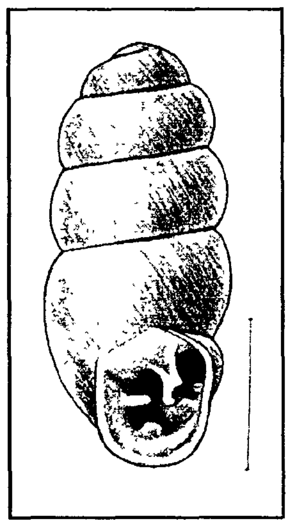
Status and Distribution of Terrestrial Snails of Southern New Mexico

COMPLETION REPORT

Submitted to:

United States Fish and Wildlife Service
Division of Federal Aid
Albuquerque, New Mexico 87103



Gastrocopta dalliana dalliana

Submitted by:

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COMPLETION REPORT

State: New Mexico **Project Number:** E-36 (1-5)

Project Title: Status and Distribution of Terrestrial Snails of Southern New Mexico

Study Title: Endangered Species

Contract Period: 1 May 1995 **To:** 30 July 2000

I. Program Narrative Objectives

1. Document the distribution and abundance of land-snail species with special emphasis on federal Species of Concern and state-listed species of southern New Mexico (Table 1).

2. Quantify microhabitat and record life history observations of target land-snail species.

3. Establish long-term population monitoring protocols for federal candidate and state listed land snail species and critical habitats.

4. Provide management recommendations based on assessment of factors posing imminent threats to land-snail species, habitats, and ecosystems of New Mexico.

A. Justification

1. Problem and Need

Following the terminal transgression of the epieric seas in the late Cretaceous, tectonic events (rifting and block faulting) associated with the Rio Grande rift (Chapin and Seager 1975, Seagar and Morgan 1979) during the early Tertiary resulted in geographic isolation of many New Mexico land snails (Metcalf 1977); especially larger snails that now occur as geographically disparate, endemic species or subspecies of relict montane refugia (Metcalf and Smartt 1997). Extensive exchange of land-snail faunas occurred during the Quaternary with latitudinal and altitudinal movements of intermediate and lower elevation molluscanfaunas continuing throughout the Pleistocene. Such interchange is evidenced by the fossil record and extant land-snail populations in New Mexico (Metcalf 1997) Thus, insularization of land snails at higher elevations with some interchange at lower elevations has resulted in a heterogeneous assemblage of genera and species with diverse origins and varied patterns of distribution in the state.

Speciation by isolation on mountain tops has resulted in a high degree of endemicity of New Mexico land snails. Excluding endemic subspecies, Metcalf et al. (*In Preparation*) estimate that about 42% (48 of 114 species) of the native land-snail fauna of New Mexico is endemic to the state (several species extend into the southern Guadalupe Mountains of Texas). Many of these insular land-snail populations are characterized by unique gene pools and species assemblages with small populations that inhabit discontinuous point-habitat patches along sparsely vegetated montane canyons, ridges, talus slopes, and rock outcrops that are critical to species survival.

Henry A. Pilsbry's, *Land Mollusca of North America* (1939-1948), provides an extensive compendium of original species descriptions, identification keys, distribution information, and bibliography for historic land-snail collections in New Mexico between the period 1874-1935. More recently, Bequeart and Miller (1973) estimated that New Mexico's terrestrial mollusks consisted of approximately 86 species. Metcalf and Smartt (1997) documented 19 families, 114 species and 27 subspecies of land snails in New Mexico Despite these notable contributions to our knowledge of the land snail fauna of New Mexico, significant areas throughout the state have not been surveyed adequately, as evidenced by the recent discovery of several undescribed species in southern New Mexico (Metcalf et al. *In Preparation*). Numerous populations documented during the past 20 years require re-inventory and threat assessment.

The systematics, distribution and abundance, population trends, microhabitat requirements, and habitat-area relationships of New Mexico land snail populations are not well understood amongst resource managers or malacologists. Resource agencies have no baseline data from which to characterize land snail populations, recognize losses, or anticipate ecological threats associated with the degradation of terrestrial ecosystems. Identification of threats to New Mexico land snails is essential for public and private land managers and decision makers Threats imminent to land-snail populations include habitat loss and fragmentation due to silvicultural practices, grazing of forested lands, wildfire, mining of aggregates and mineral resources, natural disturbances, and indirect biospheric perturbations (e.g., global warming, acid rain)

Habitat fragmentation increases the distance between snail sub-populations and may have major consequences on the metapopulation structure of land-snail species, particularly for narrow endemic species of restricted geographic distribution (Harrison 1991). As land snail populations are eliminated and dispersal distances are increased, demographic and genetic constraints can diminish the ability of local populations to respond to natural environmental disturbances and anthropogenic habitat changes.

Since terrestrial mollusks concentrate toxic chemicals in soft body parts as a result of trophic specializations (i.e., decomposers), land snails may function as sensitive "bioindicator" organisms facilitating ecological assessment of biotic communities in relation to current environmental conditions statewide. As such, population monitoring of land snails in New Mexico is timely, and may contribute to the establishment of an ecological baseline for evaluating broad-scale environmental trends and assessment of potential impacts on species, genetic, and ecosystem levels of biodiversity due to environmental degradation in the Arid Southwest. This concern becomes particularly germane considering ongoing and future deposition of air contaminants in the Border Lands of southern New Mexico, where several federal Species of Concern land snails occur at single sites (i e., endemics at type localities). These restricted land-snail populations and point habitats merit routine monitoring to ensure their continued existence.

2. Results and Benefits

This study will obtain information on the population status (distribution and abundance), life history observations, and habitat occupied by state-listed and federal Species of Concern land snails of New Mexico (Table 1). These data coupled with the identification of threats to land-snail populations and habitats can be used to determine future management options, including the initiation of long-term population and habitat monitoring protocols.

3. Status

There has been no status change in the Federal Register for eight federal Species of Concern land snails that occur in New Mexico (USFWS 1991, 1994). Five of these eight land-snail species are endemic to New Mexico and occur only at the species type locality. These point habitats are considered critical to the survival of these species. Exploratory surveys of suitable habitats in close proximity to these restricted populations, and in potential habitats of nearby mountain peaks or ranges, are needed to assess the population status of endemic species. Such a systematic survey protocol can provide data for several non-candidate land-snail species that are known from only one collecting locale or mountain range in New Mexico.

II. Procedures/Objectives

A. Sites of known occurrence of target species will be surveyed during periods of snail activity following seasonal rains from March-September. Field surveys will be conducted by the Project Leader and Contractors.

1. Inventory land-snail species listed in Table 1 at sites of known or potential occurrence to quantify extant populations.

Land-snail survey sites are indicated in map figures of Appendix A. Voucher material obtained at these sites is listed in Appendix B which also includes miscellaneous land-snail collections taken statewide.

Under grant Segment 4, the Project Leader requested expert opinion on the population status of *O. florida* from malacologists (Drs. A. L. Metcalf and R. Worthington, UTEP; Dr. Patricia Mehlhop, New Mexico Natural Heritage Program) most familiar with the molluscanfauna of the Florida Mountains.

Results of land-snail surveys conducted by Dr. Robert M. Sullivan (Contractor) are provided in Appendix C.

Land-snail survey results from the Southern Sierra Cuchillo, Sierra County, are summarized in Appendix D.

a. Population estimates will be obtained by 1 gallon leaf litter grab samples (i.e., 1-3 samples/population).

Point-centered sampling was conducted for small-shelled species, namely *Gastrocopta dalliana dalliana*, along elevational line transects in the Animas and Big Hatchet mountains with 3-5 sample sites per transect. At each sample point, land snails were obtained from a leaf litter sub-sample (labeled A) collected within a 5m diameter circle and beneath rocks within 10m of the sample point (sub-sample B). Twelve macrohabitat variables were recorded at each sample point (see A.1.d. below).

Surveys for large-shelled species typically covered several hundred feet in elevation along the wooded margins of scree slopes by searching beneath talus-rock fragments. During these surveys, leaf litter samples were taken to determine the overall land-snail community structure.

b. All snails specimens collected will be enumerated by species. Voucher material will be deposited into the Invertebrate Collection, New Mexico Museum of Natural History (NMMNH).

The NMMNH is seeking funds for museum equipment, facility improvements, and administrative infra-structure to establish a regionally based research institution focusing on Desert Southwest vertebrate and invertebrate studies (D. Haffner, Chair Science Division, *pers. com.*). Currently, the NMMNH is neither adequately funded nor staffed to process invertebrate collections requiring verification of species identifications. Accordingly, land-snail voucher material collected by the Project Leader was deposited into the Mollusk Collection, Laboratory for Environmental Biology, Department of Biological Sciences, University of Texas at El Paso, Texas. The UTEP holdings are recognized by malacologists as a regionally significant collection of Desert Southwest aquatic and terrestrial mollusks.

Accession of voucher material to existing collections has been discussed in previous annual performance reports, and procedures for collection management have been followed accordingly. See Appendix B for a listing of land snail collections deposited into the Mollusk Collection, UTEP.

c. Collect soft tissue voucher from select snail populations. Soft tissues will be frozen in liquid nitrogen and deposited into the frozen tissue collection at the New Mexico Museum of Natural History, Albuquerque.

No soft tissue material was collected during the project. However, live specimens of *Sonorella* sp. from Lang Canyon, San Luis Mountains (Gray Ranch), Hidalgo County, were either relaxed in water and menthol and preserved in 95% EtOH or shipped live to Lance Gilbertson, Orange Coast College, California, for examination of soft anatomy.

d. Macrohabitat variables will be measured at snail site occurrences following Smartt and Sullivan (1990).

Macrohabitat variables were measured only where surveys focused on line transect sampling. These 12 variables were: dominant vegetation type (grassland, woodland [pinyon-juniper-oak], forest, riparian, canyon/arroyo), bedrock geology (igneous, limestone, alkali, sandstone), elevation, aspect (direction of slope), edaphic conditions (soil temperature, humidity, pH), distance to nearest shrub and tree by species, distance to free water, percent canopy cover (densiometer), and microhabitat where collected (in soil/leaf litter, under rocks, on vegetation).

e. Land snail distributions will be mapped using GPS modules for incorporation into a GIS database. Environmental levels will include geographic and microhabitat data, where applicable.

Survey sites were recorded with a GPS unit (Trimble GeoExplorer) where topography and canopy cover allowed for adequate satellite communication. These data are stored as raw files in Geo-PC (2.01-00, 1995) software format.

Survey sites indicated on map figures 1, 2, 4, 6-8 of Appendix A were created in ArcView 3.1. Lack of GIS technical support and expertise within the NMGF prevented additional GIS mapping capabilities. Accordingly, the location of survey sites on these map figures represents the best approximate location. Maps of land-snail survey sites in the Big Hatchet (Figure 5) and Florida (Figure 3) mountains, Fra Cristobal Range (Figure 9), and Sierra Cuchillo (Appendix D) were created with Delorme TopoUSA™.

f. Data analysis will follow parametric and non-parametric statistical procedures, where applicable.

During the course of this 5-year project, it became apparent that much of the voucher material collected from quantitative line transect sampling consisted of empty shells (i.e., dead snails). This limited sample sizes for statistical analysis and posed concerns for measurement of current ecological conditions relative to past conditions. For example, several sample sites on the north slope of Animas Mountain showed evidence of forest fire (see Appendix B, BKL95-038). Wind and rain transport of small-shelled species on precipitous, sparsely vegetated slopes (i. e., Big Hatchet Mountains) may result in translocation of dead snails. Empty shells of large-shelled species found at the base of limestone facies, as observed in the Big Hatchet Mountains (Chainey Canyon collections, BKL97-066-071), raised doubts of their occurrence when living.

Accordingly, these concerns limited data analysis to qualitative results presented in Appendix E.

2. Exploratory field survey for target species will be conducted in close proximity to known site occurrences and in potential habitats of nearby mountain ranges in southern New Mexico. These localities and additional areas of north-central NM (i.e., Jemez and Sangre de Cristo mountains) will be sampled per Procedure 1.

Survey results for target species are presented in appendices A, B, and C.

Land-snails surveys were conducted in specific areas statewide that, based on limited data or recent shell material, merited further exploration. These areas included: (1) The Fra Cristobal Range (Sierra County) which represents one of the few large mountain ranges statewide that, heretofore, remained malacologically unexplored; (2) The Southern Sierra Cuchillo (Sierra County) which was last surveyed by H. A. Pilsbry and James H. Ferriss in 1915; and (3) The Sacramento Mountains (Otero County) where recent shells of *Oreohelix neomexicana* were collected from Arcente Canyon, Cloudcroft Ranger District, Lincoln National Forest.

(1) The Fra Cristobal Range is relatively depauperate of land snails compared to other xeric mountain ranges to the south (Caballo Mountains) and the east (San Andres Mountains). Only fossil shells referable to *Oreohelix caballoensis* (see Appendix B, BKL00-034-036), *Succinea* sp. (ALM-2596-2598), one live *Glyphyalinia indentata* (BKL00-039), and a recent *Gastrocopta pellucida* (BKL00-038) were recovered from six survey sites in the Fra Cristobals. Figure 9 (Appendix A) illustrates land-snail survey sites in this range. Fossil records of *O. caballoensis* from higher elevations in the southern Fra Cristobals extend the historic range of the species northward, and support the dispersalist-extinction model of primitive oreohelicids of the *O. metcalfei* complex proposed by Metcalf (1974), Crews and Metcalf (1982), and Metcalf and Smartt (1997).

(2) Appendix D details land-snail surveys in the Southern Sierra Cuchillo, Sierra, County.

(3) *Oreohelix neomexicana* **tolerates a broad variety of montane habitats where it is reported living from the Sangre de Cristo (southern extent of the range), Ortiz, Sandia, Manzano, Oscura mountains, and Gallinas Peak (Lincoln County) (Metcalf and Smartt 1997). Prior to this project,** *O. neomexicana* **was recorded as fossils from alluvial and colluvial material throughout the Sacramento Mountains. Living specimens collected from mixed leaf litter and limestone rubble at the base of a forested north-facing wall of Arcente Canyon represent the only live record of this species from numerous localities in the Sacramento Mountains (Metcalf et al.** *In Preparation***).**

3. Employ genetic analyses (if required) to identify unique land-snail populations or to determine genetic/taxonomic affinities of select snail species.

No genetic studies were initiated during this project. However, the taxonomic relationships of numerous land-snail species complexes (e.g., *Oreohelix metcalfei* **Cockerell complex, Black Range), species "groups" (e.g.,** *Oreohelix strigosa, O. subrudis, O. yavapai***; See Pilsbry [1939]), and dubious species-specific affinities (e.g., hybridization between** *Ashmunella hebardi* **and** *A. mearsnii***) in New Mexico merit evaluation by modern molecular genetic techniques. This subject is discussed at greater length in Appendix E (management) of this report.**

B. Formulate long-term population/habitat monitoring protocols for sensitive land-snail species based upon field survey results.

See Appendix E.

C. Submit annual reports summarizing activities during the reporting period. These will include preliminary analysis of results, suggested changes (if necessary) in the sampling protocol and management recommendations.

Annual performance reports were submitted under previous grant segments.

D. Prepare completion report summarizing the results of work accomplished under Procedures A and B, which includes management recommendations based on assessment of factors posing threats to land snail species, populations, and ecosystems.

Activities completed under all grant segments (1-5) are summarized herein. Species accounts of Appendix F provide general information on the identification, distribution, biology, threats, and conservation status of land-snail species that were the focus of this project.

III. Geographic Location

Project headquarters will be the New Mexico Department of Game and Fish Laboratory, Santa Fe, NM. Field work will occur primarily in southern New Mexico (Catron, Doña Ana, Grant, Hidalgo, Lincoln, Luna, Otero, Sierra and Socorro counties) and in the Sangre de Cristo and Jemez mountains of north-central New Mexico Data processing will occur at the NMDGF Laboratory and at facilities of contracting consultants

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Table 1. State-listed and federal Species of Concern land snails of New Mexico. Species categorized by geographic region and conservation status.

Common Name[1]	Species	County	2000 Status[2] State	2000 Status[2] Federal	Occurrence
Shortneck snaggletooth	*Gastrocopta dalliana dalliana*	Hidalgo	E	SC	Animas Mts.
Hacheta Grande woodlandsnail*	*Ashmunella herbardi*	Hidalgo	T	SC	Big Hachet Mts.
Cooke's Peak woodlandsnail*	*Ashmunella macromphala*	Luna	T	SC	Cooke Range
Florida mountainsnail*	*Oreohelix florida*	Luna	E	SC	Florida Mts.
Doña Ana talussnail*	*Sonorella todseni*	Doña Ana	T	SC	Doña Ana Mts.
Mineral Creek mountainsnail*	*Oreohelix pilsbryi*	Sierra	T	SC	Black Range
Cockerell's striate disc	*Discus shimekii cockerelli*	Taos	-	SC	Sangre de Cristo Mts.
Ovate vertigo	*Vertigo ovata*	Eddy, Socorro	T	SC	Blue Spring, Alamosa Creek & warm springs.

[1] Taxonomic authority: Turgeon, D. D., J. F. Quinn, A. E. Bogan, E. V. Coan, F. C. 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.
[2] 2000 Status: (State) E = Endangered, T = Threatened; (Federal) C = Candidate, SC = Species of Concern - USFWS. 1996. Endangered and Threatened Wildlife and Plants; Review of Plant and Animal Taxa That are Candidates for Listing as Endangered or Threatened Species 50 CFR Part 17 (7595-7613).
* Species endemic to New Mexico.

Appendix A. Map figures of survey sites (1995-2000) for land-snail species listed in Table 1. Map labels (green and red) are referable to collection records organized by field catalogue numbers in Appendix B. Maps are organized taxonomically by target species.

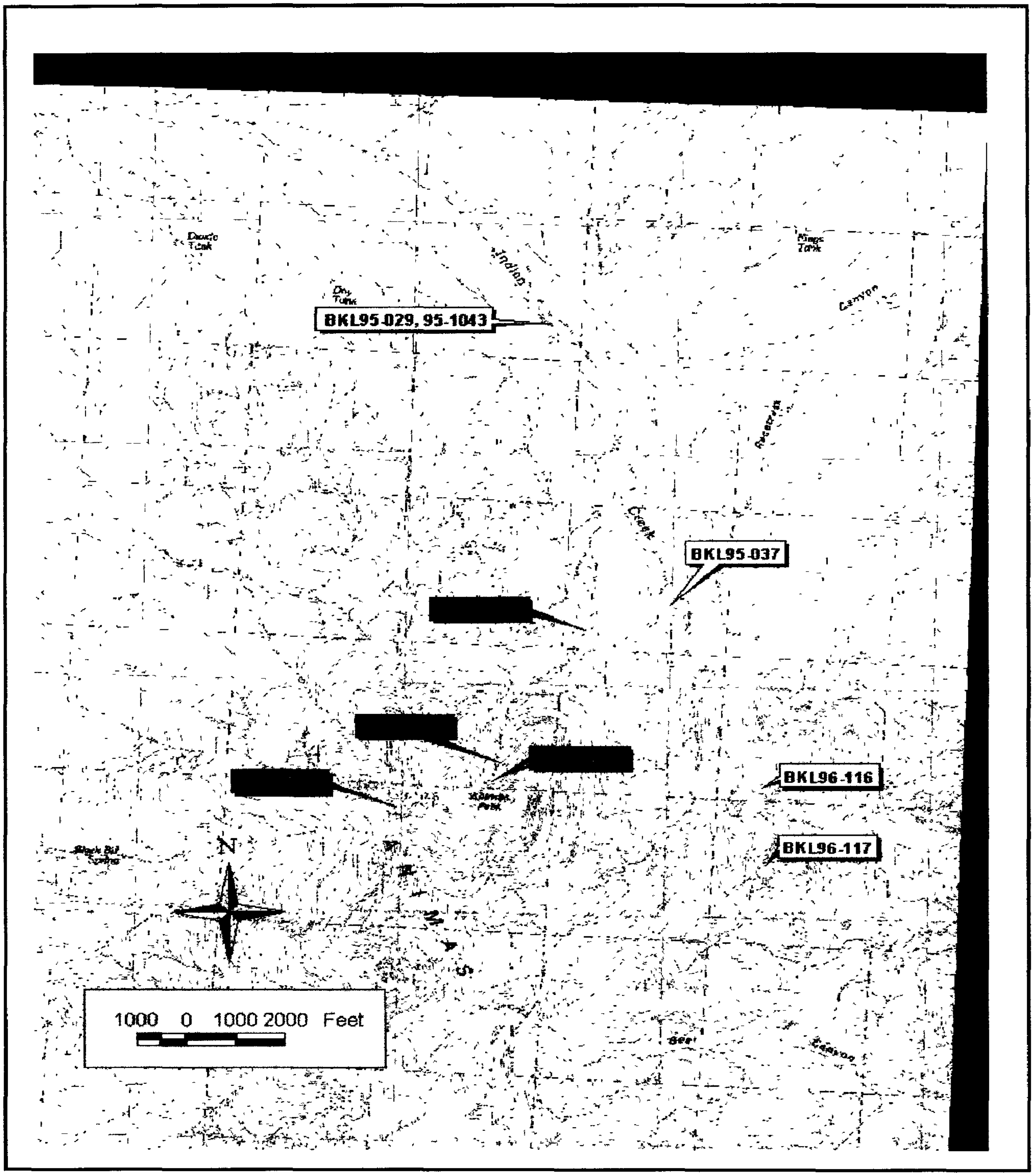


Figure 1. Map of land-snail survey sites (1995-1996) on the north slope of the Animas Mountains, Hidalgo County, New Mexico Green labels indicate collection sites for *Gastrocopta dalliana dalliana*

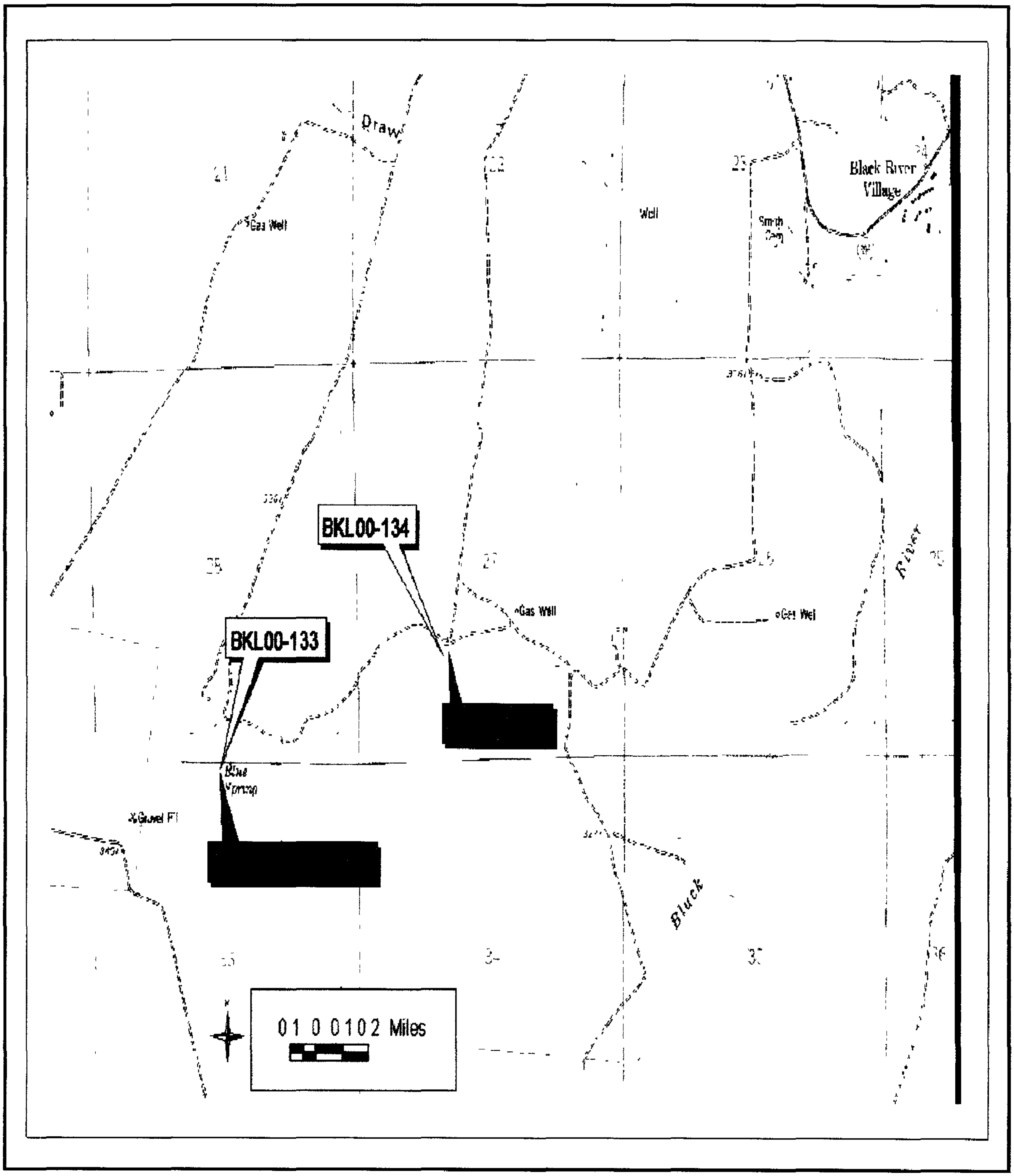


Figure 2A Map of land-snail survey sites (1998-2000) at Blue Spring, Eddy County, New Mexico Green labels indicate collection sites for live *Vertigo ovata*.

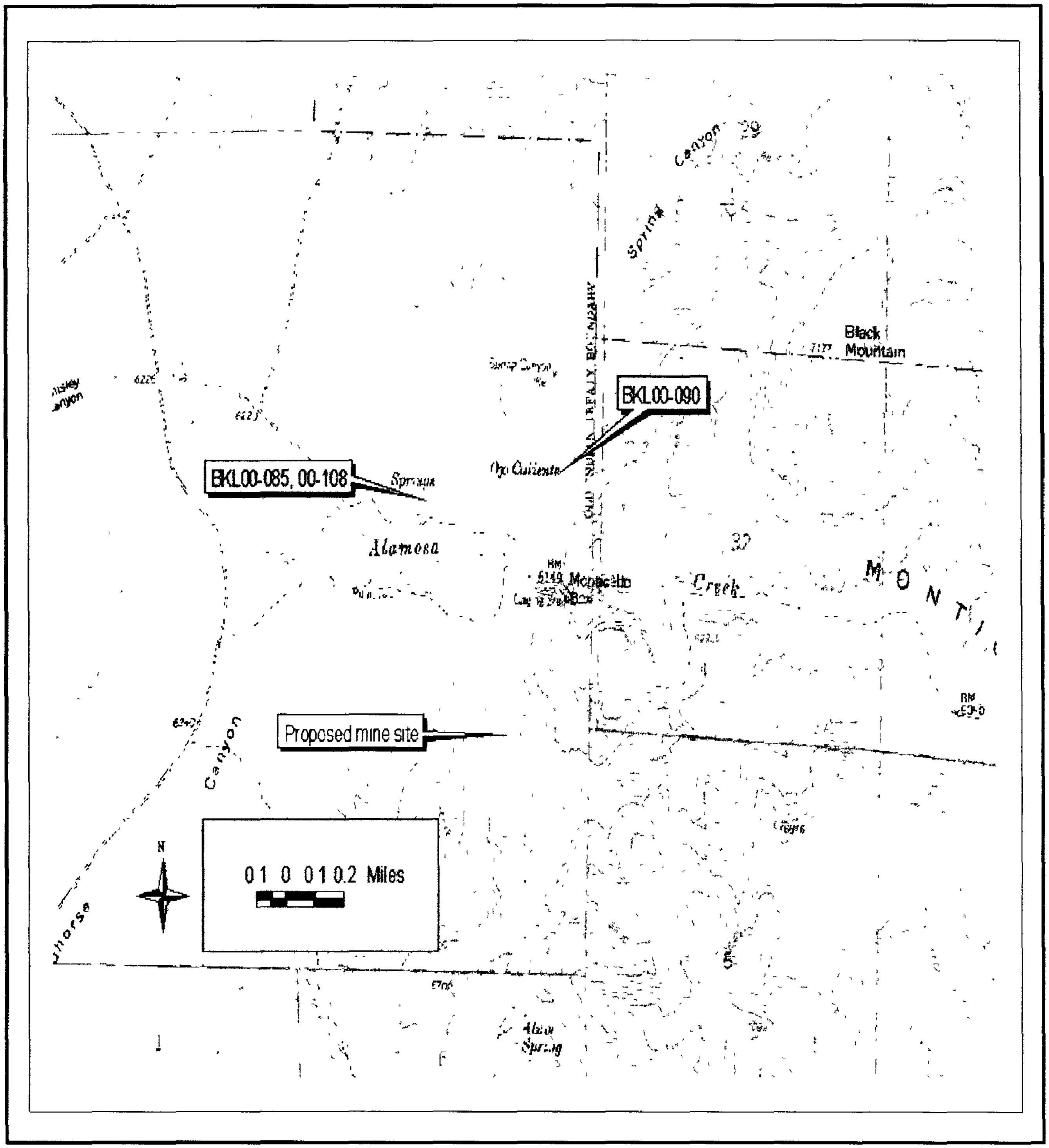


Figure 2B Map of land-snail survey sites (2000) at Alamosa Creek, Socorro County, New Mexico Green labels indicate collection sites for live *Vertigo ovata*

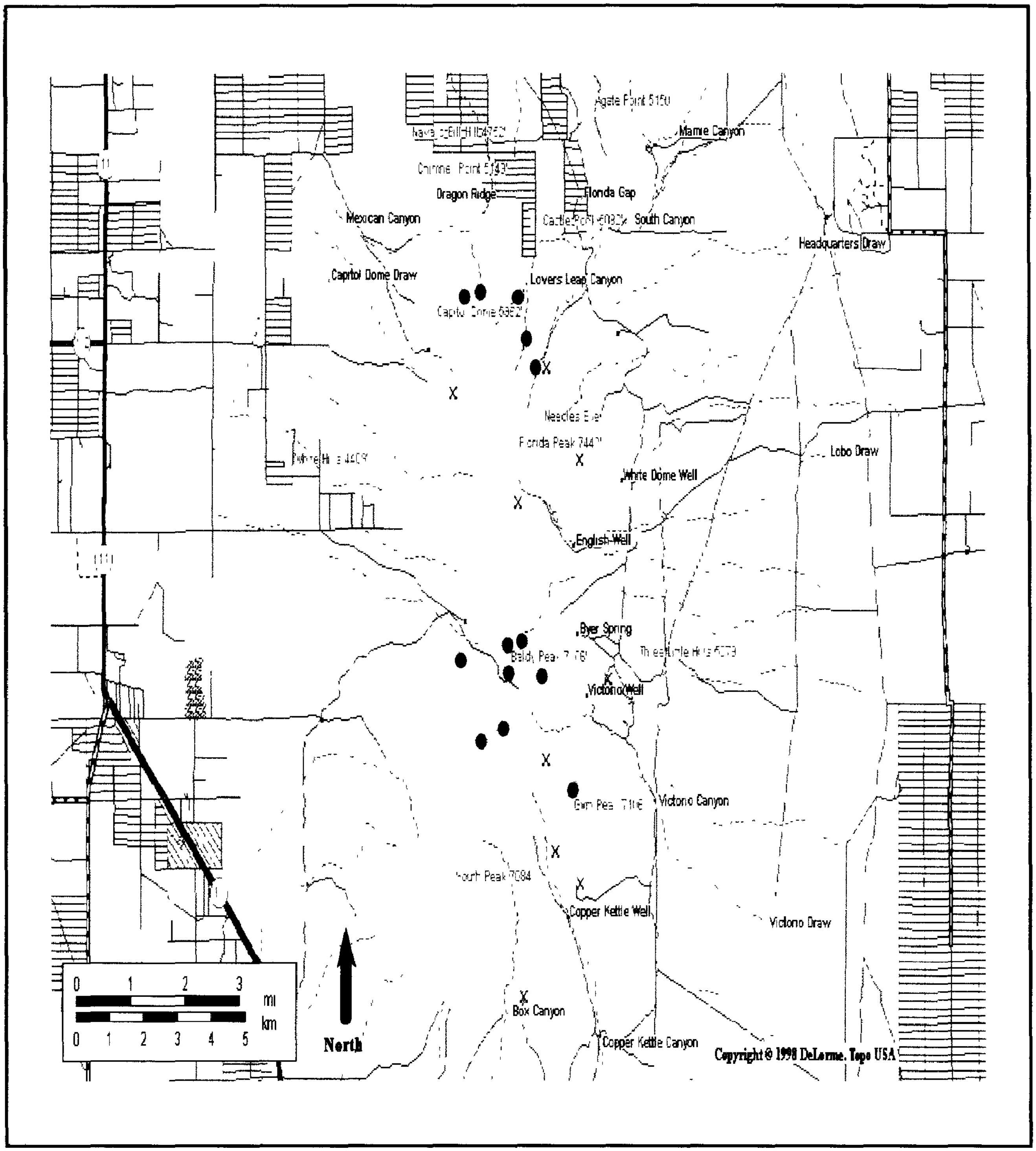


Figure 3 Map of land-snail survey sites (1970-1997) in the Florida Mountains, Luna County, New Mexico. Sites mapped (blue) are approximate locations of areas searched by Drs A L Metcalf and R. D Worthington (University of Texas at El Paso). Red dot is approximate location of type locality.

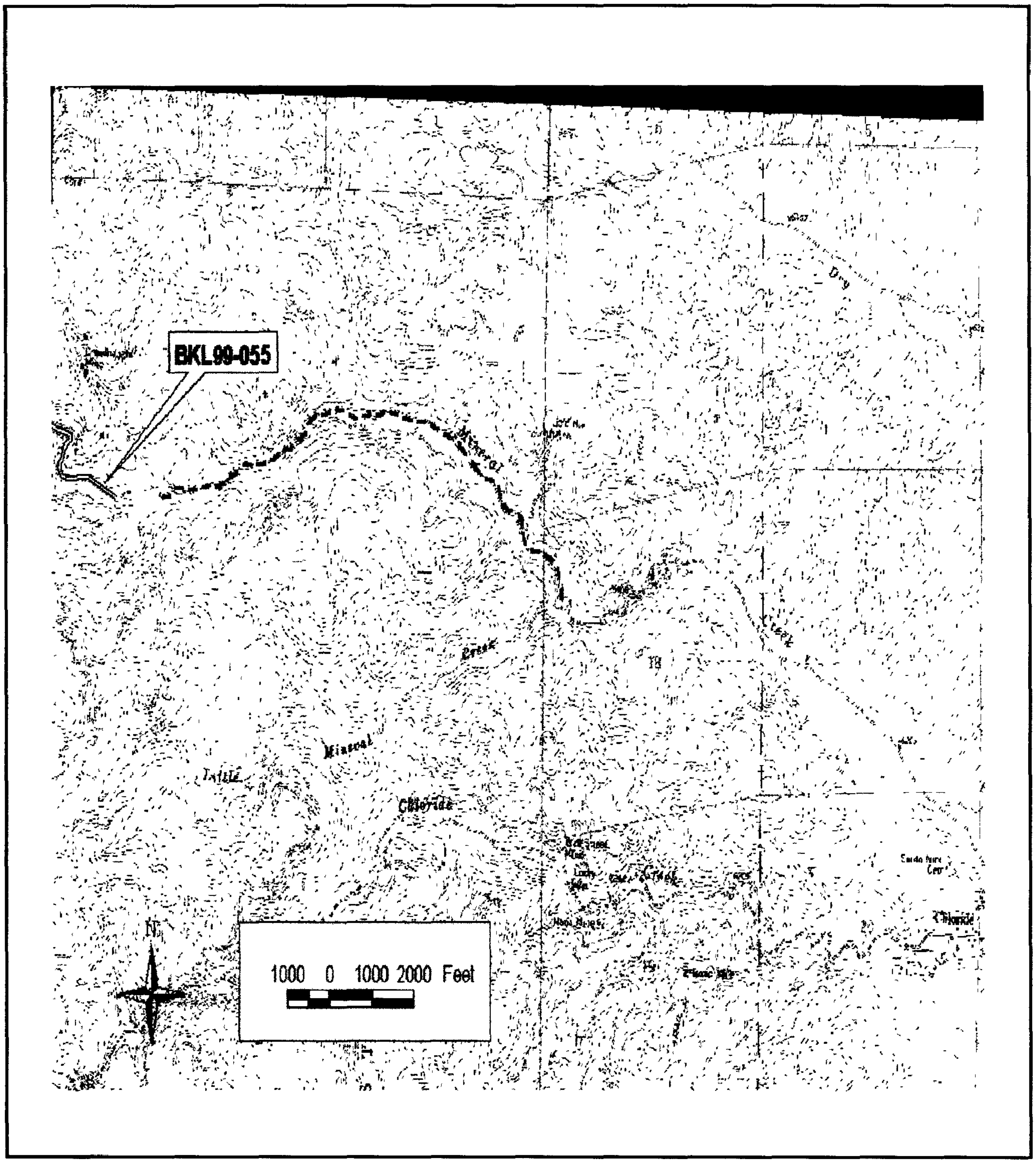


Figure 4. Map of land-snail survey sites (1999) in Mineral Creek Canyon, Sierra County, New Mexico Green label indicates collection site for live *Oreohelix pilsbryi* Red line symbol represents area surveyed, but no *O. pilsbryi* were found.

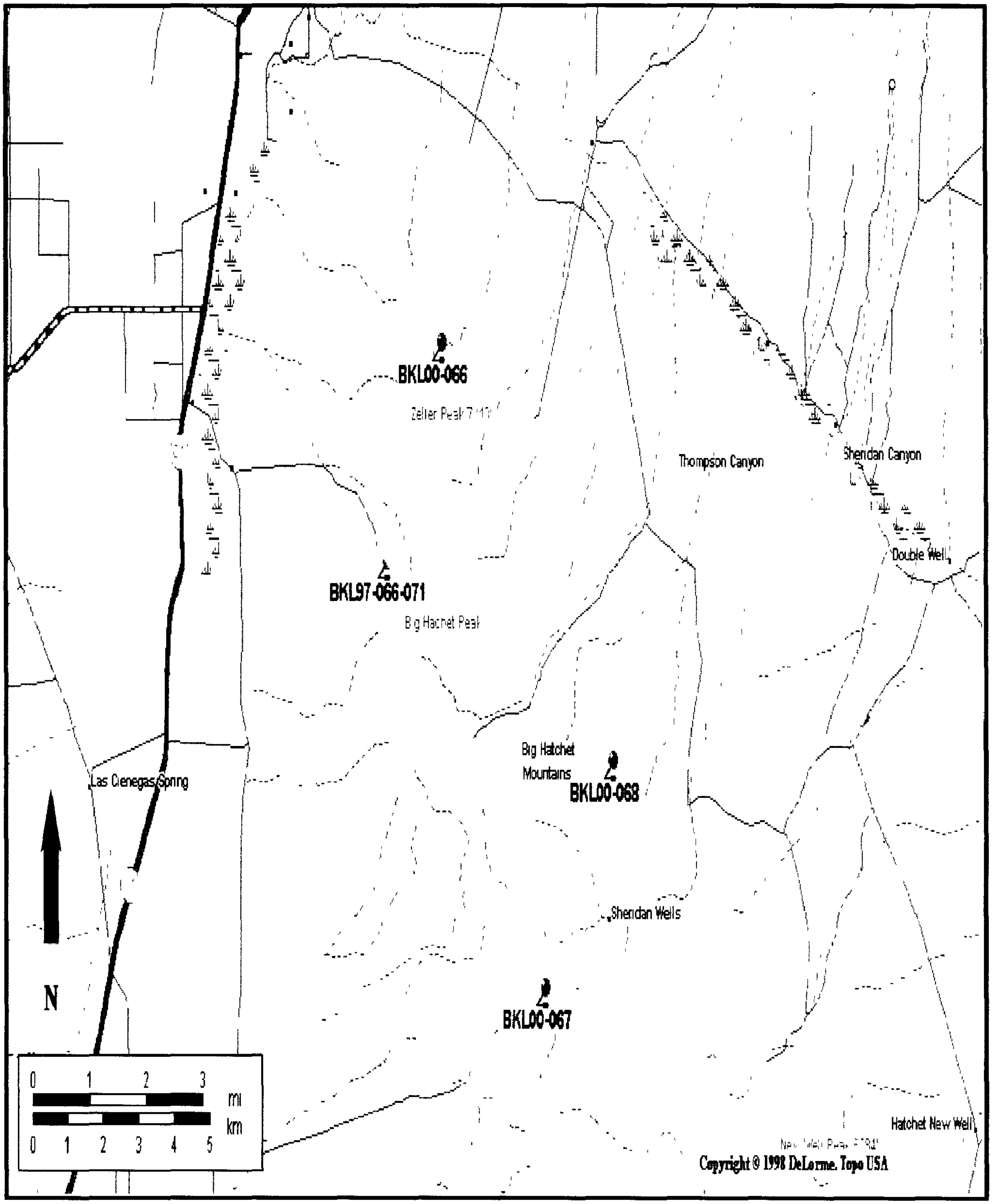


Figure 5 Map of land-snail survey sites (1997-2000) in the Big Hatchet Mountains, Hidalgo County, New Mexico Green labels represent sites where *Ashmunella hebardi* occurred as live records.

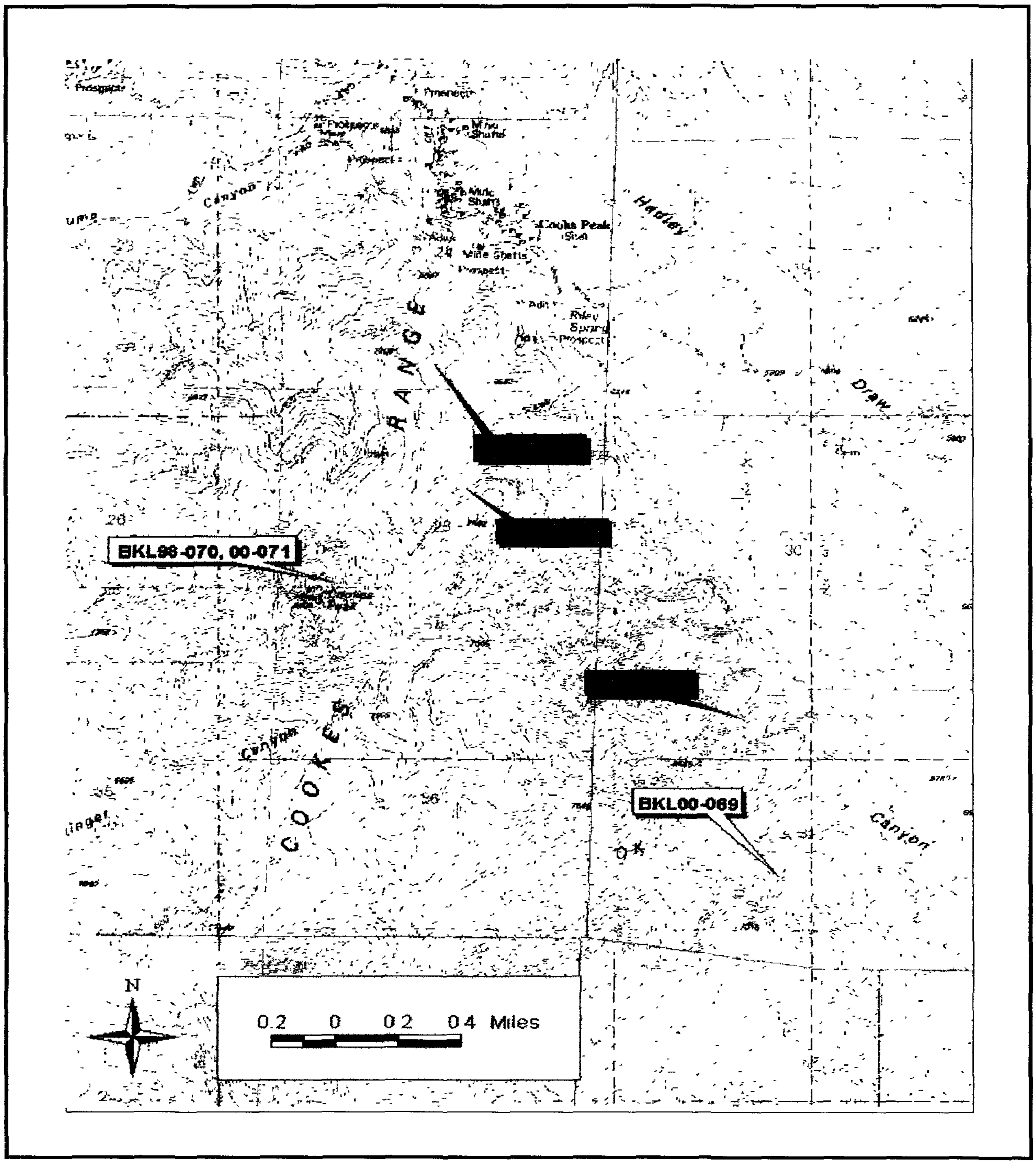


Figure 6 Map of land-snail survey sites (1998-2000) in the Cooke's Range, Luna County, New Mexico. Green labels indicate collection sites for *Ashmunella macromphala*

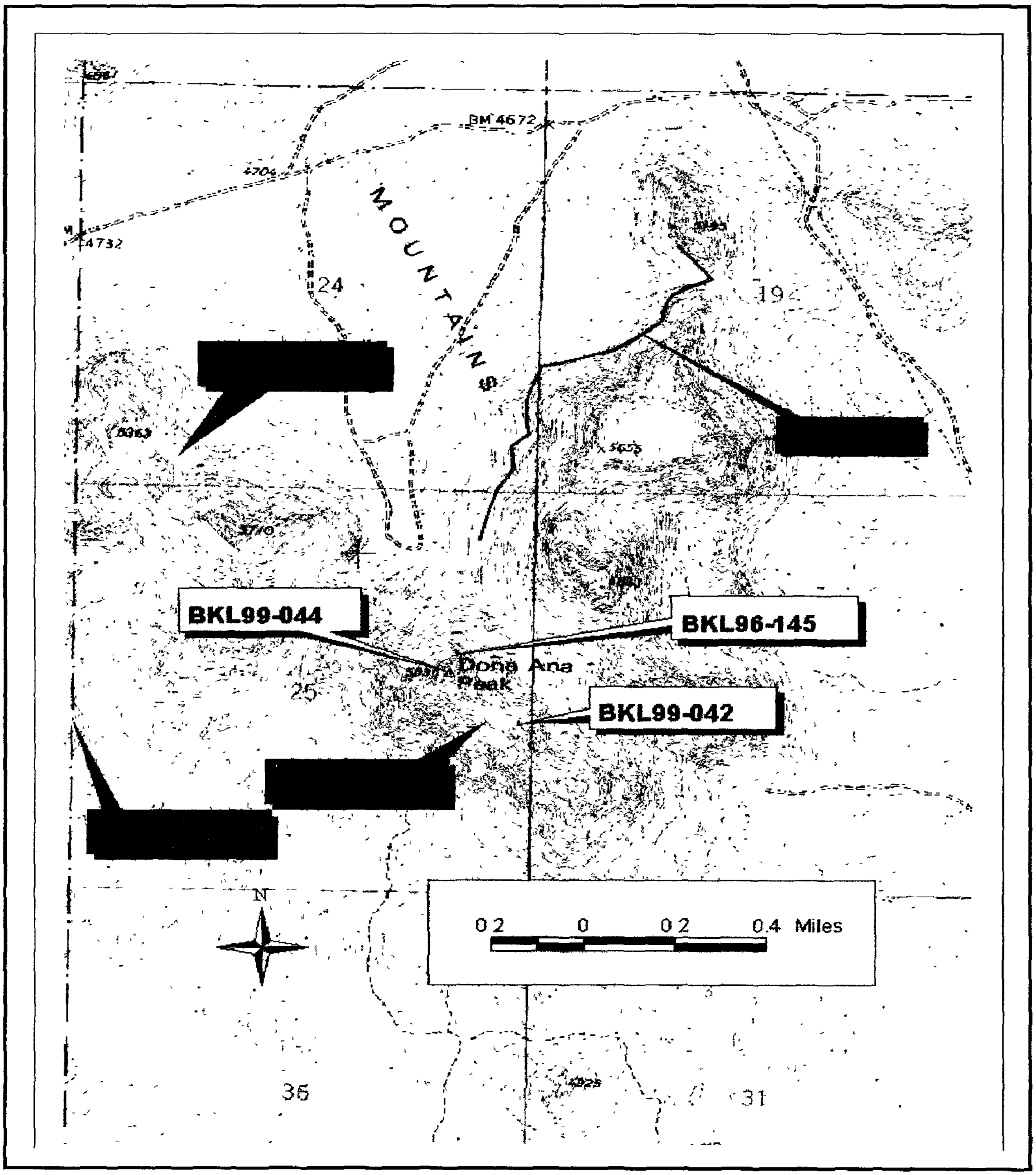


Figure 7 Map of land-snail survey sites (1996-1999) in the Doña Ana Mountains, Doña Ana County, New Mexico Green labels represent collection sites for live *Sonorella todseni* (recent shells were collected from BKL99-044)

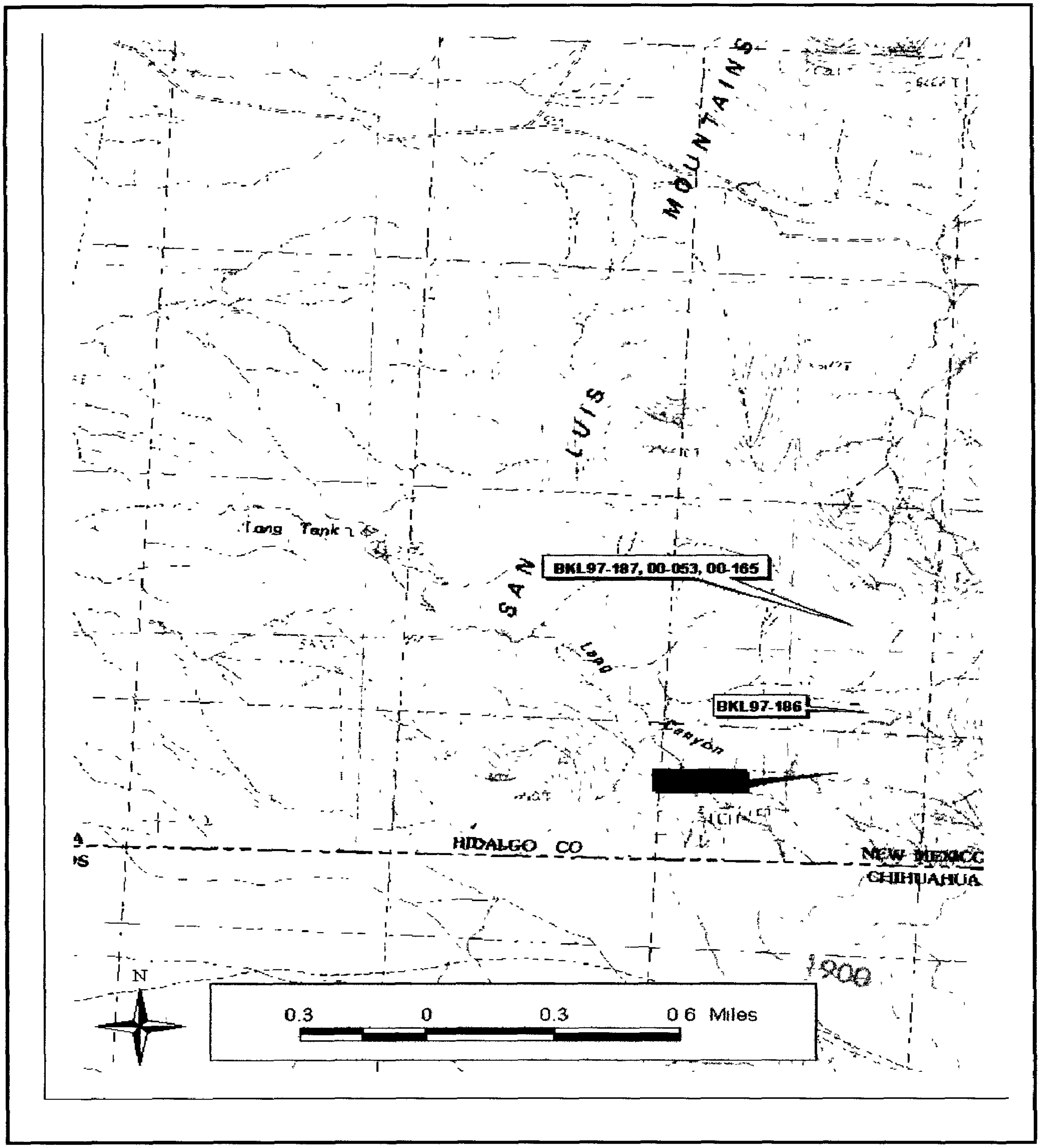


Figure 8 Map of land-snail survey sites (1997-2000) in Lang Canyon, San Luis Mountains, Hidalgo County, New Mexico Green label indicates collection site for live *Sonorella* sp (recent shells were collected at BKL97-186).

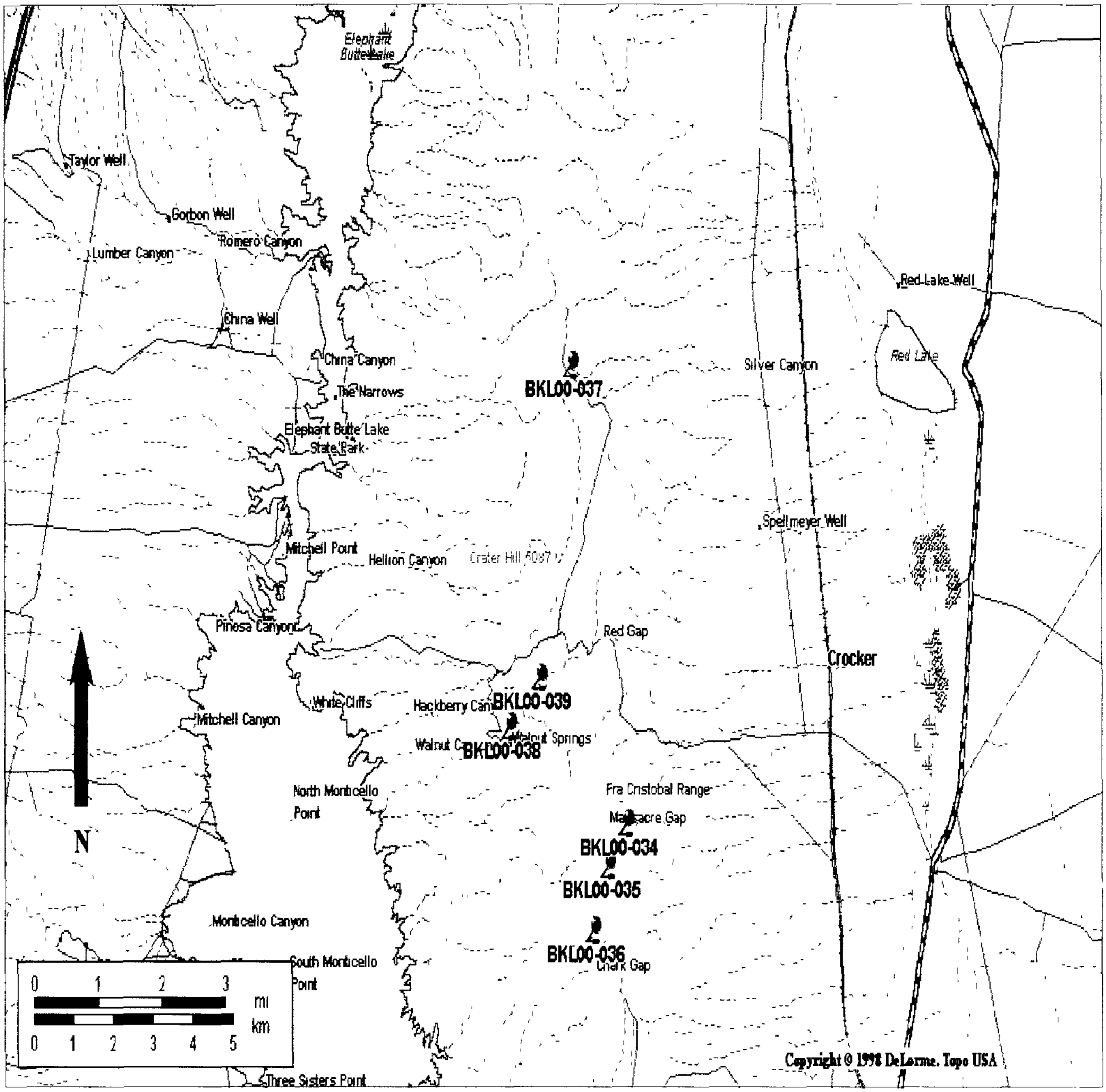


Figure 9. Map of land-snail survey sites (April 2000) in the Fra Cristobal Range, Armendaris Ranch, Sierra County, New Mexico. Red map labels are referable to collection records listed by field catalogue numbers in Appendix B

Appendix B. Voucher material collected during the 1995-2000 land-snail survey period. Data are presented taxonomically by target species listed in Table 1 and by field collection number (BKL#), site descriptor, species, and museum catalogue number (Mollusk Collection, Laboratory for Environmental Biology, Department of Biological Sciences, University of Texas at El Paso).

Gastrocopta dalliana dalliana

BKL95-029A **19 July 1995**

NM: Hidalgo County, Gray Ranch, north slope of Animas Peak, Indian Creek Canyon at 5930 ft. elevation. T31S, R19W, Sec. 16 (NW/SE). N31°36′33.3″, W108°46′31.9″. Collectors: B. K. Lang and R. D. Jennings.

Species	# Specimens	UTEP #	Comments
Gastrocopta dalliana dalliana	3	14,517	soil sub-sample
Gastrocopta pilsbryana	3	14,518	soil sub-sample
Striatura meridonalis	2	14,519	soil sub-sample

BKL95-037A (split lot) **15 August 1995**

NM: Hidalgo County, Gray Ranch, north slope of Animas Peak, Indian Creek Canyon, ca. 6200 ft. elevation. T31S, R19W, Sec. 21 (NW/NE). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta pilsbryana	5	14,080	soil sub-sample
Gastrocopta pilsbryana	31	14,081	soil sub-sample
Glyphyalina indentata	3	14,076	soil sub-sample
Hawaiia minuscula	7	14,077	soil sub-sample
Hawaiia minuscula	3	14,079	soil sub-sample
Striatura meridonalis	3	14,075	soil sub-sample
Euconulus fulvus	2	14,078	soil sub-sample
Sonorella animasensis	1	14,074	soil sub-sample
Sonorella animasensis	11	14,083	rock sub-sample
Gastrocopta pilsbryana	13	14,520	soil sub-sample
Hawaiia minuscula	6	14,521	soil sub-sample
Glyphyalina indentata	4	14,522	soil sub-sample
Striatura meridonalis	2	14,523	soil sub-sample

BKL95-037B (split lot)

Gastrocopta cochisensis	3	14,086	soil sub-sample
Gastrocopta dalliana dalliana	1	14,087	soil sub-sample
Gastrocopta pilsbryana	20	14,088	soil sub-sample
Glyphyalina indentata	2	14,084	soil sub-sample
Euconulus fulvus	1	14,085	soil sub-sample
Sonorella animasensis	7	14,089	rock sub-sample
Gastrocopta pilsbryana	16	14,524	soil sub-sample
Glyphyalina indentata	1	14,525	soil sub-sample
Striatura meridionalis	2	14,526	soil sub-sample

BKL95-037C (split lot)

Species	# Specimens	UTEP #	Comments
Gastrocopta cochisensis	1	14,091	soil sub-sample
Gastrocopta pilsbryana	51	14,092	soil sub-sample
Glyphyalinia indentata	3	14,093	soil sub-sample
Glyphyalinia indentata	6	14,096	rock sub-sample
Striatura meridionalis	4	14,094	soil sub-sample
Euconulus fulvus	1	14,095	soil sub-sample
Sonorella animasensis	9	-	rock sub-sample
Gastrocopta cochisensis	1	14,527	soil sub-sample
Gastrocopta pilsbryana	13	14,528	soil sub-sample
Glyphyalinia indentata	1	14,530	rock sub-sample
Euconulus fulvus	1	14,529	soil sub-sample
Sonorella animasensis	9	14,531	rock sub-sample

BKL95-037D (split lot)

Glyphyalina indentata	1	14,097	soil sub-sample
Glyphyalina indentata	4	14,098	rock sub-sample
Sonorella animasensis	14	-	rock sub-sample
Gastrocopta pilsbryana	8	14,533	soil sub-sample
Glyphyalinia indentata	1	14,534	soil sub-sample
Striatura meridionalis	1	14,535	soil sub-sample
Sonorella animasensis	14	14,532	rock sub-sample

BKL95-037E (split lot)

Glyphyalina indentata	1	14,100	soil sub-sample
Glyphyalina indentata	3	14,099	soil sub-sample
Hawaiia minuscula	1	14,101	soil sub-sample
Sonorella animasensis	8	-	rock sub-sample
Gastrocopta dalliana dalliana	1	14,539	soil sub-sample
Gastrocopta pilsbryana	11	14,536	soil sub-sample
Glyphyalina indentata	2	14,540	soil sub-sample
Hawaiia minuscula	9	14,537	soil sub-sample
Euconulus fulvus	1	14,541	soil sub-sample
Sonorella animasensis	8	14,538	soil sub-sample

BKL95-038A (split lot) — 16 August 1995

NM: Hidalgo County, Gray Ranch, north slope of Animas Peak, ca. 7800 ft. elevation. T31S, R19W, Sec. 28 (SE/NW). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Cionella lubrica	1	14,102	soil sub-sample
Zonitoides arboreus	1	14,104	rock sub-sample
Discus whitneyi	6	14,103	rock sub-sample
Ashmunella animasensis	1	14,105	rock sub-sample
unidentified (burned)	1	14,542	soil sub-sample
Hawaiia minuscula	3	14,543	soil sub-sample
Discus whitneyi	6	14,544	soil sub-sample

(Ash in soil samples at all sites [A-C]; evidence of past forest fire.)

BKL95-038B (split lot)

Cionella lubrica	9	14,113	soil sub-sample
Gastrocopta pilsbryana	8	14,110	soil sub-sample
Vertigo gouldii	1	14,109	soil sub-sample, burned
Vertigo hinkleyi	2	14,111	soil sub-sample
Hawaiia minuscula	10	14,106	soil sub-sample
Striatura meridonalis	4	14,107	soil sub-sample
Zonitoides arboreus	1	14,115	soil sub-sample
Discus whitneyi	34	14,114	soil sub-sample
Discus whitneyi	4	14,117	rock sub-sample
Euconulus fulvus	1	14,108	soil sub-sample
Ashmunella animasensis	2	14,116	rock sub-sample
Cionella lubrica	3	14,545	soil sub-sample
Vertigo gouldii	2	14,546	soil sub-sample
Vertigo hinkleyi	1	14,547	soil sub-sample, burned
Glyphyalinia indentata	1	14,548	soil sub-sample
Hawaiia minuscula	1	14,550	soil sub-sample
Striatura meridionalis	3	14,549	soil sub-sample
Discus whitneyi	11	14,551	soil sub-sample

BKL95-038C (split lot)

Cionella lubrica	1	14,118	soil sub-sample
Discus whitneyi	1	14,119	soil sub-sample
Discus whitneyi	5	14,121	rock sub-sample
Ashmunella animasensis	2	14,120	rock sub-sample
Gastrocopta pilsbryana	1	14,552	soil sub-sample
Glyphyalinia indentata	1	14,553	soil sub-sample
Discus whitneyi	6	14,554	soil sub-sample, burned

BKL95-041A (rock) **16 August 1995**

NM: Hidalgo County, Gray Ranch, north slope of Animas Peak, ca. 6600 ft. elevation. T31S, R19W, Sec. 21 (NE/SE). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Sonorella animasensis	1	14,555	rock sub-sample

No snails in leaf litter sub-sample (B).

BKL95-041 (B&C) (No snails in leaf litter or rock sub-samples for sites B and C.)

BKL95-1043 **17 August 1995**

NM: Hidalgo County, Gray Ranch, north slope of Animas Peak, Indian Creek Canyon, ca. 5925 ft. elevation. T31S, R19W, Sec. 16 (NW/SE). No GPS fix. Collector: B. K. Lang.

No snails in sub-samples A or B.

BKL96-116A (rock) **20 August 1996**

NM: Hidalgo County, Gray Ranch, east slope of the Animas Mountains, ca. 1.2 air miles east of Animas Peak, ca. 5790-5830 ft. elevation. T31S, R19W, Sec. 27 (NE/SW). N31°35′09.97″, W108°45′18.52″. Collector: B. K. Lang.

No snails found under rocks.

BKL96-116B (soil)

Species	# Specimens	UTEP #	Comments
Gastrocopta cochisensis	1	14,481	soil sub-sample
Gastrocopta dalliana dalliana	1	14,482	soil sub-sample
Striatura meridionalis	2	14,480	soil sub-sample

BKL96-117A (soil) **20 August 1996**

NM: Hidalgo County, Gray Ranch, east slope of the Animas Mountains, ca. 1.7 air miles east of Animas Peak, ca. 5850 ft. elevation. T31S, R19W, Sec. 26 (SW/SW). N31°34′58.57″, W108°45′17.76″. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta dalliana dalliana	3	14,467	soil sub-sample
Gastrocopta pilsbryana	11	14,468	soil sub-sample
Glyphyalinia indentata	1	14,465	soil sub-sample
Striatura meridionalis	1	14,466	soil sub-sample
Sonorella animasensis	11	14,469	soil sub-sample

BKL96-117B (rock) No snails found under rock sub-sample.

BKL96-118 **21 August 1996**

NM: Hidalgo County, Gray Ranch, northwest slope of the Animas Peak, ca. 8400 ft. elevation. T31S, R19W, Sec. 28 (NE/SW). No GPS fix. Collector: B. K. Lang.

No snails found in sub-samples A or B.

BKL96-119A (soil) **21 August 1996**

NM: Hidalgo County, Gray Ranch, north slope of the Animas Peak ca. 7800 ft. elevation (ca. 0.2 air mile ENE of Animas Peak). T31S, R19W, Sec. 28 (SE/NW). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Cionella lubrica	6	14,391	soil sub-sample
Gastrocopta pilsbryana	19	14,388	soil sub-sample
Vertigo gouldii	26	14,390	soil sub-sample
Vertigo hinkleyi	1	14,389	soil sub-sample
Radiodiscus millecostatus	98	14,395	soil sub-sample
Discus whitneyi	43	14,393	soil sub-sample
Glyphyalinia indentata	11	14,394	soil sub-sample
Hawaiia minuscula	19	14,392	soil sub-sample
Ashmunella animasensis	3	14,397	soil sub-sample
Ashmunella animasensis	1	-	live, stored in 95% EtOH
Euconulus fulvus	15	14,396	soil sub-sample

BKL96-119B (rock)

No snails found in sub-sample B.

Vertigo ovata

BKL98-045A **26 March 1998**

NM: Eddy County, Bounds Ranch, Blue Spring at artesian springhead. T24S, R26E, Sec. 33 (NW/NE). N32°10′47.10″, W104°17′55.08″. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta cristata	9	-	Retained as reference
Pupoides albilabris	7	-	Retained as reference
Punctum minutissimum	3	-	Retained as reference
Deroceras leave	1	-	Retained as reference

BKL98-045B **26 March 1998**

NM: Eddy County, Bounds Ranch, Blue Spring run immediately southeast of irrigation weir. T24S, R26E, Sec. 27. N32°11′05.05″, W104°17′02.04″. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta cristata	7	-	Retained as reference
Pupoides albilabris	6	-	Retained as reference
Deroceras leave	1	-	Retained as reference

BKL99-024 **29 April 1999**

NM: Eddy County, Bounds Ranch, Blue Spring at artesian springhead. T24S, R26E, Sec. 33 (NW/NE). N32°10′47.10″, W104°17′55.08″. Collector: B. K. Lang

No land snails observed.

BKL00-085 **12 June 2000**

NM: Socorro County, Alamosa Creek wetland complex at "Willow Spring". T08S, R07W, Sec. 31 (SW/SW; unsurveyed). Collectors: B. K. Lang and James N. Stuart.

Species	# Specimens	UTEP #	Comments
Vertigo ovata	2	14,346	live
Vertigo ovata	2	-	live, retained as reference

BKL00-090 **29 June 2000**

NM: Socorro County, Alamosa Creek wetland complex at Ojo Caliente. T08S, R07W, **Sec. 31 (SW/SW; unsurveyed).** Collectors: B. K. Lang, Scott Mackenzie, and Forrest ?.

Species	# Specimens	UTEP #	Comments
Vertigo ovata	6	14,356	live, immature
Vertigo ovata	5	-	live, retained as reference

BKL00-108 **27 July 2000**

NM: Socorro County, Alamosa Creek wetland complex, at "Willow Spring" and downstream ca. 250 meters along north streambank of Alamosa Creek beneath willow tree. T08S, R07W, **Sec.31 (?/?; unsurveyed).** Collectors: Brian K. Lang, James N. Stuart, and Scott Mackenzie.

Species	# Specimens	UTEP #	Comments
Vertigo ovata	6	-	live, retained as reference

BKL00-133 **23 August 2000**

NM: Eddy County, Bounds Ranch, Blue Spring at artesian springhead pool located just north of the rheocrene of the artesian source for Blue Spring. T24S, R26, Sec. 33 (NW/NE). ca. N32°10′47.10″, W104°17′55.08″. Collectors: B. K. Lang and Robert D. Larson.

Species	# Specimens	UTEP #	Comments
Vertigo ovata	4	14,403	live snails
Vertigo ovata	1	-	retained as reference

BKL00-134 **23 August 2000**

NM: Eddy County, Bounds Ranch, Blue Spring run immediately southwest of irrigation weir. T24S, R26, Sec. 27. N32°11′05.05″, W104°17′02.04″. Collectors: B. K. Lang and Robert D. Larson.

Species	# Specimens	UTEP #	Comments
Vertigo ovata	16	14,404	live snails
Vertigo ovata	1	-	retained as reference

Oreohelix pilsbryi

BKL99-055 **26 September 1999**

NM: Sierra County, Mineral Creek ca. 0.3 air mile south of Dreadnaught Mine (Oliver's Mine at Rounderville. No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Glyphyalinia indentata	3	14,503	loose in leaf litter
Zonitoides arboreus	1	14,504	loose in leaf litter
Discus whitneyi	14	14,505	loose in leaf litter
Oreohelix pilsbryi	38	14,502	loose in leaf litter

Ashmunella hebardi

BKL97-067A (soil) **22 May 1997**

NM: Hidalgo County, Big Hatchet Mountains, northwest slope of Hacheta Grande (Big Hatchet Peak), Chainey Canyon, ca. 6725 ft. elevation. T31S, R15W, Sec. 06 (NW/NW). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta ashmuni	57	14,401	soil sub-sample
Gastrocopta pellucida	100	14,402	soil sub-sample
Holospira crossei	15	14,398	soil sub-sample
Heliodiscus singleyanus	1	14,399	soil sub-sample
Ashmunella hebardi	1	14,400	soil sub-sample

BKL97-067B (rock)

Gastrocopta ashmuni	8	14,409	rock sub-sample
Gastrocopta pellucida	1	14,408	rock sub-sample
Vallonia perspectiva	8	14,410	rock sub-sample
Holospira crossei	4	14,405	rock sub-sample
Glyphyalinia indentata	1	14,411	rock sub-sample
Radiocentrum hachetanum	1	14,407	rock sub-sample
Ashmunella hebardi	6	14,406	rock sub-sample

BKL97-068A (soil) **22 May 1997**

NM: Hidalgo County, Big Hatchet Mountains, northwest slope of Big Hatchet Peak, Chainey Canyon, ca. 6725 ft elevation. T31S, R15W, Sec. 06 (NW/NW). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta ashmuni	1	14,416-B	soil sub-sample
Gastrocopta pellucida	21	14,415	soil sub-sample

Species	# Specimens	UTEP #	Comments
Gastrocopta pilsbryana	5	14,414	soil sub-sample
Pupilla sonorana	9	14,416-A	soil sub-sample
*Vertigo gouldii**	1	14,417	soil sub-sample
Vallonia perspectiva	172	14,413	soil sub-sample
Holospira crossei	48	14,418	soil sub-sample
Hawaiia minuscula	2	14,412	soil sub-sample
Radiocentrum hachetanum	1	14,420	soil sub-sample
Ashmunella hebardi	33	14,419	soil sub-sample

(*Species previously unreported from this mountain range).

BKL97-068B (rock) No snails found under rocks.

BKL97-069A (soil) **22 May 1997**

NM: Hidalgo County, Big Hatchet Mountains, northwest slope of Big Hatchet Peak, Chainey Canyon, ca. 6820 ft. elevation. T31S, R15W, Sec. 06 (NW/NW) No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta ashmuni	66	14,425	soil sub-sample
Gastrocopta pellucida	73	14,426	soil sub-sample
Pupilla sonorana	1	14,427	soil sub-sample
Vallonia perspectiva	56	14,424	soil sub-sample
Holospira crossei	19	14,421	soil sub-sample
Heliodiscus singleyanus	1	14,423	soil sub-sample
Hawaiia minuscula	1	14,422	soil sub-sample
Ashmunella hebardi	7	14,428	soil sub-sample

BKL97-069B (rock)

Gastrocopta ashmuni	2	14,430	rock sub-sample
Gastrocopta pellucida	1	14,431	rock sub-sample
Vallonia perspectiva	8	14,429	rock sub-sample
Holospira crossei	37	14,434	rock sub-sample
Radiocentrum hachetanum	1	14,433	rock sub-sample
Ashmunella hebardi	8	14,432	recent shells, rock sub-sample

BKL97-070A (soil) **22 May 1997**

NM: Hidalgo County, Big Hatchet Mountains, northwest slope of Big Hatchet Peak, Chainey Canyon, ca. 6808 ft. elevation. T31S, R15W, Sec. 06 (NW/NW). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta pellucida	1	14,435	soil sub-sample
*Vertigo gouldii**	1	14,439	soil sub-sample
Holospira crossei	2	14,437	soil sub-sample
Vallonia perspectiva	2	14,436	soil sub-sample
Ashmunella hebardi	3	14,438	immatures (recent)

(* Species previously unreported from the Big Hatchet Mountains. Remnants of periostracum suggest that the species may still persist in this range.)

BKL97-070B (rocks)

Gastrocopta ashmuni	1	14,443	rock sub-sample
Gastrocopta pellucida	3	14,444	rock sub-sample
Pupilla sonorana	1	14,442	rock sub-sample
Vallonia perspectiva	3	14,441	rock sub-sample
Holospira crossei	56	14,440	rock sub-sample
Radiocentrum hachetanum	1	14,446	rock sub-sample
Ashmunella hebardi	20	14,445	1 live, 4 immatures (recent)

BKL97-071A (soil) — 22 May 1997

NM: Hidalgo County, Big Hatchet Mountains, northwest slope of Big Hatchet Peak, Chainey Canyon, ca. 6800 ft. elevation. T31S, R15W, Sec. 06 (NW/NW). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Gastrocopta ashmuni	27	14,451	soil sub-sample
Gastrocopta pellucida	30	14,452	soil sub-sample
Pupilla sonorana	1	14,450	soil sub-sample
Vallonia perspectiva	9	14,449	soil sub-sample
Holospira crossei	34	14,453	soil sub-sample
Helicodiscus singleyanus	2	14,448	soil sub-sample
Hawaiia minuscula	3	14,447	soil sub-sample
Radiocentrum hachetanum	3	14,455	soil sub-sample
Ashmunella hebardi	12	14,454	recent & fossil shells

BKL97-071B (rock)

Species	# Specimens	UTEP #	Comments
Gastrocopta ashmuni	1	14,456	rock sub-sample
Gastrocopta pellucida	4	14,457	rock sub-sample
Holospira crossei	29	14,458	rock sub-sample
Radiocentrum hachetanum	2	14,459	rock sub-sample
Ashmunella hebardi	12	14,460	some recent, rock sub-sample
Ashmunella mearnsii	1	14,461	fossil, rock sub-sample*

(*Reduced dentition is suggestive of a variant of the *mearnsii-hebardi* complex; see Metcalf and Smartt [1997:60])

BKL00-066 (A &B) **8 May 1997**

NM: Hidalgo County, Big Hatchet Mountains, ENE facing canyon wall located ca. 1.67 air miles ENE of Big Hatchet Peak, ca. 5700-6000 ft. elevation. T30S, R15W, Sec. 32 (SW/SW). No GPS fix. Collectors. B. K. Lang and John P. Sherrod.

Species	# Specimens	UTEP #	Comments
Gastrocopta pellucida	14	14,367	soil sub-sample
Holospira crossei	11	14,369	soil & rock sub-sample
Radiocentrum ferrissi	5	14,370	soil & rock sub-sample
Radiocentrum hachetanum	2	14,371	soil & rock sub-sample
Glyphyalinia indentata	9	14,366	soil sub-sample
Ashmunella mearnsii	34	14,373	soil & rock sub-sample*
Thysanophora hornii	1	14,368	soil sub-sample
Sonorella hachitana hachitana	1	14,372	soil & rock sub-sample

(* 28 fresh shells, 6 fossils)

BKL00-067 (A&B) **9 May 1997**

NM: Hidalgo County, Big Hatchet Mountains, Sheridan Canyon, east-facing basalt scarp located ca. 1.0 air mile south and ca. 1.5 air miles west of Sheridan Wells (one peak south of Pilsbry's [1915] Site #3), ca. 6400 ft. elevation. T31S, R15W, Sec. 27 (NW/NW). No GPS fix. Collectors: B. K. Lang and John P. Sherrod.

Species	# Specimens	UTEP #	Comments
Gastrocopta ashmuni	27	14,374	soil sub-sample
Gastrocopta pellucida	2	14,375	soil sub-sample
Vallonia perspectiva	3	14,376	soil sub-sample
Holospira crossei	7	14,378	soil & rock sub-sample
Radiocentrum hachetanum	8	14,379	soil & rock sub-sample
Glyphyalinia indentata	1	14,381	soil sub-sample
Ashmunella mearnsii	3	14,380	soil & rock sub-sample
Thysanophora hornii	1	14,377	soil sub-sample

BKL00-068 (A&B) **10 May 1997**

NM: Hidalgo County, Big Hatchet Mountains, Sheridan Canyon, easternmost limestone scarp located immediately south of Thompson Canyon (ca. 1.5 air miles north of Sheridan Wells), ca. 6400 ft. elevation. T31S, R15W, Sec. 14 (NW/NW). No GPS fix. Collectors: B. K. Lang and John P. Sherrod.

Species	# Specimens	UTEP #	Comments
Gastrocopta ashmuni	23	14,348	soil sub-sample
*Gastrocopta dalliana dalliana**	3	14,347	soil sub-sample
Gastrocopta pellucida	28	14,349	soil sub-sample

Species	# Specimens	UTEP #	Comments
Holospira crossei	48	14,353	soil sub-sample
Glyphyalinia indentata	466	14,350	soil sub-sample
Radiocentrum hachetanum	13	14,351	fossil, rock sub-sample
Thysanophora hornii	214	14,352	soil sub-sample

(* Species previously unreported from the Big Hatchet Mountains.)

Ashmunella macromphala

BKL98-070 — 21 May 1998

NM: Luna County, Cooke's Range, northeast slope of Cooke's Peak, ca. 7630 ft. elevation. T20S, R08W, Sec. 25 (SW/SW). N32°31′13.20″, W107°43′46.61″. Collectors: B. K. Lang and Artie L Metcalf.

Species	# Specimens	UTEP #	Comments
Cionella lubrica	3	14,484	soil/talus sample
Glyphyalinia indentata	2	14,485	soil/talus sample
Striatura meridionalis	1	14,483	soil/talus sample
Ashmunella macromphala	2	14,486	recent, soil/talus sample
Ashmunella macromphala	6	-	*

(* 2 live, 3 fresh shells [immatures], and 1 fragmented fossil [adult]; all material retained as reference.)

BKL00-069 — 11 May 2000

NM: Luna County, Cooke's Range, OK Canyon, northeast-facing scree slope, ca. 6070 ft. elevation. T20S, R08W, Sec. 31 (SE/SW). No GPS fix. Collectors: B. K. Lang and John P. Sherrod.

Species	# Specimens	UTEP #	Comments
Ashmunella macromphala	15	14,497	recent & fossil shells

BKL00-070 — 11 May 2000

NM: Luna County, Cooke's Range, northeast-facing scree slope located ca. 1.75 air miles ENE of Cooke's Peak, ca. 6070 ft. elevation. T20S, R08W, Sec. 24 (SW/NW). No GPS fix. Collectors: B. K. Lang and John P. Sherrod

Species	# Specimens	UTEP #	Comments
Glyphyalinia indentata	8	14,498	leaf litter

BKL00-071 **12 May 2000**

NM: Luna County, Cooke's Range, northeast slope of Cooke's Peak, ca. 7600 ft. elevation. T20S, R08W, Sec. 25 (SW/SW). N32°31'13.20", W107°43'46.61". Collectors: B. K. Lang and John P. Sherrod.

Species	# Specimens	UTEP #	Comments
Cionella lubrica	3	14,499	-
Ashmunella macromphala	6	14,500	all recent shells

BKL00-072 **12 May 2000**

NM: Luna County, Cooke's Range, west-northwest facing scree slope located ca. 0.67 air miles ENE of Cooke's Peak, ca. 6600 ft. elevation. T20S, R08W, Sec. 25 (SW/NE). No GPS fix. Collectors: B. K. Lang and John P. Sherrod.

No snails found in leaf litter or under talus.

BKL00-171 **24 September 2000**

NM: Luna County, Cooke's Range, east-northeast facing scree slope located ca. 1.1 air miles ESE of Cooke's Peak, ca. 6560 ft. elevation T20S, R08W, Sec 31 (NW/NW). No GPS fix. Collector: B. K. Lang.

No snails found in leaf litter or under talus.

Sonorella todseni

BKL96-144 **12 September 1996**

NM: Doña Ana County, Doña Ana Mountains, unnamed mountain located immediately ENE of Doña Ana Peak, ca. 5600 ft. elevation. T21S, R01E, Sec. 19 (SW/SW) & 25 (NE/NE). No GPS fix. Collector: B. K. Lang.

No evidence of *Sonorella todseni* along transect surveyed; no voucher material collected.

BKL96-145 **12 September 1996**

NM: Doña Ana County, Doña Ana Mountains, north slope of Doña Ana Peak, ca. 5600-5800 ft. elevation. T21S, R01E, Sec. 25 (NE/NE). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Sonorella todseni	12	14,506	2 live, 8 recent shells

BKL99-042 **18 August 2000**

NM: Doña Ana County, Doña Ana Mountains, east slope of Doña Ana Peak ca. 0.2 air mile southeast of Doña Ana Peak, 5735 ft. elevation. T21S, R01E, Sec. 25 (NE/SE). N32°27′13.53″, W106°47′10.27″. Collector B. K. Lang

Species	# Specimens	UTEP #	Comments
Sonorella todseni	15	-	1 live, 14 recent shells

BKL99-043 **18 August 2000**

NM: Doña Ana County, Doña Ana Mountains, southwest slope of Doña Ana Peak ca. 0.2 air mile southeast of Doña Ana Peak, 5735 ft. elevation. T21S, R01E, Sec. 25 (NE/SE). No GPS fix. Collector: B. K Lang.

No sign of *Sonorella todseni* at site; no voucher material collected.

BKL99-044 **18 August 2000**

NM: Doña Ana County, Doña Ana Mountains, Doña Ana Peak, 5835 ft. elevation. T21S, R01E, Sec. 25 (SE/NE). N32°27′13.90″, W106°47′20.33″. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Sonorella todseni	21	-	"moderately" recent shells

BKL99-045 **18 August 2000**

NM: Doña Ana County, Doña Ana Mountains, east slope of unnamed peak located ca. 0.75 air mile west of Doña Ana Peak, 4800 ft. elevation. T21S, R01E, Sec 25 (NW/SW). N32°27′13.90″, W106°47′20.33″. Collector: B. K. Lang.

No sign of *Sonorella todseni* at site; no voucher material collected.

BKL99-046 **18 August 2000**

NM: Doña Ana County, Doña Ana Mountains, unnamed peak located ca. 0.75 air mile northwest of Doña Ana Peak, 5263 ft. elevation. T21S, R01E, Sec. 24 (SW/SW). No GPS fix. Collector: B. K. Lang.

No sign of *Sonorella todseni* at site; no voucher material collected.

BKL97-185 **8 September 1997**

NM: Hidalgo County, Gray Ranch, San Luis Mountains, eastern foothill of Lang Canyon, ca. 5890 ft. elevation. T34S, R19W, Sec. 22 (SE/NW). N31°19'02.50", W108°45'44.69". Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
*Gastrocopta dalliana dalliana**	1	14,493	soil sub-sample

(* Species previously unreported from the San Luis Mountains, Hidalgo County, NM.)

BKL97-186 **8 September 1997**

NM: Hidalgo County, Gray Ranch, San Luis Mountains, eastern foothill of Lang Canyon, ca 5970 ft. elevation. T34S, R19W, Sec 22 (NE/NW). N31°20'16.45", W108°45'37.25". Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Cionella lubrica	1	14,463-A	soil sub-sample
Gastrocopta pilsbryana	10	14,462	soil sub-sample
Sonorella sp.	4	-	recent shells*

(* Shells retained for conchological studies.)

BKL97-187 **8 September 1997**

NM: Hidalgo County, Gray Ranch, San Luis Mountains, northeast corner of Lang Canyon, ca. 6130 ft. elevation. T34S, R19W, Sec. 15 (SW/SW). N31°20'27.35", W108°45'32.24". Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Sonorella sp.	5	-	recent shells
Sonorella sp.	4	-	live*

(* Live specimens retained for dissection of genitalia.)

BKL00-053 **27 April 2000**

NM. Hidalgo County, Gray Ranch, San Luis Mountains, northeast corner of Lang Canyon, ca. 6130 ft. elevation T34S, R19W, Sec. 15 (SW/SW). N31°20'27 35", W108°45'32 24". Collectors: B. K. Lang, Artie L Metcalf, and Lance Gilbertson.

Species	# Specimens	UTEP #	Comments
Sonorella sp.	12	-	recent shells, burned*

(* Wildfire burned Lang Canyon in 1999 & 2000; evidence of burn to a depth of 4 ft. in talus rock.)

BKL00-165 **22 September 2000**

NM: Hidalgo County, Gray Ranch, San Luis Mountains, northeast corner of Lang Canyon, ca. 6130 ft. elevation. T34S, R19W, Sec. 15 (SW/SW). N31°20'27.35", W108°45'32.24". Collectors: B. K. Lang and Christopher Rogers.

Species	# Specimens	UTEP #	Comments
Sonorella sp.	4	-	empty shells, recent
Sonorella sp.	1	-	live

(* Live specimen retained for dissection of genitalia.)

Miscellaneous Land Snail Collections - Public Lands

BKL96-139 **6 September 1996**

NM: Taos County, Carson National Forest, Questa Ranger District, scree slope located ca. 0.5 air mile east of Gold Hill "peak", ca. 10,620 ft. elevation. N36°39'05.73", W105°26'34.12". Collectors: B. K Lang and Mark E. Gordon.

Species	# Specimens	UTEP #	Comments
Cionella lubrica	1	14,473	
Pupilla blandi	1	14,475	
Vertigo modesta	2	14,474	
Discus shimekii	16	14,472	
Zonitoides arboreus	1	14,471	
Microphysula ingersolli	30	14,470	

BKL96-140 **11 September 1996**

NM: Lincoln County, Lincoln National Forest, Cloudcroft Ranger District, Arcente Canyon, ca. 0.2 air mile west of West Side Road. T11S, R16E, Sec.20 (NW/NW). No GPS fix, Collectors: B. K. Lang and Artie L. Metcalf.

Species	# Specimens	UTEP #	Comments
Glyphyalinia indentata	1	14,476	
Zonitoides arboreus	1	14,477	
Oreohelix neomexicana	1	14,479	recent shell*
Ashmunella rhyssa	52	14,478	

BKL97-055 **30 April 1997**

NM: Chaves County, Bitter Lake National Wildlife Refuge, ca. 0 2 air mile west of Unit 7, ca. 3,500 ft. elevation. T10S, R25E, Sec. 20 (SE/SE). N33°25'78.65", W104°,24'57.89". Collector: B. K Lang.

Species	# Specimens	UTEP #	Comments
Lınisa texasiana	1	14,509	
Succinea sp	19	14,510	

BKL97-056 **1 May 1997**

NM: Chaves County, Bitter Lake National Wildlife Refuge, Sago Spring run, sink hole #31, ca. 3,500 ft. elevation. T10S, R25E, Sec. 05 (NW/SE). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Lınisa texasiana	10	14,511	

BKL97-139 **27 July 1997**

NM: Colfax County, Carson National Forest, Vermejo Unit, basalt outcrop located ca. 1.0 air mile south and 1.0 air mile of east of Beatty Lakes, ca. 7930 ft. elevation. N36°43'28.96", W105°,08'20.66". Collectors: B. K. Lang and Mark E. Gordon.

Species	# Specimens	UTEP #	Comments
Gastrcopta pılsbryana	2	14,490	
Vallonia cyclophorella	21	14,489	
Nesovitrea hammonis electrina	4	14,488	
Euconulus fulvus	2	14,487	

BKL98-050 **7 April 2000**

NM: Chaves County, Bitter Lake National Wildlife Refuge, south shore of Bitter Lake, ca. 3,500 ft. elevation. T10S, R25E, Sec. 04 (SW/SE). No GPS fix. Collector: B. K Lang.

Species	# Specimens	UTEP #	Comments
Linisa texasiana	3	14,556	found as drift

BKL98-113 **17 August 1998**

NM: Catron County, Gila Wilderness, West Fork Gila River, ca. 0.75 river mile downstream of ? ruins, ca. 3500 ft. elevation. T01S, R14W, Sec. 18. N33°14'46.41",W108°17"40.23" Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Ashmunella mogollonensis	3	14,508	

BKL99-017 — 4 May 2000

NM: Chaves County, Bitter Lake National Wildlife Refuge, Bitter Creek riparian corridor, ca. 300m upstream of flume, ca. 3,500 ft. elevation. T09S, R25E, Sec. 05 (SE/NW). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Linisa texasiana	12	14,507	

BKL99-051 — 8 September 1999

NM: Taos County, Carson National Forest, Questa Ranger District, east slope of the Bull of the Woods Mountain, ca. 10,945-11,000 ft. elevation. No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Vertigo modesta	1	14,495	
Discus shimekii	24	14,496	
Oreohelix strigosa	5	14,494	

BKL00-057 — 4 May 2000

NM: Chaves County, Bitter Lake National Wildlife Refuge, Dragonfly Spring riparian corridor, ca. 3,500 ft. elevation T09S, R25E, Sec. 32 (SE/SW). No GPS fix. Collector: B. K. Lang.

Species	# Specimens	UTEP #	Comments
Linisa texasiana	44	14,501	burned (Sandhill Fire)

Miscellaneous Land Snail Collections - Armendaris Ranch

BKL00-034/ALM-2596 — 3 April 2000

NM: Sierra County, southern Fra Cristobal Mountains, Massacre Gap, north slope of first mountain encountered entering the range from the east along gap road (south of road). Collectors: B. K. Lang and Artie L. Metcalf.

Species	# Specimens	UTEP #	Comments
Oreohelix caballoensis	11	14,314	fossils*
Oreohelix caballoensis	6	14,463-B	fossils*
Succinea sp.	1	14,315	

(* Specimens from hillslope colluvial deposits and crevices in limestone scarp.)

BKL00-035/ALM-2597 **3 April 2000**

NM: Sierra County, southern Fra Cristobal Mountains, Massacre Gap, double re-entrant north-facing canyon located ca 0.5 air mile west of Massacre Gap pass and 0.3 air mile south the gap road. Collectors: B. K. Lang and Artie L. Metcalf.

Species	# Specimens	UTEP #	Comments
Oreohelix caballoensis	34	14,312	fossils*
Succinea sp.	1	14,313	

(* Shells recovered from colluvial deposits along road cut switchbacks of 2-track leading south from Massacre Gap Road. Succineid recovered from leaf litter collected in the re-entrant canyon.)

BKL00-036/ALM-2598 **3 April 2000**

NM. Sierra County, southern Fra Cristobal Mountains, southwest part of southernmost Fra Cristobal Range along canyon leading east from Massacre Gap road and immediately north of Chalk Gap Canyon (unnamed canyon located ca. 0.3 air miles WNW of Chalk Gap) . Collectors: B. K. Lang and Artie L. Metcalf.

Species	# Specimens	UTEP #	Comments
Oreohelix caballoensis	140	14,311-A	fossils*
Succinea sp	1	14,311-B	

(* Shells recovered from colluvial deposits along road cut switchbacks of 2-track road at upper east end of canyon, ca. O.2 mile east of cattle drinker.)

BKL00-037 **4 April 2000**

NM: Sierra County, southern extent of northern Fra Cristobal Mountains, unnamed west-sloping canyon located immediately west of Silver Canyon, ca. 3.2 road miles north of juncture of Red Gap-Hackberry Canyon road with unnamed crest road. Collectors: B. K Lang and Artie L. Metcalf.

No snails observed under rock or recovered from leaf litter collections.

BKL00-038 **4 April 2000**

NM: Sierra County, southwest part of southernmost Fra Cristobal Range at Walnut Spring. Collectors: B. K. Lang and Artie L. Metcalf.

Species	# Specimens	UTEP #	Comments
Gastrocopta pellucida	1	14,464	

BKL00-039 **4 April 2000**

NM: Sierra County, southwest part of southernmost Fra Cristobal Range at unnamed spring located south of Hackberry Canyon Road. Collectors: B. K. Lang and Artie L. Metcalf.

Species	# Specimens	UTEP #	Comments
Glyphyalinia indentata	1	-	live, retained as reference*

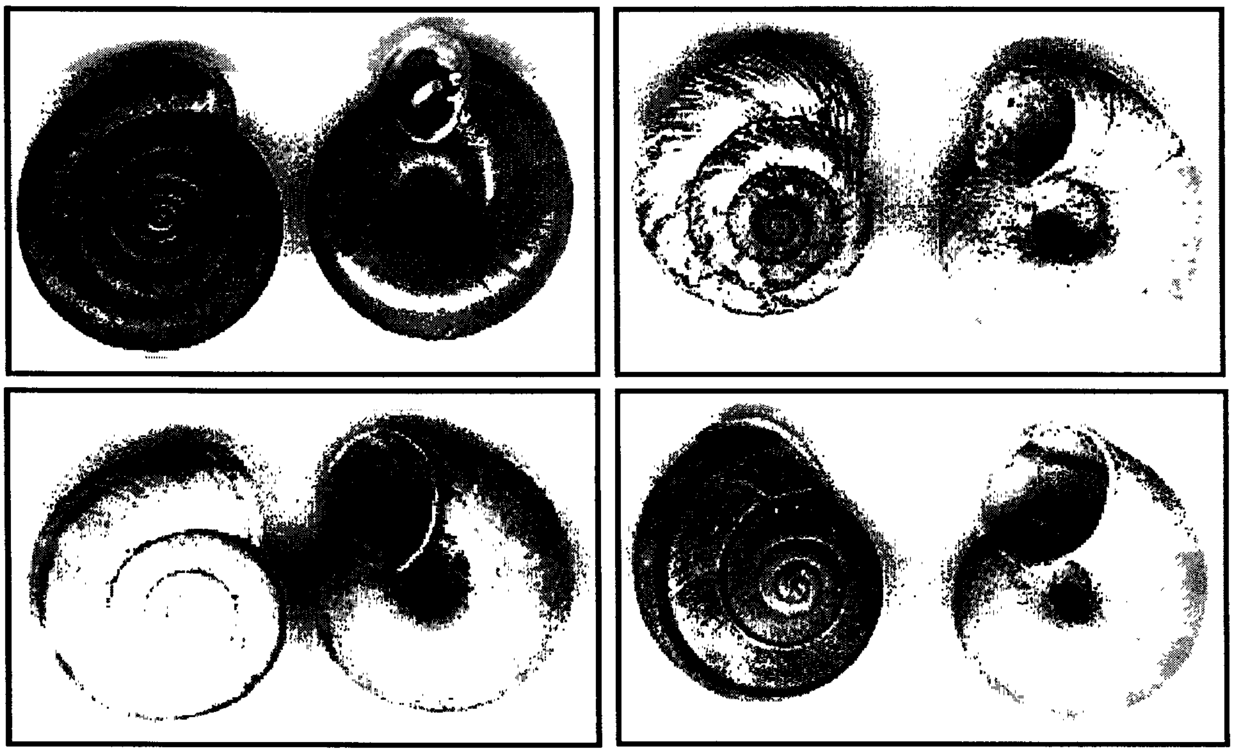
(* No snails found in leaf litter from unnamed spring located ca. 0.1 mile to the east along north side of Hackberry Canyon Road.)

Appendix C. Final report prepared by Dr. Robert Sullivan on state-listed and federal Species of Concern land snails of Doña Ana, Otero, and Socorro counties, New Mexico.

Inventory of Some Terrestrial Snails of Southern New Mexico, With Emphasis on State Listed and Federal Candidate Species of Doña Ana, Otero, and Socorro Counties

PREPARED FOR:

ENDANGERED SPECIES PROGRAM, NEW MEXICO DEPARTMENT OF GAME AND FISH
P.O. BOX 25112, SANTA FE, NM 87504



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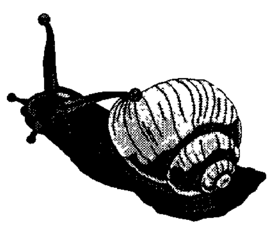
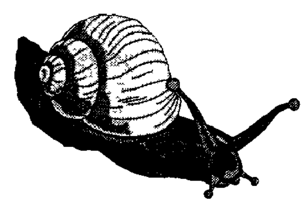
Contract No.:	**96 - 516.64 (Section 6 Grant E-36)**
Title of Professional Services Contract:	*Inventory of Terrestrial Snails of Southern New Mexico, With Emphasis on State Listed and Federal Candidate species of Doña Ana, Otero, and Socorro Counties*
Title of Report:	**Final Report**
Period Covered:	**July 1996 - 31 December 1997**
Date of Submission: 	**25 December 1997** 
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EXECUTIVE SUMMARY

This report provides results of a comprehensive field inventory of the current ecological and distributional status of selected species of terrestrial snails that occur in Doña Ana, Otero, and Socorro counties, New Mexico. The purpose of the inventory was to: (1) re-survey areas of known species occurrence; (2) delineate species geographic distribution and develop a database that can be used in a GIS framework; (3) delineate and quantify species-specific critical habitat and microhabitat characteristics; and (4) provide management mitigation recommendations based on evaluation of factors posing immanent threats for New Mexico land snails species, populations, and ecosystems. This research is complementary with the U.S. Department of Interior's National Biological Survey (NBS) inventory and monitoring objectives, which focuses on Federal Species of Special Concern (=C2), their distribution, abundance, habitat relationships, and threat assessment. Species of Special Concern requiring conservation status assessment in southern New Mexico include the: Doña Ana Mountains Talussnail (*Sonorella todseni* — C2); Koch's Woodland Snail (*Ashmunella kochii*); Oscura Mountain Land Snail (*Oreohelix neomexicana [=socorroensis*]); and newly discovered populations of the Oscura Mountains Talussnail (*Sonorella orientis*).

Fourteen microhabitat variables were measured at each site where live snails were found, which included both abiotic and biotic parameters: (1) ambient air temperature; (2) soil temperature; (3) soil humidity; (4) soil pH; (5) weather conditions (clear/cloudy); (6) elevation (m/ft); (7) slope (i.e., zero, north, south, east, west); (8) structural composition of the substrate; (9) dominant vegetation type; (10) distance to the nearest tree; (11) tree species; (12) distance to the nearest shrub; (13) shrub species; and (14) microhabitat type (i.e., leaf litter, rock, shrub/tree, talus).

Seven new geographic locations were found Koch's woodland snail (*Ashmunella kockii*) along the NE slope of Quartzite Mountain, NASA's White Sands Test Facility, head of Bear Canyon, Doña Ana County, New Mexico. Ecological characteristics are based on a sample of 236 individuals indicates an average elevation of 1,765.3 m (5,792 ft). Specimens were found primarily on mesic north (60.0%) and northeast-facing (40.0%) exposures, which had an average slope of 49.5 degrees. Dominant vegetation consisted predominantly of grasses (28.1%) and woodland (40.0%) plant species, followed by a few riparian (12.0%) and arroyo (20.0%) adapted plant plat species and associations. Percent over-story vegetation averaged 41.5% (range 25.0 to 50 %). Average distance to the nearest tree was 5.0 m (15 0 ft), to the nearest shrub was 4.6 m (14.0 ft), and to the nearest source of free water was >1000 m (3300 ft). Predominant microhabitat of sites consisted of a combination of leaf litter (43.5%), rock slabs (13.0%), and talus (43.5%). Dominant substrate at the sites was igneous parent materials (100.0%). Air temperature averaged 76.0° F; soil temperature averaged 66.6° F; soil pH averaged 7.4, and soil humidity was low (average = 2.1 on a scale of 1=dry to 5=wet). Plants species ranked by their abundance within a three (3) meter radius of the sample site included silk-tassel, followed by Gamble's oak, mountain mahogany, and one-seed juniper.

Recent new distributional and ecological information for *O. neomexicana* (=*socorroensis*) in the Oscura Mountains was summarized for 165 individuals sampled from 19 sites in the Oscura Mountains, WSMR, New Mexico. Average elevation was 2394.6 m (7856.6 ft). Specimens were found primarily on mesic north (77.8%) and northeast-facing (16.7%) exposures, which had an average slope of 51.6 degrees. Dominant vegetation consisted predominantly of piñon-juniper woodland (100.0%) plant species. Percent over-story vegetation averaged 40.5% (range 20.0 to 50 %). Average distance to the nearest tree was 6.3 m (19.0 ft), to the nearest shrub was 0.4 m (1.3 ft), and to the nearest source of free water was >1000 m (3,300 ft). Predominant microhabitat of sites consisted of a combination of leaf litter (42.2%), rock slabs (17.8%), and talus (40.0%). Dominant substrate was limestone (94.7%) and igneous (5.3%) rocks and ledges. Air temperature averaged 65.5 ° F; soil temperature averaged 58.5° F; soil pH averaged 7.3, and soil humidity was low (average = 2.2 on a scale of 1=dry to 5=wet). Plant species most commonly observed at each site where live snails were sampled included Gamble's oak, piñon pine, one-seed juniper, and mountain mahogany.

Recent new distributional and ecological information for live specimens of *S.orientis* from the Oscura Mountains shows that average elevation of the sites was 2560.0 m (8400 ft). Specimens were found primarily on mesic northwest- facing (100.0%) exposures, which had an average slope of 35.0 degrees. Dominant vegetation consisted of piñon-juniper woodland (100.0%) plant species. Percent over-story vegetation averaged 43.3% (range 30 to 50 %). Average distance to the nearest tree was 1.4 m (4.6 ft), to the nearest shrub was 1.4 m (4.6 ft), and to the nearest source of free water was >1000 m (3,300 ft). Predominant microhabitat of sites consisted of a combination of leaf litter (50.0%) and igneous lichen-covered rock ledges (50.0%). Dominant substrate was exclusively igneous lichen-covered rock (100.0%) and ledges. Air temperature averaged 68.0 ° F; soil temperature averaged 58.0° F; soil pH averaged 7.3, and soil humidity was high (average = 4 0 on a scale of 1=dry to 5=wet). This species appears to require wet, saturating, and foggy conditions for its emergence from igneous rock ledges with deep fishers and cracks.

Recent new ecological information from live specimens of *S. todseni* from the Doña Ana Mountains was summarized for 50 individuals sampled from five sites. Average elevation of the site was 1766.6 m (5760.0 ft). Specimens were found primarily on north (20.0%) and northeast (80.0%) facing exposures, which had an average slope of 49.0 degrees. Dominant vegetation consisted of desert-scrub and grassland (100%) plant species. Percent over-story vegetation averaged 42.3% (range 20 to 60 %) and live snails were commonly found in association with shade provided by low-growing juniper and shrubs species, and rarely in exposed sunny spots. Average distance to the nearest tree was 1.0 m (3.3 ft) and to the nearest shrub was 2.4 m (7.9 ft).

Characteristic critical habitat descriptions for land snails from southern New Mexico included: (1) N, E, NE facing slopes within mesic piñon-juniper-oak woodland, in association with limestone or igneous rock outcrops and cliff faces, and areas of damp leaf litter along the escarpment; (2) seams of talus boulders that stream from near the tops of peaks; (3) areas of damp leaf litter and brushy piñon-juniper-oak woodland along canyon walls; (4) grassy areas bordering riparian habitat; (5) mesic forested areas adjacent to lush wet meadow; (6) north-facing slopes of basaltic talus and deep leaf litter of Gambel oak leaves; (7) brushy areas under stones in leaf litter; (8) piñon-juniper woodland, dead juniper branches, deep leaf liter; (9) brushy hillsides and low scraps bordering brushy riparian woodland; (10) leaf litter in wooded brushy areas along canyon walls of arid mountain ranges; (11) damp areas under wood, logs and damp debris; (12) open forest with calcareous and igneous bedrock, red granite and rhyolitic talus; (13) soil and leaf litter filling interstices of igneous talus; (14) riparian fringe forest, along creek at base of canyon walls, with oak leaf litter and angular igneous stones; (15) scarp in low arid habitat supporting forbs, shrubs, piñon, juniper, and oaks; (16) slopes and bajadas under shelter of large stones, fallen yuccas, or caudices of sotol; (17) ledges on walls of canyon among ponderosa pine, piñon, and oak vegetation; (18) deciduous forest on steep sides of canyon, under volcanic rock rubble and talus

All development, construction, grazing, or other potentially adverse environmental impacts associated with civilian and military activities should be evaluated for areas of potential critical habitat for terrestrial gastropods as delineated by the above key words. Evaluations should be carefully inventoried by a qualified biologist, particularly when site data are accompanied by evidence of dead snail shells or previous distributional records of terrestrial gastropods. Suggested recommendations for mitigation of a variety of environmental effects, as well as recommendations for additional surveys also are provided.

1 *INTRODUCTION*

1.1 OBJECTIVES

- Document the current ecological and distributional status of selected species of terrestrial snails that occur in Doña Ana, Otero, and Socorro counties, New Mexico; and survey areas of potential occurrence that are poorly known malacologically.

- Re-inventory areas of known species occurrence.

- Delineate species geographic distribution and develop a database that can be used in a GIS framework.

- Delineate and quantify species-specific critical habitat and microhabitat characteristics.

- Provide management recommendations based on evaluation of factors posing immanent threats for New Mexico land snails species, populations, and ecosystems.

This research is complementary with the National Biological Survey (NBS) inventory and monitoring objectives, by focusing on Federal Species of Special Concern (=C2), species abundances, distributions, habitat relationships, and threat assessment. Data collected will provide needed biological information for resource managers and policy makers to guide objective stewardship of New Mexico's indigenous terrestrial mollusk fauna.

1.2 JUSTIFICATION

Resource agencies responsible for stewardship of New Mexico's endemic biota and unique biotic ecosystems require biological information on plants and animals that will serve the varied public interests in natural resources and landownership, while simultaneously pursuing economic development. Terrestrial mollusks are perhaps the least known of all the faunistic elements indigenous to the mosaic of biotic communities found throughout the Desert Southwest. In fact, the systematics, distribution and abundance, population trends, snail activity patterns, reproductive cycle, longevity, critical microhabitat requirements, habitat-areas relationships, and immediate response to disturbance of endemic New Mexico land snail populations are very poorly known even among resource managers and professional malacologists.

Resource agencies have no baseline information from which to characterize endemic land snail populations, recognize losses, or anticipate environmental threats associated with degradation of terrestrial ecosystems in the Southwest. Identification of threats to New Mexico's land snail fauna is essential for public and private resource managers and policy makers. Proximate threats to land snail populations include habitat loss and fragmentation owing to silvicultural practices, grazing of forests and woodlands, mining, natural disturbances including fire, and environmental perturbations (e.g., global warming, acid rain, etc.).

Fragmentation and loss of critical habitat in small populations of relict species is widely believed to have deleterious affects on genetic variability resulting in extirpation of portions of the historical range or extinction of endemic species as a whole. Habitat fragmentation increases the distance between snail sub-populations thus altering significantly the meta-population structure, particularly in narrow endemics of low vagility and restricted geographic distribution, or critical habitat requirements. As land snail populations are eliminated and dispersal distances are increased, demographic and genetic constraints diminish the ability of local populations to respond to natural environmental variation and anthropogenic habitat alteration. These negative affects of habitat fragmentation and loss have both genetic and demographic implications that are well understood in theory, but poorly documented empirically. This is partly because genetic changes in small isolated populations occur rapidly and are rarely monitored. Similarly, demographic changes are often pronounced and difficult to observe. Moreover, the low mobility and small home ranges of snails suggest that they would be likely candidates to reflect forest and woodland patch habitat dynamics. Identifying which species that have disproportionate effects in the ecosystem is and important research goal in conservation ecology. Management planning for these species should be done with particular care because any mistakes could have community-wide effects.

For example, terrestrial and aquatic mollusks concentrate toxic chemicals in soft body parts as a result of their trophic specializations (i.e., decomposers of leaf litter, filter feeders). As such, land snails may function as sensitive "biological indicator" organisms; thereby, facilitating assessment of "ecosystem health" and biotic diversity of New Mexico life zones in relation to current environmental conditions. Land snails are important not only numerically, but also ecologically, because of their role in nutrient cycling as detritivores, herbivores, and carnivores. Despite their diversity and ecological importance, most of the published information on terrestrial mollusks in the Southwest concerns systematics; relatively little is known about terrestrial mollusc ecology.

Conservation status assessment and population monitoring of New Mexico land snails is timely and will contribute to the establishment of an ecological baseline for evaluation of broad-scale environmental trends and assessment of potential impacts on species, genetic and ecosystem diversity due to ongoing environmental degradation. This concern becomes particularly germane considering ongoing and future deposition of air contaminants in the Border lands of southern New Mexico where several endemic federal candidate land snails only occur at single sites.

1.3 BACKGROUND AND LITERATURE REVIEW

New Mexico's indigenous land snail fauna is inherently of academic interest to studies of historical biogeography, paleoecology, and geology of the Desert Southwest. Pleistocene refugial ecosystems of New Mexico represent an integral and irreplaceable link in the unique evolutionary history of the Intermontane, Basin, and Range plateaus of the northern Chihuahuan Desert (Sullivan 1994). Tectonic events (rifting and blockfaulting) associated with the Rio Grande Rift resulted in geographic isolation of many New Mexico land snails; especially the larger snails that now occur as geographically disparate endemic species or subspecies of relict montane refugia (Metcalf 1977). Extensive faunal exchange during the ensuing Quaternary is evidenced by both the fossil record and extant snail populations, which demonstrate latitudinal and altitudinal movements of intermediate and lower elevation mollusk faunas (Metcalf and Smartt 1997).

Thus, insularization of land snail populations at higher elevation with some interchange at lower elevations has resulted in a heterogeneous assemblage of taxa with diverse origins and varied patterns of distribution in the state. Speciation by isolation on mountain tops has resulted in a high degree of endemicity of New Mexico land snails. Many insular snail populations are characterized by unique gene pools and species assemblages, and small effective population sizes inhabiting discontinuous point-habitat patches. (Sullivan and Smartt 1995). Most of these relictual mesic populations occur only along sparsely vegetated montane canyons, ridges, talus slopes, and rock outcrops, which provide microhabitats critical to the survival of these disjunct species (Smartt and Sullivan 1990, Sullivan and Smartt 1995).

Relict Pleistocene land snail populations of the northern Chihuahuan Desert have diverged genetically from their southern Rocky Mountain and Mexican ancestors. Recent population genetic analyses of terrestrial woodland snails (genus *Ashmunella*) have quantified microhabitat and distribution patterns, and elucidated genetic diversity and biogeographic relationships among several species and allopatric populations from the San Andres, Oscura, and Sacramento mountains, New Mexico (Sullivan and Smartt 1995).

New Mexico's terrestrial mollusks consists of approximately 86 species. Metcalf and Smartt's (1988) annotated checklist of New Mexico land snails documented 19 families, 114 species and 27 subspecies. However, significant areas throughout New Mexico have not been adequately inventoried, and numerous populations documented during the past 20 years require re-inventory for population monitoring and threat assessment (Metcalf and Smartt 1997).

There has been no status change in the Federal Register for six land snail species of Special Concern that occur in New Mexico. Four of seven land snails species of Special Concern are endemic to New Mexico and occur only at the species' type locality, which can be considered habitat critical to the survival of these species. These restricted land snail populations and point-habitats merit annual population monitoring to ensure their continued existence. Currently, such a population-habitat monitoring protocol does not exist. Exploratory field inventory of suitable habitats in close proximity to these type localities and in potential habitats of nearby mountain ranges are needed to assess the population status of these land snail Species of Special Concern. Such a systematic survey protocol will also provide additional inventory data for several non-candidate land snail species that are known from only one New Mexico collecting local (Metcalf and Smartt 1988).

1.4 LOCATION OF STUDY

Species of Special Concern (Candidate and non-candidate taxa) requiring conservation status assessment in southern New Mexico (i.e., Doña Ana, Otero, and Socorro counties) include: Doña Ana County—Doña Ana Mountains Talussnail (*Sonorella todseni*—C2), southern San Andres Mountains—Koch's Woodland Snail (*Ashmunella kochii*); Otero County (numerous localities); Socorro County— Oscura Mountain Land Snail (*Oreohelix neomexicana* [=*socorroensis*]); and the Oscura Mountain Talussnail (*Sonorella orientis*).

1.5 PRODUCTS

A report has been generated that summarizes: (A) results of the survey, including population status (abundance and distribution), habitat and microhabitat quantification, identification of existing and potential threats, and recommendations for legal status assessment of federal candidate land snails of Southern New Mexico; (B) and inventory site localities for use in GIS mapping and a photographic record (35 mm slide) of habitat conditions; and (C) samples of voucher specimens that have been deposited into the Invertebrate Collection at the New Mexico Museum of Natural History and Science, as well as a small reference collection presented to the Environmental Services Division, White Sands Missile Range.

2 METHODS AND MATERIALS

2.1 ECOLOGICAL ANALYSIS

Fourteen microhabitat variables were measured at each site where live snails were found (Smartt and Sullivan 1990; Sullivan and Smartt 1995); these environmental variables included both abiotic and biotic parameters: Abiotic Environmental Characteristics: (1) ambient air temperature; (2) soil temperature; (3) soil humidity; (4) soil pH; (5) weather conditions (clear/cloudy); (6) elevation (m/ft); (7) slope (i.e., zero, north, south, east, west); and (8) structural composition of the substrate (i.e., igneous, limestone, alkali, sandstone); Biotic Environmental Characteristics: (1) dominant vegetation type (i.e., grass, woodland, forest, riparian, and arroyo plant species); (2) distance (m) to the nearest tree; (3) tree species; (4) distance to the nearest shrub (m); (5) shrub species; and (6) microhabitat type (i.e., leaf litter, rock, shrub/tree, talus).

2.2 STATISTICAL ANALYSES MICROHABITAT ASSESSMENT

BIOΣSTAT I and II computer packages (Pimentel and Smith 1986*a* 1986*b*) were used for all statistical analyses. Seven abiotic and six biotic environmental variables were measured at each site where live terrestrial snails were found. These measures of microhabitat are considered optimal for terrestrial snails inhabiting arid woodland and forest biotic communities in southern New Mexico in general. Because terrestrial snails appear specific in their microhabitat requirements, these summary data provide a baseline for current and future environmental concerns regarding species and ecosystem management plans for terrestrial gastropods in southern New Mexico. Specific ecological and microhabitat information for each species of terrestrial gastropod is provided in each taxonomic account.

3 RESULTS

3.1 SPECIES SPECIFIC ECOLOGY

3.1.1 *Ashmunella kochii kochii* (Koch's Woodland Snail)

3.1.1.1 Type locality

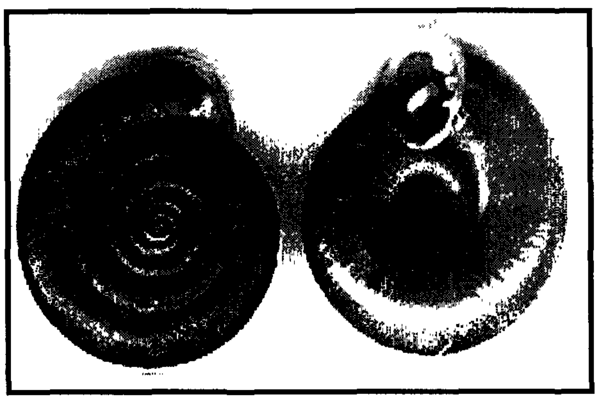

Figure 1.— Scanned image of *Ashmunella kochii* from Quartzite Mountain, Doña Ana County, New Mexico.

The Type Locality of this endemic subspecies was originally described from Black Brushy Mountain in the southern San Andres Mountains, Doña Ana County, New Mexico (Metcalf and Smartt 1997 and 1997), where it is restricted to talus accumulations of limestone rock on the higher northeastern slopes of Black Mountain; east along little San Nicolas Canyon north of Goat Mountain; south of Goat Mountain and west of Red Spring; and south of Salt Canyon and northwest of Black Brushy Mountain, San Andres Mountain Range (Metcalf and Smartt 1977, Sullivan and Smartt 1995; Metcalf and Smartt 1997).

3.1.1.2 Distribution

Ashmunella kochii comprises three subspecies, two of which are restricted to the San Andres Mountains, WSMR, New Mexico: (1) *A. kochii kochii* (the nominal race from Black Brushy Mountain and Goat Mountain within the greater San Andres Mountain Range; and Little San Nicolas Canyon (Sullivan and Smartt 1995); (2) *A. k. sanandresensis* from San Andres Peak, immediately north of Black Brushy Mountain, and (3) *A. k. caballoensis* from the Caballo Mountains, west of the San Andres Mountains. The subspecies of *A. kochii* in the Caballo Mountains is endemic to north-facing slopes of Brushy Mountain west of the central part of the WSMR on high northern slopes (Metcalf and Smartt 1977, 1997).

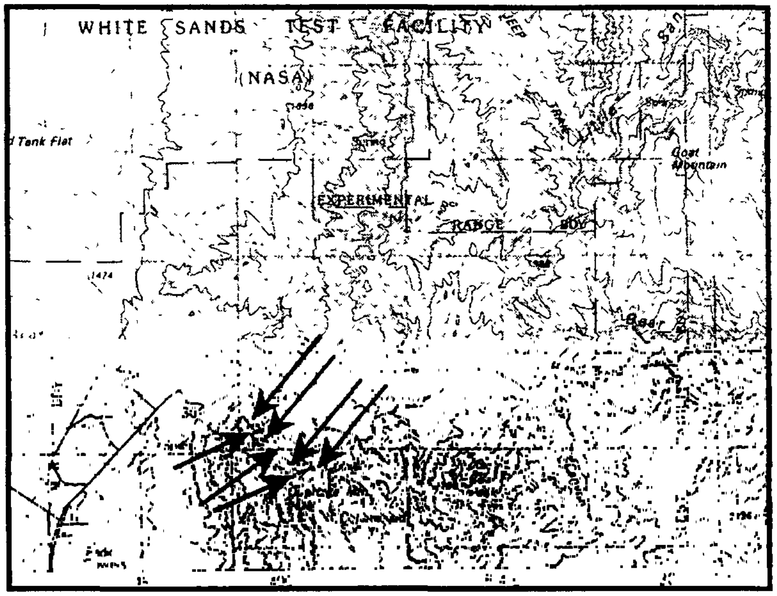

Figure 2.—Distribution of *Ashmunella kochii* on Quartzite Mountain, head of Bear Canyon, Doña Ana County, New Mexico.

In addition, seven (7) new sites have recently been found at the mouth of Bear Canyon, just east of the White Sands Test Facility (NM: Doña Ana County, NASA's White Sands Test Facility (WSTF), NE slope of Quartzite Mountain, south side head of Bear Canyon (Figure 1). Abundant shells and numerous live animals were observed and photographed along with their characteristic habitat, which consisted of extensive igneous (not limestone) accumulations of large talus boulders within mesic Chihuahuan desert-scrub vegetation. Pit depth for sampled populations ranged from 0.6 to 1.5 m (2 - 4 ft), depending on moisture conditions, shade and exposure.

Quartzite Mountain lies just east of WSTF and reaches a height of 2,100 m (6,800 ft; Figure 2). Uppermost alluvial layers consists of silt, sand, gravel, boulders and locally cemented conglomerates. Alluvium ranges from 10 to 90 m (35 - 325 ft) thick adjacent to the mountain, to greater than 610 m (2,000 ft) thick in the basin floor. Surface of the uppermost alluvial layer is a sandy silt containing some gravel and occasional boulders. Gravel and boulder content gradually increase with depth. Average annual precipitation is 36 cm (14 in); the maximum is about 48 cm (19 in). Most precipitation occurs in the summer, and an average of about 1.3 cm(0.5 in) or less occurs each month from January through May. Mean monthly humidity remains below 50 percent throughout the year. The lowest humidity occurs in the spring months of April through June, and ranges from about 40 percent in the morning to 20 percent in the afternoon. During the remainder of the year the range is approximately from 60 to 30 percent, morning to evening.

Major vegetation within the area included a combination of woody shrubs and grasses characteristic of the Chihuahuan Desert-scrub Biotic Community (Brown1982). Major plant communities include Chihuahuan Broadleaf Deciduous Desert Scrub (4222); Chihuahuan Foothill-Piedmont Desert Grassland (5221); Chihuahuan Broadleaf Evergreen Desert Scrub (4221); Rocky Mountain Montane Scrub and Interior Chaparral (4110); and Rocky Mountain-Great Basin Open Conifer Woodland (3122). All vegetation designations follow data compiled by the New Mexico Gap Analysis Project (GAP).

Bear Creek is the largest canyon draining the WSTF site. Bear Creek cuts through the San Andres Mountains and is characterized by small limestone, silt-stone, and sandstone hills. Smaller tributaries originate within these hills and flow into the valley bottom. Lower elevations, closer to the creek, contain both low and high west gravel ridges. Immediately adjacent to Bear Creek are broad, alluvial terraces or benches that widen near the mouth of the canyon. Slopes in this mountain zone range from 8 to 50 percent and elevation ranges from 1,640 to 1,797 m (5,000 - 5,480 ft).

Dominant soil types consisted of a combination of igneous cobble (talus, 14.1%), rock (limestone bedrock, 20.9%), and sand (2.5%). The predominant species of shrubs were agave (*Agave palmeri*, 2.5%), Louisiana white sage (*Artemisia ludoviciana*, 2.5%), California brickel bush (*Brickelia californica*, 1.3%), senna (*Cassia bauhiniodes*, 4.7%), mountain mahogany (*Cerocarpus montanus*, 1.3%), sotol (*Dasylirion wheeleri*, 2.5%), feather plume (*Dalea formosa*, 7.2%), turk's cap (*Echinocactus horizonthalonius*, 1.3%), tarbush (*Flourensia cernua*, 3.4%), ocotillo (*Fouquieria splendens*, 3.8%), broom Snakeweed (*Gutierezia sarothrae*, 2.5%), creosotebush (*Larrea tridentata*, 5.6%), desert four o'clock (*Mirabilis multiflora*, 1.3%), beargrass (*Nolina microcarpa*, 2.5%), pancake prickly pear (*Opuntia phaeacantha*, 1.3%), purple prickly pear (*Opuntia violaceae*, 0.9%), honey mesquite (*Prosopis glandulosa*, 2.5%), squaw bush (*Rhus trilobata*, 1.3%), and banana yucca (*Yucca baccata*, 1.9%). The most common species of grasses were six weeks grass (*Bouteloua barbata*, 1.9%) and alkali sacaton (*Sporobolus airoides*, 10.6%). Additionally, white-flowering visnagita (*Neolloydia intertexta* var. *dasyacantha*), State of New Mexico "Plant Taxa Considered, But "Not Included" (L4-1) was observed in this area. Most individual plants were observed on the lower northeast facing slope of Quartzite Mountain in soil associated with *S. airoides* [1]

3.1.1.3 Habitat

Koch's woodland snail inhabits higher, more mesic, elevations within the piñon-juniper woodland macro-habitat. Dominant topography consists of rock seams in steep canyons and cliffs associated with mesic vegetation and abundant shade. Because this species is an excellent indicator of biological diversity and quality of natural habitat, it is recommended that these populations be monitored on a yearly basis.

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1 Sullivan and Houde-Nethers. 1995. *Threatened and Endangered Species Survey Of the National Aeronautics and Space Administration's White Sands Test Facility (WSTF), New Mexico.*

Because of the isolated nature of these populations, it not anticipated that future development in areas of critical habitat will occur at WSTF. A primary concern, however, would be construction of an access roads or facilities on top of Quartzite Mountain that would result in rock-roll and deposition of earth and construction material over the edge and down slope into areas inhabited by snails. The ecological and microhabitat data for these new sites are summarized below.

Ecological characteristics are based on a sample of 236 individuals of *Ashmunella kochii kochii* collected from ten different sites along the northern, northeastern, and eastern slopes of Quartzite Mountain, southern San Andres Mountains, New Mexico are summarized in Appendix C. Average elevation of the sites was 1,765.3 m (5,792 ft). Specimens were found primarily on mesic north (60.0%) and northeast-facing (40.0%) exposures, which had an average slope of 49.5 degrees. Dominant vegetation consisted predominantly of grasses (28.1%) and woodland (40.0%) plant species, followed by a few riparian (12.0%) and arroyo (20.0%) adapted plant plat species and associations. Percent over-story vegetation averaged 41.5% (range 25.0 to 50 %). Average distance to the nearest tree was 5.0 m (15.0 ft), to the nearest shrub was 4.6 m (14.0 ft), and to the nearest source of free water was >1000 m (3300 ft). Predominant microhabitat of sites consisted of a combination of leaf litter (43.5%), rock slabs (13.0%), and talus (43.5%). Dominant substrate at the sites was igneous parent materials (100.0%). Air temperature averaged 76.0° F; soil temperature averaged 66.6° F; soil pH averaged 7.4, and soil humidity was low (average = 2.1 on a scale of 1=dry to 5=wet). Summary statistics for plant species most commonly observed at each site where live snails were sampled is provided in Appendix D. Data summarized represents species of plants ranked by their abundance within a three (3) meter radius of the sample site. Silk-tassel, followed by Gamble's oak, mountain mahogany, and one-seed juniper were the most abundant plants within three (3) meters of the sites.

Additional sampling of this species should be conducted along the north and northeast flanks of Bear Peak, and in areas of typical habitat along the boarder of WSTF and WSMR in the vicinity of Black Mountain, WSMR. The taxonomic affinities, as well as distributional relationships, among the species complex also are not resolved (see Metcalf and Smartt 1997).

3.1.2 ***Oreohelix neomexicana*** **(Oscura Mountain Land Snail)**

3.1.2.1 Type Locality

New Mexico, Canyon Diablo near Rowe, San Miguel Co. (Pilsbry 1905). *Oreohelix neomexicana* was originally described as a subspecies of *O. yavapai* (Pilsbry 1905); the nominal subspecies of which occurs in north-central Arizona. Recently, Metcalf and Smartt (1997) elevated *neomexicana* to species status on the basis of conchological differences (see Pilsbry 1939:520) and because of a geographical hiatus of more than 320 km (200 mi) between known populations of *yavapai* and *neomexicana*.

In addition, Metcalf and Smartt (1997) relegated *O. y. compactula* Cockerell 1905 and *O. socorroensis* Pilsbry 1905, to the synonymy of *O. neomexicana*. However, although the name *socorroensis* has page precedence over *neomexicana* (Pilsbry 1905), Metcalf and Smartt (1997) choose the name *neomexicana* because this taxon has an identifiable type locality, whereas *socorroensis* does not. The type locality of *socorroensis* is given as "Negra Mountains, Socorro County" in its description; however, Pilsbry could not locate the type locality or the collector of the type series. Metcalf and Smartt (1997) have been unable to identify any "Negra Mountains " in New Mexico; and they suspect that the type specimen of *socorroensis* is a fossil.

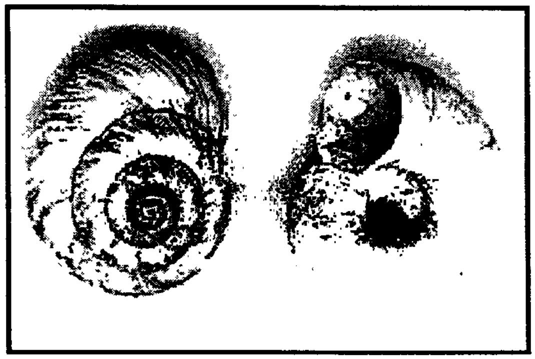

Figure 3.—Scanned image of *Oreohelix neomexicana* (=*socorroensis*) from the Oscura Mountains, White Sands Missile Range New Mexico.

3.1.2.2 Distribution

Living populations of *Oreohelix neomexicana* (=*socorroensis*) are found from north-central New Mexico, in foothill regions of the southern Sangre de Cristo and Jemez Mountains, southward through the Sandia and Manzaño Mountains, to Gallinas Peak in northwestern Lincoln County (Crews 1981; Metcalf and Smartt 1997). Recently, Richard A. Smartt and Robert M. Sullivan found a disjunct endemic population of this species living farther to the south along the crest of the Oscura Mountains, Socorro County (Figure 3). The Oscura Mountain population of *Oreohelix neomexicana* (=*socorroensis*) is listed as a State of New Mexico Sensitive (S) species, but the systematic, evolutionary, and taxonomic relationships among species of *Oreohelix* and disjunct populations of *Oreohelix neomexicana* (=*socorroensis*) are clearly unresolved and in need of future study.

The Oscura Mountains in central New Mexico form part of the northern margin of the Tularosa Basin centered on alkali Lake Lucero. They are separated (2.5 km) from the San Andres Mountains to the south by Mockingbird Gap at 1670-m elevation, and from southern edge of the Sandia-Manzaño mountains (90 km) by a broad expanse of Great Basin coniferous woodland macro-habitat (Brown1983). The Oscura Mountains are a north-south tending, generally flat-topped range 40 km long and 6-10-km wide. The escarpment faces west with the corresponding long piedmont slope leading to the bottom of the northern Jordada del Muerto basin. To the east, slopes gently dip onto the basin fill of Tularosa Basin.

Highest elevation in the range is 2,880 m above mean sea level at South Oscura Peak. Peak elevations along the crest of the range decrease northward to North Oscura Peak at an altitude of 2,800 m. In a distance of 1.6 km W South Oscura Peak, the altitude drops to 2,067 m at the basin floor. Located 10 km W South Oscura Peak in the Jornada del Muerto is the Trinity Site National Historic Landmark at an elevation of 1,633 m. The steep, west-facing escarpment of the Oscura Mountains is located in the upper member of the Pennsylvanian Madera Formation, which consists of stratigraphically complex and intermixed limestone, sandstone, and shale ranging in age from Cambrian to Quaternary. These beds strike north-northwesterly and dip 15° to the east.

Plant remains from fossil woodrat and porcupine middens in the Sacramento Mountains to the southeast and San Andres Mountains to the southwest, have documented major changes in plant communities in the vicinity of the Oscura Mountains during the past 18,000 years. At upper elevations, mixed conifer forest evolved into a juniper-oak woodland during Early and Middle Holocene (10,000 years ago). Woodland macrohabitat shifted toward grassland during the Late Holocene (4,000 years ago); and at lower elevations, juniper-oak woodlands evolved into desert grassland during Middle Holocene and to a Chihuahuan desert-scrub by Late Holocene.

The Oscura Mountains consist of steep and rugged mountainous terrain with frequent surface rock outcrops. Average annual precipitation at North and South Oscura Peaks has an expected maximum of 41cm (16 in). Summers are cool, with maximum temperature of 25° C and a nighttime low of 9° C. Winters are cold with an expected mean-maximum temperature of 8° C in January and an expected mean-minimum temperature of -8° C; the frost-free season averages 150 days. Average annual sunshine is 3,500 h, or 80% of the possible amount, and is fairly evenly distributed throughout the year. Relative humidity is low. Average annual wind speed is 9.8 km/h and is stronger in spring and lighter in autumn. The prevailing wind is

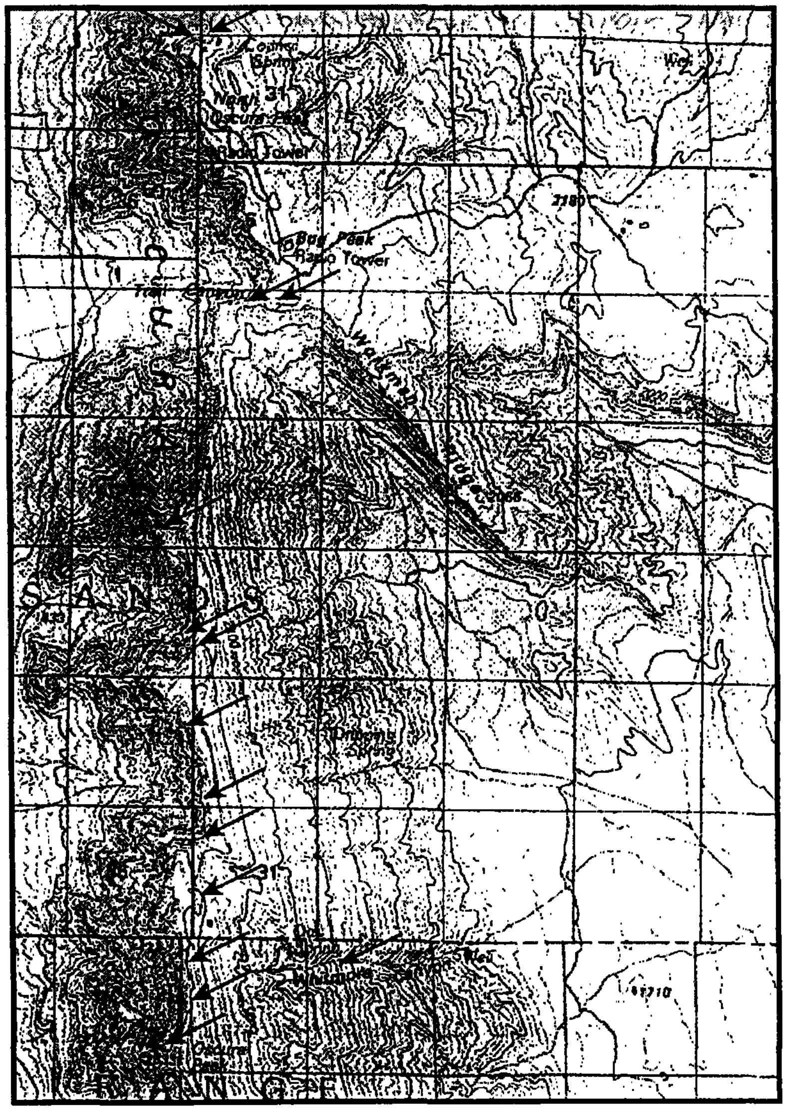

Figure 4.—Distribution of *Oreohelix neomexicana* (=*socorroensis*) in the Oscura Mountains, White Sands Missile Range, New Mexico.

from the west. Strongest gusts have been estimated a 131 km/h from the southwest.

The Oscura Mountains lie within a dense, mature piñon-juniper community. A few areas within the community are exposed-limestone bedrock and are poorly vegetated. Dominant trees are pinon (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*); whereas principal shrub species were mountain mahogany (*Cercocarpus montanus*), antelope bush (*Purshia tridentata*), four-wing saltbush (*Atriplex canescens*), and oak-brush (*Quercus* sp.). In open areas and in regions of sparse undercover, the predominant species are side-oat grama (*Bouteloua curtipendula*), black grama (*B. eriopoda*), blue grama (*B. gracilis*), Chihuahua lovegrass (*Eragostis erosa*), and soaptree yucca (*Yucca elata*).

3.1.2.3 Habitat

Contrary to the interpretation of Metcalf and Smartt (1997:46), *Oreohelix neomexicana* (=*socorroensis*) does not tolerate a broad variety of habitats in the Oscura Mountains; rather, live populations of this species occur only in specific microhabitats associated with pinon-juniper-oak vegetation and primarily north and northeastern exposures (Figure 4). Throughout its range, however, this species appears to have gone extinct over most of the southern half of its former distribution, apparently during the Holocene. The Oscura Mountains, a calcereous range, represents a relict endemic population, which was originally collected below the escarpment on the northeast side below North Oscura Peak and from a northeast exposure along the west facing escarpment 2 miles north of South Oscura Peak (Sullivan and Smartt 1997); however, shells of this species are present along some vegetated sections of the escarpment edge west of South Oscura Peak, but no additional populations of live animals have been founs.

Recent new distributional and ecological information for this species in the Oscura Mountains is summarized for 165 individuals of *Oreohelix neomexicana* (=*socorroensis*) sampled from 19 sites in the Oscura Mountains, WSMR, New Mexico (Appendix C). Average elevation was 2394.6 m (7856.6 ft). Specimens were found primarily on mesic north (77.8%) and northeast-facing (16.7%) exposures, which had an average slope of 51.6 degrees. Dominant vegetation consisted predominantly of piñon-juniper woodland (100.0%) plant species. Percent over-story vegetation averaged 40.5% (range 20.0 to 50 %) Average distance to the nearest tree was 6.3 m (19.0 ft), to the nearest shrub was 0.4 m (1.3 ft), and to the nearest source of free water was >1000 m (3,300 ft). Predominant microhabitat of sites consisted of a combination of leaf litter (42.2%), rock slabs (17.8%), and talus (40.0%). Dominant substrate was limestone (94.7%) and igneous (5.3%) rocks and ledges. Air temperature averaged 65.5 ° F; soil temperature averaged 58.5° F; soil pH averaged 7.3, and soil humidity was low (average = 2.2 on a scale of 1=dry to 5=wet). Summary statistics for plant species most commonly observed at each site where live snails were sampled is provided in Appendix D. Data summarized represents species of plants ranked by their abundance within a three (3) meter radius of the sample site. Gamble's oak, piñon pine, one-seed juniper, and mountain mahogany were the most abundant plants within three (3) meters of the site.

Considerable time and effort has been expended searching for additional localities of this species in the northern and southern reaches of the Oscura Mountains, which are more arid and are of lower elevation than is characteristic of the know localities were live snails occur. No additional populations have been found. As such, this species appears to have a very restricted range and ecological tolerance that encompasses north and northeastern exposures at upper elevations of the limestone escarpment, and within the mesic piñon-juniper-oak woodland of the Oscura Mountains.

3.1.3 *Sonorella orientalis* (Oscura Mountain Talussnail)

3.1.3.1 Type Locality

Originally described form Dripping Spring, Organ Mountains, Doña Ana County, New Mexico (Pilsbry 1936).

3.1.3.2 Distribution

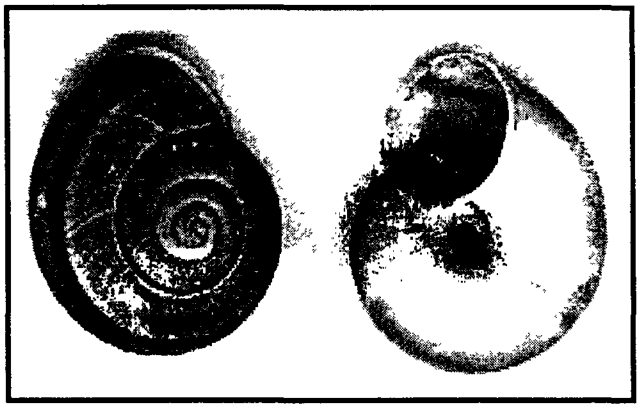

Figure 5.—Scanned image of *Sonorella orientis* from the Oscura Mountains, White Sands Missile Range, New Mexico.

In the Organ Mountains, *S. orientis* is widespread and commonly associated with igneous rock talus of rhyolitic and monzonitic structure (Metcalf 1984; Metcalf and Smartt 1997). This species was found by Metcalf (1984) at 20 of 25 localities in the Organ Mountains, which ranged in elevation from 1493.4 to 2407.8 (4,900 - 7,900 ft). According to Metcalf (1984), *S. orientis* appears to be less common in the San Andres Mountains than in the Organ Mountains (found at 4 of 25 localities sampled in the San Andres Mountains.

In the San Andres Mountain Range, this species is confined to igneous rock talus within forested habitat on Salinas Peak (Metcalf 1984, Metcalf and Smartt 1997). It also occurs in limestone talus near Salinas Peak to San Andres Peak in xeric habitat sporting shrubs and low trees. Specific localities for this species on WSMR include the southern head of San Andres Canyon; east of Salinas Mine and north of Salinas Peak; and northeast of Black Top Mountain (Metcalf 1984).

In 1995, however, several dead shells were collected in the Oscura Mountains (Figure 5; Sullivan and Smartt 1995). These snails were assumed to be associated with limestone outcrops because of the preponderance of this sedimentary rock-type in the Oscura Mountains (Metcalf and Smartt 1997);

however, recently I collected a series of live *S orientis* from two igneous rock sites in the Oscura Mountains (Figure 6).

3.1.3.3 Habitat

Recent ecological information for live specimens of this species in the Oscura Mountains is summarized for 20 individuals sampled from only 2 known sites (25 m apart), all of which are new and endemic to the Oscura Mountains, WSMR, New Mexico (Appendix C). Average elevation was 2560.0 m (8400 ft). Specimens were found primarily on mesic northwest- facing (100.0%) exposures, which had an average slope of 35.0 degrees. Dominant vegetation consisted of piñon-juniper woodland (100.0%) plant species. Percent over-story vegetation averaged 43.3% (range 30 to 50 %). Average distance to the nearest tree was 1.4 m (4.6 ft), to the nearest shrub was 1.4 m (4.6 ft), and to the nearest source of free water was >1000 m (3,300 ft). Predominant microhabitat of sites consisted of a combination of leaf litter (50.0%) and igneous lichen-covered rock ledges (50.0%). Dominant substrate was exclusively igneous lichen-covered rock (100.0%) and ledges. Air temperature averaged 68.0 ° F; soil temperature averaged 58.0° F; soil pH averaged 7.3, and soil humidity was high (average = 4.0 on a scale of 1=dry to 5=wet). This species appears to require wet, saturating, and foggy conditions for its emergence from igneous rock ledges with deep fishers and cracks. These kinds of weather conditions and rocky substrates patchily distributed and very rare in the Oscura Mountains.

Figure 6.—Distribution of *Sonorella orientis* in the Oscura Mountains, White Sands Missile Range, New Mexico.

Summary statistics for plant species most commonly observed at each site where live snails were sampled are provided in Appendix D. Data summarized represents species of plants ranked by their abundance within a three (3) meter radius of the sample site. Gamble's oak, piñon pine, one-seed juniper, and mountain mahogany were the most abundant plants within three (3) meters of the site.

Specimens of *S. orientis* were abundant and crawling on saturated lichen-covered rocks and in cracks of the rock from which they were emerging. There was no evidence of additional sources of snails in the immediate area for about 500 yards in any direction. The two (2) sampled populations were very localized and only emerged when the fog rolled into this dense woodland and shaded habitat. I have subsequently visited this site during dry weather, but found no evidence of live animals.

3.1.4 *Sonorella todsendi* (Doña Ana Mountain Talussnail)

3.1.4.1 Type Locality

Originally described form the northwestern slope of Doña Ana Peak, Doña Ana County, New Mexico (Metcalf and Smartt 1997).

3.1.4.2 Distribution

Sonorella todseni is an endemic species that appears to have a narrow ecological and restricted geographic distribution in the Doña Ana Mountains. The Doña Ana Mountains consist of a small set of low elevation mountains composed almost exclusively of igneous rock located at the southern end of the Jornada del Muerto, just north of Las Cruces, New Mexico (Metcalf and Smartt 1997). Within this small and range *S. todensi* is restricted to the type locality on the north-facing slope of Doña Ana Peak. Metcalf and Smartt (1997) describe habitat of this species consisting of an area of igneous rock talus under a sparse growth of live oaks and xeric-adapted shrubs. Only a few specimens were originally described from the type location, which caused Metcalf and Smartt (1997) to suggest that further inventories were warranted.

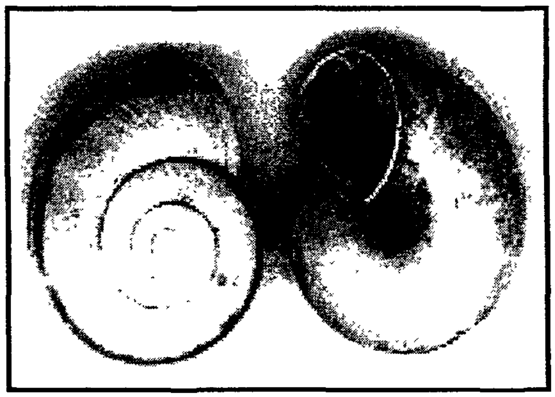

Figure 7 —Scanned image of *Sonorella todseni* from the Doña Ana Mountains, Doña County, New Mexico.

3.1.4.3 Habitat

Recent ecological information from live specimens of this species in the Doña Ana Mountains is summarized for 50 individuals sampled from five (5) sites (Appendix C, Figure 7). Average elevation of the site was 1766.6 m (5760.0 ft). Specimens were found primarily on north (20.0%) and northeast (80.0%) facing exposures, which had an average slope of 49.0 degrees. Dominant vegetation consisted of desert-scrub and grassland (100%) plant species. Percent over-story vegetation averaged 42.3% (range 20 to 60 %) and live snails were commonly found in association with shade provided by low-growing juniper and shrubs species, and rarely in exposed sunny spots. Average distance to the nearest tree was 1.0 m (3.3 ft) and to the nearest shrub was 2.4 m (7.9 ft). There was no source of free water on the peak.

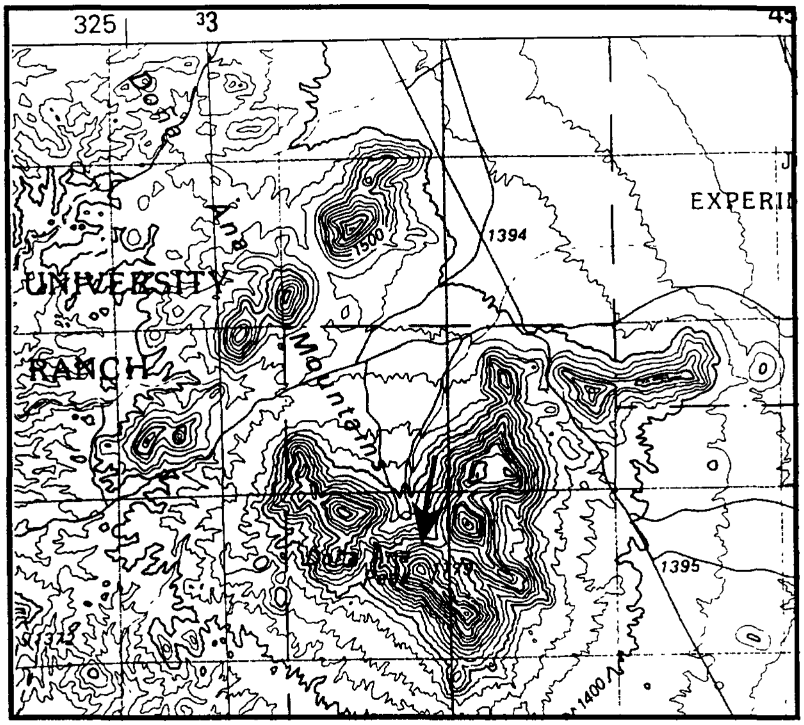

Figure 8.—Distribution of *Sonorella todseni* in the Doña Ana Mountains, Doña Ana County, New Mexico.

Predominant microhabitat of these sites consisted of thin layers of soil and leaf litter (50.0%), and extensive seams of dark igneous talus (50.0%). Dominant substrate was igneous rock (100.0%) talus and larger boulders. Air temperature averaged 48.0 ° F; soil temperature averaged 53.0° F; soil pH averaged 7.4, and soil humidity was low (average = 2.0 on a scale of 1=dry to 5=wet).

The total population size of this species appears to be very small, probably occupying only about one (1) acre of land localized on the N and NE exposures of Doña Ana Peak (Figure 8). Summary statistics for plant species most commonly observed at each site where live snails were sampled is provided in Appendix D. Data summarized represents species of plants ranked by their abundance within a three (3) meter radius of the sample site. Banana yucca, prickly pair cactus, Louisiana white sage, and silk-tassel were the most abundant plants within three (3) meters of the site.

Although localized and patchy, numerous dead shells were observed at each site, and live individuals were locally common, particularly in talus shaded by shrubs. Shaded areas of damp soil with abundant rock and air species harbored the largest numbers of live snails (n = 5 - 10 individuals). Populations of live snails an few shells were found on top of the peak, probably due to the arid nature and lack of shading vegetation at the summit. Although several days were spent sampling, not all potential sites were checked and several additional sites north of Doña Ana Peak need to be visited.

3.2 RISKS OF EXTINCTION

3.2.1 Demography

All species of terrestrial gastropods described herein consisted of very small and patchily distributed woodland or desert-scrub populations, and not all excavated sample pits contained live (aestivating) snails. Each sample pit dug in the talus of rock and soil, was about 1m (3 ft) in diameter and from 0.5 to 1 meters deep, depending upon the size of talus boulders and the steepness of the slope; thus each pit contained from 0.5 to 1 cubic m (m^3) of matrix. Average number of live snails sampled per site ranged from 8.7 to 23.6 individuals (n = 236/10 sites – *A. kockii*; n = 165/19 sites – *Oreohelix neomexicana* [=*socorroensis*]; n = 20/2 sites – *S. orientis*; and n = 50/5 sites – *S. todseni*). At each site a full range of sizes classes (=age classes) was represented, indicating good reproduction and recruitment.

Estimates of the size of terrestrial snail populations inhabiting mesic woodlands and desert-scrub habitats are difficult to obtain because of the fragile nature of the microhabitat required for survival and reproduction. Extensive and concentrated surveys and excavations of an area, particularly on steep slopes, can cause considerable long-term damage to the soil and talus substrate through This impact is the result of compaction, fragmentation and scattering of the leaf-litter, exposure of moist subsurface chambers to dessication, and physical fragmentation of the subsurface microhabitat. These activities facilitate dessication of the site and function as a barriers to local dispersal and gene flow among demes, which usually occur as a subset of a much larger meta-population structure depending on availability of critical macro and microhabitats.

Additionally, sampling and excavation activities can result in trampling and destruction of critical vegetation surrounding the site. Plant cover at the site prevents erosion and contributes significantly to the accumulation of leaf-litter that functions as insulation and food for local populations at the soil-litter interface. Similarly, vegetation provides the unique climatic conditions of associated with temperature and moisture that create for essential microhabitat conditions critical to the survival and reproduction of local snail populations. Changes in the microclimate at the soil-litter interface can cause sever mortality in snails (Secrest, et al 1996) .

As such, extensive degradation of habitat through construction anthropocentric activities, natural fire, or indiscriminate sampling can significantly and adversely impact local land snail populations over the long-term, and greatly reduce mineral and nutrient cycling in arid woodland and desert-scrub environments. Every effort should be made to prevent these activities from occurring throughout the range of sensitive species.

3.2.2 Genetics

Genetic variation within a population, effects of genetic drift on small population sizes, and inbreeding depression play a significant role in the probability of survival and reproduction of individuals in disjunct relictual populations of animals in the southwestern United States, particularly in New Mexico (Sullivan 1995, 1996). The theory of population genetics has developed the concept of the effective population size, defined as the size of the ideal population that would have the same amount of random genetic drift as the actual population. Because estimates of effective population size include non-breeding individuals, size of the total population must be large. Size of the effective population is influenced by numerous demographic and environmental factors. High variance in progeny survival, age structure of the population, spatial distribution, and variation in population sizes over time, and availability of critical habitat are some of the variables that contribute to a smaller effective population size compared to the total population size. If the actual effective population size is below the size calculated to maintain existing genetic variability, some of variability would eventually be lost. Over time, this loss may significantly and adversely affect the survival and level of risk generated by natural and anthropocentric phenomena.

Small disjunct populations of woodland and desert-scrub land snails exhibit several characteristics that contribute to lowering of effective population size. For example, the total population size is limited to a small area of critical habitat and undergoes wide demographic composition and size fluctuations due to seasonal variation in climate and availability of food plants. As such, reproduction and age structure of these populations may not be consistent with maintaining large numbers of reproductively active individuals. In times of low population size, only small, isolated groups of individuals may be present. These factors indicate an increased risk of loss of genetic variation in species that are aerial-dependent on specialized habitat and microhabitat conditions associated with critical habitat designations.

Recent estimates of intrapopulation genetic variation among disjunct populations of terrestrial gastropods on WSMR are very low or are nonexistent (Sullivan and Smartt 1995). For example, the small isolated population of *A. salinaensis*, restricted to the north and northeast facing slops of Salinas Peak exhibited no inherent genetic variation, whereas *A. kochii* from Little San Nicholas Canyon, north of the new Bear Creek sites was polymorphic at only 4.8 percent of the loci examined, and the mean proportion of loci heterozygous per individual was 0.016. These levels of genetic variation are consistent with values reported for other small populations of allopatric mollusks.

Direct, indirect, and cumulative threats to land snail populations, which primarily include loss and fragmentation of critical habitat, are widely believed to have deleterious affects on the genetic variability and can lead to extirpation of portions of the historical range, or extinction of the species as a whole. Negative effects of habitat loss and fragmentation have both genetic and demographic components that are well understood in theory, but poorly documented empirically. This is partly because genetic changes in small isolated populations occur rapidly and rarely are monitored.

Similarly, demographic changes are often pronounced and difficult to observe Nevertheless, results presented herein, as well as other recent investigations of terrestrial snails in southern New Mexico (Sullivan and Smartt 1995), clearly document the degree of isolation, patchy distribution, restrictive nature of critical habitat requirements, small effective population sizes, and the genetically depauperate nature of many populations. In addition, these species also are clearly at risk from natural as well as increasing anthropogenic environmental degradation.

Therefore, a goal of resource management in the Southwest should be to preserve biological diversity in these relict ecosystems that represent unique evolutionary links to the history of the Southwest. Within the mesic woodland and forest environments in southern New Mexico, special effort must be made to preserve as much of the species pool as possible, in the face of increased habitat destruction and fragmentation. As intra-island habitat patches become isolated through intervening habitat destruction, there may be distance thresholds beyond which searching for resources make species vulnerable to starvation and predation. In general, species with patchy distributions or taxa that use a variety of microhabitats are particularly vulnerable to extinction in a fragmented landscape. In relict mountaintop environments, preservation of the natural pattern of genetic diversity through habitat management in one species can contribute significantly toward conservation of other members of the community that often are local endemics.

Moreover, Pleistocene refugial ecosystems are an integral and irreplaceable link in the unique evolutionary history and ecology of the Intermontane, Basin, and Range Plateaus of the Southwest and southern New Mexico. Effective conservation of these relict ecosystems can only be accomplished by a thorough understanding of the history, genetic structure, and ecology of endemic biota. These objectives are consistent with resource management policies for coexistence with the environment, preservation of endemic species, conservation and sustained use of all plants and wildlife, and wise use of other natural resources withdrawn from public or private use.

3.2.3 Predation

Color polymorphism is snails has been the subject of considerable study. Much of this effoer has ben concentrated on the widespread European genus *Cepaea* (Cain and Sheppard 1952, Jones 1982). Polymorphism in snails is frequently explained as a balance between selection by climatic variables and predation (Heller 1981). Light-colored individuals have high reflectance and thus increased tolerance to high ambient temperatures. Dark individuals are more cryptic and may suffer lower rates of predation.

However, in spite of this attention, a single unifying theory of the evolution of these polymorphisms has not emerged.

Most of the species of snails studied in this report are adapted to subterranean niches and only migrate to the surface of the talus or rocky cliff habitat after saturating rains when ambient temperatures are cool and conditions are humid. Moreover, of the species examined herein, only *S. orientis* and *S. todseni* exhibit a characteristic striping pattern, which blends cryptically against the background, especially the heavily laden lichen-covered surfaces of igneous rock outcrops associated with mesic piñon-juniper-oak woodlands and upland desert-scrub habitats, respectively.

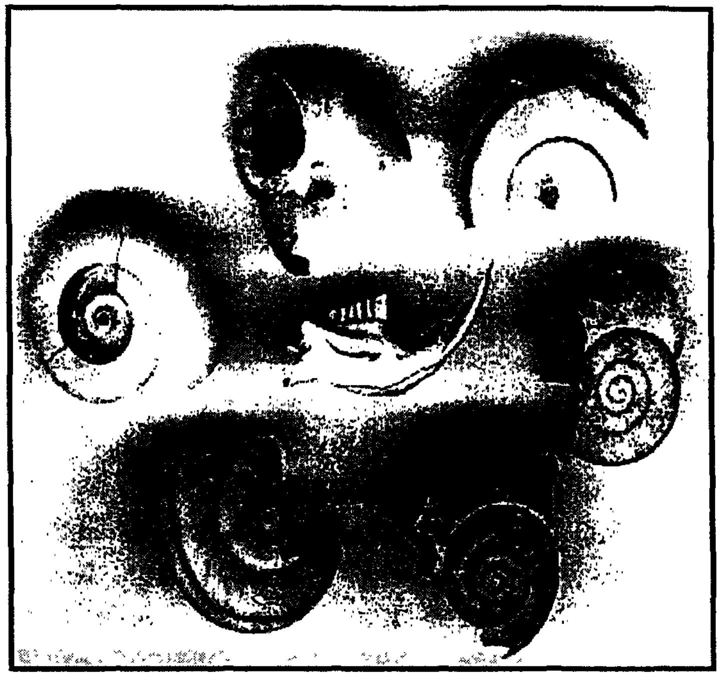

Figure 9. Series of *S. orientis* shells opened by some small rodent, probably a woodrat or a chipmunk. One-half of woodrat jaw is located in the center of the figure; it was found with the snail shells.

Various kinds of animals are known to prey on land snails, including beetles (Metcalf and Smartt 1997), songbirds and wild turkeys (Pilsbry 1940), and rodents (Metcalf and Smartt 1997). Recently, a study of shell polymorphism of desert land snails showed that neither white or brown colored snails at different heights above the ground in summer and winter exhibited a thermoregulatory advantage in either season (Slotow et al. 1993); however, although brown snails appeared more cryptic, rodent predators chose more brown snails over white snails more frequently than expected by chance.

During the present study, I found several examples where small rodents had systematically chewed a characteristically shaped opening in the shell of *S. orientis* in the Oscura Mountains, and extracted the soft snail flesh (Figure 8). These shells were found in the greatest abundance at sites located at the base of limestone ledges in piñon-juniper-oak vegetation with north-facing exposures and along the west-facing facing escarpment.

Based on a two-year small mammal live-trapping study (R.M. Sullivan and K. Wilson, in prep), the most common species of woodland small mammals in the Oscura mountains includes the brush mouse (*Peromyscus boylii*; frequency of occurrence = 68%, n = 700 individuals trapped) and the Oscura Mountain chipmunk (*Tamias quadrivittatus oscurasensis* [Sullivan 1996]; frequency of occurrence = 24%, n = 170 individual trapped). Other species occurring in less that 2 percent of the captures included the western harvest mouse (*Reithrodontomys megalotis*), white-throated woodrat (*Neotoma albigula*), Texas antelope squirrel (*Ammospermophilus interpres*), and rock squirrel (*Spermophilus variegatus*). I suspect that woodrats or chipmunks, which nest or den within deep crevices of the cliff and escarpment face, use snails as an opportunistic source of food and water resource during certain parts of the year. Similarly, small age classes of snails also may be use for food and moisture by *Peromyscus*. Both snails and woodrat middens are commonly associated with shaded and moist north and north east exposures within limestone and igneous rock outcrops. Moreover, snails may use woodrate feces as a source of nutrient material if decomposed feces are washed into accumulations of soil and leaf-litter. Thus, establishing an ecologically interdependent relationship associated with moist north and northeast facing rock outcrops, areas of high plant species diversity and cover, and areas of high animal species diversity consisting of both endemic invertebrate and vertebrate species.

The best strategy to ameliorate the potential for predation on small relictual populations of snails is to protect, retain, and avoid areas of critical natural habitat,[2] and by restoration of potential critical natural habitat[3] degraded by man-induced activities. Critical natural habitat includes areas associated with: (1) north and north-east facing limestone escarpments, and (2) diverse plant communities within natural stands of mesic piñon-juniper woodland. Potential critical natural habitat includes adjacent high quality habitat that will facilitate reproduction and survival rates that can withstand losses to predation. Use of predator control would reduce biological diversity and destabilize predator-prey dynamics within the local limestone escarpment and mesic piñon-juniper woodland ecosystem, is unnecessary, expensive, and would be entirely ineffective.

3.3 MANAGEMENT RECOMMENDATIONS

Conservation status assessment and population monitoring of terrestrial gastropods in southern New Mexico is timely. Results presented herein ontributes to the establishment of a baseline management plan for evaluation of local and broad-scale environmental trends including and assessment of: (A) geographic distribution, species richness, and community diversity, (B) general ecology and critical microhabitat requirements, (C) genetic diversity and historical biogeography, (E) the potential for

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2 The Endangered Species Act (ESA) (1993§§ 2-19, 16 U.S.C.A.) defines natural *critical habitat* as the geographic area within the area occupied by the species at the time of its listing that the U.S. Fish and Wildlife Service (FWS) determines to be essential to the conservation of the species and requiring special management consideration or protection. As such, critical habitat includes areas where chipmunks have actually been observed or are known to occur.

3 *Potential critical natural habitat* is defined herein as quality natural habitat that is characteristic or diagnostic of designated critical habitat (i.e., as per ESA), but within which chipmunks have not as het been observed.

extinction, (F)ecosystem structure and function, and (G) the potential anthropocentric impacts to populations of terrestrial snails associated with ongoing and future environmental degradation and habitat fragmentation in southern New Mexico.

For example, this last concern is particularly germane considering the ongoing and proposed future military testing and construction activities on White Sands Missile Range, particularly in the Oscura Mountains and other upland areas proposed for future fire management of woodland ecosystems. As such, this report forms the basis of current and future resource planning and management of terrestrial snails on WSMR, the San Andres National Wildlife Refuge, NASA's White Sands Test Facility (WSTF), and the Doña Ana Mountains, as well as other arid-land sites that may be surveyed in the future. As a baseline planning document, therefore, this section will emphasize potential threats to the survival and reproduction of land snails, as well as environmental conditions that are considered sensitive and constitute critical or potentially critical habitat for terrestrial snails.

3.3.1 Direct Environmental Impacts

Impacts to terrestrial snail macro and microhabitat, plant species richness and diversity, and the associated with topographic and physical characteristics of sites where live populations of terrestrial snails currently occur are considered adverse if: (A) preexisting populations of snails cannot be supported following removal or alteration of native vegetation from the area; (B) project- or test-associated disturbance such as habitat destruction, degradation or fragmentation of habitat, or human-induced disturbance or pollution results in extinction or long-term population decreases; or (C) if severe erosion occurs from direct land conversion activities resulting in irreversible adverse effects to the surrounding habitat, vegetation, moisture regime, and natural drainage basins. Because wildlife inventories are time specific, species density, patterns of distribution, and habitat use observed during the two year sampling period should provide a basis for management over the long-term. However, seasonal and stochastic variation in environmental conditions will continue to dictate management practices in the future, particularly if accompanied by environmental perturbations from numerous independent human-induced activities.

Thus, irrespective of the specific environmental setting, plant and wildlife species can be adversely affected by a potentially large number of extraneous factors associated with habitat alteration, and military testing and construction activities. As such, any decrease in biological diversity that alters the composition of both plants and animals, or degrades the physical (abiotic) structure of the environment will necessarily and adversely affect natural ecosystem structure and function, both ecologically and energetically. Therefore, it follows that a decrease in natural stability of the ecosystem increases the danger of stochastic fluctuations in small populations of mesic woodland taxa. This phenomenon is particularly problematic for small disjunct and relictual populations of species with low vagility, and greatly increases the probability of extinction due to stochastic environmental factors. What follows is a list of potential environmental impacts that will adversely impact survival and reproduction of populations of endemic woodland terrestrial snails.

3.3.1.1 Surface Disturbances

Surface disturbances include a potentially wide range of activities such as fire, construction of roads or site facilities, installation of utilities, power-lines, and fiber-optic and road-way corridors, or other actions that destroy local populations of plants and animals, as well as physical features of the local landscape. These activities can have devastating adverse affects on small relic populations of terrestrial gastropods, and their critical humid leaf-litter and talus microhabitats, which are generally restricted to a specific microsite. Effects of surface disturbance range from immediate and total removal of the organism and destruction of its critical habitat, to partial removal or disturbance of critical habitat such that habitat fragmentation, increased aridity due to edge effects and competitor/predator encroachment into critical habitat reduces individual survival and overall capacity of individual species in the local population to reproduce under the disturbance regime.

Surface disturbance impacts and habitat fragmentation are evident throughout much of the upland and higher elevations of the San Andres, Quartzite, Doña Ana, and particularly the Oscura mountains, which includes the persistent destruction of critical and moist north and northeast-facing escarpment faces and vegetation from Atom Peak to Jim Site (12 km) owing to continued 4-wheel-drive surface traffic and contractor-related Aerial Cable Lighting and TSN fiber-optic trenching activity.

3.3.1.2 Destruction of Vegetation and Critical Habitat

Loss of vegetation along shaded exposures of limestone and igneous rock outcrops, upland escarpments, talus seams, and arroyos associated with north and east facing mesic grassy areas, woodland, or forest slopes, causes rapid loss of soil stability, facilitates erosion, and reduces shade. Continued loss of vegetation will reduce leaf litter and leach organic matter and inorganic materials from the soil, alter pH, increase the temperature profile, and decrease soil humidity critical to maintain productive microhabitats and microclimates for both plants and terrestrial patchily-distributed populations of terrestrial woodland snails. Terrestrial snails are inextricably linked to piñon-juniper-oak woodland in association with limestone and igneous ledges, talus seams, and within mesic/humid north- and east-facing slopes in these mountain ranges.

Population density and prospects for long-term future survival of small populations of snails are dependent upon on these abiotic environmental conditions and specific vegetational communities. All of the above factors affect the critical microhabitat conditions, soil, and availability of leaf-litter for terrestrial snails. Microhabitat characteristics described in the ecological sections of this report for each species of terrestrial snail cover all aspects of critical microhabitat requirements for individual endemic populations of each. These data provide baseline criteria for designating and managing critical habitat for terrestrial snails in mesic upland communities of woodland terrestrial snails.

A literature survey of habitat descriptions for various species of land snails from New Mexico includes the following general habitat descriptions, which should be considered key words, phrases, or indicators in planning civilian or military construction projects, and during development of endangered species management plans or critical habitat management plans for terrestrial snail communities in southern New Mexico, particularly when site data are accompanied by evidence of dead shells:

- N, E, NE facing slopes within piñon-juniper-oak woodland, in association with limestone or igneous rock outcrops, cliff faces, and areas of damp leaf litter along the escarpment
- seams of talus boulders that stream from near the tops of peaks
- areas of damp leaf litter and brushy piñon-juniper-oak woodland along canyon walls
- grassy areas bordering riparian habitat
- mesic forested areas adjacent to lush wet meadow
- north-facing slope of basaltic talus and deep leaf litter of Gambel oak leaves
- brushy areas under stones in leaf litter
- piñon-juniper woodland, dead juniper branches, deep leaf liter
- brushy hillsides and low scraps bordering brushy riparian woodland
- leaf litter in wooded brushy areas along canyon walls of arid mountain ranges
- damp areas under wood, logs and damp debris
- open forest with calcareous and igneous bedrock, red-graniteus and rhyolitic talus
- soil and leaf litter filling interstices of igneous talus
- riparian fringe forest, along creek at base of canyon walls, with oak leaf litter and angular igneous stones
- scarp in low arid habitat supporting forbs, shrubs, piñon, juniper, and oaks
- slopes and bajadas under shelter of large stones, fallen yuccas, or caudices of sotol
- ledges on walls of canyon among ponderosa pine, piñon, and oak vegetation
- deciduous forest on steep sides of canyon, under volcanic rock rubble and talus

Areas known to harbor snails, areas adjacent to localities where snails have been sampled, and areas that exhibit the botanical and physical characteristics described above should be strictly avoided. These potential habitats should only be surveyed by a qualified biologist approved by the Endangered Species staff of the Department of Game and Fish and by Senior Wildlife Biologists at WSMR. Justification for this requirement stems from the fact that the fragile nature of the microhabitat where living snails reside can be severely trampled, compacted, and exposed to aridity, and thus adversely and permanently impacted by the simple action of the biological inventorying process.

Additionally, unless these sites are inventoried during cool and wet temperate weather. evidence of live snails may never be found, as evidenced by *S orientis* in the Oscura Mountains, because these larger saxicoline species usually emerge from deep rock crevices only after a saturating rain and while humidity is very high, typical of local fog – a rare phenomenon in southwestern New Mexico..

3.3.1.3 Habitat Fragmentation

Fragmentation of native habitat represents a direct and observable loss of wildlife resources. Habitat fragmentation increases the distance between snail subpopulations and may have major consequences on metapopulation structure of narrow endemics with low vagility and restricted geographic distribution, typical of many species of *Ashmunella, Oreohelix, and Sonorella.* As critical habitat for land snail populations is eliminated, effective population size is decreased and dispersal distances are increased. Thus, these demographic and genetic constraints diminish the ability of local populations to respond to natural environmental disturbance and anthropogenic habitat changes. Fragmentation of native habitat, therefore generally results in an overall decrease in species density and richness. Fragmentation and the resulting loss of natural habitat associated with new testing and construction activities can severely and adversely impact wildlife habitat in a local area. Although this loss may not be immediately apparent, overtime it will have an accumulative negative effect on local plant and animal species diversity and density, which will be difficult if not impossible as well as expensive, to reclaim once lost.

Terrestrial snail populations in southern New Mexico are typically small and occur in small mosaic patches of critical habitat. Additional natural or anthropocentric fragmentation of habitat becomes a sever problem when migration is absent and the habitat quality is too degraded or the area too small to sustain viable populations. Small areas may need to have critical resources augmented by planting vegetation or creating artificial physical habitat (rock slabs/ledges); whereas the problem of isolation may have to be addressed through translocation individuals. Similarly, mesic populations of terrestrial woodland snails inhabit ecosystems that have low resilience to perturbations (e.g., mountaintops) and low net primary productivity and hence recover slowly from disturbance. Because such systems are susceptible to irreversible damage, planning and management of these species must be pro-active and preventative.

Descriptions of critical habitat and specific microhabitat characteristics discussed herein, should provide the basis for designation of critical habitat for management purposes. Critical habitat for terrestrial snails should be identified and mitigated by avoidance. Areas particularly susceptible to habitat fragmentation and environmental degradation include: (A) areas of mesic piñon-juniper-oak woodland in association with limestone or igneous rock outcrops or cliff habitat along escarpments that have north- and east-facing exposures; (B) old-growth piñon-juniper woodland associated with calcareous or igneous bedrock, red-graniteus or rhyolitic talus with soil and leaf litter filling interstices of igneous talus; (C) ecotones between woodland, and arroyo and scrub vegetation associated with both minor and major drainages and talus accumulations; and (D) slopes and bajadas with extensive and large boulders, fallen yucca stems, or caudices of sotol. These areas also harbor increased species richness and diversity of both plants and animals relative to other less structurally complex or climatically more austere sites.

As such, potential critical habitat for snails should be surveyed by a qualified biologist prior to the onset of construction or testing activities, and construction activities should be monitored on a daily basis for compliance with the contractor work order (WAO) and the approved contractor's environmental plan. Additionally, specific funds for habitat restoration should be a mandatory part of the budget and biding process of every construction or testing contract issued. Further, the contractor should be under specific legal obligation to use these funds solely for the purpose of habitat restoration and wildlife conservation, irrespective of cost overruns, or the potential for cost overrun by the contractor. These activities (e.g., environmental monitoring during construction, and use of funds for environmental restoration) must be monitored on a regular basis by agency staff (e.g., NMDGF, USFWS, or WSMR Environmental Services Directorate senior biologists in charge of the project and/or in cooperation with a qualified biologist supplied by the contractor at the construction site), otherwise the desired effects of avoidance and restoration of critical habitat and conservation of listed species will not occur.

If live populations of snails are found prior or during construction, they should be immediately identified, and if necessary, mitigated by avoidance. Monitoring of these populations should occur immediately after contract completion, and thereafter every six months for the first three years following completion of construction and testing activities. The monitoring program should include evaluation of site-specific critical habitat characteristics, population density, effectiveness of contractor-mitigation, and progress of natural or artificial re-vegetation and/or site restoration after completion of the project, or after abandonment of the site.

3.3.1.4 Pollution

Effects of pollution on survival and reproduction of terrestrial snails in the San Andres, Oscura and Doña Ana mountains, and Quartzite Mountain, as well as other local species of terrestrial wildlife, should be continuously monitored. Toxic chemicals, fuels and other hazardous materials can spill into arroyos, drainages, and other low lying areas where water collects in shallow depressions. This kind of man-made pollution can have adverse environmental consequences that may result in negative direct or indirect impacts on the survival or reproduction of plants and wildlife that rely on arroyo topography, leaf-litter and soil development. In areas where free water is ephemeral (e.g., restricted to low lying and temporary pools of rain water and arroyo flow) these sources of free water may not be continuously flushed or cleansed by natural precipitation, which can cause them to be highly susceptible to pollution. Preserving critical habitat from pollution can be accomplished by strict pollution standards, and by prohibiting the dumping of man-made debris (i.e., fuels and discarded construction materials) over ledges, escarpments, or into rocky arroyos of potentially critical habitat.

Leaching of metal from discarded building materials, fuel containers, or cans can pose a potential adverse impact to populations of terrestrial ana aquatic snails that occur locally, and prevent other populations or species from immigrating into the area. Additionally, chemical materials can leach into the soil and kill essential vegetation and mycorrhizal fungi in the surrounding area that provide essential nutrients, thus degrading microhabitat conditions essential for survival and reproduction of snails and associated soil plants, bacteria, arthropods, and microfaunal communities of other terrestrial gastropods.

3.3.1.5 Pesticide and Herbicide Spraying

Pesticides and herbicides are often used to control insect infestations as well as the spread of unwanted noxious/exotic weeds. These agents often have adverse effects upon plants, large terrestrial snails, and soil-dwelling invertebrates, such as endemic microfaunal land snails. Direct application of herbicides can result in the immediate death of critical plants and chemicals can leach in to subterranean spaces in the rocky soil that harbor land snails.

Potential critical habitat for terrestrial snails should be surveyed prior to spraying of pesticides or herbicides. If live populations of snails are found, they should be identified, and if necessary mitigated by avoidance. Application of these chemicals in areas of critical habitat should be strictly avoided. Monitoring of these populations should occur every six months for the first year following spraying of pesticide or herbicide. The monitoring program should evaluate population size and reproductive output for snail populations, as well as site-specific critical habitat characteristics following completion of the project, or after abandonment of the site.

3.3.1.6 Rural Fugitive Dust and Soil Deflation

Construction activities, dirt roads, or any other activity that results in dust generation can result in damage to the local flora and soil organisms. Rural fugitive dust is often deposited on the leaf surfaces of plants adjacent to the dust source. The resulting coating of dust can reduce the photo synthetic capacity of the plant and potentially leave it in a stressed condition. Dust accumulation also decreases the palatability of vegetation for mammalian ungulates, rodents, and lagomorphs, and physically decrease the ability of snails to consume plant materials and feces of herbivorous terrestrial arthropods and mammals. Soil deflation can result in loss of topsoil down to the hardpan layer. Elimination of vegetation results in loss of shade, which increases the temperature of the surrounding soil. Loss of leaf litter reduces the amount of food and mineral resources available to terrestrial snails, as well as decreasing the humidity of critical subterranean microhabitat. Soil deflation exposes root systems of plants, and in many situations, causes desiccation and death of vegetation and soil organisms, thus further degrading potential critical habitat for soil-dwelling organisms.

3.3.1.7 Fire

Most plants and some soil-dwelling animals that exist in woodland vegetation communities have evolved adaptations for dealing with periodic natural wildfire and to disturbance-generated patches, provided that sufficient environmental differences exist between the undisturbed matrix and patches. Although the most conspicuous environmental change in fire-created gaps is the increase in light, other physical parameters also differ between gaps and undisturbed forest, such as air temperature, soil temperature, relative humidity, and soil moisture. However, the magnitude of such differences depends on factors such as gap size, height of adjacent canopy, gap shape, and gap age, as well as the legacy of previous disturbance reflected in the composition of and stereogeometry of the surrounding matrix (Lieberman et al. 1989). In particular, environmental differences between gaps and undisturbed forest are know to decrease as gap size decreases and gap age increases. Additionally, these environmental factors may be modified even further by topography, as well as by daily and seasonal variation in the position of the sun.

Similarly, because of the accumulation of woody debris, when fires eventually occur they may be exceptionally hot and kill much of the vegetation (even fire-tolerant species) and volatilize important soil nitrogen. Thus, soil may be episodically depleted of available nitrogen for plants by catastrophic wildlife fires. Except for the northern slope of the Organ Mountains adjacent to WSMR, there was no clearly visible evidence of natural or man-made fires in areas that were surveyed. However, recent lighting-caused fires in the Organ Mountains and a much smaller burn in the southern Oscura Mountains devastated the leaf liter layer, as well as the macro and microfaunal assemblages of arthropods and terrestrial gastropods dwelling therein. Weather related natural forest fires or anthropogenic fires, clearly can devastate the faunal composition of the leaf liter, particularly in areas managed to prevent natural fires from burning. The potential also exists for fire from rocket test firings association with the Aerial Cable Test Facility and proposed future U.S. Air Force laser testing at Atom Peak and along the west-facing escarpment of the Oscura Mountains.

Some wildfires create conditions that enhance or preserve desirable attributes of snail habitat. Others degrade the attribute, sometimes severely. Hot fires that kill mature stands of piñon-juniper-oak associations are of particular concern, because these areas provide critical habitat for terrestrial snails by supporting shaded, humid, and thick accumulated layers of decaying leaf-litter that produce subterranean microhabitats required by terrestrial snails, and by preventing erosion. Elimination of obligate mycorrhizal fungi that promote leaf-litter buildup also may prevent germination of seeds of plants. As such, large soil disturbances may lose the fungal inoculum and regain it only very slowly. Thus, biological diversity will be maintained if disturbances are small, but will decline in large disturbances typical of hot fires.

There likely are differential risks of catastrophic fires depending on vegetation association, For example, mature piñon-juniper woodland along the eastern exposure of the Oscura Mountains, which contains most of recovery habitat, is likely to lose habitat in the future because it is overgrown. Critical habitat and potential critical habitat associated with piñon-juniper-oak vegetation along the north and north-east escarpment are less prone to destruction by fire, because vegetation is less well developed and more dispersed, and because of the abundance of exposed rock along the escarpment, which tends to retard the spread of fire. Also, when habitat patches are small and isolated, naturally occurring fires are less frequent. Frequency of fire and intensity provides another example because a forest will respond differently to low-intensity fires that to intense fires, and the effects of frequent fires will be different than those of infrequent ones.

In addition to the direct loss of habitat by fire, surface disturbance can include a range of activities such as ground conversion associated with construction of roads, firebreaks, and tracked off-road vehicle travel, or any other action that directly removes the existing plant and animal communities. Such activities can have devastation effects on sensitive species. Effects of these surface disturbances range form immediate and total removal of the organisms that live there, to partial removal or disturbance. Surface disturbance impacts are evident in all areas surrounding the Jim Site Upper Anchor associated with the of the Aerial Cable Project, and at Atom Peak and North Oscura Peak, and in associated with the lack of environmental monitoring during construction of the Eastern Branch of the Fiber Optics installation project.

Further, recent fire suppression activities resulting in clearing of natural vegetation at Jim Site in the Oscura Mountains, also has resulted in loss of soil stability, excessive dust, erosion, and minor watershed alteration as a result of monsoonal rains. However, what are the long-term consequences of creating fire-breaks, fire-lines, and other fire control and suppression activities; and can fire breaks act as another kind of disturbance that encourages weedy species, or do fire-breaks act as barriers that inhibit dispersal of native species? These are only a few of the types of questions that need to be considered in management of disturbance processes associated with development of a comprehensive fire control and suppression management plan which should include both short- and long-term biological and ecological consequences to the ecosystem.

In 1994 a lighting-induced fire occurred along the eastern slope of the Oscura Mountains just south of Whitmore Canyon westward toward Jim Site. Although this fire consumed only a small amount (< 50 acres) of piñon-juniper woodland and desert-scrub vegetation within sub-marginal snail habitat, it had the potential to burn the mature and extensive woodland habitat northward and near South Oscura Peak, Atom Peak, and North Oscura Peak, which constitutes and encompass both critical and potential critical habitat for terrestrial gastropods in the Oscura Mountains.

Additionally, biological communities and ecosystem processes may change substantially as a result of "edge effects" caused by fragmentation of woodland habitat and associated anthropocentric barriers. The outer boundary of any habitat is not a line, but rather a "zone of influence" that varies in width depending on what is measured. Sunlight and wind impinge on a patch of woodland form edge and alter the local microclimate. Edge zones are usually drier and le shady than forest-woodland interiors, favoring shade-intolerant, xeric-adapted plants overt typical mesic woodland species (Meffe et al 1994), thus changing the entire species composition of the local plant community.

Strict fire prevention policies and measures should be implemented during any proposed construction or testing located within or near critical habitat of terrestrial snails Potential critical habitat for snails should be surveyed prior to any construction or testing activities. If evidence of live populations of snails are found, they should be immediately identified and mitigated by avoidance.

3.3.2 Indirect Biological Impacts

Indirect impacts include activities that are remote from an area but have the potential to significantly impact snail populations or critical habitat. It is suggested that the potential for indirect impacts be considered in species management and habitat plans. Although there were few potential indirect impacts apparent, affects of remote construction and testing activities could cause downstream flooding or downslope movement of contaminants, pollutants, or sediments. These potential environmental threats would appear to apply to the Oscura Mountains and the Salinas Peak areas, and along the north and northeast exposures of Quartzite Mountain at the WSTF site.

Because remote construction and testing activities can often have subtle and damaging effects upon rare plants, animals, and soil-dwelling organisms, any construction in the upper portions of canyons with designated critical habitat for land snails should be avoided. Degradation of the natural watershed by pollution or construction activities can cause erosion that can alter the natural flow of storm water runoff, resulting in flooding or sediment deposition at a downstream location that would not normally be affected by such events.

3.3.3 Cumulative Impacts

Cumulative impacts include activities that, by themselves, may not have a significant impact on species, but by interacting with other factors, can have dramatic effects on the biological resource[4]. These impacts are the most difficult to identify and usually the most difficult to control. One of the more obvious cumulative impacts can result from habitat fragmentation. Activities that by themselves may not affect an animal or plant population often become significant factors when the habitat fragmented or reduced in size—land snails are particularly susceptible to such activities. The number of potential cumulative impacts is almost infinite and the chance combination of events that can lead to significant effects from cumulative impacts often relies on factors that happen as chance events over time. Generally, any factor that alters the natural habitat of a plant or animal can contribute to cumulative impacts on that species. Therefore, it is suggested that the potential for cumulative impacts be considered in the species management and habitat plans for terrestrial snails.

Absence of grazing by livestock, lack of any evidence of overgrazing by exotic African oryx and native ungulates, including deer and elk, and the relative lack of human disturbance to plant communities in remote areas of the Oscura Mountains as well as other sites, favors continued existence of disjunct populations of snails. In most situations, current edaphic and vegetative conditions in the Oscura and San Andres mountains are relatively natural. Continued disturbance to the escarpment edge, mesic woodland vegetation, and north, east, and north-east slopes and foothills of the Oscura Mountains and San Andres Mountains will, over time, hasten erosion, habitat destruction, fragmentation, and alteration of natural habitat, particularly in the vicinity of North Oscura and Atom Peak where the density of snails populations greatest. If unchecked, these accumulative human-induced processes will significantly reduce critical habitat and biological diversity of vegetation, thus contributing to a reduction of vegetative cover and critical microclimatic regimes for terrestrial snail populations.

Construction of buildings and roads can cause fragmentation and loss of valuable critical habitat. Additionally, the combination of separate, yet ongoing, projects in the immediate vicinity of critical habitat for land snails can result in cumulative impacts to plants that provide food (leaf litter) and shade, increases in temperature, erosion, and general habitat alteration. Construction of buildings and roads can cause fragmentation and loss of natural dispersal corridors, cover, and foraging habitat. Because some areas where land snails are known to occur have been disturbed by past testing and construction activities, serious consideration should be given to the overall ecological consequences to plant and

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In 1978, the Council on Environmental Quality (CEQ) defined cumulative impacts as: "the incremental impact of the action when added to past, present, and reasonably foreseeable future actions Cumulative impacts result from individually minor but collectively significant actions taking place over a period of time."

animal species diversity resulting from loss of habitat. For example, future projects should consider using previously disturbed areas or minimizing the amount of impact on the site by limiting the amount of permanent disturbances, and through specific and immediate habitat rehabilitation following completion of a particular project.

3.4 MITIGATION OF ENVIRONMENTAL CONSEQUENCES

It is recommended that testing, construction, and operational activities be conducted in accordance with recently proposed national forest land and resource management plans as a baseline for affective management of biological resources[5]. These forest management plans provide for coexistence with the environment, preservation of sensitive species, maintenance of historical levels of biologic diversity, conservation and sustained use of other wildlife species, protection of vegetation, and wise use or protection of other natural resources on land withdrawn from the general public or private use.

Previous sections of this document summarized possible impacts that could affect the distribution, demographics, and critical habitat of terrestrial snails. In order to avoid these effects, a variety of specific management policies can be enacted. These management prescriptions vary depending upon the sensitivity of the species, its geographic distribution, its critical habitat requirements within the affected area, and the complexities of management problems associated with species and their habitats.

In general, however, management prescriptions apply to all species and areas irrespective of whether rare or protected land snails, or their critical habitats, occur in the immediate vicinity of a particular project. It is recommended that the following measures be taken to reduce or avoid potential significant biological and ecological impacts to populations of land snails, and that these recommendations be incorporated into current and future species management and habitat plans, as well as inventories required for NEPA compliance.

- Surveys of potential critical habitat for terrestrial snails should be conducted prior to the onset of construction or testing activities. If live populations of snails are found, they should be identified, and if necessary, the site should be mitigated by avoidance. Microhabitat characteristics described in the ecological section of this report cover all species simultaneously, as well as a description of critical microhabitat for individual taxa. These data provide baseline information for designating and managing critical habitat for terrestrial gastropods.

5 Cibola National Forest Land and Resource Management Plan (1991—Changing Forest Landscapes Five Years of Progress, Cibola National Forest Land and Resource Management Plan 1986-1990, U.S. Department of Agriculture, Southwestern Region, 85 pp.).

- To ensure the continued existence of endemic populations and species of land snails, monitoring of known populations should occur every year. In areas affected by construction. monitoring should occur every six months following completion of the project or testing activities, and every year thereafter. The monitoring program should include: (1) an evaluation of population size; (2) reproductive success, (3) mortality; (4) assessment of site-specific critical habitat characteristics, including both abiotic and biotic components; (5) assessment of changes in natural drainage patterns; and (6) assessment of the success of natural or artificial re-vegetation following completion of the project or after abandonment of the site.

- Future construction projects in the general vicinity of a site should be restricted to the maximum extent possible to previously disturbed portions of the property.

- Future buildings and facilities should be constructed in close proximity to one another (clustered) to minimize the potential of further degradation of natural habitat and biological diversity.

- Habitat fragmentation should be avoided whenever possible. The effects on both rare and common species of plants and animals are often times more pronounced when communities are cut up into small islands of native habitat. Fragmentation can be reduced by clustering facilities to previously disturbed sites. If clustering is not possible the next best management tool would be placement of facilities at the edge of large tracts of natural habitat, rather than in the center.

- Destruction of rocky ledges and hilly habitat associated natural desert shrub vegetation should be avoided, including sumac, piñon-juniper-oak woodland, etc.

- Future construction and access roads should not be built within 30 m (100 ft) of either side of existing natural drainages or arroyos; and erosion control measures should be installed on structures and roads built along the length of arroyos where snails populations are known to exist. Around construction sites and roads, runoff should continue to be directed by way of ditches and grading to natural drainage channels (arroyos).

- Strict standards should be imposed to prevent dirt, loose rock, brush, human refuse, or other debris resulting from construction activities from being deposited into arroyos or canyons where snail populations are known to exist..

- Vehicular traffic outside immediate construction sites and designated access roads should be prohibited, particularly within areas of natural vegetation. Restriction should include all staff, transient test observers, construction personnel, and equipment operators. Vehicles should be restricted to designated access routes only. If access to these areas is unavoidable, users should be specifically briefed by a qualified staff biologist as to the location of any managed or biological sensitive populations or snails or their critical habitats.

- Hazardous and toxic materials should be stored on a level concrete pad away from all arroyo drainages, catchment basins, and low-lying grassland habitat. Any chemical spills or excess concrete should be cleaned up immediately, and not dumped in drainages. Fuels, oils, or other chemicals must not be poured or drained onto ground surfaces, and containment devices should be placed around these materials in the event of spills. Any dumping of human refuse or building debris should be prohibited in and around the vicinity of the property and along existing roadways. All dumping and storage of trash, garbage, metal, bottles, and other man-made waste should be strictly prohibited within the property at all times. All recyclable waste from previous activity and tests should be collected and disposed of in accordance with the WSMR facility recycling plan.

- Fire control and suppression equipment should be in place at all times of the year, particularly in woodland habitats with well developed leaf litter.

- Topographic heterogeneity and species diversity of plant and animals surrounding known populations of terrestrial snails represent a unique and relatively undisturbed natural habitat, which should be left undisturbed.

As management recommendations, application of the above biological and ecological mitigation recommendations should reduce to insignificance the potential impacts to endemic populations and species of terrestrial gastropods, and their critical habitats.

3.5 RECOMMENDATIONS FOR FUTURE STUDY

Additional species and mountain ranges in southcentral New Mexico that should be surveyed include (also see Metcalf and Smartt 1997:64):

- *Ashmunella kockii caballownsis*: <u>Sierra County</u> – South-central Caballo Mountains and Blackbushy Mountain.
- *Ashmunella ambyla cornudaensis*: <u>Otero County</u> – Found only in the Cornudas Mountain complex (e.g., igneous talus accumulations in the Chatfield, Wind, Flat-top mountains).

- *Carychium exiguum* and *Oxyloma* spp: Otero County – Tularosa River Valley, head waters of the Tularosa River downstream as far as the village of Mescalero and along Fresnal Canyon above High Rolls in the Sacramento Mountains.
- *Sonorella todseni*: Doña Ana County – Although several days were spent sampling in this mountain range, not all potential sites were checked and several additional sites need to be visited.
- *Oreohelix strigosa noglaensis* (Sierra Blanca/Nogal Peak)
- *Humboldtiana ultima* (Guadalupe Mts.)

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APPENDIX A

Field Searching Locations and/or Collection Sites for Snails in Southern New Mexico. Effort Represents a Minimum of 73 Ten-Hour Days for One Individual (e.g., 730 person hrs) From 27 July 1996 to11 December 1997 (16 months); However on Most Surveys Two Individuals Were Present.

1. **27, 28 July 1996** – New Mexico: Doña Ana County, Qartzsite Mountain, White Sands Test Facility NASA, NE slope of Quartzite Mountain, south side head of Bear Canyon, UTM region 13 (2 new localities for *Ashmunella kochii kochii*—previously only known from 4 sites in the southern San Andres Mountains).

2. **1 August 1996** – New Mexico: Oscura Mts. South Oscura Pk.; UTM 13 (PDOP=3.1) UTM1 372200; UTM2 3723956; 8,100 ft; West end of sample transect moving east up-slope to establish boundaries of transect; Habitat photos taken.

3. **1 August 1996** – New Mexico: Oscura Mts. South Oscura Pk; UTM 13 (PDOP=3.3) UTM1 372262, UTM2 3723896; 8,100 ft. Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*; Photos of snails and habitat taken.

4. **2 August 1996** – New Mexico: Oscura Mts. South Oscura Pk.; UTM 13 (PDOP=3.9) UTM1 372393; UTM2 3723998; 8,500 ft. Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*; Photos of snails and habitat taken.

5. **2 August 1996** – New Mexico: Oscura Mts. South Oscura Pk.; UTM 13 (PDOP=5.0) 372444 UTM1 3723794 UTM2; 8,300 ft. Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*; Photos of snails and habitat taken.

6. **2 August 1996** – New Mexico: Oscura Mts. South Oscura Pk; UTM 13 (PDOP=6.9) UTM1 372622, UTM2 3723897; 8,800 ft. Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*. Photos of snails and habitat taken. Location directly below south Oscura Peak on west facing escarpment.

7. **3, 4, 5 August 1996** – New Mexico: Oscura Mountains, North Oscura Peak (Type Locality for *Oreohelix socorroensis/neomexicana*), Atom Peak; and west facing escarpment of Workman Ridge (searched potential critical/diagnostic habitat for *Oreohelix socorroensis/neomexicana*--none found).

8. **10, 11, 12 August 1996** – New Mexico: Oscura Mountains, South Oscura Peak to Jim Site and escarpment (searched potential critical/diagnostic habitat for *Oreohelix socorroensis/neomexicana*). Note: Found no new live snail localities for this species along the western escarpment, requires investigation of potential habitat along the eastern slope of the mountain range.

9. **17, 18, 24, 25 August 1996** – New Mexico: Oscura Mountains, South Oscura Peak and escarpment.

10. **7, 8 September 1996** – New Mexico: Oscura Mountains, approximately 3 miles south Atom Peak, Jeep trail to Jim Site (discovered first live specimens of *Sonorella orientis* ever to be described from Oscura Mountains; nearest live populations are known only from the Organ and Doña Ana mountains!).

11. **5, 6 October 1996** – New Mexico: Organ Mountains, Texas Canyon and boarder of WSMR and Fort Bliss military reservations. Two new sites of *Ashmunella todseni* (Maple Canyon Woodland Snail) were found (dead shells only) — endemic to Texas and Maple canyons only.

12. **14, 15 October 1996** – New Mexico: San Andres Mountains, White Sands Test Facility, NE slope Quartzite Mountain, 2.5 miles east of mouth of Bear Creek (Two additional sites for *Ashmunella kochii kochii* (dead material only, check again in Spring 1997) — Total of 6 sites currently known in the southern San Andres Mountains.

13. **23, 24 October 1996** – New Mexico: Doña Ana Mountains, Doña Ana Peak and vicinity. No specimens found, check in Spring of 1997).

14. **4, 6 November 1996** – New Mexico: Oscura Mountains, approximately 4 miles south Atom Peak, Jeep trail to Jim Site (new site for *Oreohelix socorroensis/neomexicana*).

15. **12, 13 November 1996** – New Mexico: Caballo Mountains, Caballo Cone and associated talus slopes. No specimens found, check in Spring of 1997. Note: Check Blackbushy Mountain in spring of 1997.

16. **17, 18 November 1996** – New Mexico: Oscura Mountains, approximately 5.5 miles south Atom Peak, Jeep trail to Jim Site (new site for *Oreohelix socorroensis/neomexicana*).

17. **21, 22 November 1996** – New Mexico: Oscura Mountains, approximately 6 miles south Atom Peak, Jeep trail to Jim Site (new site for *Oreohelix neomexicana/socorroensis*).

18. **5, 6, 7 December 1996** – New Mexico: Oscura Mountains, 12 miles north Atom Peak. No specimens found, check in Spring of 1997. Basically a total lack of habitat characteristic of terrestrial snails, because of lower elevation (<6,000 ft) and a lack of pinon-juniper-oak (mesic) habitat on N, and NE facing exposures.

19. **16, 18, 19 January 1997** – New Mexico: Oscura Mountains, 7 miles southeast Jim Site and along escarpment face.

20. **23, 25, 27 February 1997** – New Mexico: Oscura Mountains: Cottonwood Spring, Whitmore Canyon, Workman Ridge.

21. **4, 6, 8 March 1997** – New Mexico: Organ Mountains, Texas Canyon, boarder WSMR and Fort Bliss military reservations, and east of Agarie Springs. No specimens found, check in Spring of 1997.

22. **16, 17 March 1997** – New Mexico: Oscura Mountains, 1.8 and 2.0 miles (by road) north of South Oscura Peak (R5E, T7S, Sec 31; R5E, T7S, Sec. 30), elevation 2,500 and 2,500 m, respectively.

23. **27, 29, 30 March 1997** – New Mexico: San Andres Mountains, White Sands Test Facility, 4 mi E of the NE slope of Quartzite Mountain and mouth of Bear Creek to WSTF area. No specimens found, check in Spring of 1997).

24. **10 April 1997** – New Mexico: Oscura Mountains, head Dripping Spring 1.2 miles N. Whitmore Canyon (R4E, T7S, Sec. 6).

25. **12 May 1997** – New Mexico: Oscura Mountains, approximately 3 miles (by road) south Atom Peak, Jeep trail to Jim Site, (R5e, T7S, Sec 23).

26. **14, 15, 16** June 1997 – New Mexico: Doña Ana County, Quartzite Mountain, White Sands Test Facility NASA, approximately ½ mile south of Bear Canyon, and east of Quartzite Mountain, 5,900 ft. Three sites visited.

27. **6, 7, July 1997** – New Mexico: Oscura Mountains, 2.5 miles and 3 miles (by road) N of South Oscura Peak.

28. **8, 9, 10, 11 November 1997** – New Mexico, WSMR, Little Burrow Mountains and Mockingbird Mountains. Note: No evidence of snails present in these ranges.

29. **15, 16, 17 November 1997** – New Mexico: WSMR, Fairview and Silvertop Mountains. Note: No evidence of snails present in these mountain ranges.

30. **25, 26, 27, 28 November 1997** – New Mexico: Doña Ana County, Doña Ana Mountains, Doña Ana Peak, northern most peak.

31. **4, 5, 6, December 1997** – New Mexico: 1, 2, and 3 miles north of North Oscura Peak toward Highway 380 in search of northern most extension of *Oreohelix*. Note: No specimens found.

32. **8, 9, 10 December 1997** – New Mexico: 4, 5, and 6 miles north of North Oscura Peak toward Highway 380, including Garden Spring Canyon and North Canyon, in search of northern most extension of *Oreohelix*. Note: No specimens found.

5. APPENDIX B

Fieldnotes of Microhabitat Variables Measured at Each Site Where Live Snails Were Sampled. Data Includes Information on Microhabitat for 35 Different Collection Sites Encompassing Five Species and Three Genera of Terrestrial Snails.

R. M. Sullivan	***Field Journal***	**Page:** 01
1. Date: 27 July 1996		**2. Catalogue No.:** RMS# S-01
3. Species: *Ashmunella kochii* (Koch's Woodland Snail)		
4. Location: New Mexico: Doña Ana County, Guartzsite Mountain, White Sands Test Facility NASA, NE slope of Quartzite Mountain, south side head of Bear Canyon, UTM region 13		
5. N-UTM: 352469	**6. E-UTM:** 3598610	**7. Elevation (m/ft):** 6,000 ft
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): edge of woodland and grassland transition, but predominantly in woodland habitat some scattered grasses, including fluff grass.		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 45° slope) bajada, talus seam of igneous boulders at the head of major canyon.		
10. Dominant Vegetation (primary plant spp. <30 m–relative abundance [%]): <u>in order of abundance</u>: silktassal bush (*Garrya flavescens*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), tree cholla (*Opuntia imbricata*), purple prickly pear (*Opuntia phaecantha*), banana yucca (*Yucca baccata*), ephedra (*Ephedra trifurca*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), cliff rose (*Cowania mexicana*).		
11. Percent Overstory Cover: 40% silktassel bush and mountain mahogany		
12. Dominant Substrate (m; <30 m % composition): igneous rock, 3 inches to >2 ft in diameter. (e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)		
13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope (N-S-E-W):** NE slope
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.2	**19. Water pH:** n/a	**20. Dist. to Tree:** 5 ft
21. Tree spp.: 1-seed juniper	**22. Dist. to Shrub:** 8ft	**23. Shrub spp.:** silktassel
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (ephemeral, annual, perennial)		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil shallow, not much leaflitter, igneous rock covered with lichens		

28. Remarks/Photographs/Maps: Site at top (upper end) of canyon, sample moving down slope with GPS Photographs taken of habitat as well as samples Total of 8 snails sampled from site.

R. M. Sullivan	***Field Journal***	**Page:** 01

1. Date: 28 April 1996	**2. Catalogue No.:** RMS# S-02

3. Species: *Ashmunella kochii* (Koch's Woodland Snail)

4. Location: New Mexico: Doña Ana County, Guartzsite Mountain, White Sands Test Facility NASA, NE slope of Quartzite Mountain, south side head of Bear Canyon, UTM region 13

5. N-UTM: 352468	**6. E-UTM:** 3598623	**7. Elevation (m/ft):** 6,000 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): edge of woodland and grassland transition, but predominantly in woodland habitat some scattered grasses, including fluff grass.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 45° slope) bajada, talus seam of igneous boulders at the head of major canyon.

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: silktassal bush (*Garrya flavescens*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), tree cholla (*Opuntia imbricata*), purple prickly pear (*Opuntia phaecantha*), banana yucca (*Yucca baccata*), ephedra (*Ephedra trifurca*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), cliff rose (*Cowania mexicana*).

11. Percent Overstory Cover: 40% silktassel bush and mountain mahogany

12. Dominant Substrate: (<30 m % composition): igneous rock, 3 inches to >2 ft in diameter.

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope (N-S-E-W):** NE slope
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.2	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 25 ft
21. Tree Species: oak	**22. Dist to Shrub:** 3ft	**23. Shrub species:** juniper

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil shallow, not much leaflitter, igneous rock covered with lichens

28. Remarks/Photographs/Maps: Site at top (upper end) of canyon, sample moving down slope with GPS. Photographs taken of habitat as well as samples 20 snails sampled from site. Location within about 15 feet of RMS #1 site above.

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1. Date: 1 Aug. 1996 | **2. Catalogue No.:** RMS# S-03

3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mts. South Oscura Pk.; UTM 13 (PDOP=3.1) UTM1 372200; UTM2 3723956; 8,100 ft; West end of sample transect moving east up-slope to establish boundaries of transect; Habitat photos taken — (RMS #03).

5. N-UTM: 372200	**6. E-UTM:** 3723956	**7. Elevation (m/ft):** 8,100 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): pinon-juniper-oak woodland habitat

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 65° slope) occasional outcrops of limestone boulders

10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance pinon, juniper (*Juniperous monosperma*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*), cliff rose (*Cowania mexicana*), goose berry (*Ribes* spp.)

11. Percent Overstory Cover: 40% Gambel oak (*Quercus gambelii*)

12. Dominant Substrate (<30 m % composition): limestone outcrop, 4 x 12 ft
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): in leaf litter		**14. Slope (N-S-E-W):** NW slope
15. Air Temp: 62°F	**16. Soil Temp:** 53°	**17. Humidity:** dry
18. Soil pH: 7.3	**19. Water pH:** n/a	**21. Dist. to Tree (m/ft):** 4 ft
22. Tree Species: pinon	**23. Dist. To Shrub:** 1 ft	**24. Shrub Species:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph | **26. Amount** (area of water) n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil deep; much leaflitter, limestone rock well shaded by oak brush

28. Remarks/Photographs/Maps: Photographs taken of habitat and flagged; samples taken of 10 snail shells from site. Karl Wilson present on field trip

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1. Date: 1 Aug. 1996

2. Catalogue No.: RMS# S-04

3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mts. South Oscura Pk; UTM 13 (PDOP=3.3) UTM1 372262, UTM2 3723896; 8,100 ft — (RMS #04).

5. N-UTM: 372262	**6. E-UTM:** 3723896	**7. Elevation (m/ft):** 8,100 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): pinon-juniper-oak woodland habitat

9. Dominant Topography: Steep (± 65° slope) occasional outcrops of limestone boulders
(e.g., arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.)

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: pinon, juniper (*Juniperous monosperma*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*).

11. Percent Overstory Cover: 20% Gambel oak (*Quercus gambelii*)

12. Dominant Substrate (<30 m % composition): limestone outcrop, 6 x 9 ft
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): in leaflitter (n/a)		**14. Slope (N-S-E-W):** NE slope
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 8 ft
21. Tree Species: pinon	**22. Dist. to Shrub (ft):** 1 ft	**23 Shrub Species:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water): none

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil deep; much leaflitter, limestone rock well shaded by oak brush

28. Remarks/Photographs/Maps: Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*; Photos of snails and habitat taken. Karl Wilson present. Sample of 10 snails taken.

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1. Date: 2 Aug. 1996	**2. Catalogue No.:** RMS# S-05

3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mts. South Oscura Pk.; UTM 13 (PDOP=3.9) UTM1 372393; UTM2 3723998; 8,500 ft — (RMS #05)

5. N-UTM: 372393	**6. E-UTM:** 3723998	**7. Elevation (m/ft):** 8,500 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): in order of abundance: pinon, juniper (*Juniperous monosperma*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*)

9. Dominant Topography: At base f limestone escarpment, north-facing exposure, much shade and cover provided by G. oak brush
(e.g., arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.)

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): G. oak

11. Percent Overstory Cover: 60%, G. oak

12. Dominant Substrate (<30 m % composition)**:** soil and leaf litter, limestone rubble/gravel from abutting escarpment (e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): on surface of soil in leaflitter	**14. Slope (N-S-E-W):** N slope

15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 25 ft
21. Tree Species: pinon	**22. Dist. to Shrub (ft):** 1 ft	**23 Shrub Species:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water) n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): leaflitter and smaller (< 3 in) limestone rubble from abutting escarpment and tumble/rock roll

28. Remarks/Photographs/Maps: Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*; Photos of snails and habitat taken. Sample of 10 snails taken.

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1. Date: 2 Aug. 1996	**2. Catalogue No.:** RMS# S-06

3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mts. South Oscura Pk.; UTM 13 (PDOP=5.0) 372444 UTM1 3723794 UTM2; 8,300 ft; Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*, Photos of snails and habitat taken — (RMS #06)

5. N-UTM: 372444	**6. E-UTM:** 3723794	**7. Elevation (m/ft):** 8,300 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper and G. oak woodland

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 65° slope), along N-facing escarpment of limestone ledges

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), pinon (*Pinus edulus*), juniper (*Juniperous monosperma*), and cliff rose (*Cowania mexicana*).

11. Percent Overstory Cover: 60% G. oak

12. Dominant Substrate (<30 m % composition)**:** soil and leaf litter, limestone rubble/gravel from abutting escarpment
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope** (N-S-E-W)**:** NE slope
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.3	**19. Water pH:** n/a	**21. Dist to Tree:** 18 ft
22. Tree Spp.: pinon	**23. Dist. to Shrub:** 1.5 ft	**24 Shrub Spp.:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): leaflitter and smaller (< 3 in) limestone rubble from abutting escarpment and tumble/rock roll

28. Remarks/Photographs/Maps: Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*; Photos of snails and habitat taken. Sample of 10 snails taken.

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1. Date: 2 Aug. 1996		**2. Catalogue No.:** RMS# S-07
3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)		
4. Location: NM: Oscura Mts. South Oscura Pk; UTM 13 (PDOP=6.9) UTM1 372622, UTM2 3723897; 8,800 ft.		
5. N-UTM: 372622	**6. E-UTM:** 3723897	**7. Elevation (m/ft):** 8,800 ft
8. Dominant Macrohabitat (i.e., grassland, desertscrub, woodland, forest, riparian, etc.)**:** pinon-juniper-oak woodland associated with major limestone escarpment		
9. Dominant Topography (i.e., arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.)**:** Steep (± 55° slope), along N-facing escarpment of limestone ledges		
10. Dominant Vegetation (e.g., primary plant spp. <30 m–relative abundance [%])**:** in order of abundance: Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), pinon pine (*Pinus edulus*); juniper (*Juniperous monosperma*)		
11. Percent Overstory Cover: 60% G. oak		
12. Dominant Substrate (<30 m % composition)**:** soil and leaf litter, limestone rubble/gravel from abutting escarpment (e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)		
13. Height off Ground (m/ft): n/a--in leaf litter on ground		**14. Slope** (N-S-E-W)**:** N slope
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.2	**19. Water pH:** n/a	**20. Dist to Tree:** 32 ft
21. Tree spp: Junip. 1-seed	**22. Dist to Shrub:** 3 ft	**23 Shrub spp.:** G. oak
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other)**:** >1000 m/na		
25. Water Availability (ephemeral, annual, perennial)**:** eph		**26. Amount** (area of water)**:** n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.)**:** leaflitter and smaller (< 3 in) limestone rubble from abutting escarpment and tumble/rock roll		
28. Remarks/Photographs/Maps: Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus*. Photos of snails and habitat taken. Location directly below south Oscura Peak on west facing escarpment. Sample of 10 snails taken.		

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1. Date: 3 Aug. 1996 | **2. Catalogue No.:** RMS# S-08

3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mountains, North Oscura Peak (Type Locality for *Oreohelix socorroensis/neomexicana*).

5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 7,200 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-oak woodland

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 70° slope), along N-facing escarpment of limestone ledges

10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance: Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), pinon (*Pinus edulus*), juniper (*Juniperous monosperma*).

11. Percent Overstory Cover: 50% G. oak shrub/brush

12. Dominant Substrate (<30 m % composition): soil and oak leaf litter, limestone slabs (2 x 3 ft) and gravel from rim rock escarpment in the area and and buried over by leaf litter.

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): in soil/talus/leaflitter		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 65°F	**16. Soil Temp:** 55°	**17. Humidity:** dry
18. Soil pH: 7.4	**19. Water pH:** n/a	**21. Dist to Tree:** 50 ft
22. Tree Spp.: pinon	**23. Dist. to Shrub:** 1 ft	**24 Shrub Spp.:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph | **26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): leaflitter thin at the type locality; includes soil, oak leaf litter, limstone gravel (> 3 in), and scattered larger limestone slabs (2 x 3 ft) from rim rock escarpment Most of this constitutes limestone cobble resulting from tumble/rock roll down from escarpment

28. Remarks/Photographs/Maps: Photos taken of site; 10 dead snails taken for voucher specimens

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1. Date: 4, 5 Aug. 1996	**2. Catalogue No.:** RMS# S-09

3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mountains, North Oscura Peak (Type Locality for *Oreohelix socorroensis/neomexicana*).

5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 7,300 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-oak woodland

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 70° slope), along N-facing escarpment of limestone ledges

10. Dominant Vegetation (primary plant spp. <30 m–relative abundance [%]): in order of abundance: Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), pinon (*Pinus edulus*), juniper (*Juniperous monosperma*).

11. Percent Overstory Cover: 70% G. oak shrub/brush

12. Dominant Substrate (<30 m % composition)**:** soil and oak leaf litter, numerous limestone slabs (2 x 3 ft) and gravel from rim rock escarpment in the area and and buried over by leaf litter — approximately 30 feet from rim of limestine escarpment.

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): in soil/talus/leaflitter		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.4	**19. Water pH:** n/a	**21. Dist to Tree:** 50 ft
22. Tree Spp.: pinon	**23. Dist. to Shrub:** 1 ft	**24 Shrub Spp.:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water). n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): leaflitter thin at the type locality; includes soil, oak leaf litter, limstone gravel (> 3 in), and scattered. but nemerous larger limestone slabs (2 x 3 ft) from rim rock escarpment. All rock constitutes limestone cobble resulting from tumble/rock roll down from escarpment edge.

28. Remarks/Photographs/Maps: Continued to work the type licality to see how active snails were and if additional locations of snails could be foune. Photos taken of site; 10 dead snails taken for voucher specimens.

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1. Date: 17, 18 Aug. 1996

2. Catalogue No.: RMS# S-10

3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mts., North Oscura Peak (NOP) directly below DYCOMPS building. Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus* (dead)

5. N-UTM: 373000	**6. E-UTM:** 3736260	**7. Elevation (m/ft):** 7,900 ft

8. Dominant Macrohabitat **(grassland, desertscrub, woodland, forest, riparian, etc.):** Pinon-juniper and G. oak woodland

9. Dominant Topography **(arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.):** Steep (± 60° slope), along N-facing escarpment, and limestone ledges

10. Dominant Vegetation **(primary plant spp. <30 m--relative abundance [%]):** in order of abundance: Pinon (*Pinus edulus*); Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*).

11. Percent Overstory Cover: 30% G. oak; mountain mahogany (*Cercocarpus montanus*)

12. Dominant Substrate (<30 m % composition)**:** shallow soil and leaf litter, limestone rubble/gravel from abutting escarpment

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope** (N-S-E-W)**:** N slope
15. Air Temp: 62°F	**16. Soil Temp:** 55°	**17. Humidity:** dry
18. Soil pH: 7.3	**19. Water pH:** n/a	**21. Dist to Tree:** 6 ft
22. Tree Spp.: pinon	**23. Dist. to Shrub:** 2.5 ft	**24 Shrub Spp.:** mt mahogany

24. Drainage and Distance to Nearest Water **(spring, seep, arroyo, swale, other):** >1000 m/na

25. Water Availability **(ephemeral, annual, perennial):** eph	**26. Amount** (area of water): n/a

27. Micro-habitat **(leaf litter, sub-rock, on shrubs/trees, talus, etc.):** shallow gravely leaflitter and smaller (< 3 in) limestone rubble from abutting escarpment and tumble/rock roll

28. Remarks/Photographs/Maps: Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) dealbatus Sample of 10 dead snails taken.

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1. Date: 24, 25 Aug. 1996

2. Catalogue No.: RMS# S-11

3. Species: Oscura Mountain Land Snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mts., North Oscura Peak (NOP) directly below DYCOMPS building. Abundant dead shells of *Oreohelix socorroensis/neomexicana*, few *Bulimulus* (*Rabdotus*) *dealbatus* (dead)

5. N-UTM: 372436	**6. E-UTM:** 3723792	**7. Elevation (m/ft):** 8,250 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.)**:** Pinon-juniper and G. oak woodland

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.)**:** Steep (± 65° slope), along N-facing escarpment of limestone ledges

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%])**:** in order of abundance: Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), pinon (*Pinus edulus*), juniper (*Juniperous monosperma*), and cliff rose (*Cowania mexicana*).

11. Percent Overstory Cover: 20% G. oak

12. Dominant Substrate (<30 m % composition)**:** soil and leaf litter, limestone rubble/gravel from abutting escarpment

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope** (N-S-E-W)**:** N slope
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.3	**19. Water pH:** n/a	**21. Dist to Tree:** 11 ft
22. Tree Spp.: pinon	**23. Dist. to Shrub:** 5 ft	**24 Shrub Spp.:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other)**:** >1000 m/na

25. Water Availability (ephemeral, annual, perennial)**:** eph | **26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.)**:** leaflitter and smaller (< 3 in) limestone rubble from abutting escarpment and tumble/rock roll

28. Remarks/Photographs/Maps: Scattered dead shells of *Oreohelix socorroensis/neomexicana*, and a few *Bulimulus* (*Rabdotus*) *dealbatus*. A sample of 10 of each species was taken.

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1. Date: 7, 8 September 1996	**2. Catalogue No.:** RMS# S-12

3. Species: *Sonorella orientis*

4. Location: NM: Oscura Mountains, approximately 3 miles south Atom Peak, Jeep trail to Jim Site. PDOP=5 4

5. N-UTM: 372424	**6. E-UTM:** 3728448	**7. Elevation (m/ft):** 8,400 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-G. oak woodland, live oak spp., mt. mahogany, banana yucca, Gooseberry (Ribies spp.) in association with woodrat midden and igneous rock.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 35° slope), along NW-NE slope well away from N and W-facing limestone escarpment

10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance: Pinon, Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), Goose Berries (Ribes spp.)

11. Percent Overstory Cover: 50% G. oak; well shaded, contained under well-developed mature/large pinon trees

12. Dominant Substrate (<30 m % composition)**:** well developed leaf litter, igneous rubble/gravel from abutting igneous rock outcrops that were 35 ft high x 300 ft long; old rock with may cracks and cavernous species
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): 2-3 feet, and in leaflitter	**14. Slope (N-S-E-W):** NE slope

15. Air Temp: 68°F	**16. Soil Temp:** 58°	**17. Humidity:** wet and misty/fog--unusual
18. Soil pH: 7.3	**19. Water pH:** n/a	**21. Dist to Tree:** 4 ft
22. Tree Spp.: pinon	**23. Dist. to Shrub:** 2.5 ft	**24 Shrub Spp.:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): well developed oak and pinon leaflitter, but snails mostly in cracks of rocks, probably feeding on woodrat dropping and nearby vegetation

28. Remarks/Photographs/Maps: First live specimens of this species described from Oscura Mountains Nearest live populations are known only from the Organ and Doña Ana mountains. Photos of snails and habitat taken 10 live specimens taken by RMS and reared in captivity All have survived and reproduction has taken place with viable offspring—as of April 24, 1997). Other areas in the vicinity of this site (approx. 1/4 mile radius) were searched, but no dead or alive specimens were found. **Note:** R.M. Sullivan and R.A. Smartt found shells of dead specimens of this species during the early 1990's, but no living material.

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1. Date: 5 October 1996	**2. Catalogue No.:** RMS# S-13

3. Species: *Ashmunella todseni* (Maple Canyon Woodland Snail)

4. Location: Organ Mountains, Texas Canyon and boarder of WSMR and Fort Bliss military reservations.

5. N-UTM: 358355	**6. E-UTM:** 3580292	**7. Elevation (m/ft):** 5,7200

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-oak woodland

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Moderate (± 45° slope), along N-facing exposure

10. Dominant Vegetation (primary plant spp. <30 m–relative abundance [%]) — in order of abundance: Oak, juniper, *Sporobolis* spp. *Aristica purpurea*, Solto, pinon pine

11. Percent Overstory Cover: 20%

12. Dominant Substrate (<30 m % composition)**:** rock rubble and mixed leaflitter of oak and other vegetation

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): n/a		**14. Slope** (N-S-E-W)**:** N slope
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.3	**19. Water pH:** n/a	**21. Dist to Tree:** 4 m
22. Tree Spp.: 1-s juniper	**23. Dist. to Shrub:** 2 m	**24 Shrub Spp.:** *Guiterrezia* (snakeweed)

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water)· n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): leaflitter and smaller (< 3 in) igneous rubble, 5% ground cover, dense rocks

28. Remarks/Photographs/Maps: New site (dead shells only) — endemic to Texas and Maple canyons only.

R. M. Sullivan	*Field Journal*	**Page:** 01
1. Date: 6 October 1996		**2. Catalogue No.:** RMS# S-14
3. Species: *Ashmunella todseni* (Maple Canyon Woodland Snail)		
4. Location: Organ Mountains, Texas Canyon and boarder of WSMR and Fort Bliss military reservations.		
5. N-UTM: 358401	**6. E-UTM:** 3580110	**7. Elevation (m/ft):** 5,600
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Oak-mt. mahogany, *Garyia wrightii* community at base of rocky cliff		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Extreme (± 75° slope), along N-facing exposure		
10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]) — in order of abundance: Oak-mt. mahogany, *Garyia wrightii* community, *Grindelia squarosa*, *Sporobolis* contractus, common fern, *Butolua curtipendula, Salvia arizonica, Yucca baccata*		
11. Percent Overstory Cover: 35%		
12. Dominant Substrate (<30 m % composition): rock rubble and mixed leaflitter of oak and other vegetation **(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)**		
13. Height off Ground (m/ft): n/a		**14. Slope** (N-S-E-W): NW
15. Air Temp: 64°F	**16. Soil Temp:** 56°	**17. Humidity:** dry
18. Soil pH: 7.3	**19. Water pH:** n/a	**21. Dist to Tree:** 1 m
22. Tree Spp.: *Quercus, hyoleucoides*	**23. Dist. to Shrub:** 5 m	**24 Shrub Spp.:** *Garryia wrightii*
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (ephemeral, annual, perennial): eph		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): leaflitter and smaller (< 3 in) igneous rubble, 5% ground cover, dense rocks		
28. Remarks/Photographs/Maps: New site (dead shells only) — endemic to Texas and Maple canyons only.		

R. M. Sullivan	***Field Journal***	**Page:** 01
1. Date: 14 October 1996		**2. Catalogue No.:** RMS# S-15
3. Species: *Ashmunella kochii* (Koch's Woodland Snail)		
4. Location: NM, San Andres Mountains, White Sands Test Facility, NE slope Guartzite Mountain, 2.5 miles east of mouth of Bear Creek		
5. N-UTM: 352376	**6. E-UTM:** 3596640	**7. Elevation (m/ft):** 6,100 ft
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): edge of woodland and grassland transition, but predominantly in woodland habitat some scattered grasses, including fluff grass.		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 55° slope) bajada, talus seam of igneous boulders at the head of major canyon.		
10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance: silktassal bush (*Garrya flavescens*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), tree cholla (*Opuntia imbricata*), purple prickly pear (*Opuntia phaecantha*), banana yucca (*Yucca baccata*), ephedra (*Ephedra trifurca*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), cliff rose (*Cowania mexicana*) — mostly same as other sites.		
11. Percent Overstory Cover: 40% silktassel bush and mountain mahogany		
12. Dominant Substrate (m; <30 m % composition): igneous rock, 3 inches to >2 ft in diameter. (e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)		
13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope (N-S-E-W):** NE slope
15. Air Temp: 62°F	**16. Soil Temp:** 52°	**17. Humidity:** dry
18. Soil pH: 7.2	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 15 ft
21. Tree Species: silktassel	**22. Dist. to Shrb:** 15 ft	**23. Shrub Species:** silktassel
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (ephemeral, annual, perennial)		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil shallow, not much leaflitter, igneous rock covered with lichens		
28. Remarks/Photographs/Maps: Additional site for *Ashmunella kochii kochii* (dead material only, check again in Spring 1997).Sample of 10 snails taken.		

R. M. Sullivan	*Field Journal*	**Page:** 01

1. Date: 15 October 1996

2. Catalogue No.: RMS# S-16

3. Species: *Ashmunella kochii* (Koch's Woodland Snail)

4. Location: NM, San Andres Mountains, White Sands Test Facility, NE slope Guartzite Mountain, 2.5 miles east of mouth of Bear Creek

5. N-UTM: 352444	**6. E-UTM:** 3596630	**7. Elevation (m/ft):** 6,200 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): edge of woodland and grassland transition, but predominantly in woodland habitat some scattered grasses, including fluff grass.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 55° slope) bajada, talus seam of igneous boulders at the head of major canyon.

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: silktassal bush (*Garrya flavescens*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), tree cholla (*Opuntia imbricata*), purple prickly pear (*Opuntia phaecantha*), banana yucca (*Yucca baccata*), ephedra (*Ephedra trifurca*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), cliff rose (*Cowania mexicana*) — mostly same as other sites.

11. Percent Overstory Cover: 40% silktassel bush and mountain mahogany

12. Dominant Substrate (m; <30 m % composition): igneous rock, 3 inches to >2 ft in diameter.

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope (N-S-E-W):** NE slope
15. Air Temp: 62°F	**16. Soil Temp:** 52°	**17. Humidity:** dry
18. Soil pH: 7.2	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 15 ft
21. Tree Species: silktassel	**22. Dist. to Shrb:** 15 ft	**23. Shrub Species:** silktassel

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial)	**26. Amount** (area of water) n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil shallow, not much leaflitter, igneous rock covered with lichens

28. Remarks/Photographs/Maps: Additional site for *Ashmunella kochii kochii* (dead material only, check again in Spring 1997). Total of 7 sites currently known in the southern San Andres Mountains. Sample of 10 snails taken.

R. M. Sullivan	***Field Journal***	**Page:** 01
1. Date: 4, 6 November 1996		**2. Catalogue No.:** RMS# S-17
3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*).		
4. Location: NM: Oscura Mountains, approximately 4 miles south Atom Peak, Jeep trail to Jim Site (new site for *Oreohelix socorroensis/neomexicana*).		
5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 7,500 ft
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-G. oak and mt mahogany, banana yucca, NM locust.		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Slope steep (65° slope), along N-facing escarpment of limestone ledges, brushy		
10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): <u>in order of abundance</u>: Pinon, 1-s juniper, Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*).		
11. Percent Overstory Cover: 50% G. oak, pinon		
12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone cobble (e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)		
13. Height off Ground (m/ft): leaflitter, limestone cobble		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 52°F	**16. Soil Temp:** 51°	**17. Humidity:** medium
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 6 ft
21. Tree Species: pinon	**22. Dist. to Shrb:** 1.5 ft	**23. Shrub Species:** G. oak
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (ephemeral, annual, perennial): eph		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): shaded habitat along N-facing slope in shade of both G oak and cliffedge, fairly well developed leaflitter (3.5 inches); near jeep trail; limestone ledges and cobble		
28. Remarks/Photographs/Maps: get UTM readings; area of snail habitat approximately 30 x 8 feet, numerous snail shells scattered along ledge in more open, warmer habitat; Sample of 10 taken.		

R. M. Sullivan	***Field Journal***	**Page:** 01
1. Date: 17, 18 November 1996		**2. Catalogue No.:** RMS# S-18
3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*).		
4. Location: NM:Oscura Mountains, approximately 5.5 miles south Atom Peak, Jeep trail to Jim Site (new site for *Oreohelix socorroensis/neomexicana*).		
5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 7,600 ft
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-G. oak and mt. mahogany, banana yucca, NM locust.		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Slope steep (60° slope), along N-facing escarpment of limestone ledges, brushy		
10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: Pinon, 1-s juniper, Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*).		
11. Percent Overstory Cover: 60% G. oak, pinon		
12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone cobble **(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)**		
13. Height off Ground (m/ft): leaflitter, limestone cobble		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 50°F	**16. Soil Temp:** 49°	**17. Humidity:** medium
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 8 ft
21. Tree Species: pinon	**22. Dist. to Shrb:** 1 ft	**23. Shrub Species:** G. oak
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (ephemeral, annual, perennial): eph		**26. Amount** (area of water): n/a
27. (leaf litter, sub-rock, on shrubs/trees, talus, etc.): cool, shaded habitat along N-facing under both G oak and cliff edge, fairly well developed leaflitter (3 - 4 inches); near jeep trail; limestone ledges and cobble		
28. Remarks/Photographs/Maps: get UTM readings; area of snail habitat approximately 15 x 8 feet, numerous snail shells scattered along ledge in more open, warmer habitat, old but adult; Sample of 10 taken.		

R. M. Sullivan	***Field Journal***	**Page:** 01

1. Date: 21, 22 November 1996	**2. Catalogue No.:** RMS# S-19

3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*).

4. Location: NM: Oscura Mountains, approximately 6 miles south Atom Peak, Jeep trail to Jim Site (new site for *Oreohelix socorroensis/neomexicana*).

5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 7,725 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-G. oak and mt. mahogany, mt mahogany, banana yucca, NM locust.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Slope steep (65° slope), along NE-facing escarpment of limestone ledges, brushy habitat

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: Pinon, 1-s juniper, Gambel oak (*Quercus gambelii*), mt mahogany (*Cercocarpus montanus*), NM locust (*Robinia neomexicana*), banana yucca (*Yucca baccata*).

11. Percent Overstory Cover: 60% G. oak, pinon

12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone cobble

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): leaflitter, limestone cobble		**14. Slope (N-S-E-W):** NE slope
15. Air Temp: 47°F	**16. Soil Temp:** 48°	**17. Humidity:** medium
18. Soil pH: 7.3	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 11 ft
21. Tree Species: pinon	**22. Dist. to Shrb:** 4 ft	**23. Shrub Species:** G. oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): cool, shaded habitat along N-facing under both G oak and cliffedge, fairly well developed leaflitter (3 - 4 inches); near jeep trail; limestone ledges and cobble

28. Remarks/Photographs/Maps: get UTM readings; area of snail habitat approximately 15 x 8 feet, numerous snail shells scattered along ledge in more open, sunnier (=warmer habitat) but dryer; old adult some quite large; Sample of 10 taken.

R. M. Sullivan	***Field Journal***	**Page:** 01

1. Date: 16, 18, 19 January 1997	**2. Catalogue No.:** RMS# S-20

3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*).

4. Location: NM: Oscura Mountains, 7 miles southeast Jim Site and along escarpment face

5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 7,700 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-G. oak and mt. mahogany, mt mahogany, banana yucca, NM locust.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Slope steep (65° slope), along N-facing escarpment of limestone ledges, brushy habitat

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: Pinon, 1-s juniper, Gambel oak (*Quercus gambelii*), mt mahogany (*Cercocarpus montanus*), NM locust, banana yucca (*Yucca baccata*).

11. Percent Overstory Cover: 60% G. oak, pinon

12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone cobble

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): leaflitter, limestone cobble		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 45°F	**16. Soil Temp:** 47°	**17. Humidity:** medium
18. Soil pH: 7.3	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 3 ft
21. Tree Species: pinon	**22. Dist. to Shrub:** 1 ft	**23. Shrub Species:** Pinon

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): cold, shaded habitat along N-facing under both G oak, pinon, and cliff-edge, fairly well developed leaflitter (3.5 4.5 inches); limestone ledges and cobble

28. Remarks/Photographs/Maps: get UTM readings; area of snail habitat approximately 5 x 3 feet, scattered snail shells along ledge in open, sunnier (=warmer habitat) but dryer; Sample of 10 taken.

R. M. Sullivan	***Field Journal***	**Page:** 01

1. Date: 23, 25, 27 February 1997 | **2. Catalogue No.:** RMS# S-21

3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*).

4. Location: NM: Oscura Mountains: Whitmore Canyon, 7 miles southeast Jim Site along eastern exposure of the mountain ridge in lower portion of Whitmore Canyon.

5. N-UTM: | **6. E-UTM:** | **7. Elevation (m/ft):** 7,700 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-G. oak and mt. mahogany, mt mahogany, banana yucca, NM locust.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Slope steep (45° slope), along E-canyon, brushy habitat

10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance: Gambel oak (*Quercus gambelii*), Pinon, 1-s juniper, mt mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*).

11. Percent Overstory Cover: 30% G. oak, pinon

12. Dominant Substrate (m; <30 m % composition): leaflitter, igneous rock cobble

(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): leaflitter, igneous cobble | **14. Slope (N-S-E-W):** E slope

15. Air Temp: 52°F | **16. Soil Temp:** 47° | **17. Humidity:** dry

18. Soil pH: 7.2 | **19. Water pH:** n/a | **20. Dist. to Tree (m/ft):** 23 ft

21. Tree Species: pinon | **22. Dist. to Shrub:** 3 ft | **23. Shrub Species:** mt. mahogany

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): eph | **26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): open habitat, little sand along E-facing canyon leaflitter not well developed (1.5 2.5 inches); igneous, dry site

28. Remarks/Photographs/Maps: get UTM readings. Only scattered shells, material old in appearance, check upper reaches of canyon. Sample of 10 taken. Note: No snails found in Cottonwood Spring or along Workman Ridge, habitat hot mesic enough, to dry and typical plant species not present (e.g., pinon-oak-juniper).

R. M. Sullivan	***Field Journal***	**Page:** 01
1. Date: 16 March 1997		**2. Catalogue No.:** RMS# S-22
3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*).		
4. Location: NM: Oscura Mountains: 1.8 miles north of Oscura Peak (R5E, T7S, Sec 31)		
5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 2,500 m
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-oak woodland, and mountain mahogany, banana yucca, New Mexico locust.		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NW facing escarpment edge, shaded areas below limestone ledge/cliffs, abundant leaf litter, Slope steep (60° slope)		
10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: Gambel oak (*Quercus gambelii*), Piñon (*Pinus edulus*), 1-seed juniper (*Juniperus monosperma*), mt. mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*).		
11. Percent Overstory Cover: 45% oak and piñon		
12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone ledge, and some loose limestone along the edge of the ledge **(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)**		
13. Height off Ground (m/ft): leaflitter, igneous cobble		**14. Slope (N-S-E-W):** NW (shaded) slope
15. Air Temp: 52°F	**16. Soil Temp:** 54°	**17. Humidity:** damp
18. Soil pH: 7.2	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 2 ft
21. Tree Species: piñon	**22. Dist. to Shrub:** 4 ft	**23. Shrub Species:** mt. mahogany
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (ephemeral, annual, perennial): ephemeral		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): closed habitat, shaded, at base of cliff (10 ft), abundant leaf litter (3 - 5 inches)		
28. Remarks/Photographs/Maps: No UTM readings but plotted on map. Scattered shells, abundant old in		

R. M. Sullivan	***Field Journal***	**Page:** 01
1. Date: 17, March 1997		**2. Catalogue No.:** RMS# S-23
3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*)		
4. Location: NM: Oscura Mountains: Canyon, 2.0 miles north of Oscura Peak (R5E, T7S, Sec 30)		
5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 2,500 m
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-oak woodland, and mountain mahogany, banana yucca, New Mexico locust.		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NW facing escarpment edge, shaded areas below limestone ledge/cliffs, abundant leaf litter, Slope steep (60° slope)		
10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: Gambel oak (*Quercus gambelii*), Piñon (*Pinus edulus*), 1-seed juniper (*Juniperus monosperma*), mt. mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*).		
11. Percent Overstory Cover: 50% oak and piñon		
12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone ledge, and some loose limestone along edge of the ledge **(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)**		
13. Height off Ground (m/ft): leaflitter, igneous cobble		**14. Slope (N-S-E-W):** NW (shaded) slope
15. Air Temp: 52°F	**16. Soil Temp:** 54°	**17. Humidity:** damp
18. Soil pH: 7.2	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 2 ft
21. Tree Species: piñon	**22. Dist. to Shrub:** 4 ft	**23. Shrub Species:** mt. mahogany
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (ephemeral, annual, perennial): ephemeral		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): closed habitat, shaded, at base of cliff (10 ft), abundant leaf litter (3 - 5 inches)		
28. Remarks/Photographs/Maps: No UTM readings but plotted on map. Scattered old shells within cobble.		

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1. Date: 10 April 1997	**2. Catalogue No.:** RMS# S-24

3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*)

4. Location: NM: Oscura Mountains: Head Dripping Spring 1.2 miles N Whitmore Canyon (R5E, T7S, Sec 6)

5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 2,200 m

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-oak woodland, and mountain mahogany, banana yucca, New Mexico locust.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): EW running canyon, shaded limestone ledge, abundant leaf litter, Slope steep (45° slope)

10. Dominant Vegetation (primary plant spp. <30 m–relative abundance [%]): in order of abundance: Gambel oak (*Quercus gambelii*), Piñon (*Pinus edulus*), 1-seed juniper (*Juniperus monosperma*), mt. mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*).

11. Percent Overstory Cover: 40% piñon

12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone ledge, and some loose limestone along edge of the ledge
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): leaflitter, igneous cobble		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 64°F	**16. Soil Temp:** 66°	**17. Humidity:** damp
18. Soil pH: 7.5	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 4 ft
21. Tree Species: piñon	**22. Dist. to Shrub:** 3 ft	**23. Shrub Species:** juniper

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >500 m/na

25. Water Availability (ephemeral, annual, perennial): ephemeral	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): closed habitat, shaded, at base of cliff (5 ft), abundant leaf litter (3 - 4 inches)

28. Remarks/Photographs/Maps: No UTM readings, but plotted on map. Scattered shells, abundant old specimens in and among existing cobble.

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1. Date: 12 May 1997	**2. Catalogue No.:** RMS# S-25
3. Species: *Sonorella orientis*	
4. Location: NM: Oscura Mountains, approximately 3 miles south Atom Peak, Jeep trail to Jim Site. R5E, T7S, Sec 23	

5. N-UTM: 372501	**6. E-UTM:** 3728454	**7. Elevation (m/ft):** 8,400 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.)**:** Pinon-juniper-G. oak woodland, live oak spp., mt. mahogany, banana yucca, Gooseberry (*Ribies* spp.) in association with woodrat midden and igneous rock.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.)**:** Steep (± 35° slope), along NNE slope well away from N and W-facing limestone escarpment

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%])**:** in order of abundance: Pinon, Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), Goose Berries (*Ribes* spp.), banana yucca (*Yucca baccata*)

11. Percent Overstory Cover: 50% G. oak; well shaded, contained under well-developed mature/large pinon trees on ledges above cliff and at base of cliff were snails were

12. Dominant Substrate (<30 m % composition)**:** well developed leaf litter, igneous rubble/gravel from abutting igneous rock outcrops that were 25 ft high x 150 ft long; old rock with may cracks and cavernous species.
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): 2-3 feet, and in leaflitter		**14. Slope** (N-S-E-W)**:** NE slope
15. Air Temp: 68°F	**16. Soil Temp:** 58°	**17. Humidity:** wet and misty/fog--unusual
18. Soil pH: 7.3	**19. Water pH:** n/a	**21. Dist to Tree:** 2 ft
22. Tree Spp.: pinon	**23. Dist. to Shrub:** 5 ft	**24 Shrub Spp.:** Gamble oak

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other)**:** >1000 m/na

25. Water Availability (ephemeral, annual, perennial)**:** eph	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.)**:** well developed oak and pinon leaflitter, but snails mostly in cracks of rocks, probably feeding on woodrat dropping and nearby vegetation

28. Remarks/Photographs/Maps: Few shells observed, appears to be on the edge of the species distribution in this localized area. Additional exploration of the area since last year when the species was found living among the igneous rocks. 5 dead shells collected for reference.

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1. Date: 14 June 1997	**2. Catalogue No.:** RMS# S-26
3. Species: *Ashmunella kochii* (Koch's Woodland Snail)	
4. Location: New Mexico: Doña Ana County, Guartzsite Mountain, White Sands Test Facility NASA, approximately ½ mile south of Bear Canyon east of Quartzite Mountain	

5. N-UTM: 352484	**6. E-UTM:** 3598674	**7. Elevation (m/ft):** 5,900 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): edge of woodland and grassland transition, but predominantly in woodland habitat some scattered grasses, including fluff grass.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 45° slope) bajada, abundant seams of talus igneous boulders at the head along east-facing slope,

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: silktassal bush (*Garrya flavescens*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), tree cholla (*Opuntia imbricata*), purple prickly pear (*Opuntia phaecantha*), banana yucca (*Yucca baccata*), ephedra (*Ephedra trifurca*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), cliff rose (*Cowania mexicana*)

11. Percent Overstory Cover: 25% silk-tassel

12. Dominant Substrate (m; <30 m % composition): igneous rock, 5 inches to >2 ft in diameter.
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope (N-S-E-W):** E slope
15. Air Temp: 78°F	**16. Soil Temp:** 70°	**17. Humidity:** dry
18. Soil pH: 7.5	**19. Water pH:** n/a	**20. Dist. to Tree:** 3 ft
21. Tree spp.: 1-seed juniper	**22. Dist. to Shrub:** 4ft	**23. Shrub spp.:** silk-tassel

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial)	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil shallow, not much leaflitter, igneous rock covered with lichens

28. Remarks/Photographs/Maps: Site at mid to upper reaches of the ridge east of Quartzite Mountain. Total of 5 snails sampled from site.

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1. Date: 15 June 1997		**2. Catalogue No.:** RMS# S-27
3. Species: *Ashmunella kochii* (Koch's Woodland Snail)		
4. Location: New Mexico: Doña Ana County, Guartzsite Mountain, White Sands Test Facility NASA, E slope of ridge running of Quartzite Mountain, south side head of Bear Canyon, UTM region 13		
5. N-UTM: 352529	**6. E-UTM:** 3598590	**7. Elevation (m/ft):** 5,900 ft
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): edge of woodland and grassland transition, but predominantly in woodland habitat some scattered grasses, including fluff grass.		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 45° slope) bajada, talus seams of abundant igneous boulders along east facing slope of mountain.		
10. Dominant Vegetation (primary plant spp. <30 m–relative abundance [%]): in order of abundance: silk-tassal bush (*Garrya flavescens*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), purple prickly pear (*Opuntia phaecantha*), banana yucca (*Yucca baccata*), ephedra (*Ephedra trifurca*), tree cholla (*Opuntia imbricata*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), cliff rose (*Cowania mexicana*).		
11. Percent Overstory Cover: 30% silk-tassel		
12. Dominant Substrate (m; <30 m % composition): igneous rock, 6 inches to >3 ft in diameter. (e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)		
13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope (N-S-E-W):** E slope
15. Air Temp: 78°F	**16. Soil Temp:** 75°	**17. Humidity:** dry
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree:** 6 ft
21. Tree spp.: Silk-tassel	**22. Dist. to Shrub:** 8ft	**23. Shrub spp.:** 1-seed juniper
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (ephemeral, annual, perennial): epi		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil shallow, little leaflitter, igneous rock covered with lichens as is typical of this area, not much litter on top of soil, somewhat dryer that N-facing slopes		
28. Remarks/Photographs/Maps: Total of 5 snails sampled from site for reference. Would be advisable to look at habitat associated with Bear Peak (2150 ft elevation) along north and east facing canyon walls (NNE Sec. 4).		

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1. Date: 16 June 1997 — **2. Catalogue No.:** RMS# S-28

3. Species: *Ashmunella kochii* (Koch's Woodland Snail)

4. Location: New Mexico: Doña Ana County, Guartzite Mountain, White Sands Test Facility NASA, E slope of ridge running of Quartzite Mountain, south side head of Bear Canyon, UTM region 13

5. N-UTM: 352489	**6. E-UTM:** 3598600	**7. Elevation (m/ft):** 5,800 ft

8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): edge of woodland and grassland transition, but predominantly in woodland habitat some scattered grasses, including fluff grass.

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): Steep (± 50° slope) bajada, talus seams of abundant igneous boulders along east facing slope of mountain.

10. Dominant Vegetation (primary plant spp. <30 m--relative abundance [%]): in order of abundance: silk-tassal bush (*Garrya flavescens*), Gambel oak (*Quercus gambelii*), mountain mahogany (*Cercocarpus montanus*), juniper (*Juniperous monosperma*), purple prickly pear (*Opuntia phaecantha*), banana yucca (*Yucca baccata*), ephedra (*Ephedra trifurca*), tree cholla (*Opuntia imbricata*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), cliff rose (*Cowania mexicana*).

11. Percent Overstory Cover: 50% silk-tassel

12. Dominant Substrate (m; <30 m % composition): igneous rock, 6 inches to >3 ft in diameter.
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): n/a--talus boulders		**14. Slope (N-S-E-W):** E slope
15. Air Temp: 79°F	**16. Soil Temp:** 74°	**17. Humidity:** dry
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree:** 2 ft
21. Tree spp.: Silk-tassel	**22. Dist. to Shrub:** 4ft	**23. Shrub spp.:** silk-tassel

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (ephemeral, annual, perennial): epi — **26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Soil shallow, little leaflitter, igneous rock covered with lichens as is typical of this area, little top of soil.

28. Remarks/Photographs/Maps: Total of 5 snails sampled from site for reference.

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1. Date: July 6 1997		**2. Catalogue No.:** RMS# S-29
3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*)		
4. Location: NM: Oscura Mountains: 2.5 miles by road South Oscura Peak (T7S, R5E, Sec 24)		
5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 2,200 m
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-oak woodland, and mountain mahogany, banana yucca, New Mexico locust.		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NW running canyon, shaded limestone ledge, abundant leaf litter, Slope steep (35° slope)		
10. Dominant Vegetation (primary plant spp. <30 m–relative abundance [%]): in order of abundance: Piñon (*Pinus edulus*), Gambel oak (*Quercus gambelii*), 1-seed juniper (*Juniperus monosperma*), mt. mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*).		
11. Percent Overstory Cover: 50% piñon		
12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone ledge, and some loose limestone along edge of the ledge (e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)		
13. Height off Ground (m/ft): leaflitter, igneous cobble		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 64°F	**16. Soil Temp:** 66°	**17. Humidity:** damp
18. Soil pH: 7.5	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 6 ft
21. Tree Species: piñon	**22. Dist. to Shrub:** 1 ft	**23. Shrub Species:** Gamble oak
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >500 m/na		
25. Water Availability (ephemeral, annual, perennial): ephemeral		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): closed habitat, shaded, at base of cliff (3 ft), abundant leaf litter (3 - 4 inches)		
28. Remarks/Photographs/Maps: No UTM readings, but plotted on map. Scattered shells, abundant old specimens in and among existing cobble; 5 specimens were taken from site.		

R. M. Sullivan	***Field Journal***	**Page:** 01
1. Date: July 7 1997		**2. Catalogue No.:** RMS# S-30
3. Species: Oscura Mountain Land snail (*Oreohelix socorroensis/neomexicana*)		
4. Location: NM: Oscura Mountains. 3 miles by road South Oscura Peak (T7S, R5E, Sec 13)		
5. N-UTM:	**6. E-UTM:**	**7. Elevation (m/ft):** 2,200 m
8. Dominant Macrohabitat (grassland, desertscrub, woodland, forest, riparian, etc.): Pinon-juniper-oak woodland, and mountain mahogany, banana yucca, New Mexico locust		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NW running canyon, shaded limestone ledge, abundant leaf litter, Slope steep (35° slope)		
10. Dominant Vegetation (primary plant spp. <30 m–relative abundance [%]): in order of abundance: Piñon (*Pinus edulus*), Gambel oak (*Quercus gambelii*), 1-seed juniper (*Juniperus monosperma*), mt. mahogany (*Cercocarpus montanus*), banana yucca (*Yucca baccata*), New Mexico locust (*Robinia neomexicana*).		
11. Percent Overstory Cover: 30% piñon		
12. Dominant Substrate (m; <30 m % composition): leaflitter, limestone ledge, and some loose limestone along edge of the ledge **(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)**		
13. Height off Ground (m/ft): leaflitter, igneous cobble		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 74°F	**16. Soil Temp:** 66°	**17. Humidity:** damp
18. Soil pH: 7.5	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 6 ft
21. Tree Species: piñon	**22. Dist. to Shrub:** 3 ft	**23. Shrub Species:** NM locust
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >500 m/na		
25. Water Availability (ephemeral, annual, perennial): ephemeral		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): closed habitat, shaded, at base of cliff (3 ft), abundant leaf litter (3 - 4 inches)		
28. Remarks/Photographs/Maps: No UTM readings, but plotted on map. Scattered shells, abundant old specimens in and among existing cobble; 5 specimens collected from site.		

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1. Date: 25 November 1997	**2. Catalogue No.:** RMS# S-31

3. Species: Doña Ana Mountain Land Snail (*Sonorella todsendi*)

4. Location: NM: Doña Ana Mountains, Doña Ana Peak, northern most peak

5. N-UTM: 3595219	**6. E-UTM:** 331757	**7. Elevation (m/ft):** 1788 m

8. Dominant Macrohabitat: Piñon-juniper woodland and adjacent desert scrub

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NE exposure with a steep slope of about 60 degrees, approximately 550 feet from peak in accumulated seems of talus

10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance: Banana yucca (*Yucca baccata*), prickly pear (*Opuntia phaeacantha*), LA white sage (*Artemisia ludoviciana*), silk-tassel (*Garrya wrightii*), Mormon-tea (*Ephadera trifuca*), sacaton (*Sporobolus airoides*), broom snakeweed (*Guttierezia sarothrae*), soap tree yucca (*Yucca elata*), *Echinocereus* spp., winter-fat (*Ceratoides lanata*), heavy lichens

11. Percent Overstory Cover: 50% of 1 seed juniper

12. Dominant Substrate (m; <30 m % composition): talus seams, or rock varying in size from 6 to 14 inches in diameter, gray and purple in color (volcanic), no accumulations of leaf-litter
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): within in talus		**14. Slope (N-S-E-W):** NNE slope
15. Air Temp: 48°F	**16. Soil Temp:** 53°	**17. Humidity:** damp
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 6 ft
21. Tree Spp: 1-seed juniper	**22. Dist. to Shrub:** 3 ft	**23. Shrub Spp:** LA sage

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (none, ephemeral, annual, perennial): none	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Open habitat, talus (6 - 14 inches diameter), few and small rocky ledges, approximately 550 feet from peak, steep N slope

28. Remarks/Photographs/Maps: Photos and sample of 5 recently dead snails taken; snails appeared to be few in number, probably because of nearness to top of the peak and greater aridity and sunlight. All snails sites appeared darker from a distance of approximately 1/4 of-a-mile than the lighter surrounding sites.

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1. Date: 26 November 1997

2. Catalogue No.: RMS# S-32

3. Species: Doña Ana Mountain Land Snail (*Sonorella todsendi*)

4. Location: NM: Doña Ana Mountains, Doña Ana Peak, northern most peak

5. N-UTM: 3592206 | **6. E-UTM:** 331848 | **7. Elevation (m/ft):** 1807 m

8. Dominant Macrohabitat: Piñon-juniper woodland and adjacent desert scrub

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NE exposure with a steep slope of about 60 degrees, approximately 150 feet from peak in accumulated seems of talus

10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance: Banana yucca (*Yucca baccata*), prickly pear (*Opuntia phaeacantha*), LA white sage (*Artemisia ludoviciana*), silk-tassel (*Garrya wrightii*), Mormon-tea (*Ephadera trifuca*), sacaton (*Sporobolus airoides*), broom snakeweed (*Guttierezia sarothrae*), soap tree yucca (*Yucca elata*), *Echinocereus* spp., winter-fat (*Ceratoides lanata*), heavy lichens

11. Percent Overstory Cover: 20% of 1 seed juniper

12. Dominant Substrate (m; <30 m % composition): talus seams, or rock varying in size from 6 to 14 inches in diameter, gray and purple in color (volcanic), no accumulations of leaf-litter
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): within in talus		**14. Slope (N-S-E-W):** N slope
15. Air Temp: 48°F	**16. Soil Temp:** 53°	**17. Humidity:** damp
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 23 ft
21. Tree Spp: 1-seed juniper	**22. Dist. to Shrub:** 3 ft	**23. Shrub Spp:** 1-seed juniper (< 30 cm DBH)

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (none, ephemeral, annual, perennial): none | **26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Open habitat, talus (6 - 14 inches diameter), few and small rocky ledges, approximately 150 feet from peak, steep N slope

28. Remarks/Photographs/Maps: Photos and sample of 5 recently dead snails taken; snails appeared to be few in number, probably because of nearness to top of the peak and greater aridity and sunlight. All snails sites appeared darker from a distance of approximately 1/4 of-a-mile than the lighter surrounding sites.

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1. Date: 27 November 1997	**2. Catalogue No.:** RMS# S-33

3. Species: Doña Ana Mountain Land Snail (*Sonorella todsendi*)

4. Location: NM: Doña Ana Mountains, Doña Ana Peak, northern most peak

5. N-UTM: 3592474	**6. E-UTM:** 331854	**7. Elevation (m/ft):** 1694 m

8. Dominant Macrohabitat: Piñon-juniper woodland and adjacent desert scrub

9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NE exposure with a steep slope of about 60 degrees, approximately 600 feet from peak in accumulated seems of talus

10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): <u>in order of abundance</u>: Banana yucca (*Yucca baccata*), prickly pear (*Opuntia phaeacantha*), LA white sage (*Artemisia ludoviciana*), silk-tassel (*Garrya wrightii*), Mormon-tea (*Ephadera trifuca*), sacaton (*Sporobolus airoides*), broom snakeweed (*Guttierezia sarothrae*), soap tree yucca (*Yucca elata*), *Echinocereus* spp., heavy lichens

11. Percent Overstory Cover: 20% of 1 seed juniper

12. Dominant Substrate (m; <30 m % composition): talus seams, or rock varying in size from 1 to 3 inches in diameter, gray and purple in color (volcanic), no accumulations of leaf-litter
(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)

13. Height off Ground (m/ft): within in talus		**14. Slope (N-S-E-W):** NE slope
15. Air Temp: 48°F	**16. Soil Temp:** 53°	**17. Humidity:** damp
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 3 ft
21. Tree Spp: 1-seed juniper	**22. Dist. to Shrub:** 3 ft	**23. Shrub Spp:** silk-tassel

24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na

25. Water Availability (none, ephemeral, annual, perennial): none	**26. Amount** (area of water): n/a

27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Open habitat, talus (1-3 inches diameter), few and small rocky ledges, approximately 600 feet from peak, steep NE slope

28. Remarks/Photographs/Maps: Photos and sample of 10 recently dead snails taken.

R. M. Sullivan	***Field Journal***	**Page:** 01
1. Date: 28 November 1997		**2. Catalogue No.:** RMS# S-34
3. Species: Doña Ana Mountain Land Snail (*Sonorella todsendi*)		
4. Location: NM: Doña Ana Mountains, Doña Ana Peak, northern most peak		
5. N-UTM: 3595353	**6. E-UTM:** 331902	**7. Elevation (m/ft):** 1733 m
8. Dominant Macrohabitat: Piñon-juniper woodland and adjacent desert scrub		
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NE exposure with a steep slope of about 60 degrees, approximately 500 feet from peak in accumulated seems of talus		
10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance: Banana yucca (*Yucca baccata*), prickly pear (*Opuntia phaeacantha*), LA white sage (*Artemisia ludoviciana*), silk-tassel (*Garrya wrightii*), Mormon-tea (*Ephadera trifuca*), sacaton (*Sporobolus airoides*), broom snakeweed (*Guttierezia sarothrae*), soap tree yucca (*Yucca elata*), *Echinocereus* spp., heavy lichens		
11. Percent Overstory Cover: 60% of 1- seed juniper (site shaded by juniper tree)		
12. Dominant Substrate (m; <30 m % composition): talus seams, or rock varying in size from 6 to 12 inches in diameter, gray and purple in color (volcanic), no accumulations of leaf-litter **(e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)**		
13. Height off Ground (m/ft): within in talus		**14. Slope (N-S-E-W):** NE slope
15. Air Temp: 48°F	**16. Soil Temp:** 53°	**17. Humidity:** damp
18. Soil pH: 7.4	**19. Water pH:** n/a	**20. Dist. to Tree (m/ft):** 1 ft
21. Tree Spp: 1-seed juniper	**22. Dist. to Shrub:** 5 ft	**23. Shrub Spp:** silk-tassel
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na		
25. Water Availability (none, ephemeral, annual, perennial): none		**26. Amount** (area of water): n/a
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Open habitat, talus boulders (6 - 12 inches diameter), few and small rocky ledges, approximately 500 feet from peak, steep NE slope		
28. Remarks/Photographs/Maps: Photos and sample of 10 recently dead snails taken.		

R. M. Sullivan	*Field Journal*		Page: 01
1. Date: 28 November 1997		2. Catalogue No.: RMS# S-35	
3. Species: Doña Ana Mountain Land Snail (*Sonorella todsendi*)			
4. Location: NM: Doña Ana Mountains, Doña Ana Peak, northern most peak			
5. N-UTM: 3592308	6. E-UTM: 331872	7. Elevation (m/ft): 1717 m	
8. Dominant Macrohabitat: Piñon-juniper woodland and adjacent desert scrub			
9. Dominant Topography (arroyo, canyon, playa, bajada, swale, dunes, stream, ledge, cliff, escarpment, marsh, pond, etc.): NE exposure with a steep slope of about 60 degrees, approximately 450 feet from peak in accumulated seems of talus			
10. Dominant Vegetation (primary plant spp. <30 m—relative abundance [%]): in order of abundance: Banana yucca (*Yucca baccata*), prickly pear (*Opuntia phaeacantha*), LA white sage (*Artemisia ludoviciana*), silk-tassel (*Garrya wrightii*), Mormon-tea (*Ephadera trifuca*), sacaton (*Sporobolus airoides*), broom snakeweed (*Guttierezia sarothrae*), soap tree yucca (*Yucca elata*), *Echinocereus* spp., winter-fat (*Ceratoides lanata*), heavy lichens			
11. Percent Overstory Cover: 60% of 1- seed juniper (site shaded by juniper tree)			
12. Dominant Substrate (m; <30 m % composition): talus seams, or rock varying in size from 6 to 12 inches in diameter, gray and purple in color (volcanic), no accumulations of leaf-litter (e.g., igneous, clay, rock, limestone, caliche, alkali, sand, silt, loam, desert pavement, gravel, volcanic, etc.)			
13. Height off Ground (m/ft): within in talus		14. Slope (N-S-E-W): NE slope	
15. Air Temp: 48°F	16. Soil Temp: 53°	17. Humidity: damp	
18. Soil pH: 7.4	19. Water pH: n/a	20. Dist. to Tree (m/ft): 1 ft	
21. Tree Spp: 1-seed juniper	22. Dist. to Shrub: 3 ft	23. Shrub Spp: Mormon-tea	
24. Drainage and Distance to Nearest Water (spring, seep, arroyo, swale, other): >1000 m/na			
25. Water Availability (none, ephemeral, annual, perennial): none		26. Amount (area of water): n/a	
27. Micro-habitat (leaf litter, sub-rock, on shrubs/trees, talus, etc.): Open habitat, talus boulders (6 - 12 inches diameter), few and small rocky ledges, approximately 450 feet from peak, steep NE slope			
28. Remarks/Photographs/Maps: Photos and sample of 10 recently dead snails taken.			

APPENDIX C

Summary Statistics for Microhabitat Variables Measured at Each Site Where Live Snails Were Sampled. Data Summarized Includes Information on Snails from 35 Different Sampling Sites for Four Species of Terrestrial Snails.

SUMMARY STATISTICS FOR *Ashmunella kochii*

Dominant Vegetation Within 3 Meters of Site

	Grass	Woodland	Forest	Riparian	Arroyo
n =	7	10	0	3	5
% =	28.0%	40.0%	0.0%	12/0%	20.0%

Dominant Substrate Within 3 Meters of Site

	Igneous	Alkali	Limestone	Sandstone
n =	10	0	0	0
%	100.0%	0.0%	0.0%	0.0%

Abiotic Factors

	Temperature		Soil		Weather		Elevation	
	Air	Soil	Humidity	pH	Clear	Clouds	Feet	Meters
n =	10	10	10	10	10	0	10	10
Maximum =	91	80	3	8	100.0%	0.0%	6200	1889.7
Minimum =	62	52	2	7			5340	1627.6
Average =	76.0	66.6	2.1	7.4			5792.0	1765.3

Biotic Factors

	Distance (Meters) to Nearest Tree/Shrub/Water		
	Tree	Shrub	Water
n =	10	10	10
Maximum =	10.0	10.0	10000
Minimum =	1.0	1.0	10000
Average =	5.0	4.6	10000

Exposure

	N	NE	NW	S	E	W
n =	6	6	4	0	0	0
% =	66.0%	40.0%	0.0%	0.0%	0.0%	0.0%

Microhabitat of Site

	Leaflitter	Rock	Tree & Shrub	Talus
n =	10	3	0	10
% =	43.5%	13.0%	0.0%	43.5%

% Overstory Vegetation

Average =	41.5
Maxi,um =	50.0
Minimum =	25.0

Average Slope =	49.5 degrees

SUMMARY STATISTICS FOR *Oreohelix socorroensis/neomexicana* -- *Oscura Mountains*

Dominant Vegetation Within 3 Meters of Site

	Grass	Woodland	Forest	Riparian	Arroyo
n =	0	19	0	0	0
% =	0.0%	100.0%	0.0%	0.0%	0.0%

Dominant Substrate Within 3 Meters of Site

	Igneous	Alkali	Limestone	Sandstone
n =	1	0	18	0
%	5.3%	0.0%	94.7%	0.0%

Abiotic Factors

	Temperature		Soil		Weather		Elevation	
	Air	Soil	Humidity	pH	Clear	Clouds	Feet	Meters
n =	19	19	19	19	16	3	19	19
Maximum =	85	74	3	7.4	84.2%	15.8%	8800	2682.1
Minimum =	45	47	2	7.2			7200	2194.5
Average =	65.5	58.5	2.2	7.3			7856.6	2394.6

Biotic Factors

	Distance (Meters) to Nearest Tree/Shrub/Water		
	Tree	Shrub	Water
n =	19	19	19
Maximum =	15.0	2.5	10000
Minimum =	1.0	0.3	10000
Average =	6.3	0.7	10000

Exposure

	N	NE	NW	S	E	W
n =	14	14	3	0	1	0
% =	77.8%	16.7%	0.0%	5.6%	0.0%	0.0%

Average Slope = 51.6 degrees

Microhabitat of Site

	Leaflitter	Rock	Tree & Shrub	Talus
n =	19	8	0	18
% =	42.2%	17.8%	0.0%	40.0%

% Overstory Vegetation

Average =	40.5
Maxi,um =	50.0
Minimum =	20.0

SUMMARY STATISTICS FOR *Sonorella orientis* - Oscura Mountains

Dominant Vegetation Within 3 Meters of Site

	Grass	Woodland	Forest	Riparian	Arroyo
n =	0	2	0	0	0
% =	0.0%	100.0%	0.0%	0.0%	0.0%

Dominant Substrate Within 3 Meters of Site

	Igneous	Alkali	Limestone	Sandstone
n =	2	0	0	0
%	100.0%	0.0%	0.0%	0.0%

Abiotic Factors

	Temperature		Soil		Weather		Elevation	
	Air	Soil	Humidity	pH	Clear	Clouds	Feet	Meters
n =	2	2	2	2	0	2	2	2
Maximum =	68	58	4	7.3	0.0%	100.0%	8400	2560
Minimum =	68	58	4	7.3			8400	2560
Average =	68.0	58.0	4.0	7.3			8400.0	2560.2

Biotic Factors

	Distance (Meters) to Nearest Tree/Shrub/Water		
	Tree	Shrub	Water
n =	2	2	2
Maximum =	1.5	1.5	10000
Minimum =	1.3	1.3	10000
Average =	1.4	1.4	10000

Exposure

	N	NE	NW	S	E	W
n =	0	0	2	0	0	0
% =	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%

Microhabitat of Site

	Leaflitter	Rock	Tree & Shrub	Talus
n =	2	2	0	0
% =	50.0%	50.0%	0.0%	0.0

% Overstory Vegetation

Average =	43.3
Maxi,um =	50.0
Minimum =	30.0

Average Slope = 35.0 degrees

SUMMARY STATISTICS FOR *Sonorella todsendi* - Doña Ana Mountains

Dominant Vegetation Within 3 Meters of Site

	Grass	Woodland	Forest	Riparian	Arroyo
n =	5	0	0	0	0
% =	100.0%	0.0%	0.0%	0.0%	0.0%

Dominant Substrate Within 3 Meters of Site

	Igneous	Alkali	Limestone	Sandstone
n =	5	0	0	0
%	100.0%	0.0%	0.0%	0.0%

Abiotic Factors

	Temperature		Soil		Weather		Elevation	
	Air	Soil	Humidity	pH	Clear	Clouds	Feet	Meters
n =	5	5	5	5	5	0	5	5
Maximum =	48	53	2	7.4	100.0%	0.0%	6000	1828.7
Minimum =	48	53	2	7.4			5600	1706.8
Average =	48.0	53.0	2.0	7.4			5760.0	1755.6

Biotic Factors

	Distance (Meters) to Nearest Tree/Shrub/Water		
	Tree	Shrub	Water
n =	5	5	5
Maximum =	2.0	8.0	10000
Minimum =	0.3	0.3	10000
Average =	1.0	2.4	10000

Exposure

	N	NE	NW	S	E	W
n =	1	1	4	0	0	0
% =	20.0%	20.0%	80.0%	0.0%	0.0%	0.0%

Micro-habitat of Site

	Leaflitter	Rock	Tree & Shrub	Talus
n =	5	0	0	0
% =	100.0%	0.0%	0.0%	0.0

% Overstory Vegetation

Average =	42.3
Maxi,um =	60.0
Minimum =	20.0

Average Slope = 49.0 degrees

APPENDIX D

Summary Statistics for Plant Species Most Commonly Observed at Each Site Where Live Snails Were Sampled. Data Summarized Represents Species of Plants ranked by their Abundance within a three (3) Meter Radius of the Sample Site.

Species of Plant	Species and Populations of Snails							
	Ashmunella kochii		*Oreohelix socorroensis*		*Sonorella orientis*		*Sonorella todsendi*	
	No.	%	No.	%	No.	%	No.	%
Banana yucca (*Yucca baccata*)	8	11.3	9	7.6	2	16.7	4	9.1
Beargrass (*Nolina mocrocarpa*)	7	9.9	1	0.8				
Broom snakeweed (*Guttierezia sarothrae*)							4	9.1
Cliff rose (*Cowania mexicana*)	6	8.5						
Echinocereus spp.							4	9.1
Ephedra (*Ephedra trifurca*)	7	9.9					4	9.1
Gambel's oak (*Quercus gambelii*)	7	9.9	33	28.0	2	16.7		
Goose Berries (*Ribes spp.*)			8	6.8	2	16.7		
Lichens							4	9.1
Mt. mahogany (*Cercocarpus montanus*)			12	10.2	2	16.7		
One-seed juniper (*Juniperous monosperma*)	7	9.9	15	12.7	2	16.7		
Piñon pine (*Pinus edulus*)			24	20.3	2	16.7		
Purple prickly pear (*Opuntia phaecantha*)	2	2.8	12	10.2			4	9.1
Sacaton (*Sprobolus arioides*)							4	9.1
Silk-tassel (*Garrya flavescens*)	7	9.9					4	9.1
Soaptree yucca (*Yucca elata*)							4	9.1
Sotol (*Dasylirion wheeleri*)			4	3.3				
Tree Cholla (*Opuntia imbricata*)	7	9.9						
Winterfat (*Ceratoides lanata*)							4	9.1

APPENDIX E

Species-specific Sampling Locations for GIS Mapping.

Species	n	Collector	Date	Specific Locality	Coordinates	
					UTM-N	UTM-E
Ashmunella kocii	24	RAS 351/RMS	16-Jun-94	NM: San Andres Mts. Little San Nicolas Canyon	358310	3604216
Ashmunella kocii	80	RAS 351/RMS	16-Jun-94	NM: San Andres Mts. Little San Nicolas Canyon	358310	3604216
Ashmunella kocii	34	RAS 352/RMS	16-Jun-94	NM: San Andres Mts. Little San Nicolas Canyon	358310	3604216
Ashmunella kocii	8	RMS# S-01	27-Jul-96	NM· Dona Ana Co., WSTF, NE slope Quartizite Mt., head Bear Creek Canyon	352469	3598610
Ashmunella kocii	20	RMS# S-02	28-Jul-96	NM Dona Ana Co., WSTF, NE slope Quartizite Mt., head Bear Creek Canyon	352468	3598623
Ashmunella kocii	20	RMS# S-15	14-Oct-96	NM: Dona Ana Co., WSTF, NE slope Quartizite Mt., head Bear Creek Canyon	358401	3580110
Ashmunella kocii	20	RMS# S-16	15-Oct-96	NM: Dona Ana Co , WSTF, NE slope Quartizite Mt., head Bear Creek Canyon	352376	3596640
Ashmunella kocii	10	RMS# S-26	14-Jun-97	NM: Dona Ana Co., WSTF, NE slope Quartizite Mt., head Bear Creek Canyon	382484	3598674
Ashmunella kocii	10	RMS# S-27	15-Jun-97	NM Dona Ana Co., WSTF, NE slope Quartizite Mt., head Bear Creek Canyon	352529	3598590
Ashmunella kocii	10	RMS# S-28	16-Jun-97	NM: Dona Ana Co., WSTF, NE slope Quartizite Mt., head Bear Creek Canyon	353489	3598600

Oreohelix socorroensis	10	RMS-#S03	1 Aug 96	NM Oscura Mts , South Oscura Peak (SOP)	372200 0	3723956 0
Oreohelix socorroensis	10	RMS-#S04	1 Aug 96	NM: Oscura Mts., South Oscura Peak (SOP)	372262.0	3723896.0
Oreohelix socorroensis	10	RMS-#S05	2 Aug 96	NM Oscura Mts., South Oscura Peak (SOP)	372393 0	3723998 0
Oreohelix socorroensis	10	RMS-#S06	2 Aug 96	NM Oscura Mts , South Oscura Peak (SOP)	372444 0	3723794 0
Oreohelix socorroensis	10	RMS-#S07	2 Aug 96	NM: Oscura Mts., South Oscura Peak (SOP)	372622 0	3723897 0
Oreohelix socorroensis	10	RMS-#S08	3 Aug 96	NM· Oscura Mts., North Oscura Peak (NOP); Type locality for live snails found in Oscura Mts	R5E T6S Sec 29	
Oreohelix socorroensis	10	RMS-#S09	4,5 Aug 96	NM· Oscura Mts , North Oscura Peak (NOP); Type locality for live snails found in Oscura Mts	R5E T6S Sec 29	
Oreohelix socorroensis	10	RMS-#S10	17,18 Aug 96	NM· Oscura Mts , North Oscura Peak (NOP) directly below DYCOMPS building	373000 0	3736260 0

Oreohelix socorroensis	10	RMS-#S11	24, 25 Aug 96	NM Oscura Mts., North Oscura Peak (NOP) directly below DYCOMPS building	372436 0	3723792.0
Oreohelix socorroensis	10	RMS-#S17	4,6 Nov 96	NM Oscura Mts, approximately 4 miles S Atom Peak, Jeep trail to Jim Site (NW corner Sec 30)	R5E T6S Sec 30	
Oreohelix socorroensis	10	RMS-#S18	17, 18 Nov 96	NM· Oscura Mts, approximately 5.5 miles S Atom Peak, Jeep trail to Jim Site (SW corner Sec 30)	R5E T6S Sec 30	
Oreohelix socorroensis	10	RMS-#S19	21, 22 Nov 96	NM. Oscura Mts, approximately 6 miles S Atom Peak, Jeep trail to Jim Site (NW Sec 6)	R5E T7S Sec 31	
Oreohelix socorroensis	10	RMS-#S20	16, 18, 19 Jan 96	NM· Oscura Mts, approximately 7 mi S Atom Peak, Jeep trail to Jim Site (W-central Sec 6)	R5E T7S Sec 6	
Oreohelix socorroensis	10	RMS-#S21	23, 25, 27 Feb 97	NM Oscura Mts, Whitmore Canyon, E exposure of mt ridge in lower portion Whitmore Canyon	R5E T7S Sec 7	
Oreohelix socorroensis	5	RMS-#S22	17 Jul 95	NM Oscura Mts., 1.8 mi north of South Oscura Peak (R5E, T7S, Sec 31)	R5E T7S Sec 31	
Oreohelix socorroensis	5	RMS-#S23	17 Jul 95	NM· Oscura Mts., 2.0 mi north of South Oscura Peak (R5E, T7S, Sec 31)	R5E T7S Sec 31	
Oreohelix socorroensis	5	RMS-#S24	17 Jul 95	NM Oscura Mts., head Dripping Springs, 1.2 mi N Whitmore Canyon (R5E, T7S, Sec 6)	R5E T7S Sec 06	
Oreohelix socorroensis	5	RMS-#S29	17 Jul 95	NM. Oscura Mts., 2 5 miles by road South Oscura Peak (R5E, T7S, Sec 24)	R5E T7S Sec 24	
Oreohelix socorroensis	5	RMS-#S30	17 Jul 95	NM. Oscura Mts., 3 mi by road N of South Oscura Peak (R5E T7S Sec 13)	R5E T7S Sec 13	

Sonorella orietis	10	RMS-#S12	7, 8-Sep-97	NM Oscura Mts , approx. 3 miles south Atom Peak, Jeep trail to Jim Site	372424 0	3728448 0
Sonorella orietis	10	RMS-#S25	12-May-97	NM Oscura Mts , approx. 3 miles south Atom Peak, Jeep trail to Jim Site	372501 0	3728454 0

Sonorella todsendi	10	RMS-#S31	25-Nov-97	NM Dona Ana Mts, Dona Ana Peak, northern most peak, N exposure	3595219.0	331757 0
Sonorella todsendi	10	RMS-#S32	26-Nov-97	NM Dona Ana Mts, Dona Ana Peak, northern most peak, N exposure	3592206 0	331848 0
Sonorella todsendi	10	RMS-#S33	27-Nov-97	NM· Dona Ana Mts, Dona Ana Peak, northern most peak, N exposure	3592474 0	331854 0
Sonorella todsendi	10	RMS-#S34	28-Nov-97	NM Dona Ana Mts, Dona Ana Peak, northern most peak, N exposure	3595353 0	331902 0
Sonorella todsendi	10	RMS-#S35	28-Nov-97	NM Dona Ana Mts, Dona Ana Peak, northern most peak, N exposure	3592308 0	331872 0

Appendix D. Results of the 1997 land-snail survey of the Southern Sierra Cuchillo, Sierra County, New Mexico.

DRAFT

LAND SNAILS OF THE SOUTHERN SIERRA CUCHILLO, SIERRA COUNTY, NEW MEXICO

Artie L. Metcalf and Brian K. Lang

Abstract

The primary objective of this survey of the land snail fauna of the Southern Sierra Cuchillo has been to ascertain whether discernible changes have occurred in the species composition of the fauna over the past 83 years, since the first and only other report concerning it was made in 1915. Concomitantly, we discuss how snail distribution in the range seems to be related to arboreal vegetation, bedrock-type, and elevation.

Physiography and Geology

The Sierra Cuchillo is located mainly in northwestern Sierra County, New Mexico, although extending a short distance northward into Socorro County. It is one of numerous mountain ranges that border the Rio Grande Rift Valley of central New Mexico. As is typical of many such ranges, it is narrow, east-west, and elongate, north-south, comprising a tilted fault block bounded by north-south oriented faults. It is separated from the higher and much more extensive Black Range, to the west, by a valley averaging some 8 km (5 mi.) wide in which is located the village of Winston. Eastward, there are scattered, lower hills and extensive graded surfaces that gradually descend to the Rio Grande floodplain.

A major transverse fault bisects the range at about its mid-length, ca. 1.2 km (0.75 mi.) south of Red Hill Pass on New Mexico Highway 52 and in N 1/2, Sec. 7, T. 11 S, R. 7 W. The initial part of a primitive road leading from Hwy. 52 westward up an upper canyon of the Willow Spring Draw complex is located approximately in the position of this transverse fault. The fault zone was utilized by Jahns (1955:159) to create a boundary between "Northern Cuchillo" and "Southern Cuchillo" subdivisions of the range. We deal here only with the Southern Cuchillo component. From the transverse fault, the Southern Cuchillos extend ca. 10 km (6.3 mi.) southward to form canyon walls along Cuchillo Negro Creek. Jahns et al (1978:131) considered the range to extend southward beyond the canyon some 3.2 km (2 mi.) to include Cross Mountain and Twin Peaks, and terminating at the latter.

Although there are minor outcrops of pre-Pennsylvanian rocks in the complexly faulted southwestern part of the Southern Cuchillos, most rocks exposed in the range are of Pennsylvanian, Permian, or Cenozoic age. Pennsylvanian sedimentary rocks of the Madera Limestone Formation of the Magdalena Group are exposed widely in the Southern Cuchillos. Where these calcareous strata occur at higher elevations the most productive habitat for land snails in the range is provided, as discussed below.

There are several intrusive masses of monzonitic rocks of Tertiary age in the southern Cuchillos. The largest and most salient of these is Cuchillo Mountain in the central part of the Southern Cuchillos. Lozinsky *et al* (1995:38) describe this mountain as a laccolith, probably originating as a magma chamber of a stratovolcano some 50 million years ago. Cuchillo Mountain attains a height of 2,406 m (7,895 ft). According to Jahns (1955:159) it has an outcrop area of "nearly 3 square miles." The main mass of the mountain extends ca. 2.8 km (1.75 mi.), north to south. However, there is a narrower, linear monzonitic outcrop that extends a further 2.4 km (1.5 mi.) south along the west side of the crest, and, after a hiatus, a similar outcrop extends northward along the west side of the Sierra to terminate abruptly at the major transverse fault, discussed above (Jahns, 1955: Fig. 1). The crest of Cuchillo Mountain is somewhat serrate, and is a conspicuous topographic feature. As can easily be observed from a distance, it is more sparsely forested than are adjacent areas with bedrock of Madera Limestone. In addition to Cuchillo Mountain, there are several other outcrops of intrusive monzonite in the Southern Cuchillos, as in the central cores of Cross Mountain and Twin Peaks at the extreme southern end of the range.

A third bedrock type is represented in the Southern Cuchillos by a small outcrop of olivine basalt that caps a mesa, locally called Tabletop Mesa, located just southwest of the western terminus of the aforementioned major transverse fault, bounding the Southern Cuchillos on the north (in S 1/2, Sec. 12, and N central part of Sec. 13, T. 11 S, R. 8 W). The mesa is approximately 107 m (350 ft) high. On its northwest side it forms a wall of Schoolhouse Canyon, and parallels NM Highway. 52, which follows the canyon floor.

Distributional Patterns

In our collections made in 1997-98, eleven species of land snails were taken. These are listed in Table 1. In the table habitat types are indicated, based on the bedrock types discussed above: Pennsylvanian limestone, Tertiary intrusive monzonite, and Pleistocene olivine basalt. Within each habitat grouping localities are arranged from higher (to left) to lower elevations.

Pennsylvanian Limestone Terrane

As noted above, there are extensive outcrops of the Madera Limestone Formation in the range. These are especially prominent (1) from the north end of Cuchillo Mountain north to the transverse fault at the north end of the Southern Cuchillos and (2) southward from Cuchillo Mountain to the southern end of the range, including lower elevations of Cross Mountain and Twin Peaks. At higher elevations, above 2,072 m(6,800 ft), where this terrane occurs in the central and northern part of the Southern Cuchillos, forested areas occur, especially in canyons, and on north-facing slopes. The forest is comprised of low trees, preponderantly Pinyon Pine (*Pinus edulis*), One-seeded Juniper (*Juniperus monosperma*), and Gray Oak (*Quercus grisea*). Alder-leaved Mountain Mahogany (*Cercocarpus montanus*) is a common understory shrub and in mesic areas along cliffs and in narrow canyons occur shrubs such as currant (*Ribes* spp.), Apache plume (*Fallugia paradoxa*), and barberry (*Berberis* spp.).

It is in such wooded areas that the greatest numbers and kinds of snails were found, as shown in Table 1. The two largest species, *Holospira cockerelli* and *Oreohelix metcalfei cuchillensis*, were found only in this habitat-type, mainly under limestone rocks, ranging from single stones to small accumulations of talus. Several of the smaller species were commonest in the most mesic habitats, as along cliffs or in narrow canyons, chiefly in leaf litter and/or under logs or limestone rocks. These comprised the species *Cionella lubrica*, *Gastrocopta pilsbryana*, *Vallonia perspectiva*, *Glyphyalinia indentata*, and *Hawaiia minuscula*.

Tertiary intrusive monzonite terrane

Several collections were made in the higher parts of Cuchillo Mountain, discussed above, which includes the highest elevations found in the Southern Cuchillos.

Quaternary basaltic terrane

Basaltic terrane was limited to the small olivine basalt flow capping Tabletop Mesa. It was of special interest, because such basaltic outcrops in New Mexico sometimes yield surprisingly large numbers of small land snails, as, for instance, in the extensive areas of extrusive volcanic rocks in the northeasternmost part of the state. We wondered it this would be the case here, also.

Malacological History

To our knowledge, the first and only published account concerning land snails of the Sierra Cuchillo resulted from explorations made in the area by Henry A. Pilsbry and James H. Ferriss and their party in 1915. Beginning in the second week of August, of that year, the group traveled by wagon from Deming, New Mexico, to Swarts (or Swartz) in the Mimbres Valley, Grant County. Thence, they proceeded with a pack train of horses east to the Black Range, which they then explored to its northern end. Pilsbry and some other members of the party departed from the group by way of Chloride, Sierra County, to the Rio Grande Valley on September 12. Ferriss and remaining members of the party then explored in the northernmost Black Range, and made an excursion from Chloride to the Sierra Cuchillo and San Mateo Mountains, returning to Chloride apparently via some part of the Northern Sierra Cuchillo, since brief mention is made of fossiliferous rocks and drift shells observed in that part of the range. They then returned to Deming by a route southward along the eastern foothills of the Black Range, visiting Hermosa, where they discovered *Oreohelix metcalfei hermosensis*, which they later described, deeming it as being closely related to *O. m. cuchillensis* (Ferriss, 1917; Pilsbry and Ferriss, 1917).

Ferriss's route to the Sierra Cuchillo from Chloride or Winston and in the range, itself, is not at all clear. The list of collecting stations provided by Pilsbry and Ferriss (1917:106) states only

"Three stations at the south end of this range, 6 miles east of Chloride." Elsewhere (p. 87), they note that a collection was made "on a brushy northern slope on the Thomas Scale [*sic*] trail, in the southern end of the range" and "a couple of miles further on in Frank Calhoun's pasture." They noted that at both these localities snails "lived in groves of oak, under limestone spawls and dead timber." The first of these localities was the type locality of *Oreohelix metcalfei cuchillensis,* the only taxon described as new from the range.

Thomas Scales was a prominent citizen in the early history of Fairview (now Winston). Scales Canyon in the northern Black Range bears his name. His home in Winston is still occupied, but Winstonites contacted by us did not know where the Thomas Scales trail was located. Scales was a military man turned prospector and miner (Stanley, 1962:16). Harley notes (1934:117,120) that he developed the Dictator Mine "about 1901 or 1902." Thus, it seems likely that the trail would have led from Fairview/Winston, where Scales resided, over the Sierra Cuchillo to its eastern side, where the Dictator Mine is located. It also seems likely that Scales would have selected a fairly direct route, and would have utilized one of the lower passes over the crest of the mountain. He well may have used the trail still shown on the 7.5 min. Winston and Chise topographic quadrangles of 1965. This trail originates at Winston and leads easterly up a canyon along the northern boundaries of sections 23 and 24, T. 11 S, R. 8 W. The canyon leads up to the lowest pass in the central part of the Southern Cuchillos at 2,213 m (7,260 ft), located ca. 0.3 km (0.2 mi.) northwest of the Becky Mine. East of the pass, another canyon descends the eastern slope of the range, emerging in the foothills ca. 1.2 km (0.75 mi.) north of the Dictator Mine, tailings of which are still visible from NM Highway 52, to the east. If this was the route used by Scales, and then by Ferriss, the type locality of *Oreohelix metcalfei cuchillensis* would likely have been along the north-facing wall in the uppermost part of the canyon west of the pass, in the southwestern part of Section 18. This accords with the description "brushy northern slope" of Pilsbry and Ferriss (1917:87) if "northern" is taken to mean north-facing.

From Locality 1, Ferriss went on about two miles where he again collected *Oreohelix* and other snails in "Frank Calhoun's pasture." Since the *Oreohelix* and *Holospira* collected were calciphiles, it seems reasonable that he had to pass around or over monzonitic Cuchillo Mountain before encountering limestone terrane again. Possibly his party proceeded southeastward along the crest of Cuchillo Mountain, or, more likely, continued eastward and downslope on the Thomas Scales Trail, to the Dictator Mine area, and then southward towards limestone cliffs that they could have seen in the distance. These cliffs are on and near the HOK Ranch, which is part of the present Ladder Ranch, but, in 1915, it would have belonged to Frank Calhoun. Lang collected *Oreohelix* and *Holospira* along this impressive limestone scarp, which reaches an elevation of 2,400 m (7,871 ft). It seems likely that when this scarp came into view that Ferriss would have headed towards it, as he would have assumed that limestone, montane forest, and higher elevations all portended good snail habitat.

Discussion

Ferriss collected eight species of snails in the Southern Cuchillos, as indicated in Table 1. All of these species were also collected by us except *Thysanophora hornii.* However, *T. hornii* is a widespread species in the Lower and Upper Sonoran zones of southern New Mexico, and almost certainly still occurs in the Cuchillo Mountains, as well. Our collections included four species not taken by Ferriss: *Gastrocopta ashmuni, G. pellucida, Hawaiia minuscula*, and a succineid. Except for the succineid, not identified to species, these are common species that were surely present in the Sierra Cuchillo in 1915. However, the two *Gastrocopta* were probably to be found at lower elevations than those where Ferriss collected. *Oreohelix metcalfei cuchillensis* was restricted to the highest elevations of the southern Sierra Cuchillo, where outcrops of the Madera Limestone Formation occur in the northern part of this range near Vindicator Mine north to NM Highway 52 pass, and in the general vicinity of Cuchillo Mountain. This latter locality appears to be the most southern and northern extent of geographic range of *O. m. cuchillensis* and *H. cockerelli*, respecitvely.

In overview, then, there seems to be no evidence that the species composition of the land-snail fauna in the Southern Sierra Cuchillo has changed over the past 80 years. There may well be, however, more subtle changes that have taken place in regard to flora and fauna, which would not be reflected in such a broad-based comparison. As regards land use, emphasis on cattle ranching was already firmly established by 1915, and continues to be practiced in parts of the Sierra Cuchillo.

Acknowledgements

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Table 1. Species of land snails reported by Pilsbry and Ferriss (1915), and taken in 1997 collections from the southern Sierra Cuchillo, Sierra County, New Mexico. Sample size is reported by species at sample sites for 1997 collections.

	Pilsbry & Ferriss,	**1997 Collections Site #**												
Species	**1915**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Cionella lubrica	X	9	9	-	-	-	1	-	-	-	-	-	-	-
Gastrocopta pilsbryana	X	121	-	-	-	-	-	-	-	-	-	-	-	-
Gastrocopta ahsmuni	-	5	10	-	-	-	1	3	-	1	-	4	-	-
Gastrocopta pellucida	-	-	-	-	1	1	-	2	-	-	1	-	-	-
Vallonia perspectiva	X	-	3	-	-	-	-	-	-	-	-	-	-	-
Holospira cockerelli	X	-	70	6	8	3	15	5	-	-	-	-	-	-
Heliodiscus eigenmanni	X	-	-	-	1	-	-	1	1	-	-	-	-	-
Oreohelix metcalfi cuchillensis	X	-	-	-	-	-	60	-	1	35	-	-	-	-
Glyphalinia indentata	X	15	2	-	-	-	-	4	1	1	-	3	-	-
Hawaiia minuscula	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Succineide	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Thysanophora hornii	X	-	-	-	-	-	-	-	-	-	-	-	-	-

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Sierra Cuchillo Land Snail Collection Localities

Site 1 **ALM 2275/2560 and BKL97-157** **5 Aug 1997**

Lat: ? Long: ? Elev: 7200 ft.

Sierra Cuchillo, approximately 0.5 air miles north of Vindicator Mine.

Site 2 **ALM 2561 and BKL97-158** **6 Aug 1997**

Lat: N33°19'02.68" Long: W107°34'14.99" Elev: 6293 ft.

Sierra Cuchillo (southern range), Ladder Ranch, approximately 2.5 air miles west of the HOK Ranch headquarters.

Site 3 **BKL-97-189** **11 Sep 1997**

Lat: N33°18'44.41" Long: W107°34'40.68" Elev: 7400 ft.

Sierra Cuchillo (southern range), Ladder Ranch, approximately 0.4 air miles south and 2.6 air miles west of the HOK Ranch headquarters.

Site 4 **BKL-97-190** **11 Sep 1997**

Lat: N33°18'51.75" Long: W107°34'46.76" Elev: 7510 ft.

Sierra Cuchillo (southern range), highest peak of Cuchillo Mountain.

Site 5 **BKL-97-191** **11 Sep 1997**

Lat: N33°18'51.03" Long: W107°34'47.97" Elev: 7510 ft.

Sierra Cuchillo (southern range), west slope of Cuchillo Mountain, approximately 0.25 air miles west of the highest peak.

Site 6 **BKL-97-192** **11 Sep 1997**

Lat: N33°18'59.95" Long: W107°34'48.42" Elev: 7440 ft.

Sierra Cuchillo (southern range), northeast slope of Cuchillo Mountain, approximately 0.2 air miles north of the highest peak.

Site 7 **BKL-97-193** **11 Sep 1997**

Lat: ? Long: ? Elev: 6980 ft.

Sierra Cuchillo (southern range), Ladder Ranch, limestone outcrop in unnamed canyon located approximately 0.2 air miles south and 2.25 air miles west of HOK Ranch headquarters.

Site 8 **ALM 2562/BKL-97-194** **12 Sep 1997**

Lat: N33°21'48.20" Long: W107°36'07.84" Elev: 7200 ft.

Sierra Cuchillo (southern range), west slope, approximately 0.1 air miles south of Vindicator Mine.

Site 9 **ALM 2563/BKL-97-195** **12 Sep 1997**

Lat: N33°21'42.52" Long: W107°36'03.27" Elev: 7340 ft.

Sierra Cuchillo (southern range), east slope, approximately 0.1 air miles south and 0.15 air miles east of Vindicator Mine.

Site 10 **BKL-97-215** **23 Oct 1997**

Lat: N33°15'54.90" Long: W107°34'39.21" Elev: 6110 ft.

Twin Peaks, east slope of most northern peak, approximately 600 ft. below summit.

Site 11 **BKL-97-216** **23 Oct 1997**

Lat: ? Long:? Elev: 6790 ft.

Twin Peaks, northeast slope, approximately 200 ft. below summit of most northern peak.

Site 12 **BKL-97-217** **23 Oct 1997**

Lat: N33°18'03.44" Long: W107°33'46.69" Elev: 6200 ft.

Sierra Cuchillo (southern range), Ladder Ranch, approximately 1.5 air miles south and 2.0 air miles west of the HOK Ranch heaquarters.

Site 13 **BKL-97-218** **23 Oct 1997**

Lat: N33°18'27.60" Long: W107°33'58.08" Elev: 6720 ft.

Sierra Cuchillo (southern range), Ladder Ranch, approximately 1.3 air miles south and 2.6 air miles west of the HOK Ranch headquarters.

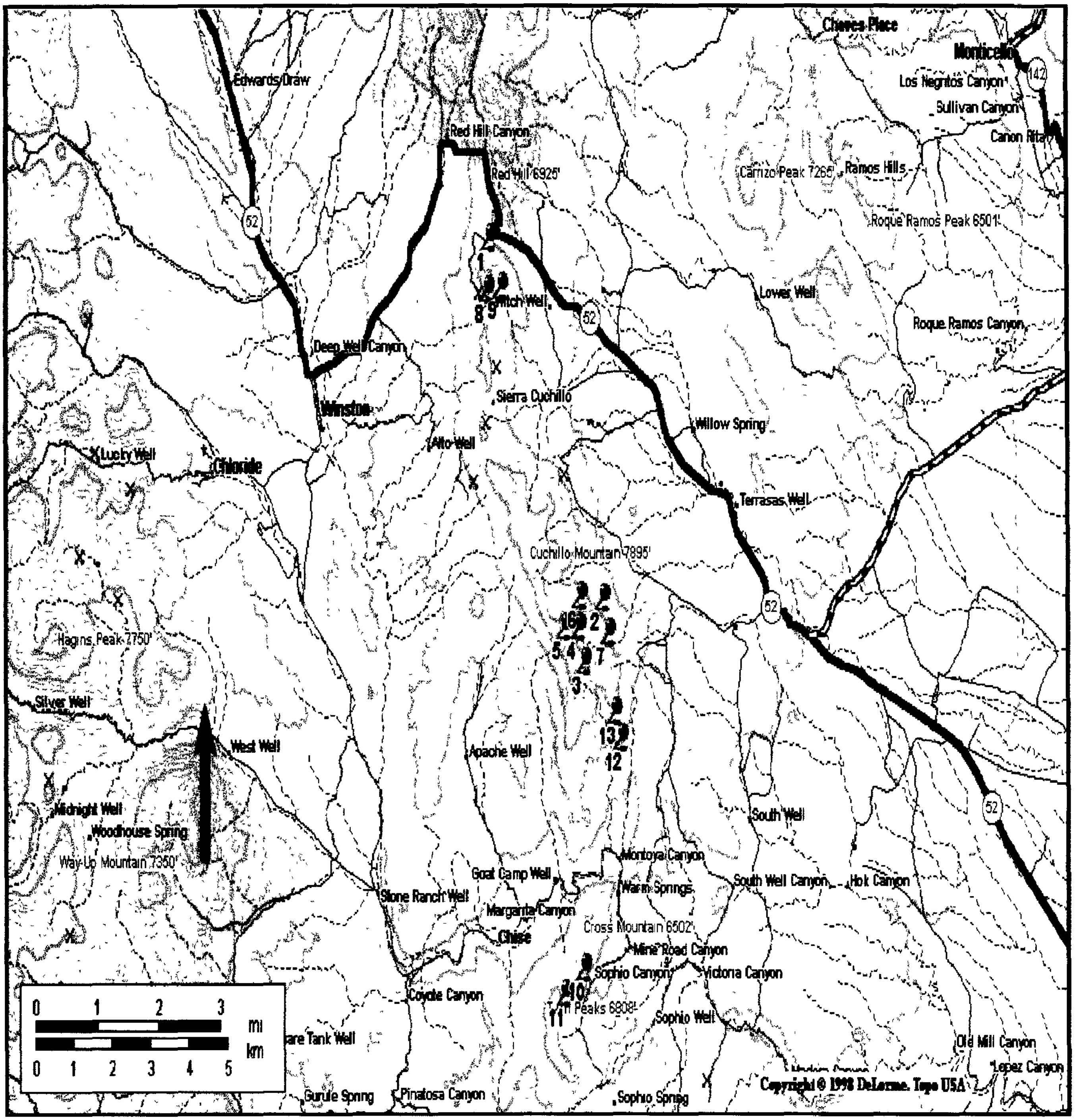

Figure 1. Land snail survey sites (blue) in the Southern Sierra Cuchillo, Sierra County, New Mexico. Site numbers correspond to the 1997 collection records listed in the report.

Appendix E. Land-snail survey results and management recommendations (1995-2000).

LAND-SNAIL SURVEY RESULTS AND MANAGEMENT RECOMMENDATIONS

Gastrocopta dalliana dalliana

Survey Results: Prior to this survey, *Gastrocopta dalliana dalliana* was known in New Mexico from only two specimens collected in leaf litter along a wooded section of Indian Creek Canyon at 5900 ft. elevation on the north flank of Animas Peak, Hidalgo County (Metcalf and Smartt 1997)

Land-snail survey sites (1995-1996) in the Animas Mountains mapped in Figure 1 are cross-referenced to voucher material listed taxonomically in Appendix B. A total of nine *G. d. dalliana* was recovered from leaf litter samples during the 1995-1996 land-snail survey in the Animas Mountains. In 1995, this species was collected in Indian Creek Canyon from 5930 ft (n=3 shells, BKL95-029A) upgradient to 6200 ft. (n=2 shells, BKL95-037B & E) elevation. Subsequent surveys in 1996 extended the range of *G. d. dalliana* to northeast slope of Animas Peak between 5810 ft. (n=1 shell, BKL96-116A) and 5850 ft. (n=3 shells, BKL96-117A) elevation.

All specimens occurred in dense woodland habitat dominated by an oak (*Quercus grisea, Q. hypoleucoides*, and *Q. rugosa*) overstory ($\bar{x}$ canopy cover = 66.4%, range = 26.6-94.6%) with *Juglans major* (only in Indian Creek Canyon), *Junniperus deppeana,* and *Pinus cembroides* admixed sparsely. Distance to the nearest tree averaged 1.9m (range =0.8-4.5m) and the understory cover was sparse ($\bar{x}$ distance to nearest shrub =3.0m, range = 0.4-6.8m) consisting of *Fallugia paradoxa, Cercocarpus* sp., *Spiraea* sp., *Rhus aromatica, Ribes* sp., *Mahonia* sp., and *Robinia neomexicana*. Aspect (direction of slope) ranged from 285° WNW to 7° ENE. Edaphic conditions were variable during the 2-year survey period and fluctuated with seasonal rain events. Soils conditions where *G. d. dalliana* occurred were dry ($\bar{x}$ % humidity =3, range = 0-10%), slightly basic ($\bar{x}$ pH =7.88, range = 6.5-8.6). Soil tempertures ranged from 19.5° to 25°C ($\bar{x}$ = 21.7°) The underlying bedrock geology at all sites was limestone.

Land snail surveys in mountain ranges adjacent to the south (San Luis Mountains) and to the east (Big Hatchet Mountains) of the Animas Mountains documented additional populations of *G. d. dalliana,* which represent new records of occurrence in New Mexico (Metcalf and Smartt 1997:31).

A single specimen of *G. d. dalliana* (see Appendix B, *Sonorella* sp., BKL97-185) occurred at 5890 ft. elevation under dense oak cover (*Q. turbinella*) in the exposed southwest-facing (255° WSW) eastern foothill of Lang Canyon, San Luis Mountains, Hidalgo County. While the bedrock geology of the northen San Luis Mountains is predominately igneous, limestone rubble is common at canyon base-elevations. This specimen was obtained from a leaf litter-soil sample collected beneath a pile of limestone rubble. *Cionella lubrica* (n=1) and *G. pellucida* (n=10) were recovered from similar habitat per BKL97-186. In the southeastern Big Hatchet Mountains, three *G. d. dalliana* were recovered from a leaf litter-soil sample collected on an exposed western slope of Sheridan Canyon at the base of a limestone scarp at 6400 ft. elevation (see Appendix B, *Ashmunella hebardi*, BKL00-068A & B).

The habitat of these "outlying" populations of *G. d. dalliana* in exposed canyonlands is characterized by typical Upper Sonoran Life Zone (Bailey 1913) vegetation dominated by xerophylic woody monocots (*Dasylirion* spp., *Nolina microcarpa*, *Yucca* spp., *Agave* spp.), cacti, and desert shrub species Although this vegetative association appears in sharp contrast with the gestalt habitat for *G. d. dalliana* in the Animas Mountains, as described above, it does conform to the species habitat affinities in xeric regions of adjacent Arizona and México (Chihuahua, Sonora, Baja California Sur) (Bequaert and Miller 1973, Metcalf and Smartt 1997).

Status: *Gastrocopta dalliana dalliana* is more widespread than previously thought. It occurred sporadically on warmer slopes in the Big Hatchet and San Luis mountains and comprised only 0.4% and 2.3%, respectively, of the land snail community at single-site occurrences in these mountain ranges. This species appears to be a denizen of the more mesic and densely wooded habitat of the Animas Mountains, where it occurred at nearly 38% (5 of 16) of all sites surveyed and represented 2-50% of the overall molluscanfauna at sites where it was collected. *Gastrocopta dalliana dallina* seems particularly fond of the cool, moist, densely wooded corridor along Indian Creek Canyon, as three of five total site occurrences in the Animas Mountains were recorded in this canyon. This species seems to be closely associated with limestone outcrops and loose soils with deep leaf litter over limestone rubble.

In New Mexico, *G. d. dalliana* appears restricted to geographically disparate populations in the Upper Sonoran Life Zone of the Animas, Big Hatchet, and San Luis mountains between 5900-6400 ft. elevation. Future land-snail surveys may extend the known east-west range of the species in similar habitats along the western and southern state boundaries. Currently, the northern extent of this species range, albeit disjunct, in New Mexico conforms to a latitude extending from the north slope of the Animas Mountains east to Sheridan Canyon, Big Hatchet Mountains, Hidalgo County.

Threats: Habitat critical to *G. d. dalliana* in the Animas and San Luis Mountains is under stewardship of the Animas Foundation (Gray Ranch). The lone population in the Big Hatchet Mountains occurs on public lands (BLM). While such stewardship would seem to afford some degree of protection under current land use practices, localized populations of this species are susceptible to fire.

Wildfires have scorched significant areas in Hidalgo County, New Mexico, during the last five years, including lower elevations of Indian Creek Canyon in the Animas Valley (Spring 2000) and Lang Canyon (Summer 1994, 1999, 2000). Evidence of past forest fire on the north slope of Animas Peak (1989) was noted by presence of ash and burned land-snail shells recovered from leaf litter collections at 7800 ft. elevation (see Appendix B, BKL95-038). While fire is considered a significant ecological component shaping forest seral succession, short- and long-term return effects on forest ecosystem dynamics are poorly understood, especially with respect to molluscanfaunal recovery periods.

Any form of soil disturbance (e.g., mineral mining) or vegetative removal (e.g. logging or grazing) would likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur. However, such practices currently pose no threat to any known population of *G. d. dalliana* in New Mexico. In most locations such activities would seem impracticable, with mineral extraction being the exception. Mineral resources and mining rights existing in areas where *G. d. dalliana* occurs were not researched.

Recommendations:

(1) Suggest downlisting *G. d. dalliana* from state Endangered to Threatened with possible consideration for delisting in the future if additional populations are discovered elsewhere in southern New Mexico.

(2) Recommend continuance of land-snail surveys in southern New Mexico.

Vertigo ovata

Survey Results: In New Mexico, Metcalf and Smartt (1997) reported live *Vertigo ovata* only from the riparian corridor of Blue Spring, Eddy County, with the species occurring in the fossil record and from recent specimens in ten counties statewide (Metcalf et al. *In Preparation*).

Recent surveys document the persistence of this species at two localities along the riparian corridor of Blue Spring (see Appendix A, map figures 2A and 2B; Appendix B, BKL00-133, 134). In August 2000, *V. ovata* was collected live from the muddy margins of a springhead pool located immediately north of and ca.100m downstream of the primary artesian source of Blue Spring. A second live population occurred in a small emergent marsh wetland area associated with what appear as the vestiges of Blue Spring run immediately west-southwest of the irrigation weir. This site is located about one mile downstream (east) from the artesian source. This species likely occurs in disjunct populations upstream of the irrigation weir where the hydrologic regime affords some semblance of habitat stability. Despite significant search effort *V. ovata* has not been found in the Blue Spring wetland complex downstream of the irrigation weir although the diversity of habitats types (e.g., a sinuous springbrook, extensive marsh, and narrow wooded swamp corridor) would seem to provide microhabitats suited for successful colonization and reproduction.

Extant populations of *V. ovata* were also documented along the riparian corridor and warm springs complex associated with Alamosa Creek located immediately upstream of the Monticello Box, southwest Socorro County, near Dusty, NM (Appendix B, BKL00-085, 090, 108). In this wetland complex, *V. ovata* occurs from "Willow Spring" downstream along Alamosa Creek to its confluence with Ojo Caliente springrun, and in hillside spring seeps around the perimeter of Ojo Caliente and lower reaches of Spring Canyon.

Vetigo ovata at Blue Spring and Alamosa Creek occur on wetted mud margins of shallow marsh habitats dominated by reeds (*Eleocharis* sp., *Juncus* sp., and *Scirpus americanus)* and the perennials, *Rorippia* sp. and *Nasturtium officinale*. In the densely vegetated palustrine habitat of "Willow Spring" (Alamosa Creek), *V. ovata* is typically found on moist, matted stems of *S. americanus* within several centimeters of standing water. This species also occurs on moist soils and exposed damp roots beneath willow trees along the north streambank of Alamosa Creek Immature *V. ovata* were observed live at both sites in June and August 2000.

Pilsbry (1948) recognized three species of *Vertigo ovata* in North America: the nominate form and two subspecies (*V. o. diaboli* and *V. o. mariposa*). Populations of *V. ovata* at Blue Spring and in Alamosa Creek Canyon appear referable to the nominate species (A. L. Metcalf, *pers. com.*).

Status: *Vertigo ovata* at Blue Spring appears stable under past and current land use practices and irrigation withdrawals, with evidence of successful reproduction and recruitment of immature snails into the adult population. However, a proposed beryllium mine within the immediate watershed of Alamosa Creek Canyon poses imminent risks to the riparian habitats and native invertebrate populations at this site.

Threats: Although *V. ovata* is widespread in North America north of México, this paludal species occurs sporadically in the Desert Southwest, where Bequaert and Miller (1973) considered it a "relict species". Fossil specimens of *V. ovata* from spring-related Pleistocene and Holocene deposits, and historic collection records, chronicle extirpation of localized populations throughout Arizona, New Mexico, and western Texas (Bequaert and Miller 1973, Metcalf and Smartt 1997). The apparent reduction in habitat suitability and availability for this species in New Mexico is attributable to natural stochastic events (e.g., Holocene warming, arroyo entrenchment) exacerbated by human-related land use activities (e.g., wetland [marsh] drainage and development, stream diversion, grazing) (Metcalf et al. *In Preparation*).

Based on extensive technical review of a Minimal Impact New Mining Permit Application (No. 6950), the NMDGF rendered biological opinion that the prospects of survival and recruitment of the *V. ovata* are in jeopardy due to the threatened destruction, modification, or curtailment of its habitat by a proposed beryllium mine on property adjacent to and within the immediate watershed of Alamosa Creek and associated wetland areas that provide critical riparian habitat for this species. Accordingly, it was further determined that *V. ovata* is subject to take as defined by Section 17-3-28 of the amended (1995) Wildlife Conservation Act (WCA). State Threatened species currently are not afforded protection from take under the state WCA

Under the 2000 Biennial Review of Threatened and Endangered Species in New Mexico, the State Game Commission accepted the Department's recommendation to withhold uplisting *V. ovata* from Threatened to Endangered pending further review of a revised permit application that addresses numerous outstanding issues regarding proposed mine site operations.

Recommendation:

(1) In collaboration with the Monticello Community Ditch Association (MCDA), continue routine monitoring of riparian habitat conditions at Alamosa Creek to assess population dynamics (e.g., distribution, abundance, seasonal aspects of life history, etc.) of *V. ovata* under current land stewardship practices.

(2) Assess any changes in a revised mining proposal relative to potential impacts to extant riparian habitat conditions of Alamosa Creek wetland complex.

(3) Cultivate interests expressed by the MCDA for wetland restoration and riparian corridor enhancement on private lands under stewardship by the MCDA. Such activities may include, but are not necessarily limited to: phreatophyte removal, planting of native woody trees to stabilize streambanks, implement erosion control measures, and installation of an unattended data-logging hydrologic flume. Data generated by this flume would provide baseline data on groundwater hydrology under natural conditions, which will facilitate review and assessment of proposed mining activities in the area. These data would also prove beneficial for ongoing population/habitat monitoring of the state and federal Endangered Alamosa springsnail (*Tryonia almosae*).

(4) Secure funding to survey marsh habitats in New Mexico, which would not only provide rigor for status assessment of *V. ovata* statewide, but also allow for systematic inventory for other obscure hydrophylic land snails (i.e., *Carychium exiguum*, *Gastrocopta pentodon* form "*tappaniana*", *Pupilla muscorum*, *Vertigo milium*, *Oxyloma retusum*) and aquatic macroinvertebrates (e.g., hydrobiid spring snails, amphipods) with affinities for this rapidly disappearing habitat type.

Discus shimekii cockerelli

Survey Results: No surveys for this subspecies were conducted under this project since malacological taxonomic authorities do not recognize *Discus shimekii cockerelli* as a valid taxon.

Bequaert and Miller (1973:58) acknowledged that ecophenotypic variants of *Discus shimekii* in Arizona and New Mexico, often referred to as *D. shimekii cockerelli*, were undistinguishable from the nominate species:

> "Commenting on specimens from Alberta, S. S. Berry (1922, *Victoria Mem Mus Ottawa Bull.* 36:10; Pl. 1, 3 figs. 8) quotes Pilsbry (in litt.): 'The *D. shimekii* from Canada are about intermediate between typical *shimekii* and *cockerelli*...The distinction of the race *cockerelli* is probably of doubtful expediency'...It thus appears that the subspecies *cockerelli* is scarcely recognizable, as B. Shimek concluded long ago (1901, Bull. Lab. Nat. Hist. State Univ. Iowa 5:39)."

Accordingly, these authors only listed two species, *D. cronkhitei* and *D. shimekii*, in Arizona.

Based on conchological similarities of type specimens, Roth (1987) subsumed *D. cronkhitei* under *D. whitneyi* with the latter species retaining taxonomic priority.

Metcalf and Smartt (1997) likewise recognized only two species of *Discus* in New Mexico: *D. whitneyi* from lower montane elevations (Transition Life Zone; see Bailey 1913) in southern latitudes of the state, and *D. shimekii* from the Canadian Life Zone in northern montane habitats. In areas of overlap in northern New Mexico separation to species level is difficult (Metcalf et al *In Preparation*).

Turgeon et al. (1988, 1998) did not recognize the taxon *Discus shimekii cockerelli*. There is no information on file with the New Mexico Department of Game and Fish (NMGF) that verifies the taxonomic validity of this subspecies (see Metcalf and Smartt 1988).

The U. S. Fish and Wildlife Service (1991) first assigned conservation status to *D. s. cockerelli* as a Notice of Review Category 2 species under the USFWS Region 6 in South Dakota, and subsequently increased the range of such consideration to encompass several western states in Region 2, including New Mexico, as a Species of Concern (USFWS 1994). Background information supporting this designation as a Species of Concern is lacking in files of both federal administrative regions. Dr. Terry Frest, consulting malacologist with the USFWS (Region 6), concurred (*pers. com.* with B. K. Lang) that *D. s. cockerelli* is not a valid taxon

Status: This putative taxon has no formal status at the state level. Malacological taxonomic authorities do not recognize *Discus shimekii cockerelli* as a valid taxon.

Recommendation:

(1) The priority assignment of this putative subspecies as a federal Species of Concern appears to merit reconsideration.

Oreohelix florida

Survey Results: Under grant Segment 4, the project biologist requested expert opinion on the population status of *Oreohelix florida* from malacologists (Drs. A. L. Metcalf and R. D. Worthington, UTEP; Dr. Patricia Mehlhop, New Mexico Natural Heritage Program [NMNHP]) most familiar with the molluscanfauna of the Florida Mountains. Voucher material reported by UTEP malacologists consisted of fragments and whole shells of fossil *O. florida* collected from 14 sites in the Florida Mountains and five sites at the periphery of the species historic range (Metcalf and Smartt 1997). Figure 3 (Appendix A) illustrates the extent of explorations (Metcalf and Worthington surveys; only 12 of 14 sites are mapped) for this species in the Florida Mountains from 1970 to 1997. In 1997, the NMNHP surveyed 22 sites around the base of Baldy Peak and at six sites "adjacent to Baldy Peak" (Score 1997).

Status: Collections made this century suggest that *O. florida* is extinct (Metcalf and Smartt 1997). Pilsbry (1915) first reported this species as "Oreohelix strigosa var." from "Two broken and very old bones...". Pilsbry (1939) described it as a subspecies of *Oreohelix metcalfei*. Metcalf (1974) elevated *florida* to full species status. Additional state records from the Santa Rita and Tres Hermanas mountains, Cooke's Range (near the ghost town of Cooke), and Apache Hills are also of fossil specimens (Metcalf and Smartt 1997).

Pilsbry's historic records of *O. florida* as fossil specimens have been confirmed repeatedly by contemporaneous collection records in the Florida Mountains and at several sites from the periphery of the species presumed historic range (Metcalf and Smartt 1997). These fossil records support the dispersalist-extinction model of primitive oreohelicids proposed by Metcalf (1974) and Crews and Metcalf (1982). Metcalf and Smartt (1997) recognized that a model of vicariance biogeography could explain the distributional patterns of primitive oreohelicids that once occurred as peripheral dispersalists from the source populations of the *Oreohelix metcalfei* complex in the Black Range, New Mexico.

Threats: The extinction of primitive oreohelicids in southern (O. *florida*) and eastern (*O. caballoensis*) New Mexico might be attributed to climatic deterioration during the Holocene (Metcalf and Smartt 1997) and/or natural extinction processes characteristic of insular populations on oceanic islands (MacArthur 1972).

Recommendation:

(1) Repeated inventory during this century indicates that *Oreohelix florida* is, in all probability, extinct. Accordingly, the conservation status of this species at state and federal levels merits change to reflect its fate.

(2) Molluscanfaunal surveys in montane habitats along the New Mexico-México border are encouraged to explore remote possibilities of discovering extant populations of oreohelicids.

Oreohelix pilsbryi

Survey Results: Field surveys in 1999 focused along a three mile reach of Mineral Creek from an unnamed mining camp (abandoned), located 0.3 mile east of the Little Mineral Creek and Mineral Creek confluence, upstream (west) to the type locality (see Figure 4, Appendix A). Throughout this survey area *Oreohelix pilsbryi* was collected live only at the type locality. No dead shells or fragments were observed downstream of this site. This species was remarkably abundant throughout a 0.25-0.3 mile reach of stream along limestone outcrops that constrict Mineral Creek to a narrow sinuous channel. *Oreohelix pilsbryi* occurred most abundantly along the south canyon wall, which is densely shaded during the diel solar period. The leaf litter-soil interface under such aspect (direction of slope) was more humid than edaphic noted conditions along the north canyon wall. Only a few live *O. pilsbryi* were observed along the north canyon wall. No empty shells were littered on the forest floor as observed along the south canyon wall.

Status: The type locality is relatively unaccessible by vehicle. The native forest at this site is undisturbed with a dense, mixed canopy (*Quercus* sp., *Alnus oblongifola, Pinus* sp) that shades the narrow canyon floor and walls. While evidence of grazing was noted throughout the entire canyon reach surveyed in 1999, site conditions suggests that grazing is likely most frequent and of greater duration downstream of the type locality, where the well-insolated canyon floor widens and supports an abundance of native grasses and forbs. Habitat conditions noted under such grazing pressure appeared stable.

Several small (<10 mm *W*) shells (recent and live *O. pilsbryi*) confirmed a successfully reproducing population with an abundance of large adults snails aggregated in what appeared to be breeding "huddles".

Threats: Habitat critical to *O. pilsbryi* is located on private land bordered by the Gila National Forest. Higher elevations at this site were actively mined (Oliver's and Dreadnaught mines) in the early 1900's. Mineral resources and mining rights still likely exist in areas adjacent to habitat occupied by *O. pilsbryi*. Favorable economic conditions could renew extractive interests in this area which could result in soil disturbance or forest clearing. Such activities could likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur.

This species, like most land snails, is susceptible to fire. While fire is considered a significant ecological component shaping forest seral succession, short- and long-term return effects on forest ecosystem dynamics are poorly understood, especially with respect to molluscanfaunal recovery periods.

Recommendations:

(1) The distribution of *O. pilsbryi* is likely limited to contiguous limestone habitat at the type locality, as oreohelicids are, in most cases, strict calciphiles (Bequeart and Miller 1973, Metcalf and Smartt 1997). However, surveys conducted during this project did not include limestone outcrops located upstream (west) from the type locality to the headwaters of Mineral Creek at the base of Lookout Mountain, or in drainages to the north (e.g., Dry Creek, Cliff, and Little Bear Creek canyons). Surveys in these isolated drainages would likely require considerable effort by mule or horseback, but might serve to define more precisely the distribution of *O. pilsbryi*.

(2) Federal and/or state aquisition of private lands immediately adjacent to the national forest that habor the only known extant population of *O. pilsbryi* would secure habitat for this species. However, such real estate dealings may encumber intractable mineral right issues.

Ashmunella hebardi

Survey Results: A total of 102 *Ashmunella hebardi* shells was recovered from five survey sites along an elevational line transect covering 6725-6820 ft. elevation at the base of a precipitous limestone scarp on the exposed north slope of Hacheta Grande (Big Hatchet Peak). This voucher material included shells of *A. hebardi* as live, recent, and fossil specimens, as indicated for collections listed in Appendix B. All specimens were recovered from leaf litter, beneath limestone rubble, or in fissures at the base of the limestone scarp. Empty, bone-white shells of *Holospira crossei*, *Ashmunella* spp., and *Radiocentrum hachetanum* were remarkably abundant and loosely littered on the ground, suggesting former occurrences of these species at higher elevations on Hacheta Grande. Figure 5 (Appendix A) illustrates extent of land-snail surveys in the Big Hatchet Mountains (1997-2000).

All specimens of *A. hebardi* occurred in exposed canyonland habitat of sparse canopy cover ($\bar{x}$ = 11.1%, range = 0-36.4%) dominated by oak (*Quercus* spp.) with *Junniperus deppeana* and *Pinus cembroides* variously admixed. Distance to the nearest tree averaged 3.4m (range =2.1-5.6m). Shrub understory cover was likewise sparse ($\bar{x}$ distance to nearest shrub =3.0m, range = 2.7-3.7m) consisting of *Ephydra* sp., woody monocots (*Dasylirion* spp., *Nolina microcarpa*, *Yucca* spp., *Agave* spp.), cacti, and desert shrubs (*Garrya* sp., *Fallugia paradoxa*, *Cercocarpus breviflorus*, *Rhus aromatica*, *Mahonia haematocarpa*, and *Robinia neomexicana*). Aspect (direction of slope) ranged from 323° WNW to 36° ENE. Groundwater seepage from deep fissures along the limestone scarp likely accounted for the humid soil conditions recorded under otherwise hot, dry survey conditions ($\bar{x}$ % relative humidity =16%, range = 10-30%). Mean soil pH was 7.0 (range = 6.8-7.2) and soil tempertures ranged narrowly (19.0-19.5°C; $\bar{x}$ = 19.1°). The underlying bedrock geology is limestone.

Ashmunella hebardi was not collected in exploratory surveys (May 2000) east of Hacheta Grande (Appendix B, BKL00-066) or in the southeastern range of the Big Hatchet Mountains (Sheridan Canyon, BKL00-067,068). These findings confirm Metcalf and Smartt's (1997) account that *A. hebardi* appears to be a local endemic restricted to the north slope of Hacheta Grande in Chainey Canyon, where this species shows conchological evidence of hybridization with the more widespread *A. mearnsii*. The reduced dentition of a single *A. meansii* specimen from BKL97-071B (see Appendix B) corraborates the suggestion of a hybrid contact zone in this area (Metcalf and Smartt 1997:60).

Two pupillids, *Gastrocopta dalliana dalliana* and *Vertigo gouldii*, were recovered from leaf litter samples collected during this survey. Both of these species were previously unreported from the Big Hatchet Mountains. Heretofore, *G. d. dalliana* was only known to occur in Indian Creek Canyon, Animas Mountains (Metcalf and Smartt 1997; see account above). Remnants of shell periostricum suggest that *V. gouldii* is extant in the Big Hatchet Mountains.

Status: *Ashmunella hebardi* is state-listed as Threatened and considered a federal Species of Concern. Hybridization between *A. hebardi* and *A. mearnsii* is problematic for resource agencies charged with conservation and stewardship of protected species. State Threatened species are currently not protected from take under the state Wildlife Conservation Act (1995).

Threats: Habitat critical to *A. hebardi* in the Big Hatchet Mountains is under stewardship of the Bureau of Land Management (BLM). While such stewardship would seem to afford some degree of protection under current land use practices, localized populations of this species are susceptible to fire. Wildfires have scorched significant areas in Hidalgo County, New Mexico, during the last 5-10 years. Most of these events have occurred in western mountain ranges along the state border. Evidence of past forest fire in the Big Hatchet Mountains was not observed during land-snail surveys. While fire is considered a significant ecological component shaping forest seral succession, short- and long-term return effects on forest ecosystem dynamics are poorly understood, especially with respect to molluscanfaunal recovery periods.

Any form of soil disturbance (e.g., mineral mining) or vegetative cover removal (e.g. logging or grazing) would likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur. Chainey Canyon is adjacent to unfenced private lands (U-Bar Ranch) that are under intense grazing pressure. This raises concern as free-ranging cattle have ready access to BLM lands at lower elevations in Chainey Canyon where the distribution of *A. hebardi* is not well-understood (Metcalf and Smartt 1997) Mineral resources and mining rights existing in areas where *A. hebardi* occurs have not been researched.

Recommendations:

(1) Additional land-snail surveys in the Big Hatchet Mountains are required to investigate hybridization between *A. hebardi* and *A. mearsnsii*. This study should include molecular genetic techniques, conchology, and collection of ecological data. Such an holistic approach would provide an opportunity to resolve outstanding genetic affinities within the putative *Ashmunella hebardi-mearnsii* complex, which will facilitate threat assessment and prescription of management recommendations on a species-specific basis.

The Big Hatchet Mountains harbor a number of land snail species that are either endemic (*Radiocentrum hachetanum hachetanum, R. ferrissi ferrissi*) or presently restricted (*Sonorella hachitana hachitana*) to the higher elevations in the range (Metcalf and Smartt 1997). Two of these species, *R. ferrissi ferrissi* and *S. h. hachitana*, were last documented from live specimens during the H. A. Pilsbry and L. E. Daniels expedition in 1910. Based on fossil material collected during this expedition, Pilsbry (1915) also described two endemic subspecies, *R. hachetanum cadaver* and *R. ferrissi morticinum*, from "Daniels Mountain" located southwest of Hacheta Grande.

Little knowledge concerning the distribution of *Radiocentrum* in New Mexico has been added since the 1910 Pilsbry and Daniels expedition to the Big Hatchet Mountains The range begs further malacological survey

(2) Fencing of property along the western limits of BLM land in Chainey Canyon could provide protection from overgrazing, but benefits derived from this effort must be considered in relation to costs of sensitive landowner-agency liaison relations in the region.

(3) Funding for further studies of the unique molluscanfauna of the Big Hatchet Mountains appears warranted for numerous reasons posed above. However, if a change in conservation status at state or federal levels will facilitate such an initiative, then a change in status for *A. hebardi* merits consideration. State and federal agencies might also consider recognition of *R. ferrissi*, *R. hachetanum*, and *S. h. hachitana* as species that merit formal conservation measures since these two land snails are as ecologically and geographically restricted and under-studied as any land-snail species in New Mexico.

Ashmunella macromphala

Survey Effort: Figure 6 (Appendix A) illustrates the location of survey sites for *Ashmunella macromphala* in the Cooke's Range, Luna County. Voucher material collected from these sites are listed in Appendix B.

Small (<5 mm *w*) and adult-sized (>10 mm) *A. macromphala* were collected live from mixed leaf litter to a depth of three ft. in igneous talus-rock at the type locality (north slope of Cooke's Peak) during the May 1998 and 2000 survey periods.

Exploratory surveys north and south of Cooke's Peak documented a single isolated population of *A. macromphala* on a north-facing igneous scree slope at 6070 ft. elevation in OK Canyon (See BKL00-0069, Appendix B). While no live snails were observed at this site, the abundance of recent shell material indicated an extant population. Shells from the OK Canyon population are notably larger than those at the type locality, but the similarity of apetural dentition implies that the OK Canyon population is referable to the nominant species at the type locality. Shell size varies greatly in the genus *Ashmunella* and is related to a number of factors including: elevation, slope exposure, humidity, and nutrition (Metcalf and Smartt 1997, see references cited therein; Metcalf et al. *In Preparation)*.

Surprisingly, there was no evidence of *A. macromphala* from extensive search effort in two high-elevation igneous sprawls (BKL00-072 and 00-171) located geographically more proximate to and continuous with the primary range associated with massif of Cooke's Peak. Physiognomically, habitat conditions at these two sites were strikingly more similar to conditions at the species type locality than at the lower-elevation occurrence of *A. macromphala* in OK Canyon. In fact, both of these sites were relatively depauperate of any land-snail taxa. Generally speaking, a lone snail hunter while searching with face buried in talus will observe loose shells of more common species, such as *Cionella lubrica*, *Glyphyalinia indentata*, *Discus* sp., and with serendipity, an occasional pupillid (e.g., *Gastrocopta ashmuni*). Such effort is not in vain, but exemplary, and cautions against broad interpretation of the geographic distribution of narrow endemic land snails in New Mexico.

Status: *Ashmunella macromphala* persists at the type locality where it occurs on public land (Bureau of Land Management). The OK canyon population of this species likewise occurs on BLM land bounded by state lands with private in-holdings to the east. Cattle grazing was noted throughout the drainages where these isolated populations occur. Extensive high-elevation grazing poses concern for the population at the type locality on the north slope of Cooke's Peak.

Threats: Localized populations of this species are susceptible to fire. Evidence of past forest fire in the Cooke's Range was not observed during these land-snail surveys. While fire is considered a significant ecological component shaping forest seral succession, short- and long-term return effects on forest ecosystem dynamics are poorly understood, especially with respect to molluscanfaunal recovery periods.

Any form of soil disturbance (e.g., mineral mining) or vegetative cover removal (e.g. logging or grazing) would likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur. Mineral resources and mining rights existing in areas where *A. macromphala* occurs have not been researched.

The May 2000 survey documented significant sign of cattle grazing throughout the unnamed canyon leading up to the base of the type locality of *A. macromphala*. While cattle will likely not venture onto or across a talus slope, intense grazing of deciduous woody vegetation around the perimeter of a scree slope can potentially decrease leaf litter available as food for snails, significantly alter seral succession, and affect plant community composition. Vagvolgyi (1974) discussed the importance of deciduous leaf litter for this species. Morever, removal of vegetation and destablization of soils immediately downslope of this talus sprawl poses concern for long-term soil and slope stability, especially for highly erosive, exposed soils during heavy rain events. At the time of this survey, grazing intensity near the *A. macromphala* population in OK canyon appeared less threatening than such land-use near the type locality.

Recommendations:

(1) While a change in conservation status of *A. macromphala* appears unwarranted at this time, elimination of cattle grazing either by fencing or establishment of a grazing-free allotment at the base of the type locality would be prudent.

(2) Expand malacological surveys for this species to include potentially suitable habitats in southwestern areas of the Cooke's Range.

Sonorella todseni

Survey Effort: Figure 7 (Appendix A) maps survey sites (n=7) for *Sonorella todseni* between

1996 and 1999. Surveys in 1996 documented disjunct populations of *S. todseni* in black rhyolitic talus sprawls restricted to narrow, sparsely vegetated drainage rivulets on the north slope of Doña Ana Peak. Line transect sampling along the north slope of an unnamed range located immediately east of Doña Ana Peak yielded no evidence, past or present, of occurrence of this species (See Appendix B, BKL96-144). This slope was densely vegetated with xerophyllic vegetation (e.g, woody monocots, cacti, and Chihuahuan Desert shrub species) characteristic of Bailey's (1913) Lower Sonoran Life Zone; "tawny-colored" rhyolitic talus was strewn randomly across the slope. This left the impression that *S. todseni* might possess some undetermined affinity for black versus brown rhyolitic talus.

In 1999, 15 *S. todseni* were located in similar habitat (i.e, negritic talus) about 0.2 air mile southeast Doña Ana Peak on a steep slope with an easterly aspect at 5735 ft. elevation (BKL99-042). This species was not recovered from similar habitat on the west slope of Doña Ana Peak at the same elevation (BKL00-043), or from a northeast-facing negritic scree at a lower elevation (4800 ft.) located ca. 0.75 air mile west of Doña Ana Peak (BKL00-45). Areas searched in similar habitat on an adjacent mountain peak immediately north of Doña Ana Peak did not produce any evidence of *S. todseni* (BKL00-046). This site consisted of loosely aggregated brown rhyolitic rubble.

Per BKL00-044, 21 "moderately recent" *S. todseni* were collected from loosely aggregated rhyolitic rocks of the brown variety on Doña Ana Peak (5835 ft.). These rocks laid randomly on the ground, and the sun-bleached empty shells were easily spotted on the ground. Such site physiognomy, which is similar to that described per BKL96-144 above, gave the impression of snails dispersing from adjacent black talus sprawls under ideal conditions that subsequently perished while aestivating during subsequent inclement weather. This notion is further supported by lack of overt sign of continuous occupation by *S. todseni* (e.g., slime trails, epiphram attachment scars, or egg masses), as observed in black talus scree at similar elevations.

Sullivan (1997; Appendix C, this report) provides detailed habitat information for this species.

Status: The geographic range of *S. todseni* appears restricted to black rhyolitic talus sprawls on the north and east slope of Doña Ana Peak between 5600-5835 ft. elevation. Live snails and egg masses observed during the survey period imply the presence of a viable population.

Threats: The southern range of the Doña Ana Mountains is public land (Bureau of Land Management) This site is frequently accessed by vehicle to the base of Doña Ana Peak. Evidence of native plant removal in areas adjacent to black scree slopes at lower elevations on the north slope of Doña Ana Peak was documented in 1996 by dig holes and a tag from a local gardening center. Such activity was not observed in subsequent site visits.

Removal of woody vegetation not only disturbs talus slopes, but also results in loss of food and cover for snails (Vagvolgyi 1974), increases slope erosion, and effectively reduces water retention capacity of the soil. Accumulative effects of these processes can have irrevocable impacts by exacerbating habitat desiccation and increasing substrate temperatures, which can dessicate developing egg masses deposited in talus just below the soil surface; thereby, adversely affecting the reproductive capacity of *S. todseni*. The extant population is highly vulnerable to any form of soil disturbance, including foot traffic by humans or cattle, or mining activity in the general vicinity of talus slopes.

Recommendations:

(1) Due to the restricted distribution of *S. todseni*, and apparent narrow habitat affinity for negritic talus sprawls, which are inherently fragile, habitat protection is paramount for the conservation of this species. Fencing of habitats occupied by this species should diminish immediate threats of foot traffic in talus areas.

(2) Posting signs that prohibit removal of native vegetation would provide additional habitat protection.

(3) Control of site access can be achieved by locked gates at 2-track roads that lead to the base of Doña Ana Peak.

(4) If resolve is unsatisfactory under 1- 3 above, then a change in federal conservation status of *S. todseni* might be in order.

Sonorella sp.

Survey Effort: In 1997, land-snail surveys along the U.S.-México border in Lang Canyon, San Luis Mountains, Hidalgo County, yielded live *Sonorella*. Figure 9 (Appendix A) illustrates areas surveyed in Lang Canyon (1997-2000). Voucher records from these surveys are listed in Appendix B.

This population represents the first record of occurrence of this genus from the San Luis Mountains in New Mexico. The Lang Canyon *Sonorella* is at least 20 miles south and 18 miles east of the nearest known *Sonorella* populations in the Animas (*S. animasensis*) and Peloncillo (*S. hachitana peloncillensis*) mountains, respectively. *Sonorella hachitana hachitana*, a species endemic to the Big Hatchet Mountains, is even more distant than the former two species. The nearest known *Sonorella* populations in México are far removed (>100 miles) from the Lang Canyon population.

Bequaert and Miller (1973) recognized four complexes of *Sonorella* in Arizona, of which only two, *Sonorella hachitana* Complex and *Sonorella binneyi* Complex, are reported in New Mexico (Metcalf and Smartt 1997) The Lang Canyon *Sonorella* appears to represent an undescribed species. Preliminary analysis of soft anatomy by Lance Gilbertson (Department of Biology, Orange Coast College, Coast Mesa, CA), indicates that the male genitalia and shells of the Lang

Canyon *Sonorella* are most similar to *S. hachitana peloncillensis* and *S. orientis* of the *hachitana* complex, but the verge is only about half the length and is wider than the penis of these two species. In contrast, neither the genitalia nor the shell are like *S. animasensis* of the *binneyi* complex.

Additional voucher material was collected in May and September 2000 after two wildfires scorched Lang Canyon in 1999 and 2000. No evidence of live *Sonorella* sp. was observed in the May 2000 survey, as only empty shells (n=12; see BKL00-053, Appendix B) were collected, most of which showed evidence of burn to a depth of four feet in the talus slope. Search effort in several talus sprawls located along the south canyon slope and west of the known population revealed no sign, past or present, of *Sonorella* colonization, which raised concern for the persistence of this species in Lang Canyon. A single live *Sonorella* sp. and four recent shells (BKL00-165) were collected in September 2000. These records and observations of numerous fresh shell attachment scars on talus rock relieved concerns for the effects of the Lang Canyon fires on this restricted *Sonorella* population.

Status: This snail appears restricted to higher elevations of the most prominent talus sprawl in the northeastern corner of Lang Canyon. Recent shells (n=4), implying an extant population, were also recovered beneath a loose pile of limestone rubble at canyon base elevations in the easternmost foothill of Lang Canyon located approximately 0.2 air mile south of the former site (see BKL97-186, Appendix B).

Threats: Wildfire indeed affects this species, however the Lang Canyon *Sonorella* still persists. Any form of soil disturbance (e.g., mineral mining) or vegetative cover removal (e.g. logging or grazing) would likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur.

Recommendation:

(1) Examination of genitalia and conchological studies of the Lang Canyon *Sonorella* are ongoing with collaborative efforts focused on assessing the taxonomic affinities of this population relative to other *Sonorella* species in New Mexico and adjacent Arizona. Additional funding would support this effort.

(2) Additional surveys of *Sonorella* species in isolated talus slopes of montane habitats in Hidalgo County are warranted. Exploratory surveys in the northern San Luis Mountains would serve to refine the distribution of the Lang Canyon *Sonorella*. The endemic *Sonorella hachitana hachitana* of the Big Hatchet Mountains was last documented live in 1910 (Metcalf and Smartt 1997). Herpetological surveys for the ridgenose rattlesnake (*Crotalus willardi obscurus*) yielded a recent shell of *Sonorella* sp. (collection by A. Holycross, 10 August 1998) from a talus slope in Skeleton Canyon, Peloncillo Mountains, Cochise County, AZ, with reports of similar shells in Owl Canyon (B. L. Christman, Herpetologist, NMGF

Contractor, *pers. com.*), of this same range in Hidalgo County, NM. These populations are not reported in Bequaert and Miller (1973) or Metcalf and Smartt (1997), and stimulate great interest regarding their specific identity. A comprehensive survey of this genus in Hidalgo County, NM, and adjacent Arizona merits funding.

(3) The role of fire ecology and the effects of fire on the habitat-area relationships, population biology, and evolution of talus-slope inhabiting land snails implores further research. Such an initiative would prove insightful for resource agencies and private land stewards sharing common interests for the conservation of native fauna.

Endemism in Land Snails of New Mexico: Implications for Future Research

Metcalf and Smartt (1997) considered 3 parameters (vegetation, effective precipitation, and elevation) interrelated with Bailey's (1913) life zones of New Mexico and geologic history, as biotic and abiotic components exerting ecological and physiological constraints largely responsible for the distribution and abundance of land snails statewide. Numerous species of land snails are state endemics, especially in the arid mountains of southern New Mexico where geographically isolated populations are restricted to a single mountain range or peak (Metcalf 1997), recently termed "sky islands" by Warshall (1994). This pattern of endemism is most common in large-shelled land snails of the genera *Ashmunella* (includes some 30 endemic species and subspecies), *Oreohelix*, and *Sonorella* (Metcalf and Smartt 1997), which inhabit high- elevation talus sprawls. In these "island" habitats, land-snail distribution and abundance is directly related to the aerial extent of talus available to them.

Studies of island biogeography indicate that insular (endemic) species typically show a tendency towards extinction (MacArthur 1972; see Soulé and Wilcox 1980:93-195). This scenario may likewise apply to the endemic land-snail fauna of New Mexico. Fossil evidence reveals that numerous ashmunellas and oreohelixes in the Sacramento Mountains became extinct during the Quaternary (Metcalf and Smartt 1997:7). Conversely, there is a tendency for species of land snails inhabiting rugged mountains with deep canyons and high ridges to speciate and produce diverse races, which may evolve into new species (i.e., *Ashmunella* of New Mexico and *Sonorella* of Arizona and México; see Bequaert and Miller 1973, Metcalf and Smartt 1997).

Approximately 42% (48 of 114 species, excluding subspecies) of the land snail fauna native to New Mexico is endemic to the state (see Metcalf and Smartt 1997, Metcalf et al., *In Preparation*). This rate of endemism is commensurate with that of any well-inventoried terrestrial biota (flora or fauna) of North America, and in some cases, it even rivals rates of endemism amongst continental (non-insular) terrestrial rainforest biotas throughout the world. Ongoing malacological inventories in New Mexico and adjacent Texas continue to produce new endemic species of land snails: *Holospira* sp., Animas Mountains, Hidalgo Co., NM (R. D. Worthington, UTEP, *pers. com.*); *Ashmunella* sp., Organ Mountains, NM (P. Mehlhop, NMNHP, *In Preparation*); *Sonorella* sp., Hueco Mountains, TX (A. L. Metcalf, *pers. com.*); and the putative Lang Canyon *Sonorella* sp., San Luis Mountains, Hidalgo County, NM (L. Gilbertson, *pers. com.*; reported herein). Several species complexes of land snails in New Mexico merit further study. Continuance of exploratory malacological inventories will provide data and voucher material for taxonomic reassessment of known species complexes, opportunity to recognize undescribed species, and will facilitate conservation status assessment of land snails of restricted occurrence in New Mexico.

Metcalf and Smartt (1997:63-64) listed 31 species and subspecies of land snails of restricted occurrence in New Mexico that "may or may not be threatened or endangered", but merit further study. Exploratory field surveys conducted during this project focused on six (Table 1 this report) of these 31 rare land snails and limited data was generated for three additional species (i.e., *Oreohelix metcalfei cuchillensis*, *Sonorella animasensis*, and *Linisa texasiana*).

Table 2 lists land-snail species and subspecies of New Mexico that require population survey and conservation status assessment. Many of these endemic taxa are as geographically restricted and under-studied as those species target by this 5-year survey. Numerous species were last documented from live specimens during malcological explorations in the late 1800's and early 1900's (e.g., endemic land snails of the Big Hatchet Mountains). Accordingly, formal recognition of these taxa at state and federal levels appears warranted (e.g., state "sensitive", USFWS "Species of Concern", USGS "Species at Risk"), which could provide funding to continue malacological surveys in New Mexico.

Insularity of Land Snails on Talus Sprawls

Discontinous limestone outcrops and talus sprawls (igneous and limestone) on montane "sky islands" (Warshall 1994) have proven fertile ground for adaptive radiation and speciation within the molluscanfauna of New Mexico. This is clearly evidenced by the plethora of species complexes and species groups within the oreohelixes and ashmunellas of the state (Metcalf and Smartt 1997). Although insularity of isolated populations on "sky islands" has presumably led to evolution within these taxa, taxonomic affinities within known species complexes and species groups remains dubious and subject to interpretation of highly variable conchological characters (morphology and dentition). For example, *Ashmunella* of large mountain ranges in New Mexico and Arizona typically have large, relatively elevated shells that are either edentulous or possess weak dentition. In contrast, numerous smaller, more arid ranges in southern New Mexico have *Ashmunella* with relatively depressed shells with well-developed denticles. Habitat diversity likely exerts ecological constraints responsible for such conchological disparities as adaptations to reduce dessication and/or to discourage predation (Metcalf and Smartt 1997; see references cited therein). While exceptions to this categorization do exist, the general pattern noted solicits taxonomic questions whether or not conchological differences and similarities are attributed to genetic relationship or evolutionary convergence or divergence (Metcalf et al. *In Preparation*).

Metcalf and Smartt (1997) provided a comprehensive review of the taxonomically confusing species groups and complexes of *Ashmunella* and *Oreohelix* of New Mexico. These examples are numerous and replete with detailed information on taxonomy, distribution, and conchology. These topics are discussed at even greater length in Metcalf et al. (*In Preparation*). Recountment of these highly detailed accounts herein would seem superfluous. Notwithstanding, resolve to the outstanding taxonomic and systematic relationships within the numerous complexes and groups of oreohelixes and ashmunellas of New Mexico will require an holistic approach employing molecular genetic techniques, phylogenetic analysis, and conchology coupled with collection of ecological data. Such an effort is timely and will require substantial funding and logistical support from resource management agencies working in collaboration with academic institutions and private land stewards in New Mexico. It would seem incumbent on resource agencies charged with protection and conservation of native fauna to consider this call for continuance of malacological studies of the unique land-snail fauna of New Mexico

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Table 2. Land snails of southern New Mexico that merit population surveys and conservation status assessment.

I. Endemic species or subspecies known only from small to medium-sized isolated mountains*:	
Vallonia sonorana	Big Hatchet Mountains, Hidalgo County
Holospira metcalfi	Howells Ridge, Little Hatchet Mountains, Hidalgo County
Coelostemma pyrgonasta	Bishop Cap Mountain, Doña Ana County
Radiocentrum ferrissi ferrissi	Big Hatchet Mountains, Hidalgo County
Radiocentrum ferrissi morticinum	Big Hatchet Mountains, Hidalgo County
Radiocentrum hachetanum hachetanum	Big Hatchet Mountains, Hidalgo County
Radiocentrum hachetanum cadaver	Big Hatchet Mountains, Hidalgo County
Ashmunella amblya cornudasensis	Cornudas Mountains, Otero County
Ashmunella harrisi	Goat Mountain (San Andres Mountains), Doña Ana County
Ashmunella tetradon fragilis	rock slide north of Hillsboro, Sierra County
Ashmunella rileyensis	Mount Riley, Doña Ana County
Ashmunella walkeri	Baldy Peak, Florida Mountains, Luna County
Ashmunella mearnsii	Big Hatchet Mountains, Hidalgo County
Ashmunella animasensis	Animas Mountains, Hidalgo County
Sonorella hachitana hachitana	Big Hatchet Mountains, Hidalgo County
Sonorella hachitana peloncillensis	Peloncillo Mountains, Hidalgo County
Sonorella animasensis	Animas Mountains, Hidalgo County
Sonorella sp.	Peloncillo and San Luis Mountains, Hildago County
II. Species of restricted occurrence within a large mountain range or in more than one range*:	
Oreohelix nogalensis	Sierra Blanca Mountains, Lincoln and Otero counties
Oreohelix confragosa	Pinos Altos Mountains, Grant County
Oreohelix litoralis	San Augustin Plains, Catron County
Sonorella metcalfi	Organ Mountains, Otero County
Humboltiana ultima	Guadalupe Mountains, Otero and Eddy counties
III. Species restricted to mesic and xeric, montane habitats*	
Gastrocopta cochisensis	Animas Mountain, Hidalgo County
Vertigo hinkleyi	Animas Mountain, Hidalgo County
Vertigo milium	Eddy and Lincoln counties
Vertigo ovata	Blue Spring, Eddy County; Alamosa Creek, Socorro County
Oxyloma retusum	Tularosa River near Mescalero, Fresnal Canyon, Otero County

* See Metcalf, A. L. and R. A. Smartt. 1997. Land snails of New Mexico: a systematic review. Pp. 1-69, *In* Land Snails of New Mexico. (A. L. Metcalf and R. A. Smartt, Eds.). New Mexico Museum of Natural History and Science Bulletin 10

Appendix F. Draft species accounts for federal Species of Concern and state-listed land snails of New Mexico.

Shortneck snaggletooth, *Gastrocopta dalliana dalliana* (Sterki, 1898)

Listing Status: New Mexico - Endangered (19 NMAC 33.1), listed 30 November 1990 (NMGF Reg. 682); Federal - Species of Concern (USFWS 1996).

Description: *Gastrocopta dalliana dalliana* (Mollusca: Gastropoda) is a pulmonate land snail of the family Pupillidae, which differs from other land snail families in New Mexico by having minute to small (1.7-5.0 mm *h*), pupilliform shells (pupa-shaped: cylindrical, ovate, conic) with an elongate spire and impressed sutures, peristome walls generally thickened, and aperture usually bearing at least 1 tooth. The genus *Gastrocopta* is distinguished from other pupillids by an ovate-elongate conic shell, 3 or more apertural teeth present with parietal and angular lamellae converging inward, and more or less united. Four subgenera of *Gastrocopta* occur in New Mexico, and are discerned by morphology of the convergent parietal lamellae. The subgenus *Immersidens,* to which *G. dalliana* belongs, is characterized by forward-diverging angular and parietal teeth united away from the aperture, and other teeth located far back in the aperture barely visible in apertural view. Shells of *G. dalliana* are small (< 2.0 mm *h*) with straight angular and parietal teeth of similar size. Two subspecies, *bilamellata* and *dalliana,* comprise *G. dalliana*; the latter is distinguished by upper ends of the peristome widely separated on the body whorl and a very thin, weak parietal callus. (See Pilsbry 1948, Bequaert and Miller 1973, Metcalf and Smartt 1997). In areas of overlap in southcentral Arizona, both subspecies are known to interbreed yielding intermediate shell characters (Bequaert and Miller 1973).

Distribution: *Gastrocopta dalliana dalliana* is common in southeastern Arizona and México (Chihuahua and Baja California Sur). In New Mexico, *G. d. dalliana* is known from geographically disparate populations in the Upper Sonoran Life Zone of the Animas, Big Hatchet, and San Luis mountains between 5900-6400 ft. elevation. The northern extent of this species range in New Mexico, albeit disjunct, conforms to a latitude extending from the northeast slope of the Animas Mountains east to Sheridan Canyon, Big Hatchet Mountains, Hidalgo County (Metcalf et al *In Preparation*).

Biology: The biology of *G. d. dalliana* is unknown. In general, all New Mexico land snails are herbivorous, consuming angiosperm plants, fungi, and lichens. Land snails may also consume dead, decaying plant material and soil which appears to serve as a source of minerals (e.g., calcium and magnesium) utilized in shell formation (Gomot et al. 1989). Although New Mexico land snails are hermaphroditic (i.e., both female and male reproductive organs within a snail), several modes of reproduction are known, including the transfer of sperm to another, reciprocal sperm exchange, and self-fertilization (Metcalf and Smartt 1997). Presumably pupillids, like most land snails, are oviparous (egg layers) and attach gelatinous-like egg masses to rocks, leaves, and branches in protected areas of soil interstitial spaces (Duncan 1975). The ability of land snails to distinguish cues from slime trails has been implicated in mate recognition, location of homesite, orientation, formation of hibernating "huddles" (aggregations), and avoidance of danger (McAndrew 1975, Cook 1979, Chelazzi et al. 1988, Pakarinen 1992, Baur and Baur 1993, Bailey 1989, Metcalf and Smartt 1997). Temperature and moisture account for the nocturnal habits of land snails and slugs, especially in the Arid Southwest (Bequaert and Miller 1973); however, land snails can be active in daylight on overcast rainy days. Land snails survive adverse environmental conditions, such as drought, by secreting an epiphragm (calcified mucous membrane) over the shell aperture to prevent desiccation (Machin 1975, Barnhardt 1989). Some snails remain dormant for months, even years, but will resume activity when moistened (Burch 1962, Metcalf and Smartt 1997).

Metcalf and Smartt (1997) considered 3 parameters (vegetation, effective precipitation, and elevation) interrelated with Bailey's (1913) Life Zones of New Mexico and geologic history, as biotic and abiotic components exerting ecological and physiological constraints largely responsible for the distribution and abundance of the land snails statewide. Consequently, numerous species of land snails are state endemics, especially in the arid mountains of southern New Mexico where geographically isolated populations are restricted to a single mountain range or peak (Metcalf 1997), commonly termed "sky islands" (Warshall 1994). This pattern of endemism is most common in large-shelled land snails of the genera *Ashmunella* (includes some 30 endemic species and subspecies), *Oreohelix*, and *Sonorella* (Metcalf and Smartt 1997), but is less common amongst the "lesser" (small-shelled taxa) land snails; which in part is attributed to their more widespread occurrences, especially in sparsely vegetated areas, and to dispersal mechanisms (Bequaert and Miller 1973). Small size and light weight allow for passive dispersal by wind and precipitation events (e.g., arroyo floods), which is common for snails that are often attached to leaves by epiphragm secretions. Such a dispersal mechanism can explain the widespread occurrence of *G. dalliana* from the Baja California Territorio Sur, México, north throughout the Sonoran and Chihuahuan desert shrublands and dry montane forests (Bequaert and Miller 1973).

In New Mexico, *G. d. dalliana* is closely associated with loose soils and deep leaf litter at the base of limestone outcrops. This species appears to be a denizen of the more mesic and densely wooded habitat of Indian Creek Canyon on the north slope of Animas Peak . The habitat of *G. d. dalliana* in exposed canyonlands of the San Luis and Big Hatchet mountains is characterized by xerophylic woody monocots, cacti, desert shrubs, and trees (*Quercus* spp, *Pinus* spp.) (Metcalf et al. *In Preparation*).

Status: Habitat critical to *G. d. dalliana* in the Animas and San Luis Mountains is under stewardship of the Animas Foundation (Gray Ranch). The lone population in the Big Hatchet Mountains occurs on public lands (BLM). While such stewardship would seem to afford some degree of protection under current land use practices, localized populations of this species, like most land snails, are susceptible to fire.

Conservation: Wildfires have scorched significant areas in Hidalgo County, New Mexico, including lower elevations of Indian Creek Canyon in the Animas Valley (Spring 2000) and Lang Canyon (1994, 1999, 2000). Evidence of past forest fire on the north slope of Animas Peak was noted by presence of ash and burned land-snail shells recovered from leaf litter collections at 7800 ft. elevation. While fire is considered a significant ecological component shaping forest seral succession, short- and long-term return effects on forest ecosystem dynamics are poorly understood, especially with respect to molluscanfaunal recovery periods.

Any form of soil disturbance (e.g., mineral mining) or vegetative cover removal (e.g. logging or grazing) would likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur. However, such practices currently pose no threat to any known population of *G. d. dalliana* in New Mexico. In most locations these activities would seem impracticable, with mineral extraction being the exception.

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Ovate vertigo, *Vertigo ovata* Say, 1822

Listing Status: New Mexico - Threatened (19 NMAC 33.1), listed 30 November 1990 (NMGF Reg. 682); Federal - Species of Concern (USFWS 1996).

Description: *Vertigo ovata* (Mollusca· Gastropoda) is a pulmonate land snail of the family Pupillidae, which differs from other land snail families in New Mexico by minute to small (1.7-5.0 mm *h*), pupilliform (pupa-shaped: cylindrical, ovate, conic) shells with an elongate spire and impressed sutures, peristome walls generally thickened, and aperture usually bearing at least 1 tooth. The genus *Vertigo* belongs to the subfamily Vertigininae, and is distinguished from other pupillids by an ovate to ovate-conic shell (1.5-3.0 mm *h*), 3 or more apertural teeth present, angular lamellae absent, reduced, or not near lip insertion, periostracum smooth (Burch 1962). The dark brown shells of *V. ovata* are small (<2.0 mm *h*) with 4½-5 whorls (body whorl relatively large), peristome thickened on all sides (parietal wall included) with 6 teeth. See Pilsbry 1948, Burch 1962, Metcalf and Smartt 1997.

Distribution: *Vertigo ovata* is a widespread species that occurs from Alaska and northern Canada, south to Florida, westward to Washington and California, but is found sporadically as a "relict species" in the western United States (Pilsbry 1948, Burch 1962, Bequaert and Miller 1973). In New Mexico, there are numerous fossil records of *V. ovata* from Pleistocene and Holocene deposits in 10 counties statewide (Metcalf et al. *In Preparation*). Currently, extant populations of this species are known from the riparian corridor of Blue Spring near Black River Village, Eddy County, and from the warm springs wetland complex of Alamosa Creek, Alamosa Canyon upstream of the Monticello Box, southwest Socorro County (Metcalf et al. *In Preparation*).

Biology: The biology of *V. ovata* is unknown. In general, all New Mexico land snails are herbivorous, consuming angiosperm plants, fungi, and lichens. Snails may also consume dead, decaying plant material and soil which appears to serve as a source of minerals (e.g., calcium and magnesium) utilized in shell formation (Gomot el al. 1989). Although New Mexico land snails are hermaphroditic (i.e., both female and male reproductive organs within a snail), several modes of reproduction are known, including the transfer of sperm to another, reciprocal sperm exchange, and self-fertilization (Metcalf and Smartt 1997). Presumably pupillids, like most land snails, are oviparous (egg layers) and attach gelatinous-like egg masses to rocks, leaves, and branches in protected areas of soil interstitial spaces (Duncan 1975). The ability of land snails to distinguish cues from slime trails has been implicated in mate recognition, location of home-site, orientation, formation of hibernating "huddles" (aggregations), and avoidance of danger (McAndrew 1975, Cook 1979, Chelazzi et al. 1988, Pakarinen 1992, Baur and Baur 1993, Bailey 1989, Metcalf and Smartt 1997) Temperature and moisture account for the nocturnal habits of land snails and slugs, especially in the Desert Southwest (Bequaert and Miller 1973); however, land snails can be active in daylight on overcast, rainy days Land snails survive adverse environmental conditions, such as drought, by secreting an epiphragm (calcified mucous membrane) over the shell aperture to prevent desiccation (Machin 1975, Barnhardt 1989). Some snails remain dormant for months, even years, but will resume activity when moistened (Burch 1962).

Metcalf and Smartt (1997) considered 3 parameters (vegetation, effective precipitation, and elevation) interrelated with Bailey's (1913) life zones of New Mexico and geologic history, as biotic and abiotic components exerting ecological and physiological constraints largely responsible for the distribution and abundance of the land snails statewide. Consequently, numerous species of land snails are state endemics, especially in the arid mountains of southern New Mexico where geographically isolated land snail populations are restricted to a single mountain range or peak (Metcalf 1997), commonly termed "sky islands" (Warshall 1994). This pattern of endemism is most common in large-shelled snails of the genera *Ashmunella* (includes some 30 endemic species and subspecies), *Oreohelix*, and *Sonorella* (Metcalf and Smartt 1997), but is less common amongst the "lesser" (small-shelled taxa) land snails, which in part is attributed to their more widespread occurrences, especially in sparsely vegetated areas, and to dispersal mechanisms (Bequaert and Miller 1973). Small size and light weight allow for passive dispersal by wind and precipitation events (e.g., arroyo floods), which is common for pupillids that are often attached to leaves by epiphragm secretions. Unlike most pupillids of New Mexico, *V. ovata* is a hydrophyllic species that occurs in close proximity to water (e.g., ponds, marshes, creeks) where it is found on marsh emergent vegetation, beneath rocks and organic debris, or on damp muddy soils (Metcalf and Smartt 1997). This land snail, like many aquatic mollusks (e.g., pulmonate snails and sphaeriid bivalves), is likely transported by wading shorebirds or waterfowl that inadvertently carry adults and/or eggs in mud adhering to feet or plumage (Bequaert and Miller 1973).

Vetigo ovata at Blue Spring and Alamosa Creek occur on wetted mud margins of shallow marsh habitats dominated by reeds (*Eleocharis* sp., *Juncus* sp., and *Scirpus americanus)* and perennials (*Rorippia* sp. and *Nasturtium officinale*). In the densely vegetated palustrine habitat of "Willow Spring" (Alamosa Creek), *V. ovata* is typically found on moist, matted stems of *S. americanus* within several centimeters of standing water. This species also occurs on moist soils and exposed damp roots beneath willow trees along the north streambank of Alamosa Creek. Immature *V. ovata* were observed live at both sites in June and August 2000.

Status: Pilsbry (1948) recognized three species of *Vertigo ovata* in North America: the nominate form and two subspecies (*V. o. diaboli* and *V. o. mariposa*). Populations of *V. ovata* at Blue Spring and in Alamosa Creek Canyon appear referable to the nominate species (A. L. Metcalf, *pers. com.*).

Localized populations of *V. ovata* in the Desert Southwest are vulnerable to extirpation. Natural stochastic events (e.g., Holocene warming, arroyo entrenchment) exacerbated by human-related land use activities (e.g., wetland [marsh] drainage and development, stream diversion, grazing) have reduced habitat suitability and availability for this species and other hydrophylic land snails (e.g., *Carychium exiguum*, *Gastrocopta pentodon* form "*tappaniana*", *Vetigo milium*, *Pupilla muscorum*, *Oxyloma retusum*) in the Desert Southwest (Haynes 1968, Bequaert and Miller 1973, Metcalf and Smartt 1997, Metcalf et al. *In Preparation*).

Vertigo ovata at Blue Spring appears stable under past and current land use practices and irrigation withdrawals, with evidence of successful reproduction and recruitment of immature snails into the adult population. Threats to the Blue Spring population may include: local/regional ground-water depletion (Hennighausen 1969, Quarles 1983), springrun dewatering (NMGF 1988), surface and groundwater contamination from oil and gas industry operations (e.g., exploration, storage, transfer, refining; Jercinovic 1982, 1984; Longmire 1983; Quarles 1983; Boyer 1986; Eisler 1987; Green and Trett 1989), agricultural practices (Rail 1989), and poor watershed stewardship (Taylor 1983, Mehlhop 1992). Prolonged drought could adversely impact the Blue Spring population by reducing hydrologic discharge through the system, thereby desiccating riparian plant communities and increasing grazing pressure along Blue Spring run.

Based on extensive technical review of a Minimal Impact New Mining Permit Application (No. 6950), the NMDGF rendered biological opinion that the prospects of survival and recruitment of *V. ovata* are in jeopardy due to threatened destruction, modification, or curtailment of its habitat by a proposed beryllium mine on property adjacent to and within the immediate watershed of Alamosa Creek and associated wetland areas that provide critical riparian habitat for this species. It was further determined that *V. ovata* is subject to take as defined by Section 17-3-28 of the amended (1995) Wildlife Conservation Act (WCA). State Threatened species currently are not afforded protection from take under the state WCA.

Under the 2000 Biennial Review of Threatened and Endangered Species in New Mexico, the State Game Commission accepted the Department's recommendation to withhold uplisting *V. ovata* from Threatened to Endangered pending further review of a revised permit application that addresses numerous outstanding issues regarding proposed mine site operations.

Conservation: Long-term viability of this species is contingent upon protection of the riparian corridors where it is known to occur. A comprehensive statewide survey of low-elevation marsh and springbrook wetlands may reveal extant populations of this species elsewhere in New Mexico.

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Florida mountainsnail, *Oreohelix florida* Pilsbry, 1939

Listing Status: New Mexico - Endangered (19 NMAC 33.1), listed 30 November 1990 (NMGF Reg. 682); Federal - Species of Concern (USFWS 1996).

Description: *Oreohelix florida* (Mollusca: Gastropoda) is a pulmonate land snail of the family Oreohelicidae. Shells of *Oreohelix* are large, helicoid, wider (≥10 mm) than high (<18 mm), slightly depressed to moderately elevated, lack parietal teeth, possess 2 or more broken or fused dark bands (or entire shell brown), periphery rounded to angular to carinate, nepionic (embryonic) whorls with diverse ornamentation patterns (e.g., fine vertical striae, spiral engraved lines). *Oreohelix* shells are distinguished from those of the only other genus of the family, *Radiocentrum*, by having striate (well-developed, spirally-lined), embryonic whorls numbering 2½; whereas *Radiocentrum* embryonic shells possess strongly developed radial riblets and 1½ whorls. While accurate species identifications commonly require dissection of genitalia, Metcalf and Smartt (1997) employed geographic distribution as a reliable criterion by which to distinguish most *Oreohelix* species in New Mexico. The shell of *O. florida* is moderately elevated, body whorl angular peripherally. See Pilsbry 1905, 1939; Bequaert and Miller 1973; Metcalf and Smartt 1988, 1997.

Distribution: *Oreohelix florida* is endemic to southwestern New Mexico where it is known only from fossil specimens in Luna (Baldy Peak [type locality], Florida Mountains; the north slope of Cooke Peak, Cooke's Range; Tres Hermanas Mountains), Grant (Santa Rita Mountains) and Hidalgo counties (Apache Hills) (Metcalf and Smartt 1997).

Biology: The soft anatomy, reproductive tract morphology, and biology of *O florida* are undescribed, as this species is known only from fossil specimens. All New Mexico land snails are herbivorous, consuming angiosperm plants, fungi, and lichens. Snails may also consume dead, decaying plant material and soil which appears to serve as a source of minerals (e.g., calcium and magnesium) utilized in shell formation (Gomot el al. 1989). Although New Mexico land snails are hermaphroditic (both female and male reproductive organs within a snail), several modes of reproduction are known, including the transfer of sperm to another, reciprocal sperm exchange, and self-fertilization (Metcalf and Smartt 1997). Oreohelicids, unlike most oviparous (egg layers) land snails, are ovoviviparous: eggs hatch in the uterus where young snails mature before leaving the parent (Bequaert and Miller 1973). The ability of land snails to distinguish cues from slime trails has been implicated in mate recognition, location of homesite, orientation, formation of hibernating "huddles" (aggregations), and avoidance of danger (McAndrew 1975, Cook 1979, Chelazzi et al. 1988, Pakarinen 1992, Baur and Baur 1993, Bailey 1989, Metcalf and Smartt 1997). Temperature and moisture account for the nocturnal habits of land snails and slugs, especially in the Arid Southwest (Bequaert and Miller 1973); however, land snails can be active in daylight on overcast, rainy days. Land snails survive adverse environmental conditions, such as drought, by secreting an epiphragm (calcified mucous membrane) over the shell aperture to prevent desiccation (Machin, 1975, Barnhardt 1989). Some snails remain dormant for months, even years, but will resume activity when moistened (Burch 1962).

Metcalf and Smartt (1997) considered 3 parameters (vegetation, effective precipitation, and elevation) interrelated with Bailey's (1913) life zones of New Mexico and geologic history, as biotic and abiotic components exerting ecological and physiological constraints largely responsible for the distribution and abundance of the land snails statewide. Consequently, numerous species of land snails are state endemics, especially in the arid mountains of southern New Mexico where geographically isolated populations are restricted to a single mountain range or peak (Metcalf 1997), commonly termed "sky islands" (Warshall 1994). This pattern of endemism is most common in large-shelled land snails of the genera *Ashmunella* (includes some 30 endemic species and subspecies), *Oreohelix*, and *Sonorella* (Metcalf and Smartt 1997); but is less common amongst the "lesser" land snails (small-shelled taxa), which in part is attributed to their more widespread occurrences resulting from passive dispersal mechanisms (e.g., wind, arroyo flooding) (Bequaert and Miller 1973). In southern New Mexico, *Oreohelix* species typically occur in high elevation limestone outcrops (Metcalf and Smartt 1997). Fossil *O. florida* have been collected in colluvial and cave deposits in areas of limestone outcrop throughout its historic range (Pilsbry 1939; Metcalf and Smartt 1988, 1997).

Status: Collections made this century indicate that *O. florida* is extinct (Metcalf and Smartt 1997). The species was first reported from fossil specimens as "*Oreohelix strigosa* var." from the Florida Mountains (Pilsbry 1915). In his species description, Pilsbry (1939) considered it a subspecies of *O. metcalfei*. Based on unique conchological characteristics, Metcalf (1974) elevated *florida* to full species status. Additional state records from adjacent mountains are also of fossil specimens only (Metcalf and Smartt 1997).

Pilsbry's historic records of *O. florida* as fossil specimens have been confirmed repeatedly by contemporaneous collection records in the Florida Mountains and at several sites from the periphery of the species presumed historic range. Recent malacological surveys (1970-1997) at 47 sites in the Florida Mountains yielded only fossil specimens. Accordingly, this species appears extinct throughout its historic range.

These fossil records support the dispersalist-extinction model of primitive oreohelicids proposed by Metcalf (1974) and Crews and Metcalf (1982). Metcalf and Smartt (1997) recognized that a model of vicariance biogeography could explain the distributional patterns of primitive oreohelicids that once occurred as peripheral dispersalists from the source populations of the *Oreohelix metcalfei* complex in the Black Range, New Mexico. The extinction of primitive oreohelicids in southern (*O. florida*) and eastern (*O. caballoensis*) New Mexico might be attributed to climatic deterioration during the Holocene (Metcalf and Smartt 1997) and/or natural extinction processes characteristic of small oceanic islands (MacArthur 1972).

Conservation: Inventory of suitable habitat(s) along the international border with México is recommended to explore the possibility of locating an unknown population of this species. If an extant population exists, then habitat protection would be paramount. Land snails occupying high-elevation limestone outcrops are vulnerable to any form of soil disturbance or mining activity in the general vicinity of the population (NMGF 1988).

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Mineral Creek mountainsnail, *Oreohelix pilsbryi* Ferriss, 1917

Listing Status: New Mexico - Threatened (19 NMAC 33.1), listed 30 November 1990 (NMGF Reg. 682); Federal - Species of Concern (USFWS 1996)

Description: *Oreohelix pilsbryi* (Mollusca: Gastropoda) is a pulmonate land snail of the family Oreohelicidae. Shells of *Oreohelix* are large, helicoid, wider (≥10 mm) than high (<18 mm), slightly depressed to moderately elevated, lacking parietal teeth, possess 2 or more broken or fused dark bands (or entire shell brown), periphery rounded to angular to carinate, nepionic (embryonic) whorls with diverse ornamentation patterns (e.g., fine vertical striae, spiral engraved lines). *Oreohelix* shells are distinguished from those of the only other genus of the family, *Radiocentrum*, by having striate (well-developed, spirally-lined), embryonic whorls numbering 2½; whereas *Radiocentrum* embryonic shells possess strongly developed radial riblets and 1½ whorls. While accurate species identifications commonly require dissection of genitalia, Metcalf and Smartt (1997) employed geographic distribution as a reliable criterion by which to distinguish most *Oreohelix* species in New Mexico. The shell of *O. pilsbryi* is depressed, and possesses distinct, strongly developed spiral ridges. See Pilsbry 1905, 1939; Ferriss 1917; Bequaert and Miller 1973; Metcalf and Smartt 1988, 1997.

Distribution: Turgeon et al. (1998) termed *Oreohelix* land snails as "mountainsnails", conforming to the distribution of the Oreohelicidae throughout much of the Rocky Mountain region of western North America, from southern Canada south to northern Chihuahua and Sonora and Baja California Sur, México (Bequaert and Miller 1973). Oreohelicids occur throughout the mountains of New Mexico. *Oreohelix pilsbryi* is endemic to southwestern New Mexico where it is known from a limestone outcrop at Oliver's Mine (type locality) on Mineral Creek, about five miles upstream of Chloride, Sierra County, and a second small population ¼ mile up-slope from the type locality (Metcalf and Smartt 1997).

Biology: The biology of *O. pilsbryi* is unknown In general, all New Mexico land snails are herbivorous, consuming angiosperm plants, fungi, and lichens. Snails may also consume dead and decaying plant material and soil which appears to serve as a source of minerals (e.g., calcium and magnesium) utilized in shell formation (Gomot el al. 1989). Although New Mexico land snails are hermaphroditic (both female and male reproductive organs within a snail), several modes of reproduction are known, including the transfer of sperm to another, reciprocal sperm exchange, and self-fertilization (Metcalf and Smartt 1997). Oreohelicids, unlike most oviparous (egg layers) land snails, are ovoviviparous; eggs hatch in the uterus where young snails mature before leaving the parent (Bequaert and Miller 1973). The ability of land snails to distinguish cues from slime trails has been implicated in mate recognition, location of homesite, orientation, formation of hibernating "huddles" (aggregations), and avoidance of danger (McAndrew 1975, Cook 1979, Chelazzi et al. 1988, Pakarinen 1992, Baur and Baur 1993, Bailey 1989, Metcalf and Smartt 1997). Temperature and moisture account for the nocturnal habits of land snails and slugs, especially in the Arid Southwest (Bequaert and Miller 1973); however, land snails can be active in daylight on overcast, rainy days. Land snails survive adverse environmental conditions, such as drought, by secreting an epiphragm (calcified mucous membrane) over the shell aperture to prevent desiccation (Machin 1975, Barnhardt 1989). Some snails remain dormant for months, even years, but will resume activity when moistened (Burch 1962).

Metcalf and Smartt (1997) considered 3 parameters (vegetation, effective precipitation, and elevation) interrelated with Bailey's (1913) life zones of New Mexico and geologic history, as biotic and abiotic components exerting ecological and physiological constraints largely responsible for the distribution and abundance of the land snails statewide. Consequently, numerous species of land snails are state endemics, especially in the arid mountains of southern New Mexico where geographically isolated populations are restricted to a single mountain range or peak (Metcalf 1997), commonly termed "sky islands" (Warshall 1994). This pattern of endemism is most common in large-shelled land snails of the genera *Ashmunella* (includes some 30 endemic species and subspecies), *Oreohelix*, and *Sonorella* (Metcalf and Smartt 1997); but is less common amongst the "lesser" land snails (small-shelled taxa), which in part is attributed to their more widespread occurrences resulting from passive dispersal mechanisms (e.g., wind, arroyo flooding) (Bequaert and Miller 1973). In southern New Mexico, *Oreohelix* typically occurs in high-elevation limestone outcrops (Metcalf and Smartt 1997).

At the type locality, this species is abundant throughout a ca. ¼-mile reach of stream along limestone outcrops that constrict Mineral Creek to a narrow sinuous channel. Survey in September 1999 yielded several small (<10 mm *W*) *O. pilsbryi* shells (recent and live) which confirmed a successfully reproducing population with an abundance of large adults snails aggregated in what appeared to be breeding "huddles". *Oreohelix pilsbryi* was most abundant along the south canyon wall, which is densely shaded during the diel solar period. The leaf litter-soil interface under such aspect (direction of slope) was more humid than edaphic conditions along the north canyon wall. Only a few live *O. pilsbryi* were observed along the north canyon wall, and no empty shells were littered on the forest floor as observed along the south canyon wall. *Oreohelix pilsbryi* occurs in mixed leaf litter and limestone rubble that collects on rock ledges and at the base of large boulders. Solitary individuals were observed within the Mineral Creek floodway at 2.0 m distant of flowing water. This species seems more tolerant of natural habitat disturbance due to large-volume stream discharges associated with seasonal rains than xeric edaphic conditions.

Status: The type locality is relatively unaccessible by vehicle where the forest is undisturbed with a dense, mixed canopy (*Quercus* sp., *Alnus oblongifola*, *Pinus* sp.) that shades the narrow canyon floor and walls. While evidence of grazing was noted throughout the entire canyon reach surveyed in 1999, site conditions suggests that grazing is likely most frequent and of greater duration downstream of the type locality, where the well-insolated canyon floor widens and supports an abundance of native grasses and forbs. Habitat conditions noted under such grazing pressure appeared stable. Whereas cattle may not graze at the type locality, cows do travel the narrow stream corridor and rest along shaded canyon walls Soil disturbance from such foot traffic and trampling could adversely affect *O. pilsbryi*, if frequency and duration of downstream grazing intensity increases so as to push cattle into marginal habitats upstream in search of forage

Habitat critical to *O. pilsbryi* is located on private land bordered by the Gila National Forest. Higher elevations at this site were actively mined (Oliver's and Dreadnaught mines) in the early 1900's. Mineral resources and mining rights still likely exist in areas adjacent to habitat occupied by *O. pilsbryi*. Favorable economic conditions might renew extractive interests in this area which could result in soil disturbance or forest clearing. Such activities would likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur.

This species, like most land snails, is susceptible to fire. While fire is considered a significant ecological component shaping forest seral succession, short- and long-term return effects on forest ecosystem dynamics are poorly understood, especially with respect to molluscanfaunal recovery periods.

Conservation: This species is highly vulnerable to any form of soil disturbance or mining activity within the general vicinity of its known distribution (NMGF 1988). Overstory canopy removal, whether by cutting or forest fire, would likely dry the forest floor and potentially render edaphic condition unsuitable to *O. pilsbryi*., which is likely limited to contiguous limestone habitat at the type locality, as oreohelicids are, in most cases, strict calciphiles (Bequeart and Miller 1973, Metcalf and Smartt 1997). Surveys of limestone outcrops upstream (west) of the type locality to the headwaters of Mineral Creek at the base of Lookout Mountain, and in drainages to the north (e.g., Dry Creek, Cliff, and Little Bear Creek canyons) would serve to define more precisely the distribution of *O. pilsbryi*.

Federal and/or state aquisition of private lands immediately adjacent to the national forest that habor the only known extant population of *O. pilsbryi* would secure habitat for this species. However, such real estate dealings may encumber intractable mineral right issues. Under such a scenario, a habitat conservation agreement would appear prudent.

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Hacheta Grande woodlandsnail, *Ashmunella hebardi* Pilsbry and Vanatta, 1923

Listing Status: New Mexico - Threatened (19 NMAC 33.1), listed 30 November 1990 (NMGF Reg. 682); Federal - Species of Concern (USFWS 1996).

Description: *Ashmunella hebardi* (Mollusca: Gastropoda) is a pulmonate land snail of the family Polygyridae (Pilsbry and Vanatta 1923). *Ashmunella* is a distinctive Southwestern genus of large snails characterized by a helicoid shell (convex and flattened), wider (≥10 mm) than high (<18 mm), rounded to carinate periphery, brownish pigmentation and banding, peristome walls thickened to form a well-defined pale lip, parietal tooth absent or not V-shaped, if present. Distinction between cryptic species of *Ashmunella* requires examination of genitalia. Identification of *Ashmunella* species in New Mexico is based on distributional occurrence (i.e., mountain range) and shell characters. *Ashmunella* from the Big Hatchet and nearby mountains of southern New Mexico belong to 1 of 2 species. The carinate shells of *A. hebardi* are granulose (papillose), rough-textured, not glossy, and with a thickened parietal wall that is detached from the body whorls to the left. See Pilsbry 1940, Bequaert and Miller 1973, Metcalf and Smartt 1997.

Distribution: The genus *Ashmunella* occurs primarily in mountainous regions from trans-Pecos Texas, west across New Mexico to the southeast corner of Arizona, and south to northern Chihuahua, México. Species diversity of *Ashmunella* is highest in the southern two-thirds of New Mexico, where nearly all of the 30 *Ashmunella* species are state endemics. *Ashmunella hebardi* is a narrow endemic known only from Chainey Canyon on the northwest precipitous slope of Hacheta Grande, Big Hatchet Mountains, Hidalgo County, New Mexico (Metcalf et al. *In Preparation*).

Biology: The biology of *A. hebardi* is unknown. In general, all New Mexico land snails are herbivorous, consuming angiosperm plants, fungi, and lichens. Snails may also consume dead, decaying plant material and soil which appears to serve as a source of minerals (e.g., calcium and magnesium) utilized in shell formation (Gomot el al. 1989). Although New Mexico land snails are hermaphroditic (i.e., both female and male reproductive organs within a snail), several modes of reproduction are known, including the transfer of sperm to another, reciprocal sperm exchange, and self-fertilization (Metcalf and Smartt 1997). Presumably polygyrids, like most land snails, are oviparous (egg layers) and attach gelatinous-like egg masses to rocks, leaves, and branches in protected areas of soil interstitial spaces (Duncan 1975). The ability of land snails to distinguish cues from slime trails has been implicated in mate recognition, location of homesite, orientation, formation of hibernating "huddles" (aggregations), and avoidance of danger (McAndrew 1975, Cook 1979, Chelazzi et al. 1988, Pakarinen 1992, Baur and Baur 1993, Bailey 1989, Metcalf and Smartt 1997). *Ashmunella* appear as a k-selected taxon (slow maturation, long-lived) relative to other land snail species, as captive *A. kochii* mated at 5 years and lived for at least 8 years, whereas *A. rhyssa* survived almost twice that length of time (Walton 1970) Reproductive capacity in wild populations has not been assessed. Temperature and moisture account for the nocturnal habits of land snails and slugs, especially in the Arid Southwest (Bequaert and Miller

1973); however, land snails can be active in daylight on overcast, rainy days. Land snails survive adverse environmental conditions, such as drought, by secreting an epiphragm (calcified mucous membrane) over the shell aperture to prevent desiccation (Machin 1975, Barnhardt 1989). Some snails remain dormant for months, even years, but will resume activity when moistened (Burch 1962).

Metcalf and Smartt (1997) considered 3 parameters (vegetation, effective precipitation, and elevation) interrelated with Bailey's (1913) life zones of New Mexico and geologic history, as biotic and abiotic components exerting ecological and physiological constraints largely responsible for the distribution and abundance of the land snails statewide. Consequently, numerous species of land snails are state endemics, especially in the arid mountains of southern New Mexico where geographically isolated populations are restricted to a single mountain range or peak (Metcalf 1997), commonly termed "sky islands" (Warshall 1994). This pattern of endemism is most common in large-shelled land snails of the genera *Ashmunella* (includes some 30 endemic species and subspecies), *Oreohelix*, and *Sonorella* (Metcalf and Smartt 1997); but is less common amongst the "lesser" land snails (small-shelled taxa), which in part is attributed to their more widespread occurrences resulting from passive dispersal mechanisms (e.g., wind, arroyo flooding) (Bequaert and Miller 1973).

In Chainey Canyon, *A. hebardi* occurs in exposed canyonland habitat of sparse canopy cover dominated by oak (*Quercus* spp.) with *Junniperus deppeana* and *Pinus* spp. variously admixed The shrub understory consists of *Ephydra* sp., woody monocots (*Dasylirion* spp., *Nolina microcarpa*, *Yucca* spp., *Agave* spp.), cacti, and desert shrubs (*Garrya* sp., *Fallugia paradoxa*, *Cercocarpus breviflorus*, *Rhus aromatica*, *Mahonia haematocarpa*, and *Robinia neomexicana*). This species is typically found under loose stones below limestone cliffs in sparsely wooded areas (Metcalf et al. *In Preparation*).

Status: *Ashmunella hebardi* appears restricted to higher elevations of Chainey Canyon, Big Hatchet Mountains, where recent surveys (1995-2000) documented its persistence. Conchological evidence suggests a narrow hybrid contact zone between *A. hebardi* and *A. mearnsii* along the north slope of Big Hatchet Peak (Metcalf and Smartt 1997, Metcalf et al. *In Preparation*). Hybridization between *A. hebardi* and *A. mearnsii* is problematic for resource agencies charged with conservation and stewardship of protected species. This species is state-listed as Threatened. Currently, state Threatened species are not provided protection from take under the state Wildlife Conservation Act (1995).

Conservation: Habitat critical to *A. hebardi* in the Big Hatchet Mountains is under stewardship of the Bureau of Land Management (BLM). This species, like most land snails, is susceptible to fire. Evidence of past forest fire in the Big Hatchet Mountains was not observed during recent land-snail surveys. While fire is considered a significant ecological component shaping forest seral succession, short- and long-term return effects on forest ecosystem dynamics are poorly understood, especially with respect to molluscanfaunal recovery periods.

Any form of soil disturbance (e.g., mineral mining) or vegetative cover removal (e.g. logging or grazing) would likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur. Chainey Canyon is adjacent to unfenced private lands (U-Bar Ranch) that are under intense grazing pressure. This raises concern as free-ranging cattle have ready access to BLM lands at lower elevations in Chainey Canyon where the distribution of *A. hebardi* is not well-understood (Metcalf and Smartt 1997). Mineral resources and mining rights existing in areas where *A. hebardi* occurs have not been researched.

Additional land-snail surveys in the Big Hatchet Mountains are required to investigate hybridization between *A. hebardi* and *A. mearsnsii*. This study should include molecular genetic techniques, conchology, and collection of ecological data. Such an holistic approach would provide an opportunity to resolve outstanding genetic affinities within the putative *Ashmunella hebardi-mearnsii* complex, which will facilitate threat assessment and prescription of management recommendations on a species-specific basis.

The Big Hatchet Mountains harbor a number of land snail species that are either endemic (*Radiocentrum hachetanum hachetanum, R. ferrissi ferrissi*) or presently restricted (*Sonorella hachitana hachitana*) to the higher elevations in the range (Metcalf and Smartt 1997). These species were last documented from live specimens during the H. A. Pilsbry and L. E. Daniels expedition in 1910. Based on fossil material collected during this expedition, Pilsbry (1915) also described subspecies for these two living *Radiocentrum* species from "Daniels Mountain" located southwest of Hacheta Grande; these endemic subspecies are *R. hachetanum cadaver* and *R. ferrissi morticinum*. Little knowledge concerning the distribution of *Radiocentrum* in New Mexico has been added since the 1910 Pilsbry and Daniels expedition to the Big Hatchet Mountains. The range begs further malacological survey.

Fencing of property along the western limits of BLM land in Chainey Canyon could provide protection from overgrazing, but benefits derived from this effort must be considered in relation to costs of sensitive landowner-agency liaison relations in the region.

Funding for further studies of the unique molluscanfauna of the Big Hatchet Mountains appears warranted for numerous arguments posed above. However, if a change in conservation status at state or federal levels will facilitate such an initiative, then a change in status for *A. hebardi* merits consideration. State and federal agencies might also consider recognition of *R. ferrissi* and *R. hachetanum* as species that merit formal conservation measures since these two land snails are as ecologically and geographically restricted and under-studied as any land-snail species in New Mexico.

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Cook's Peak woodlandsnail, *Ashmunella macromphala* Vagvolgyi, 1974

Listing Status: New Mexico - Threatened (19 NMAC 33.1), listed 30 November 1990 (NMGF Reg. 682); Federal - Species of Concern (USFWS 1996).

Description: *Ashmunella macromphala* (Mollusca: Gastropoda) is a pulmonate land snail of the family Polygyridae, which is primarily a family of temperate, humid woodlands ranging from northern Canada and southern Alaska south into the tropics. *Ashmunella* is a distinctive Southwestern genus of large snails characterized by a helicoid shell (convex and flattened), wider (≥10 mm) than high (<18 mm), rounded to carinate periphery, brownish pigmentation and banding, peristome walls thickened to form a well-defined pale lip, parietal tooth absent or not v-shaped, if present. Distinction between cryptic species of *Ashmunella* requires examination of genitalia. Identification of *Ashmunella* species in New Mexico is based on distributional occurrence (i.e., mountain range) and shell characters. The only *Ashmunella* from the Cookes Range of southern New Mexico is *A. macromphala*. Shells of *A. macromphala* are medium-sized (5.4-6.5 *h* x 12.5-14.9 mm *w*), whorls number 5.0-5.5, body whorl slightly carinate, descending before the aperture, deeply furrowed near the peristome. The aperture is rounded anteriorly, auricular posteriorly with numerous apertural teeth and lamellae, and a reflexed (receded) outer lip. See Pilsbry 1940; Vagvolgyi 1974; Burch 1962; Bequaert and Miller 1973; Metcalf and Smartt 1988, 1997.

Distribution: The genus *Ashmunella* is restricted primarily to mountainous regions from trans-Pecos Texas, west across New Mexico to the southeast corner of Arizona, and south to northern Chihuahua, México. *Ashmunella* species diversity is highest in the southern two-thirds of New Mexico, where nearly all of the 30 *Ashmunella* species are state endemics (Metcalf and Smartt 1997).

Ashmunella macromphala is a local endemic known only from two isolated populations in Cooke's Range, Luna County. In May 1998 and 2000, small (<5 mm *w*) and adult-sized (>10 mm) *A. macromphala* were collected live from mixed leaf litter to a depth of three feet in igneous talus at the type locality on the north slope of Cooke's Peak (ca. 7600 ft. elevation). Exploratory surveys north and south of Cooke's Peak documented a single isolated population of *A. macromphala* on a north-facing igneous scree slope at 6070 ft. elevation in OK Canyon. While no live snails were observed at this site, the abundance of recent shell material indicated an extant population (Metcalf et al. *In Preparation*).

Biology: The biology of *A. macromphala* is unknown. In general, all New Mexico land snails are herbivorous, consuming angiosperm plants, fungi, and lichens. Snails may also consume dead, decaying plant material and soil which appears to serve as a source of minerals (e.g., calcium and magnesium) utilized in shell formation (Gomot el al. 1989). Although New Mexico land snails are hermaphroditic (both female and male reproductive organs within a snail), several modes of reproduction are known, including the transfer of sperm to another, reciprocal sperm exchange, and self-fertilization (Metcalf and Smartt 1997). Polygyrids, like most land snails, are oviparous (egg layers) and attach gelatinous-like egg masses to rocks, leaves, and branches in protected areas of soil and substrate interstitial spaces (Duncan 1975). The ability of land snails to distinguish cues from slime trails has been implicated in mate recognition, location of homesite, orientation, formation of hibernating "huddles" (aggregations), and avoidance of danger (McAndrew 1975, Cook 1979, Chelazzi et al. 1988, Pakarinen 1992, Baur and Baur 1993, Bailey 1989, Metcalf and Smartt 1997). *Ashmunella* appear as a k-selected taxon (slow maturation, long-lived) relative to other land snail species, as captive *A. kochii* mated at 5-6 years and lived for at least 8 years, whereas *A. rhyssa* survived almost twice that length of time (Walton 1970). Reproductive capacity in wild populations has not been assessed. Temperature and moisture account for the nocturnal habits of land snails and slugs, especially in the Arid Southwest (Bequaert and Miller 1973); however, land snails can be active in daylight on overcast, rainy days. Land snails survive adverse environmental conditions, such as drought, by secreting an epiphragm (calcified mucous membrane) over the shell aperture to prevent desiccation (Machin, 1975, Barnhardt 1989). Some snails remain dormant for months, even years, but will resume activity when moistened (Burch 1962)

Metcalf and Smartt (1997) considered 3 parameters (vegetation, effective precipitation, and elevation) interrelated with Bailey's (1913) life zones of New Mexico and geologic history, as biotic and abiotic components exerting ecological and physiological constraints largely responsible for the distribution and abundance of the land snails statewide. Consequently, numerous species of land snails are state endemics, especially in the arid mountains of southern New Mexico where geographically isolated populations are restricted to a single mountain range or peak (Metcalf 1997), commonly termed "sky islands" (Warshall 1994). This pattern of endemism is most common in large-shelled land snails of the genera *Ashmunella* (includes some 30 endemic species and subspecies), *Oreohelix*, and *Sonorella* (Metcalf and Smartt 1997); but is less common amongst the "lesser" land snails (small-shelled taxa), which in part is attributed to their more widespread occurrences resulting from passive dispersal mechanisms (e.g., wind, arroyo flooding) (Bequaert and Miller 1973). In 1988, *A. macromphala* was collected under loose stones and woody debris from two talus rock slides at 6900-7000 ft. elevation on the precipitous north slope of Cooke Peak (Metcalf and Smartt 1997). Prior collections by Vagvolgyi (1974) were type specimens from this same locality where 80-90 live snails were found in a rock slide; 20-30 empty shells were recovered from talus located approximately ¼ mile east Dwarfed stands of oak (*Quercus* sp.) bordered talus areas, providing food and cover for snails (Vagvolgyi 1974). Metcalf collected fossil *A. macromphala* from colluvial sediments at the "ghost village" of Cooke in the northern extent of Cooke's Range (Metcalf and Smartt 1997).

Shells from the OK Canyon population are notably larger than those at the type locality, but the similarity of apetural dentition implies that the OK Canyon population is referable to the nominant species at the type locality. Shell size varies greatly in the genus *Ashmunella* and is related to a number of factors including: elevation, slope exposure, humidity, and nutrition (Metcalf et al. *In Preparation;* see references cited therein).

Status: Any form of soil disturbance (e.g., mineral mining) or vegetative cover removal (e.g. logging or grazing) would likely result in adverse impacts to edaphic conditions and direct habitat loss in areas were this species is known to occur. Mineral resources and mining rights existing in areas where *A. macromphala* occurs have not been researched.

Habitats critical to *A. macromphala* in the Cooke's Range are under stewardship of the Bureau of Land Management. While such stewardship would seem to afford some degree of protection under current land use practices, extensive high-elevation grazing on steep grassy slopes and around the perimeter of the type locality was observed during the May 2000 survey. This poses concern for the population on the north slope of Cooke's Peak. Cattle will likely not venture onto or across a talus slope. However, intense grazing of deciduous woody vegetation around the perimeter of a scree slope can potentially decrease leaf litter available as food for snails, significantly alter seral succession, and affect plant community composition. Morever, removal of vegetation and destablization of soils immediately downslope of this talus sprawl poses concern for long-term soil and slope stability, especially for highly erosive, exposed soils during heavy rain events. At the time of this survey, grazing intensity near the *A. macromphala* population in OK canyon appeared less threatening than such land-use near the type locality.

Localized populations of this species, like most land snails, are susceptible to fire. Evidence of past forest fire in the Big Hatchet Mountains was not observed during recent land-snail surveys. Whereas fire is considered a significant ecological component shaping forest seral succession, short- and long-term return effects on forest ecosystem dynamics are poorly understood, especially with respect to molluscanfaunal recovery periods.

Conservation: A change in conservation status of *A. macromphala* appears unwarranted at this time. Notwithstanding, elimination of cattle grazing either by fencing or establishment of a grazing-free allotment at the base of the type locality would be prudent. Continuance of malacological surveys is recommended to explore potentially suitable habitats for this species in southwestern areas of the Cooke's Range.

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Doña Ana talussnail, *Sonorella todseni* Miller, 1976

Listing Status: New Mexico - Threatened (19 NMAC 33.1), listed 30 November 1990 (NMGF Reg. 682); Federal - Species of Concern (USFWS 1996).

Description: *Sonorella todseni* (Mollusca: Gastropoda) is a pulmonate land snail of the family Helminthoglyptidae. *Sonorella* is a speciose genus of helminthoglyptid snails with a depressed, globose, helicoid shell, wider (≥10 mm) than high (<18 mm), umbilicate or perforate, wide aperture with a thin barely expanded peristome, lightly colored with a dark, single peripheral band extending from the third whorl to the aperture. Whereas shells of *Sonorella* show few reliable diagnostic characters, specific differences are largely determined by analysis of genitalia and geographic distribution in New Mexico. See Pilsbry 1905, 1939; Bequaert and Miller 1973; Metcalf and Smartt 1997.

Distribution: Turgeon et al. (1998) termed species of *Sonorella* as "talussnails", conforming to the localized distribution of helminthoglyptids, which are restricted largely to arid montane talus slopes, from the Grand Canyon south to northern Chihuahua and Sonora, México. Bequaert and Miller (1973) recognized 4 species complexes throughout the Desert Southwest (southwestern Texas, New Mexico, and Arizona), including northern Chihuahua and northeastern Sonora, México. In Arizona *Sonorella* is notably speciose, with some 75 recognized species and subspecies. Species diversity decreases dramatically east into New Mexico, where Metcalf and Smartt (1997) reported only 7 species endemic to talus slopes of arid montane habitat islands along the southern border of the state.

Sonorella todseni occurs east of the Rio Grande Valley in the Doña Ana Mountains, Doña Ana County. The geographic range of this species appears restricted mostly to black rhyolitic talus sprawls on the north and east slopes of Doña Ana Peak between 5600-5835 ft. elevation (Metcalf et al. *In Preparation*). Miller (1976) named the species in honor of Dr. Thomas K. Todsen (Las Cruces), who first collected them. Fossil *Sonorella* specimens from mountains of southwestern New Mexico imply a wider ranging fauna during the Pleistocene (Metcalf and Smartt 1988, 1997).

Biology: The biology of *S. todseni* is unknown In general, all New Mexico land snails are herbivorous, consuming angiosperm plants, fungi, and lichens Snails may also consume dead, decaying plant material and soil, which appears to serve as a source of minerals (e.g., calcium and magnesium) utilized in shell formation (Gomot el al. 1989). Although New Mexico land snails are hermaphroditic (both female and male reproductive organs within a snail), several modes of reproduction are known including the transfer of sperm to another, reciprocal sperm exchange, and self-fertilization (Metcalf and Smartt 1997). Helminthoglyptids, like most New Mexico land snails, are oviparous (egg layers). Gilbertson (1969) reported that *S. odorata* deposited eggs only after the inception of seasonal rainfall, with clutches consisting of 7-8 eggs deposited underground. In the laboratory, clutches hatched within 15-20 days. The ability of land snails to distinguish cues from slime trails has been implicated in mate recognition, location of homesite, orientation, formation of hibernating "huddles" (aggregations), and avoidance of danger (McAndrew 1975, Cook 1979, Chelazzi et al. 1988, Pakarinen 1992, Baur and Baur 1993, Bailey 1989, Metcalf and Smartt 1997). Temperature and moisture account for the nocturnal habits of land snails and slugs, especially in the Arid Southwest (Bequaert and Miller 1973); however, land snails can be active in daylight on overcast, rainy days. Land snails survive adverse environmental conditions, such as drought or cold temperatures, by secreting an epiphragm (calcified mucous membrane) over the shell aperture to prevent desiccation (Machin 1975, Barnhardt 1989). Some snails remain dormant for months, even years, but will resume activity when moistened (Burch 1962). Dormant *S. odorata* spent most of their life cycle hibernating or aestivating, emerging only during summer rains to feed and reproduce (Gilbertson 1969). Hibernating *S. odorata* occurred singly or in groups of 20 snails. Weight loss in captive, aestivating snails was 39-59% over an 8-month period in the laboratory (Gilbertson 1969). Walton (1970) reported that hatchling *S. sabinoensis* matured at 2 years, reproduced about 6 months later, and lived for at least 3 years in captivity.

Metcalf and Smartt (1997) considered 3 parameters (vegetation, effective precipitation, and elevation) interrelated with Bailey's (1913) life zones of New Mexico and geologic history, as biotic and abiotic components exerting ecological and physiological constraints largely responsible for the distribution and abundance of the land snails statewide. Consequently, numerous species of land snails are state endemics, especially in the arid mountains of southern New Mexico where geographically isolated populations are restricted to a single mountain range or peak (Metcalf 1997), commonly termed "sky islands" (Warshall 1994). This pattern of endemism is most common in large-shelled land snails of the genera *Ashmunella* (includes some 30 endemic species and subspecies), *Oreohelix*, and *Sonorella* (Metcalf and Smartt 1997); but is less common amongst the "lesser" land snails (small-shelled taxa), which in part is attributed to their more widespread occurrences resulting from passive dispersal mechanisms (e.g., wind, arroyo flooding) (Bequaert and Miller 1973). In southern New Mexico, *Sonorella* typically occurs in low- to mid-elevation talus slopes (Metcalf and Smartt 1997).

Status: Recent inventories (1996-1999) documented disjunct populations of *S. todseni* occurring in black rhyolitic talus sprawls at higher elevations on the north and east slopes of Doña Ana Peak. Live snails and egg masses observed during these surveys and imply the presence of a viable population. Similar habitat on adjacent mountain peaks to the west and north of Doña Ana Peak were searched, but *S. todseni* (live or dead) was not observed (NMGF files).

The southern range of the Doña Ana Mountains is public land (BLM). This site is frequently accessed by vehicle to the base of Doña Ana Peak. *Sonorella todseni* is directly threatened by human activity in the area. Evidence of native plant removal in areas adjacent to black scree slopes at lower elevations on the north slope of Doña Ana Peak was documented in 1996 by dig holes and a tag from a local gardening center. This activity was not observed in subsequent site visits.

Removal of woody vegetation not only disturbs talus slopes, but also results in loss of food and cover for snails (Vagvolgyi 1974), increases slope erosion, and effectively reduces water retention capacity of the soil. Accumulative effects of these processes can have irrevocable impacts by exacerbating habitat desiccation and increasing substrate temperatures, which can dessicate developing egg masses deposited in talus just below the soil surface; thereby, adversely affecting the reproductive capacity of *S. todseni*. The extant population is highly vulnerable to any form of soil disturbance, including foot traffic by humans or cattle, or mining activity in the general vicinity of talus slopes.

Conservation: Due to the restricted distribution of *S. todseni*, and apparent narrow habitat affinity for negritic talus sprawls, which are inherently fragile, habitat protection is paramount for the conservation of this species. The extant population is highly vulnerable to any form of soil disturbance, including foot traffic, or mining activity in the general vicinity of talus slopes.

Fencing of habitats occupied by this species should diminish immediate threats of foot traffic in talus areas. Posting signs that prohibit removal of native vegetation would provide additional habitat protection. Control of site access can be achieved by locked gates at 2-track roads that lead to the base of Doña Ana Peak. If these measures prove ineffective, then a change in the federal conservation status of *S. todseni* might be in order.

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