Peak	0	(1 possible)	nc	-
10/01/2005	N slope of Clark Peak	2	18	nc	-
10/01/2005	Camp S of Soldier Creek	0	10	nc	-
	Cumulative Totals:	**2**	**~37**	**nc**	**-**
Notes: Weather was cool, dry, and no substantial rain prior to the survey. *Waypoint 62 identified as "along Rt366 talus slope S facing post Pitchfork Canyon on way to Heliograph"—one *Sonorella* shell was found at this location. All observed *Sonorella* and *Oreohelix* specimens found during this survey were collected for the University of Colorado Museum of Natural History					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
and the Arizona Heritage-funded genetic study on Pinaleño talussnails (Weaver *et al*. 2010). Survey crew: Pablo Weaver (University of Colorado) and Jeff Sorensen (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
07/28/2004	Wet Canyon, Upper and Middle Reaches	25	0	~1680	0.15
07/28/2004	Lower WC (Bridge Area)	0?	0?	?	0
	Cumulative Totals:	**25**	**0**	**~1680**	**0.15**
Notes: Weather was warm and humid, with a soaking rain the night before. This was an ideal weather condition to find active land snails. This survey was conducted immediately following the Gibson-Nuttall Fire that burned through Wet Canyon—an interagency team surveyed the area for impacts on the resident talussnail population. Approximately 209 shells (genus unverified, but most likely were *Sonorella*) were found in Upper WC (Above and Below Trail), many of which showed signs of being burnt from the wildfire. Survey crew: Brian Wooldridge and Thetis Gamberg (USFWS), Larry Jones, Tom Skinner, and Anne Casey (USFS), and Clay Nelson and Tim Snow (AGFD). Approximately four hours total search time for each of the seven surveyors.					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
07/31/2003	Upper WC (Above Trail)	10	0	~270	0.37
07/31/2003	Upper WC (Below Trail)	12*	0	~270	0.44
07/31/2003	Lower WC (Bridge Area)	10	0	60	1.67
07/31/2003	Twilight Canyon	10	0	90	1.11
	Cumulative Totals:	**42**	**0**	**690**	**0.61**
Notes: Weather was warm (Temp=18°C) and humid (RH=90%) that morning of the survey, with a soaking rain the night prior. This was an ideal weather condition to find active land snails. All talussnails encountered were collected for genetic analysis, including one snail found along the trail (*). This was the last mollusk survey in Wet Canyon prior to the Gibson-Nuttall Fire in June 2004. Survey crew: Clay Nelson, Darren Bolen, and Jessica Thiebeau (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
05/01/2003	Upper WC (Above Trail)	0	0	~60	0
05/01/2003	Upper WC (Below Trail)	0	0	~60	0
	Cumulative Totals:	**0**	**0**	**~120**	**0**
Notes: Weather was warm and dry, with no recent rain. Survey crew: Larry Jones (USFS), Paul Barrett (USFWS), Darren Bolen and Jeff Sorensen (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
09/11/2002	Upper WC (Above Trail)	6	0	~60	1.00
09/10/2002	Upper WC (Below Trail)	35	0	~630	0.56
09/10/2002	Lower WC (Bridge Area)	Included above (Below Trail)	0	Included above (Below Trail)	Included above (Below Trail)
	Cumulative Totals:	**41**	**0**	**~690**	**0.59**
Notes: Weather was warm (Temp=21.6°C), rainy, and humid (RH=87%) during the survey on the afternoon of September 10, with a soaking rain that night; similar conditions on the morning of September 11. This was an ideal weather condition to find active land snails. The survey on September 10 started at the Upper WC trail crossing and continued down to the picnic area at Lower WC. HOBO sensor downloads and water sample collections at Upper WC (Above Trail) were the primary effort on September 11; snail observations were secondary. Survey crew: Larry Jones (USFS) and Alicia Jontz and Clay Nelson (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
05/22/2002	Upper WC (Above Trail)	0	0	~120	0
05/22/2002	Twilight Canyon	0	0	~750	0
	Cumulative Totals:	**0**	**0**	**~870**	**0**
Notes: Weather was not reported in field notes, other than there had been no recent rain. Found one shell (genus unverified) in Twilight Canyon, and one small shell (genus unverified) in Upper WC. Two HOBO sensors were placed in Upper WC (Above Trail); one within talus habitat and the other above for ambient surface conditions. Survey crew: Larry Jones (USFS) and Alicia Jontz and Clay Nelson (AGFD).					

Survey Date	Survey Site	# *Sonorella* Observed	# *Oreohelix* Observed	Minutes of Search Effort	CPUE (# snails per 10 min search)
08/08/2001	Upper WC (Above Trail)	>82	1	~540	1.52
08/08/2001	Lower WC (Bridge Area)	3	0	~180	0.17
08/08/2001	Twilight Canyon	12	0	~60	2.00
08/08/2001	Unnamed drainage ¼ mile west of Twilight Canyon	~15	0	~60	2.50
	Cumulative Totals:	**>112**	**0**	**~840**	**1.33**
Notes: Weather was warm (Temp=16.1°C), light rain, and humid (RH=90%). This was an ideal weather condition to find active land snails. Found one shell in Upper WC (Above Trail), one shell in the unnamed drainage ¼ mile west of Twilight Canyon, and three shells in Lower WC; genus unverified for each shell. Three live *Sonorella* from Twilight Canyon were taken as voucher specimens. Survey crew: Mike Demlong, Clay Nelson, and Jeff Sorensen (AGFD).					

Figure 5 shows a five-month display of daily mean air temperature and relative humidity readings from an above-ground HOBO® sensor in 2002.

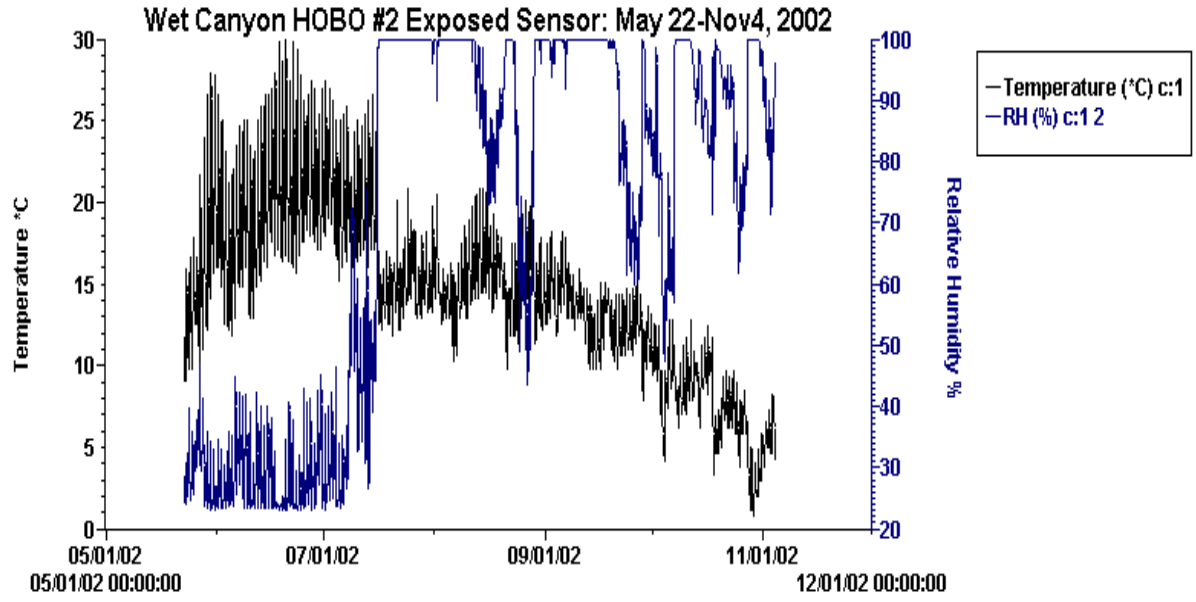

Figure 5. Mean air temperatures and relative humidity readings from a HOBO® environmental sensor (exposed ambient conditions) from a five-month timeframe in 2002, near the trail crossing in Wet Canyon.

Observations and counts of *Sonorella* and *Oreohelix* in the Pinaleño Mountains during AGFD-led surveys appear to depend on local moisture conditions. During surveys where numerous talussnails were observed it was either raining on Mount Graham or completely overcast with high humidity. When active talussnails were observed during wet or high humid conditions, they were found throughout the day from early morning to late afternoon. Active talussnails were not observed during surveys under dry conditions—no recent rains and low humidity.

The Gibson Fire, which was started by lightning on June 22, 2004, burned through portions of Mount Graham along with the Nuttall Fire, which began on June 26, 2004. Both of these fires caused much damage to habitat on Mount Graham. The Gibson Fire burned through Wet Canyon causing damage to land snail habitat and resulting in some individual mortality of snails, based on burnt shells found after the fire. During the July 28, 2004 survey, investigators counted 25 live talussnails and 209 dead. Heavy siltation as a result of post-fire rains had occurred (AGFD 2015). Figures 6-11 show pre-fire and post-fire habitat conditions of the trail crossing at Wet Canyon, along with images of a burnt talussnail and a live talussnail.

The Gibson-Nuttall Fire

On July 28, 2004, Tim Snow and Clay Nelson (AGFD), Anne Casey, Larry Jones, and Tom Skinner (USFS), Brian Wooldridge and Thetis Gamberg (USFWS) met to assess impacts of the Gibson-Nuttall Fire on Wet Canyon and the talussnail species that inhabit the drainage.

At the time of the survey, weather was overcast and relatively cool with high humidity. Wet Canyon was saturated from a recent rain, which is ideal for looking for talussnails. Assessment of habitat damage and impacts to the talussnail populations was anecdotal with no formal survey process. After a quick lesson on talussnail habitat preferences and identification, all workgroup members walked the Wet Canyon drainage from the intersection of the Arcadia Campground-Heliograph Peak trail down to the main bridge/picnic area (approximately 1 mile with a 300 m drop in elevation). During the walk, group members made observations of live and dead talussnails, habitat conditions, and stream runoff.

Direct damage to talussnails and habitat within the Wet Canyon drainage appeared to be severe, with large portions of habitat completely burned and subjected to extreme heat, as evidenced by cracked rocks. Secondary damage was also apparent from the siltation of interstitial spaces of talus rock outcroppings within the drainage. A decrease in canopy cover leading to lower levels of humidity, and increases in direct sunlight and temperatures may also result from burned areas.

Fortunately, the Gibson-Nuttall Fire burned in a mosaic throughout many parts of Wet Canyon, leaving undamaged “fingers” of habitat and surviving snails that extend from ridgeline to the drainage. These areas were likely vital for the recolonization of the burned habitat.

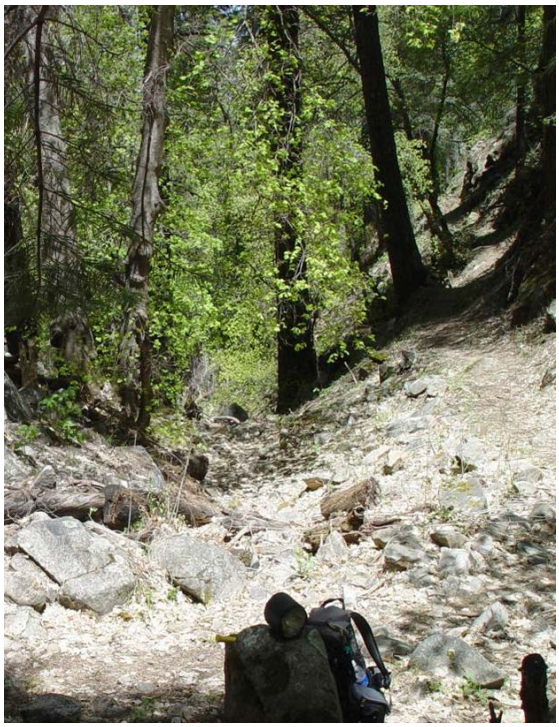
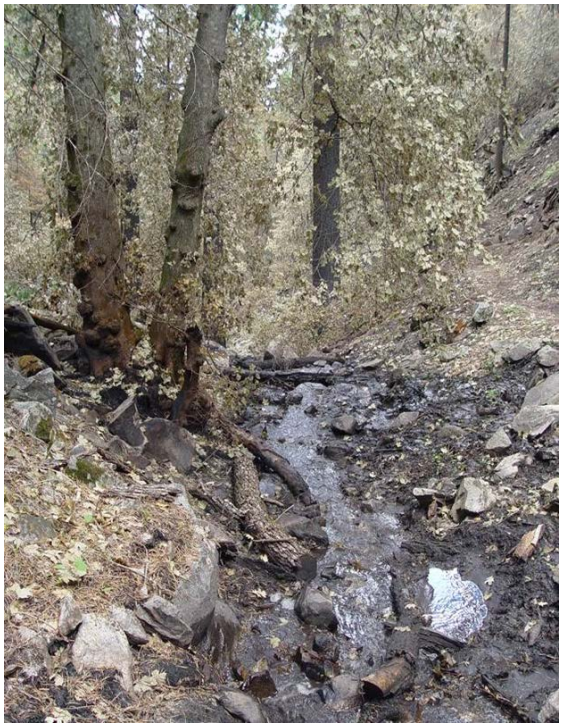

Figure 6 and 7. Repeat photos of the Wet Canyon trail crossing facing downstream. Image on the left was taken prior to the Gibson-Nuttall Fire (May 2003) and the right image was taken post-fire (July 2004). Photos by Clay Nelson (AGFD).

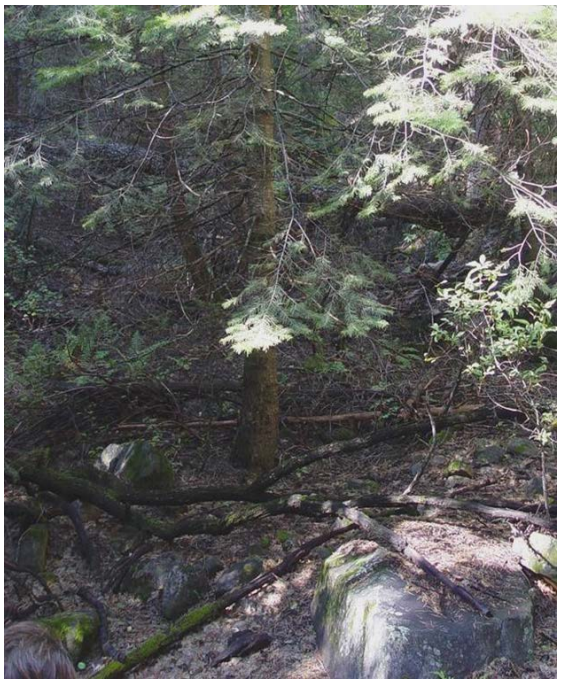
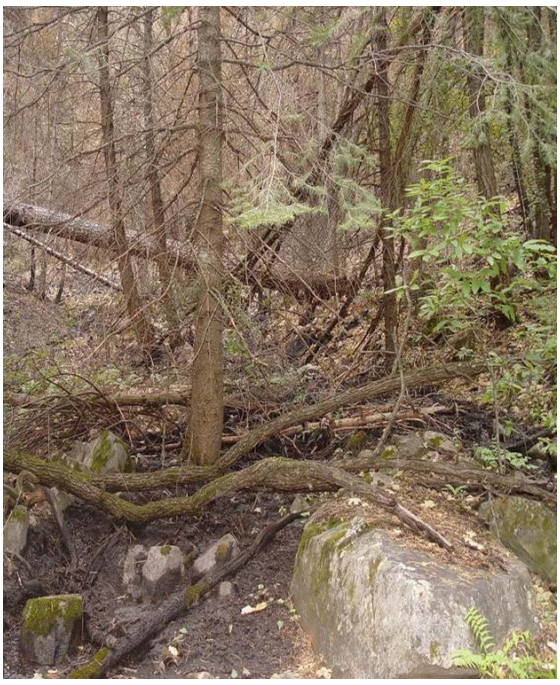

Figure 8 and 9. Repeat photos of the Wet Canyon trail crossing facing upstream. Image on the left was taken prior to the Gibson-Nuttall Fire (May 2003) and the right image was taken post-fire (July 2004). Photos by Clay Nelson (AGFD).


Figure 10 and 11. A burnt talussnail shell in Wet Canyon and a surviving talussnail (July 2004). Photos by Clay Nelson (AGFD).

DISCUSSION

Little is known about the life history, diet, reproduction, activity patterns, home range size, survivorship, and basic biology of land snails in the Pinaleño Mountains. The cryptic nature of these snails has made it difficult to conduct population surveys, much less research on their life history. Prior to August 2001, Wet Canyon talussnail were known to occur only in a small portion of the Wet Canyon drainage (Hoffman 1990). As a result of the initial surveys, it is now known that talussnails occur throughout the Wet Canyon drainage (approximately three miles have been surveyed), in Twilight Canyon and in at least one other unnamed drainage uphill of Twilight Canyon along Highway 366. According to Hoffman (1990), each of these species occur at different elevations and in canyons with slightly different moisture conditions; however, genetic analysis (Weaver *et al*. 2010) have demonstrated that Wet Canyon talussnail overlap with other *Sonorella* species at the upper end of their distribution. Across the expanse of the Pinaleño Mountains, Hoffman (1990) documented numerous populations of Clark Peak talussnails, Pinaleño mountainsnails, and mimic talussnails, with fewer populations of Pinaleño talussnails and Wet Canyon talussnails.

Talussnails appear locally abundant with fluctuations in their relative abundance dependent upon moisture conditions during the surveys. For example, in August 2001, AGFD biologists observed over 112 live talussnails in the Wet Canyon drainage, and over 27 live talussnails in Twilight Canyon and a nearby unnamed drainage during a survey in wet, humid weather (Jontz *et al*. 2002). In September 2002, AGFD and USFS biologists observed 41 live talussnails in Wet Canyon, also under wet, humid weather. No live talussnails were observed during surveys conducted in May 2002 and 2003, October 2005, and November 2006 under drier conditions and no recent rains. All other surveys during wet, summer monsoon weather over the past decade had found live or active land snails. These surveys were not exhaustive in effort from year to year, and search time was estimated in the earlier surveys.

The Catch-Per-Unit-Effort estimates (snail counts divided by total search time) were similar in range both before and after the 2004 Gibson-Nuttall Fire, although the pre-fire surveys that had active snails observed (3 of 5 surveys) had an average CPUE estimate of 0.84 snails per 10-min search, compared to the post-fire surveys (6 of 9 surveys) that had an average CPUE estimate of 0.66 snails per 10-min search. Although, the averaged CPUE estimate from the 4 post-fire surveys that had "ideal, wet weather conditions" to observe active snails (in 2004, 2011, 2013, and 2016), the average CPUE estimate is 0.80, which is very similar to the pre-fire averaged CPUE estimate of 0.84. Each of the 3 pre-fire surveys with active snails observed had "ideal, west weather conditions" (in 2001, September 2002, and July 2003).

Based on these survey results over a 16-year timeframe, it appears that the averaged relative abundance of the talussnail and mountainsnail populations in Wet Canyon and vicinity are essentially unchanged following the 2004 Gibson-Nuttall Fire. Fire certainly impacts these species and their habitats, but these effects may be temporal. The land snail populations in the eastern Pinaleño Mountains survived a major wildfire and severe post-fire impacts, but even after a decade has passed since that fire, they appear to be stable with robust relative abundance and distribution.

LITERATURE CITED

Arizona Game and Fish Department. 2012. Arizona's State Wildlife Action Plan: 2012-2022. Arizona Game and Fish Department, Phoenix, Arizona.

Arizona Game and Fish Department. 2015. Field notes on Pinaleño land snail surveys 2001-2015. Unpublished compilation. 31 pp

Arizona Game and Fish Department. 2016a. Email from Jeff Sorensen to interagency partners and AGFD staff on the reviewing the deliberative draft (v6) Pinaleño Land Snail Conservation Agreement. September 6, 2016.

Arizona Game and Fish Department. 2016b. Unpublished abstract compiled and edited by the Heritage Data Management System (*Sonorella macrophallus*). 6 pp

Arizona Game and Fish Department. 2016c. Email from Jeff Sorensen to interagency partners and AGFD staff on Pinaleño land snail survey results from July 2016. August 16, 2016.

Bequaert, J.C. and W.B. Miller. 1973. The Mollusks of the Arid Southwest: With an Arizona Check List. The University of Arizona Press. Tucson, Arizona.

Fairbanks, H.L. and R.L. Reeder. 1980. Two new species of *Sonorella* (Gastropoda: Pulmonata: Helminthoglyptidae) from the Pinaleño Mountains, Arizona. Proceedings of the Biological Society of Washington 93:395-404.

Gregg, W.O. and W.B. Miller. 1974. Two new species of land snails from the Pinaleño Mountains, Arizona. Bulletin of the Southern California Academy of Science 73 (3): 146-151.

Hoffman, J.E. 1990. Status surveys of seven land snails in the Mineral Hills and Pinaleño Mountains, Arizona. Contract Report to the U.S. Fish and Wildlife Service, Arizona Ecological Services Office, Phoenix, Arizona.

Jontz, A.K., C.B. Nelson, and J.A. Sorensen. 2002. Wet Canyon Talussnail Monitoring Interim Progress Report. Arizona Game and Fish Department.

Pilsbry, H.A. 1939. Land Mollusca of North America (North of Mexico). The Academy of Natural Sciences of Philadelphia. Volume I, Part 1. 573 pp.

Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. 2nd Edition. American Fisheries Society Special Publication 26, Bethesda, Maryland. 526 pp.

U.S. Fish and Wildlife Service. 2009. Endangered and Threatened Wildlife and Plants; Partial 90-Day Finding on a Petition to List 475 Species in the Southwestern United States as Threatened or Endangered With Critical Habitat; Proposed Rule. Federal Register 74:66866-66905.

U.S. Fish and Wildlife Service. 2014. Review of native species that are candidates for listing as endangered or threatened; annual notice of findings on resubmitted petitions; annual description of progress on listing actions. Federal Register 79:72449-72497.

U.S. Forest Service, U.S. Fish and Wildlife Service, and Arizona Game and Fish Commission. 1999. Conservation Agreement for the Conservation Assessment and Strategy of the Wet Canyon talussnail *Sonorella macrophallus* from the Pinaleño Mountains, Graham County, Arizona. December 15, 1999. 10 pp.

U.S. Forest Service. 2013. Southwest R3 Regional Forester's Sensitive Species: Animals. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_021328.pdf

Weaver, K.F., P.F. Weaver, and R. Guralnick. 2010. Origin, diversification and conservation status of talus snails in the Pinaleño Mountains: a conservation biogeography study. Animal Conservation (2010) 1-9.

APPENDIX A:

AZGFD Land Snail Survey Protocol – October 2016

Target Species

Identify the target species for the survey (for example: "San Xavier talussnail" or "Pinaleño land snails"); this can include multiple species covered under a conservation agreement or project activity.

Site Information

Record the name of the site (for example: "White Hill" or "Wet Canyon, Pinaleño Mtns"), and location description – more specific detail on where the survey occurred (for example: "SW of Tucson, near Pima Mine and Red Roan Rd" or "Upper Wet Canyon, Below Trail"). Identify the AZGFD Region (1 through 6).

Record the date of the survey in year, month, and day (YYYYMMDD) format, and identify the full names of the data recorder and each of the searchers.

Identify the landowner agency (U.S. Forest Service, Bureau of Land Management, National Park Service, Department of Defense, Arizona State Land Department, or county) or entity (private or other) by circling one of the choices on the front of the datasheet. If "Other" describe who under the location description. Private landowners may not want to be specifically named, so ask first; if they decline, then just identify as "private".

Using a GPS receiver, record the UTM coordinates (NAD83 datum) for the start of the search area. Use an active track recording on the GPS receiver to document distance and route of the search.

Note the local weather conditions, and approximately when it last rained in the area and qualitatively how much (if known, or check online for recent rainfall data if a weather station is close by). If a thermohygrometer or Kestrel weather meter is available, report the ambient air temperature (°C) and relative humidity (%) present during the survey. Take environmental readings in the shade at about 1m above ground level. If available, other environmental readings such as—dew point, wind speed, and barometric pressure (from a Kestrel meter) would be useful to record; note these readings beneath the Last Rain Event input line.

Presence/Detection Method

Use a search team to systematically cover the habitat to be surveyed; one of the searchers should act as the data recorder. All searchers start and stop searching at the same time. Alternately, each searcher is their own data recorder and they keep track of their own search times; especially if they are working alone and covering a lot of area. Searchers should look on the ground, on and under rocks, within interstitial spaces of talus or rock piles, under branches and leaf litter, under dead wood, and on live and decaying plants. A flashlight is helpful in illuminating dark crevices, within talus slopes, and other "hibernaculum"—places where snails may estivate. Slime trails and epiphragm marks are useful indicators that snails may be found nearby.

Use a digital watch to record the starting and ending time of the search. Report the amount of time it takes (among any of the searchers) to find the first live snail OR shell of the target species. Continue the search until 30 minutes are up.

Each of the searchers will count as many live snails and shells (of the target species and other species of interest) without covering the same area twice. At the end of the 30 minutes, report the total number of live snails and shells found (including the first one). Searchers should keep track of numbers of snails per genera, per age class (mature or juvenile), live and dead (shells), partial shells, and if any were marked (previously by researchers or during this survey, as a mark-recapture effort for live snails or to determine how long the shells persist in the environment). Examples images of land snails are shown at the end of this section.

If any live snails or shells are collected as voucher specimens place an "*" in the appropriate category described above, and report the number taken in the last column of the survey results table. For example:

Mollusk Genus (Common Descriptor)	# Mature Live	# Juvenile Live	# Mature Shells	# Juvenile Shells	# Partial Shells	# Marked Live	# Marked Shells	# Voucher Specimens
Sonorella (talussnail)	**14***	**8**	**3***	**1**	**2**	**0**	**1-M, 1-J**	**4 live, 2 shells**
Oreohelix (mountainsnail)	**0**	**1**	**2***	**0**	**0**	**0**	**0**	**2 shells**
Other – **Naesiotus sp.**	**2***	**0**	**1***	**3***	**0**	**0**	**0**	**2 live, 4 shells**

Mature live snails are preferred as vouchers over juveniles, since taxonomists often rely on examinations of the snails' developed reproductive tract to help identify species. It is recommended to collect all shells encountered (to be available for morphometric analysis and museum collections), except those used in mark/recapture efforts.

Take a few up-close and wide-angle digital photographs of live snails (including those in estivation) within their natural habitat and the substrate they are on. Also take a few wide-angle photos of the area the snails and shells are found in to provide a visual record of their surrounding habitat. A photo taken across the slope of the habitat may provide a good reference to document percent slope (see the Habitat Data section below). Likewise, a photo taken straight up into the tree canopy may be used to determine percent canopy cover. A GPS-enabled camera is preferred, with the images having geo-referenced metadata.

If the searchers don't find a live snail or shell (target species) within 30 minutes, then end the search and report "none" for the time to find first snail, 30 minutes total search time, and "0" live snails and shells under the appropriate categories in the survey results table.

If the searchers cover all of the available or accessible habitat before finding a live snail or shell OR before the end of the 30 minute search, then report the total time spent searching and note "all habitat searched" or "all accessible habitat searched" as appropriate. If the habitat is extensive, a second 30-minute search can be conducted and the results of that effort should be reported separately. The front page of the datasheet has tables to report two separate search efforts. Longer search efforts can use additional datasheets.

Note if any snails were estivating, mating, or mobile and the substrate they were found on (for example: under rocks, on downed logs, on rock face, or within leaf litter. Also note presence of epiphragm seals on rocks, and nearby plant species. If any feral, introduced snails and slugs are observed they should be reported as well, and how many were seen. It is recommended to collect and preserve any feral, introduced snails and slugs as voucher specimens.

Aid to Identification - Reference Photos of Land Snails

***Sonorella* (talussnails)**

Nickel to quarter-size;
Whorls generally smooth;
Shell and body color varies

***Eremarionta* (desertsnails)**

Nickel-size

***Oreohelix* (mountainsnails)**

Dime to quarter-size;
Striated / wrinkled whorls

***Ashmunella* (woodlandsnails)**

M&M to dime-size;
Reddish-brown shell color;
"Toothed" aperature

Other land snails:

Naesiotus (10-15mm length)

Succinea / Catinella (5-15mm length)

Zonitoides (3-4mm diameter)

Cornu aspersum (Brown Garden Snail – **Introduced**)

Rumina decollata (Decollate Snail – **Introduced**)

Photo credits: *Sonorella* (left), *Eremarionta, Oreohelix,* and *Naesiotus* images by Nick D. Waters; *Ashmunella* and *Sonorella* (right) images by Jeff A. Sorensen; other land snails—unknown, from various online sources.

Habitat Data

On the back of the datasheet, briefly describe the habitat type, such as: pine/oak woodland, pine forest, mixed evergreen conifer forest, riparian woodland, upland desert, low desert, semi-desert grassland, etc.. Estimate the overall percent tree canopy cover for most of the habitat searched.

If a compass or clinometer is available, record the aspect (which compass direction the area drains to or faces) and the overall slope of the area searched. Identify the predominate rock type(s) associated with that habitat as indicated on the datasheet, if known.

Estimate the approximate area searched (in square meters) and the elevation range of the search area or the UTM waypoint elevation where the search started (meters preferred; indicate which measurement unit used). Alternately, estimate the approximate distance searched if along a linear route (can use a GPS track route for that estimate).

Draw a sketch of the area habitat with search area shaded (also indicate North direction and nearby landscape features such as a stream, rock outcrops, trail, or large fallen trees)—or use a site map with habitat features identified, and shade the area searched. The data recorder should take a digital photo of the habitat searched using a wide-angle perspective that shows landscape features to put the habitat in context with the area. Use repeat photo points if already established.

Visually assess the area searched (and the immediate surrounding landscape) and note evidence of habitat disturbance or habitat loss on the following stressors/threats. Briefly describe the observed stressor and overall impact level.

- Hard rock mining or rock and gravel extraction (removal or infill of talus)
- Development projects (i.e. construction, roadways & utility corridors)
- Reduced tree canopy and riparian habitat (loss of moisture)
- Livestock (trampling or sedimentation)
- Off-trail OHV use or hiking trails (trampling or sedimentation)
- Wildfire (high fuel load, loss of tree canopy, or sedimentation)
- Invasive plants (bufflegrass, lovegrass, red brome, Russian thistle, etc.)
- Invasive mollusks (predatory or competitor snails and slugs)
- Chemical contamination (pesticides or fire retardant by-products)
- Other [describe]

Submitting Data to AZGFD

Please submit completed datasheets (or electronic data collection app records) along with digital photos taken during the survey, relevant field notes, and any voucher specimens (if taken) to AZGFD's Invertebrate Wildlife Program, attention: Jeff Sorensen, Invertebrate Wildlife Program Manager, at 5000 W. Carefree Hwy, WMTW, Phoenix, AZ 85086. Office Phone: 623-236-7740, cell phone: 480-243-5496. Email: jsorensen@azgfd.gov or snails@azgfd.gov. Additional survey data—such as: an image of the survey area depicted on a topographic quadrangle map or GoogleEarth image, or preferably a jpg image of the survey GPS-tracked route with waypoints of shells and/or live snail observations (and collections, too) would be very helpful documentation.

10/15/2016 version

Land Snail Survey Form: **Presence/Detection with Timed Counts** **Target Species:**_____

Site:_____ **Date:**_____ (YYYYMMDD) **Recorder:**_____ (list full name)

Location Description:_____ **Searchers:**_____

_____ _____

Landowner: USFS BLM NPS DOD ASLD County Private Other _____

UTMs (NAD83): N_____ E_____ Zone_____ _____

Weather:_____ **Air Temp:**_____°C **Rel. Humidity:**_____%

Last Rain Event:_____ **Amount of Rain:** Soaking Light Unknown

Survey Start Time:_____ **Survey End Time:**_____ **Total Search Time:**_____minutes

Notes:_____ **Time to Find 1st Snail:**_____minutes

Mollusk Genus (Common Descriptor)	# Mature Live	# Juvenile Live	# Mature Shells	# Juvenile Shells	# Partial Shells	# Marked Live	# Marked Shells	# Voucher Specimens
Sonorella (talussnail)								
Eremarionta (desertsnail)								
Oreohelix (mountainsnail)								
Ashmunella (woodlandsnail)								
Other								
Other								
Other								

Survey Start Time:_____ **Survey End Time:**_____ **Total Search Time:**_____minutes

Notes:_____ **Time to Find 1st Snail:**_____minutes

Mollusk Genus (Common Descriptor)	# Mature Live	# Juvenile Live	# Mature Shells	# Juvenile Shells	# Partial Shells	# Marked Live	# Marked Shells	# Voucher Specimens
Sonorella (talussnail)								
Eremarionta (desertsnail)								
Oreohelix (mountainsnail)								
Ashmunella (woodlandsnail)								
Other								
Other								
Other								

Land Snail Survey Form: **Habitat Data** **Target Species:**_____

Site:_____ **Date:**_____ (YYYYMMDD) **Recorder:**_____ (list full name)

Location Description:_____ **Approximate % Canopy Cover:**_____

Habitat Type:_____ **Aspect:**_____ **Slope:**_____

Rock Type: Limestone Sandstone Siltstone Basalt Granite/Metamorphic Conglomerate None Unknown

Approximate Area Searched:_____ **Elevation Range or Waypoint Elevation:**_____

Sketch of Habitat Searched

Evidence of Habitat Disturbance or Habitat Loss:		**Describe Observed Stressor and Impact Level:**
Hard rock mining or rock and gravel extraction (removal or infill)	Y or N	
Development projects (construction, roadways & utility corridors)	Y or N	
Reduced tree canopy and riparian habitat (loss of moisture)	Y or N	
Livestock (trampling or sedimentation)	Y or N	
Off-trail OHV use or hiking trails (trampling or sedimentation)	Y or N	
Wildfire (high fuel loads, loss of tree canopy, or sedimentation)	Y or N	
Invasive plants (bufflegrass, lovegrass, red brome, Russian thistle)	Y or N	
Invasive mollusks (predatory or competitor snails and slugs)	Y or N	
Chemical contamination (pesticides or fire retardant by-products)	Y or N	
Other [describe]	Y or N	

10/15/2016 version