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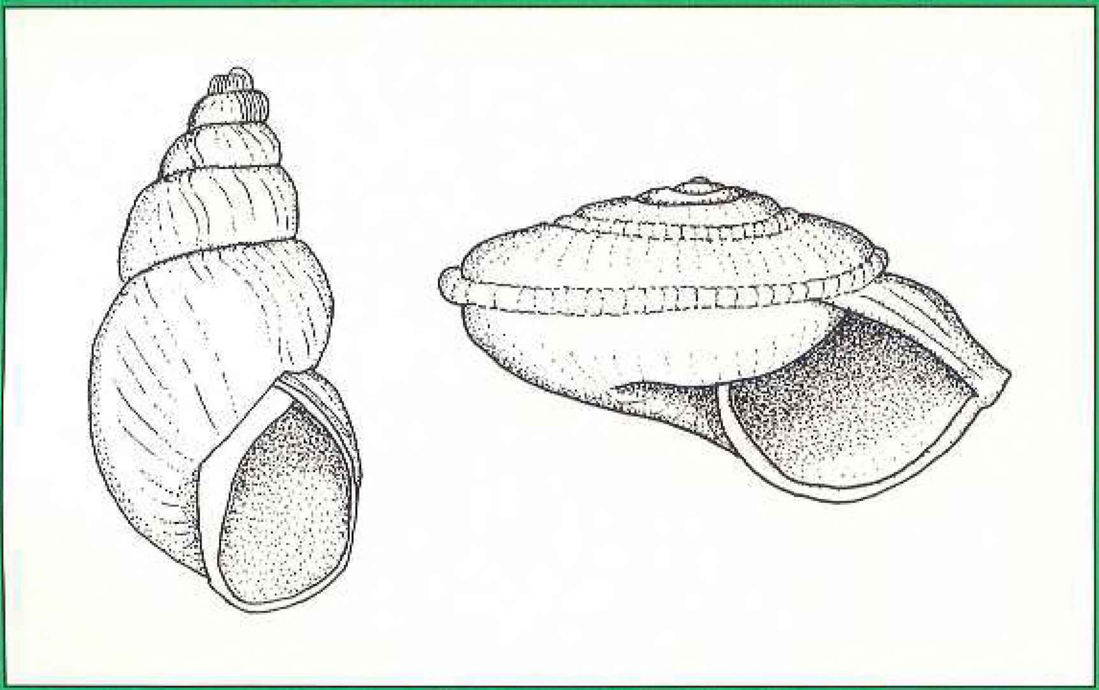
New Mexico Museum of Natural History and Science

A Division of the

OFFICE OF CULTURAL AFFAIRS

Land Snails of New Mexico



edited by

Artie L. Metcalf and Richard A. Smartt

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University of Texas at El Paso

and

New Mexico Museum of Natural History and Science

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LAND SNAILS OF NEW MEXICO

Artie L. Metcalf and Richard A. Smartt, Editors

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ALTITUDINAL DISTRIBUTION OF LAND SNAILS IN SOME MONTANE CANYONS IN NEW MEXICO

Timothy J. Dillon and Artie L. Metcalf

PREFACE

The development of this collection of reports on land snails has been somewhat circuitous because none of the authors actually began their careers as malacologists. Artie Metcalf began as an ichthyologist, turning to the study of land snails only after leaving eastern Kansas to take a teaching position at the University of Texas at El Paso. Fossil snails and Pleistocene sediments drew his attention in the early 1960s, and his interests broadened to include modern snail faunas to use as comparisons with paleofaunas. A graduate student, Tim Dillon, took an interest in ecological relationships among snails, elevation, and vegetation, which led to his contribution to this Bulletin. I was trained as a vertebrate paleontologist with a focus on Pleistocene microfaunas. Many years ago, I began working with Artie to compare assemblages of fossil rodents and their paleoecological implications with assemblages of fossil snails from the same sites. This was done to test the reliability of predictions concerning past environments from two independent sources (rodents and snails). As this process evolved, it became more and more necessary to collect faunas of live snails from around New Mexico in order to more accurately reconstruct paleoenvironments and vegetation. As a result, a large collection was assembled over the years, including a complete database at this museum.

Several years ago, after receiving an increasing number of requests from resource managers and other academicians for use of the snail data, we considered developing a Bulletin to summarize our work on New Mexico's land snails. The majority of the collecting had resulted from Artie Metcalf's efforts. I was able to obtain private funding and support from the New Mexico Department of Game and Fish to make collections from those localities around the state that had not been covered in our earlier efforts. Also instrumental in pushing this project to a published Bulletin were the encouragement and financial resources of Jacquenette C. Ostheimer, who made several generous donations on behalf of herself and her late husband, Alfred J. Ostheimer. Ms. Ostheimer also donated a large malacological collection to the Museum, and established an endowment to support and expand the collection. We are indebted to Ms. Ostheimer for her support of malacological studies at this museum. I think, however, that we might never have completed the manuscript without the tremendous efforts of Pauline Ungnade, an experienced editor and volunteer at the Museum. Her enthusiasm and hard work kept us on track until the day we turned the manuscript over to the NMMNHS Bulletin editorial staff, which worked diligently to get the manuscript into camera-ready format.

Although this Bulletin is intended primarily for a more academic audience, we hope that it will meet the needs of a far wider audience. In particular, we trust that it will prove useful to resource managers and those members of the general public with an interest in identifying and learning more about land snails.

Richard A. Smartt
Albuquerque
July, 1997

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LAND SNAILS OF NEW MEXICO: A SYSTEMATIC REVIEW

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ABSTRACT: Summarized in an introductory section are several topics of a general nature, including information about early collections, classification of land snails, and structure of their shells. A key, based on shell features for families and for most genera and species, is provided to assist in identification. Included is a discussion of some aspects of ecosystems and ecological niches, which seem pertinent to the species surveyed. There are species accounts of the 114 native land snails (all pulmonates) known from New Mexico. It is likely that at least three of these species have gone extinct during the last century, some probably because of habitat loss or degradation. There are additional accounts for some subspecies. In the accounts, general, New Mexico, and altitudinal distributions are discussed, as well as habitat. In some accounts taxonomic and paleontological aspects are discussed. Following the species accounts there is a summary of species or subspecies that seem to be of restricted occurrence in New Mexico. Finally, accounts are given for eight species of land snails or slugs considered not native to New Mexico, but which have become established, mainly in urban areas.

INTRODUCTION

Three interrelated papers concerning land snails of New Mexico are in this Bulletin. The first and present paper (Metcalf and Smartt) surveys species of land snails occurring in the state. In this paper, patterns of present geographic, altitudinal, and habitat distribution are stressed. The second paper (Metcalf) discusses historical zoogeographic aspects of the fauna of New Mexico land snails. The third paper (Dillon and Metcalf) describes altitudinal surveys of some mountains in different sections of the state.

CLASSIFYING SNAILS

A vast number of different organisms may be compared to a vast number of different library books. To be useful, productively, both require some form of classification system.

In the classification system used by zoologists, it is required that land snails, like all animals, be assigned to a hierarchy of obligate categories: Kingdom, Phylum, Class, Order, Family, Genus, and Species. Snails are in the Kingdom Animalia. They belong to the Phylum Mollusca, which, in number of species, is surpassed only by the Phylum Arthropoda, containing the insects and crustaceans. The Phylum Mollusca is apportioned among seven or eight classes, and the majority of molluscs in these classes inhabit marine waters, likely the original molluscan home. However, some groups in the Class Bivalvia, to which clams, oysters, mussels, and others belong, have invaded the freshwater environment successfully. Some groups in the Class Gastropoda, to which snails and slugs belong, have established themselves not only in freshwater, but also in terrestrial environments. Gastropoda is the largest class of molluscs, numbering more than 50,000 kinds. In addition to the basic (obligate) units of classification, zoologists often feel the need to squeeze additional classification levels (called non-obligate) in between obligate levels--for example, inserting subclass and superorder between class and order. The Class Gastropoda is divided into several subclasses. A small group of land snails, together with a great number of aquatic species, are placed in the Subclass Prosobranchia. None of these prosobranch land snails occurs in New Mexico at this time, although some occur in Texas and México. There is, however, a family of prosobranch aquatic snails (Hydrobiidae) represented in some spring habitats in New Mexico. All New Mexico land snails belong to the Subclass Pulmonata, a name that refers to the lung-like, air-breathing apparatus employed by these snails. All pulmonate land snails in New Mexico, save one minute, rare species (see species account of *Carychium exiguum*), belong to the Stylommatophora, considered as either an order or a superorder by various malacologists. Snails in the Stylommatophora have two pairs of tentacles arising from the head, with eyes borne at the outer tips of the upper pair.

The Order (or Superorder) Stylommatophora is divided into numerous families of land snails, of which 19 are native to New Mexico. A key to these families is provided, hereafter. (The names of all families in the Animal Kingdom terminate in -idae).

Families are, in turn, divided into genera, and genera are comprised of species. Examples are the genus *Homo* and species *sapiens* for a human being, or genus *Pupilla* and species *muscorum* for a New Mexico land snail. This combination of a generic and a specific name makes up, then, a *scientific name* for the species. This name is in Latin, as in the examples, or latinized as in the species name *blandi*, applied to another member of the genus *Pupilla*. In this name, the Latin genitive ending *-i* is added to the surname Bland, thus coining a name called a patronym, which honors the zoologist Thomas Bland. Generic names are often Latin versions of classical Greek words. A patronym should not be confused with the name of the person (author) who named (described) a species. Often the author's name may be seen immediately after the species' name, as in

Homo sapiens Linnaeus. If the author's name is *not* in parentheses, it indicates that the species is still in the genus in which it was described originally. If the author's name is *in* parentheses, it indicates that the species is now in a different genus. The year in which the species was described may appear after the author's name, as in the species accounts hereafter.

In recent years, some malacologists have felt a need to have common, English-language names for the molluscs of the United States and Canada. The results of these efforts have been assembled in a publication (Turgeon, 1988, with a second ed. in prep.), in which common names have been sought out or invented. To refer to inventing a common name is something of a contradiction, because most common names evolve slowly in a language. Despite the availability of a list of common names, it appears that zoologists still mainly use the scientific name of land molluscs when discussing and writing about them, as herein. In the species accounts below common names are indicated where available in the list of Turgeon (1988).

EARLY COLLECTORS OF NEW MEXICO LAND SNAILS

Yarrow (1875) reported two species of land snails collected in New Mexico in 1874, in connection with the Wheeler Survey West of the 100th Meridian: *Vallonia perspectiva* (as *Patula*), taken at San Ildefonso, and a succineid, listed as *Succinea stretchiana* Bland, from Tierra Amarilla. This appears to be the first published reference to New Mexico land snails.

It has been supposed that a Dr. G. M. Levette collected snails in the vicinity of Santa Fe prior to 1880 (Ewan, 1950:250), but this may not be the case. Shells acquired from Levette by Thomas Bland were described by Bland as *Helix levettei*. Bland thought they were from the Santa Fe area. Later, it was ascertained that *H. levettei* was from the Huachuca Mountains of Arizona, instead. In the meantime, C. F. Ancey (1887) had described a variety of *Helix levettei* from Santa Fe Canyon, which he named *thomsoniana*. With the transfer of the type locality of *H. levettei* from Santa Fe to the Huachucas, the name *thomsoniana* was retained and elevated to species rank to apply to the "real" Santa Fe area snail, which in 1899 had been placed in the genus *Ashmunella*. By these rather convoluted circumstances, *Ashmunella thomsoniana* seems to have acquired the honor of being the earliest New Mexico land snail to be described--in 1887.

Next, in 1892 and 1893, Edgar Alexander Mearns, a physician and naturalist with the Mexican Boundary Survey, made biological collections along the southern border of New Mexico. He mentioned (1907:83,85) collecting "land shells" at only two localities in New Mexico: the Carrizalillo Mountains in April 1892 and Big Hatchet Peak in May 1892. From the Carrizalillo Mountains, apparently only *Sonorella hachitana* was collected (Pilsbry:1939:274). Pilsbry (1915:324) discussed the ascent of Big Hatchet Peak by Mearns. On this trip, Mearns collected at two localities, finding 7 species, as interpreted by Pilsbry, including the types of several species subsequently described by William H. Dall. These species were described in the mid-1890s and are the earliest land-snail species described with type locality in New Mexico except for *A. thomsoniana*, mentioned above.

In 1893, Theodore Dru Alison Cockerell, a British naturalist with a wide range of interests, arrived in Las Cruces where he was associated with the young agricultural college for the next seven years. Subsequently, he spent three years at New Mexico Normal University, Las Vegas, to round out "his New Mexican decade," as termed by Ewan (1950:109). During this ten-year period, Cockerell collected snails from various parts of New Mexico. His earliest New Mexico paper, published in 1894, reported the slug *Deroceras laeve* (as *Agriolimax campestris*) from Santa Fe, noting "So far as I know, this is the first slug recorded from New Mexico." Between 1898 and 1905 he described several new taxa of land snails from New Mexico, either as sole or joint author. Some of his descriptions were coauthored with Henry A. Pilsbry and in one paper (see Cockerell, 1899) he collaborated with Edward H. Ashmun to name a new subspecies (*capitanensis*) of the species *Polygyra* (later *Ashmunella*) *pseudodonta* from the Capitan Mountains. Cockerell apparently had several encounters with the Rev. E. H. Ashmun. He discussed two of these in a paper of reminiscences on "snails and slugs" (Cockerell, 1936:210):

> One night I happened to be in Albuquerque, and was looking for a place where a meeting was to be held. I accosted a stranger, asking the way. We were going to the same place, and walked together. Thus I met the Rev. E. H. Ashmun, the only other student of snails at that time resident in New Mexico. The next time I saw him was on a train, and he at once said "I have found some new *Polygyra*"--this being a genus of snails common in the Eastern states. But we later found, on dissecting them, that they were not *Polygyra* at all, but a very distinct genus simulating it. Pilsbry and I wrote a paper, describing the genus under the name *Ashmunella*. It proves to be quite rich in species in New Mexico and Arizona, but has not been found elsewhere.

According to Johnson (1905:121), Ashmun was a native of Ohio; he had attended Yale Divinity School. and was a minister of the Congregational Church. Ashmun's ministry was in the West, where he resided in several states. He was "Home Missionary Superintendent of Arizona and New Mexico" for 6 years in the 1890s. Ashmun himself discusses his malacological interests in a paper, "Collecting in Arizona and New Mexico," published in *The Nautilus* in 1899. Although limited in scope, this is the first paper to attempt a general view of the southwestern land-snail fauna. He observed that most land snails were to be found in forests of the higher mountains in New Mexico and discussed some of his collecting trips into these mountains. He was an early advocate of collecting plant litter and soil to inspect, at one's leisure, for small snails: "I usually have a flour sack in my pocket for the purpose." (p. 14). He listed 15 taxa that had been named from materials he collected in Arizona and New Mexico. These included *Bifidaria ashmuni* and five taxa of *Ashmunella*, this genus of southwestern polygyrid having been named in Ashmun's honor by Pilsbry and Cockerell in 1899. Most of the new taxa discovered by Ashmun were named formally by Victor Sterki, William H. Dall, and Pilsbry.

The snails collected by Cockerell and Ashmun were coming to the attention of Henry A. Pilsbry of the Academy of Natural Sciences of Philadelphia, and this may have stimulated his wish to visit the Southwest. However, Pilsbry himself (1926), in a eulogy and short biography for James H. Ferriss, credits Ferriss with inspiring him to undertake investigations in the Southwest. Ferriss had traveled in Arizona and New Mexico in 1904, and collected some new species. In 1906, Ferriss and Pilsbry made their first joint expedition to the Southwest, crossing through, and collecting in, northern New Mexico on the way to Arizona. In 1910, Pilsbry and party collected at several New Mexico localities, concentrating on the Big Hatchet Mountains, where Mearns had collected 18 years earlier. The most extensive and intensive Pilsbry-Ferriss expedition was to the Black Range in 1915. The party secured a pack train of horses, skillfully managed by Teodoro Solis, whom Ferriss (1917:99) described as "the best packer and camper alive." Pilsbry was with the group for about a month as they proceeded leisurely up the crest of the Black Range, with numerous side excursions. Pilsbry left the party in mid-September, and Ferriss continued to explore the northern Black Range and the area over to the southern San Mateo Mountains (Pilsbry and Ferriss, 1917) for about a month.

In 1922, Pilsbry and Ferriss traveled from Santa Fe to the Big Bend area in Texas, collecting en route in the Organ, San Andres, and Guadalupe Mountains and in some western canyons of the Sacramento and Sierra Blanca ranges. Several localities in southern New Mexico were visited in 1934 and 1935, in connection with collecting trips that Pilsbry made into México. Field notes from some of the above expeditions were published by Metcalf (1970).

J. H. Ferriss, a newspaper editor, published several accounts about land snails of New Mexico, including interesting and jocular accounts of the expedition to the Black Range (Ferriss, 1917) and of an extended excursion into the Mogollon Mountains of western New Mexico and adjacent Arizona in 1914 (Ferriss, 1915). The Mogollons excursion was made by a party of four in a farm wagon over a period of three months with some 335 miles being covered in an unhurried fashion.

The above summary would seem to include the major collectors of New Mexico land snails in the period 1874-1935, although numerous smaller collections were made and reported in publications by various authors. Deserving mention are the papers of W. H. Dall (paleontologist, U.S. Geological Survey from 1884 to 1927) and of Junius Henderson of Colorado. Henderson wrote extensively on molluscs of the western states, including a few reports concerning New Mexican species. In a short paper, "The Mollusca of New Mexico and Arizona," Henderson (1939) summarized some general aspects of the land-snail faunas of the two states, and listed the genera of molluscs that had been reported from the states.

Alexander G. Ruthven collected snails at several localitites while studying the herpetofauna in a transect from Cloudcroft to Alamogordo, Otero Co., in 1906 (Ruthven, 1907). His collections are at the University of Michigan Museum of Zoology (UMMZ). Collecting in the same area as Ruthven were: 1) the entomologists James A. G. Rehn and Henry L. Viereck (in 1902; collections at the Academy of Natural Sciences of Philadelphia [ANSP]); 2) Bohumil Shimek (in 1903 and 1906); and 3) C. R. Orcutt (in 1926). The collections of Shimek (for whom *Discus shimekii* was named) and of Orcutt are at the National Museum of Natural History (USNM). Collections were made by the paleontologist Ermine C. Case in the years immediately prior to 1915 at eight localities in north-central New Mexico. These were shells picked out of stream-drift, as was often the case in early southwestern collections. A list of localities and of species, by locality, from the Case collection (now at UMMZ) was published by Bryant Walker (1915). In reference to Case's collections in the arid lands of the west, Walker suggested, not to presciently, that "...many of the localities have never been visited by conchologists and are not likely to be on account of the local conditions."

We have studied earlier collections, mainly in USNM, UMMZ, the Museum of Comparative Zoology, Harvard University (MCZ), and, most importantly, ANSP, which houses the extensive collections of the Pilsbry and Ferriss expeditions to the Southwest. These earlier collections and associated literature provide a basis for understanding the land-snail fauna of the state.

The present survey is based on collections made between 1966 and 1996 and housed in the Laboratory of Environmental Biology at the University of Texas at El Paso and the New Mexico Museum of Natural History and Science, Albuquerque. It is anticipated that, in the future, both these collections will be housed at the latter institution.

ECOSYSTEMS AND NICHES

Collections were made during the period when contours on U.S. topographic maps were indicated in *feet* and this system has been used rather than the *metric system* in the following discussion, and in the species accounts, hereafter.

To describe separately the various aspects of the New Mexico environment that impinge on land snails, even in summary fashion, would be unduly complicated. By using the concept of *ecosystems*, many aspects may be brought together. Raymond L. Lindeman (1942:399) provided an early and basic definition of an *ecosystem* by characterizing it as a "system composed of physical-chemical-biological processes active within a space-time unit of any magnitude, i.e., the biotic community *plus* its abiotic environment." The phrase "of any magnitude" indicates that an ecosystem could be as small as an ephemeral desert pool or laboratory terrarium, or as large as the central North American prairies, or even larger. This allows ecologists great latitude in the ways they use this concept. The definition also stresses that an ecosystem comprises both the biotic (living organisms) and abiotic (physical) features of the environment. These are further interrelated, through the decay of dead organisms, which returns them to the dust of the abiotic, including the calcareous dust of disintegrating snail shells.

A snail, a population, or a species may occupy an ecological niche (often simply termed niche) within its ecosystem. In fact, its niche is rather like a personalized ecosystem, including its own role and that of the abiotic and biotic features with which it interacts. Much of the more detailed work exploring aspects of the niches of land snails has been done in Europe. *Helix aspersa*--a common, introduced snail in New Mexico--has received much attention largely because it is used for human food and is grown commercially in land-snail farms, especially in France (Cabaret, et al., 1988).

The relationship of snails and the organisms that supply their food is, of course, an integral aspect of their ecological niche. New Mexico land snails are herbivorous, although carnivorous species exist in other parts of the United States and in México. Land snails have been recorded as eating many kinds of angiosperm plants, fungi, and lichens. In experiments, they have eaten apple, cabbage, carrot, clover, dandelion, lettuce, potato, and pellets made of wheat flour, cornmeal, or peas. They exhibit preferences for some foods over others. Commercial foods have been produced for use in *Helix aspersa* farms. Snails eat plant materials that are living, decaying, or dead. To aid in digesting this diet, snails produce cellulase, an enzyme that digests cellulose, and chitinase, which digests the complex carbohydrate chitin, found in higher fungi and in lichens. The earliest land snails may have been the first land animals to produce these enzymes, asssuming that they were eating plants of their time, the late Paleozoic. Most present-day herbivores (e.g., termites and cows), which have large proportions of cellulose in their diet, depend on cellulase from their gut microorganisms to digest cellulose. Large numbers of bacteria may be found in the digestive tracts of land snails, but these seem to enter and pass out along with ingested food or soil. However, such bacteria may produce additional cellulase and chitinase during their time in the snail gut (Charrier, 1990). The relative importance of snail-produced versus bacteria-produced enzymes is far from clear. Neither is it entirely clear just where snail-produced digestive enzymes are synthesized, although it has been assumed that they arise within cells of the digestive glands of the animals. Some snails are known to interact with the abiotic part of their niche by eating soil, which seems to serve as a source of calcium and magnesium used in shell construction (Gomot et al., 1989). The importance of these elements in the diet has been shown experimentally.

Food habits of New Mexican land snails have not been studied, but several European species have been recorded as eating nettle (*Urtica*) leaves. Collectors, to their discomfort, have learned that nettle patches are good places to search for some kinds of New Mexico snails.

Land snails interact with various kinds of animals, especially, of course, with members of their own species (conspecifics). The land snails of New Mexico have both female and male reproductive organs (hermaphroditic) within a single animal. Most commonly, two individuals come together and one transfers a sperm packet to the other. However, reciprocal exchange of sperm packets has been reported (Duncan, 1975:355). Also reported for a few kinds of snails has been self-fertilization, as in certain succineid snails and in *Rumina decollata*, an introduced species in New Mexico (Selander et al., 1974). Eventually, continued self-fertilization may produce a clone-like population. In New Mexico mountains where considerable numbers of land snails of the genus *Ashmunella* occur, pairs may be observed in copula during the rainy summer months.

Studies have shown that land snails can detect and follow the slime trails of members of their species; this may be useful in detecting potential mates. McAndrew (1975) conducted T-maze experiments for specimens of *Ashmunella rhyssa* from New Mexico and *Sonorella metcalfi* from the Franklin Mountains in Texas. It appeared that individuals of both species were capable of discerning and following slime trails laid down by members of their species. Some studies have indicated that snails and slugs can discern airborne odors, as well as cues from slime trails--an ability possibly useful in locating homesites (Chelazzi, et al., 1988).

The cues discussed above may be used to form aggregations. This phenomenon, called huddling (Waite, 1988), has been observed in some kinds of snails and slugs. Hibernating aggregations of *Ashmunella rhyssa* have been noted during winter in the Sacramento Mountains. Clusters of the introduced slug *Limacus flavus* were observed along the Gila River Valley; aggregating behavior in this species has been reported in Europe as well (Chelazzi, et al., 1988).

In contrast to the attraction that some snails seem to have for mucus laid down by their own species, Pakarinen (1992) showed that, in Finland, several kinds of slugs and snails avoided aqueous solutions of crushed snails of their own species. It might be adaptive to avoid areas in which conspecifics had been killed.

Some land snails may use slime trails or airborne cues in homing or other orientation. Cook (1979) and Bailey (1989) have documented them as having homesites in rock crevices or more general areas, from which they venture a few feet for food and then return. Other snails seem to wander at random within an area, which may or may not be construed as a home range (Baur and Baur, 1993).

Various kinds of birds and mammals are known to prey on land snails. In Europe, songbirds, such as thrushes, have been reported as predators. Individual birds may use a favorite stone as an anvil in snail-bashing, crushing the shell to extract the soft parts. Pilsbry (1940:933) reported that crops of wild turkeys taken in the northern Sierra Blanca Mountains, Lincoln Co., contained *Ashmunella rhyssa.* Also in this area, well-crushed *Ashmunella* shells have been seen in the scat of an unidentified kind of mammal. Some shells, which we have observed, appeared to have been chewed, probably by rodents. Heller and Godot (1984) reported that, in Israel, gerbils preyed on land snails. Beetles also may prey on snails. Shells of urocoptid snails found in southern New Mexico sometimes contained small round holes drilled by a carabid beetle.

Land-snail parasites have received little attention, probably because few seem to be involved in parasite life cycles that include humans or domestic animals, as is the case in some freshwater pulmonate snails. Redetzke and Canaris (1977) analyzed the life cycle of the parasitic trematode flatworm, *Brachylaime microti* in Montana, which used *Oreohelix strigosa* as an intermediate host and two rodents as definitive hosts. Canaris (1960:524) listed five species of land snails in Washington and Oregon that were found to harbor "cysticercoids of the tapeworm *Liga soricis* Neilamd 1953." In a European study, Cabaret, et al. (1988) reported infection of a *Helix aspersa* population by three kinds of nematode parasites. If so many species of parasites infect land snails in general, there may be many kinds of these parasites yet to be discovered and identified.

As we can see, aspects of the ecological niche of a snail are many and complex, and their analysis laborious and time-consuming. Much as Bequaert and Miller observed over 20 years ago (1973), there is, to date, little detailed ecological information available about southwestern snails. At a less detailed level, three aspects of ecosystems of special significance to New Mexico land snails are those pertaining to vegetation, effective precipitation, and elevation, all closely interrelated. These ecosystem parameters vary greatly within the confines of New Mexico, and merit further discussion. As vegetation is of great importance to snails, it is stressed below, giving special attention to Dick-Peddie's (1993) analysis of New Mexico vegetation. Effective precipitation is also of much importance to land snails and, in typical ecosystem fashion, involves numerous factors such as temperature, wind, evaporation, gradient, ground cover, and nature of the soil. Some notes regarding precipitation have been drawn from articles by Bennett (1986) in the publication *New Mexico in Maps*. Bennett has noted that New Mexico is one of the most arid states; 90% of the land surface has an annual precipitation of <20 in., with 20-30% <10 in.

Many abiotic and biotic factors vary with elevation. New Mexico has an altitudinal span of ca. 10,000 ft, from the Pecos Valley, at the southern state boundary, to the high summits of the Sangre de Cristo Mountains. Examples of how ecosystems change with elevation are noted, even by the casual observer, as when driving up the steep western face of the Sacramento Mountains from Alamogordo to Cloudcroft or up the eastern face of the Sangre de Cristo Mountains from Cimarron to Eagle Nest. Rather presciently, C. Hart Merriam, Vernon Bailey, and others of their school of natural history of the early 20th century anticipated the concept of ecosystems to some extent in their definition and description of "life zones" for parts of the western United States, including Bailey's study (1913) of New Mexico. For the various life zones, these authors described characteristic plants and animals, and related their occurrences to such abiotic factors as elevation, slope exposure, and precipitation. Elevation, in fact, played a central role in their models, in which they distinguished zones, each of which occupied a particular altitudinal span. From lowest to highest in New Mexico (Bailey, 1913), these were: Lower Sonoran, Upper Sonoran, Transition, Canadian, Hudsonian, and Arctic-Alpine Life Zones. The life zones described by Bailey (1913) for New Mexico also can be interpreted as ecosystems, and we treat them as such below. The names of the life zones have the advantage of long usage, and of being a "neutral" terminology that does not employ the names of either plants or animals, as do some other classifications. This classification also has been employed in a study of montane land-snail distribution by Dillon and Metcalf (this volume). Bailey (1913) indicated elevations (in ft) of life zones for cooler (northeastern) and warmer (southwestern) slopes, which are given below, except for the Lower Sonoran Zone.

Lower Sonoran Life Zone--below 4,000 -4,500 ft in Bailey's scheme, but extended here to include the somewhat higher desert (or plains) of northwestern New Mexico. This zone comprises most areas of low gradient in the state, and is also the driest zone. Average annual precipitation in an arc from the northwestern part of the state southeast to Sandoval Co. and down the Rio Grande Valley ranges from 8 to 10 in.

Precipitation is greater in grasslands of the eastern quarter of the state. Dick-Peddie (1993:37-38) described occurrence of both grassland and scrub components at lower elevations. Except for the occurrence of some relatively unaltered riparian or marshy habitats, mentioned below, few species of land snails are found in any of these arid-to-semiarid habitats. In the grassland or scrub of the Chihuahuan Desert, the main species found are *Gastrocopta pellucida*, *Pupoides albilabris*, *Succinea grosvenori*, and *Thysanophora hornii*. These same species, *sans T. hornii*, also occur in the eastern plains along with *Gastrocopta cristata*, *G. procera*, and *Helicodiscus singleyanus*.

Upper Sonoran Life Zone--4,000-7,000 ft on cooler slopes and 4,500-8,000 ft on warmer slopes. Average annual precipitation in this zone is generally some 12-16 in. This zone commonly is referred to as the Pinyon-Juniper Zone. Dick-Peddie (1993:87-90) proposed fairly equivalent zones that he termed Pinyon-Juniper Woodland and Mixed Woodland. Like the preceding zone, the Upper Sonoran is not very productive of land snails, although a few hardy species succeed very well in hillier habitats. For example, in the San Andres Mountains, mainly within this zone, many minute pupillid snails of the species *Gastrocopta pellucida* and *G. ashmuni* were found, along with larger species such as *Rabdotus dealbatus neomexicanus*, *Glyphyalinia indentata*, *Hawaiia minuscula*, and *Thysanophora hornii*. In this zone, on the sides of arid-appearing mesas in eastern Colfax Co., great numbers of *Gastrocopta pilsbryana* and *Vallonia gracilicosta* occurred along with four or five less common species.

Transition Life Zone--7,000-8,500 ft on cooler slopes and 8,000-9,500 ft on warmer slopes. Average annual precipitation may reach or slightly exceed 20 in. This has been referred to as a Pine-Oak Belt (Elmore and Janish, 1976:109), and to most casual observers it is probably defined mainly by the presence of extensive stands of Ponderosa Pine. Dick-Peddie (1993:66) identified a Lower Montane Coniferous Zone "generally below about 8,500 ft.," which seems to correspond, in large part, to the Transition Zone. He listed five "series" within this forest type, four of which incorporate Ponderosa Pine plus a kind of oak in their identifying name (the fifth incorporates Chihuahua Pine). Although pines and oaks are dominant throughout most of this zone, as on hillsides and interfluves, there are narrow corridors of riparian habitat in which deciduous trees and shrubs dominate. These deciduous elements, in turn, supply leaf litter and decaying logs that are attractive to land snails. Narrow riparian habitats support a snail fauna much like that of the Canadian Zones, whereas habitats in this zone, other than riparian, tend to share species with the Upper Sonoran Zone.

Canadian Life Zone--8,500-11,000 ft on cooler slopes and 9,500-12,000 ft on warmer slopes. Annual precipitation in this zone may range from 20-30 in. In the Dick-Peddie system (1993:51,58), most of this zone would fall in his Upper Montane Coniferous Forest (8,000-10,000 ft), but Bailey's warmer-slope aspect would be equivalent to his Subalpine Coniferous Forest (9,500-12,000 ft). This often has been referred to as a "spruce-fir" zone. Blue and Engelmann Spruce, White and Douglas Fir, and Limber Pine are important conifers, and Gambel Oak and Aspen are important deciduous species.

The study of Dillon and Metcalf (this volume) showed the Canadian Zone to be the most productive of kinds and of numbers of land snails of any ecosystem in the mountains surveyed in the study. In the Canadian Zone, both riparian and nonriparian habitats are favorable for land snails. In the Sacramento Mountains, for example, the snail *Ashmunella rhyssa* may be found widely, as along creeks, on slopes, or in mountaintop forests with low relief.

Of special importance to land snails are stands of Aspen, which have their greatest development in the Canadian Zone. The leaf litter and decaying logs and branches found in Aspen groves are extensively colonized by snails. The term "colonized" is perhaps advisable inasmuch as Aspens come and go. Dick-Peddie discussed (1993:70 ff.) what he termed "Aspen disturbance forest." In the simplest model, Aspens establish themselves after fire has destroyed coniferous forest, a number of trees arising as clones from a common Aspen rootstock that had existed within the former conifer-dominated forest, and which had survived the fire. Resulting stands of Aspens may persist for many decades or for over a century, but gradually fall victim to pathogens, insects, and browsing of young growth, and eventually give way once more to reestablishment of conifer forest. Presumably, populations of land snails fluctuate in accordance with the cycles of Aspen versus coniferous forest. Although forest fires kill many snails directly, such fires may be of long-term benefit insofar as Aspens establish themselves subsequently. However, factors that contribute to decline in stands of Aspens produce a concomitant decline in prime snail habitat.

Hudsonian Life Zone--11,000-12,000 ft on cooler slopes and 12,000-13,000 ft on warmer slopes. In this and the next higher zone, precipitation may exceed slightly 30 in. per annum. This is a narrow zone in the Bailey Life Zone scheme, being the timberline ecosystem. In the study of Dillon and Metcalf (this volume), a definite diminution in diversity and numbers of snails was noted in progressing from the Canadian to the Hudsonian Life Zone. In other words, the sharp decline in larger trees, which occurs at timberline, seems to be reflected clearly in a decline in land-snail density and diversity.

Arctic-Alpine Life Zone--12,000 ft and above on cooler slopes and above 13,000 ft on warmer slopes. This zone corresponds to the Alpine Tundra category of Dick-Peddie (1993:47). The trend towards decreasing numbers and kinds of land snails continues here, with only a few species to be found, such as *Pupilla blandi*, *Columella columella*, *Vertigo modesta*, *Discus shimekii* (in the north), *Vitrina pellucida*, *Euconulus fulvus*, and *Microphysula ingersolli*.

In summary, density and species diversity of snails are distributed along a bell-shaped curve in New Mexico, with lower ends of the curve in the Lower Sonoran and Arctic-Alpine Zones, and the apex in the Canadian Life Zone.

Riparian and Marsh Habitats--Cutting across all but the highest montane zones, noted above, are corridors of riparian (stream-bordering) vegetation. These have the effect of lowering life zones. This is marked especially in the montane life zones where, as noted, Canadian Zone vegetation and associated fauna occur down into the Transition Zone and the latter into the Upper Sonoran Zone, allowing species to thrive at elevations lower than they would otherwise. Thus, a life-zone depression is produced, comparable in this small-scale context, to life-zone depressions of much larger scale that apparently took place during times of Pleistocene glaciations.

At lower elevations, Dick-Peddie (1993:151 ff.) recognized several kinds of riparian situations: floodplains of major rivers, "Plains Riparian" along intermittent streams in eastern New Mexico, arroyo-related riparian, and vegetation associated with the ponded waters of closed basins and their feeder streams. Fossils indicate that many of these lowland riparian communities supported a sometimes rich land-snail fauna in the past, but most such communities are gone today. The floodplains of major rivers are inhabited by humans and cultivated. In many places the main riparian woody plant is Salt Cedar (*Tamarix* spp.), and dense *Tamarix* bosques generally are not inhabited by land snails. Before arroyo entrenchment occurred (related to grazing by domestic animals), it seems likely that there was better retention of pools of water in the low-banked arroyos, and that there was a higher local water table alongside the arroyo. This would have enabled moisture-requiring plants to grow, which, in turn, would have encouraged populations of some small species of land snails, like those that now occur as fossils in arroyo-bank sediments.

Similar to the fate of a previous "arroyo ecosystem" is one associated with marshes at lower elevations, often called *cienegas* in New Mexico. Fossils indicate former presence of marshes associated with springs at lower elevations. Many seem to have existed during the Pleistocene and disappeared with progressive Holocene warming. Others seem to have disappeared concomitantly with human settlement and subsequent farming, diversion of waters, and the effect of livestock. If large numbers of livestock concentrate at a small springbrook and marsh for water, predictably they will overgraze associated vegetation and trample the area into something of a mud hole. The fortuitously well-preserved area around and below Blue Spring, Eddy Co., allows some perception of the former appearance of other spring-related areas that have not been so fortunate. Here, the brook-side snail *Vertigo ovata* seems to retain one of its few remaining populations in New Mexico. There are numerous indications that marshes formerly existed more widely in the state. For example, fossils show that marshes along the Tularosa River, which presently extend downstream to near Mescalero, formerly extended over 10 miles and 1,000 ft beyond and below Mescalero to the level of the Tularosa Basin. Historical accounts attest to presence of marshes along the eastern side of the Tularosa Basin, reflected, it seems, in the names Carrizozo (reedy) and Tularosa (from *tule*, applied to various marsh-inhabiting plants). The disappearance of spring-related wetland ecosystems is, of course, part of a problem of national dimensions. For marshes at higher elevations, especially those on national lands, the prognosis may be better, but these also are vulnerable, being of such limited extent. We believe that a detailed survey of the molluscan fauna of the state's remaining marshes would be of value.

ENDEMISM IN MONTANE LAND SNAILS

There are numerous species of land snails in New Mexico that are endemic to, i.e., restricted to, certain mountain ranges, often to a single range or peak. Most of these are species that grow to relatively large sizes. For example, almost all of the 30-odd species and subspecies of the genus *Ashmunella,* discussed below, are endemic to a specific range. They mainly inhabit accumulations of talus, usually in the higher parts of the mountains where they occur. Thus, their numbers are in direct proportion to the extent of the areas of talus available to them. This pattern of endemism in *Ashmunella* and other genera, such as *Oreohelix* and *Sonorella,* is responsible for the relatively large number of species of land snails inhabiting the state.

It is likely that these endemic "snails on mountaintops" are analogous to species that are endemic to oceanic islands. From studies of island biogeography, it is known to be part of an expected cycle for such insular species to go to extinction. This may apply to our endemic land snails as well. For example, fossil evidences show that in the Sacramento Mountains, several kinds of Ashmunellas and Oreohelixes have become extinct during the Quaternary. Opposed to a tendency towards extinction, however, 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.

THE PULMONATE LAND SNAIL

General

The molluscs are a venerable group, already having shells that became part of the fossil record by the Cambrian Period, in the early Paleozoic Era over 500 million years ago. According to Solem (1979), one order of prosobranch and two orders of pulmonate land snails appear in the fossil record in the late Paleozoic (Pennsylvanian and Permian). Thus, they were among the early colonizers of the terrestrial environment, and more or less contemporaries of early terrestrial vertebrates. Despite their long history, land snails have remained rather conservative in regard to some characteristics that likely trace back to their early Paleozoic ancestors. Such features include a ventral, muscular, mucus-producing foot upon which the animal crawls. The foot is surmounted by organs of the viscera (visceral mass or hump) and these, in turn, by a fleshy mantle. The mantle might be likened to the roof of a thatched hut that hangs down to form projecting eaves. The space between the eaves and upper walls of the hut would be comparable to a space under the peripheral margins of the mantle, which is termed a *mantle cavity.* In the early, aquatic, pregastropod molluscs, it is supposed that the mantle cavity was best developed in the posterior region where gills were located, and into which the anus and excretory ducts discharged wastes that then passed through the mantle cavity and into the water. The mantle secreted a shell of calcium carbonate and of an organic material, conchiolin.

Digestive-tract features, probably inherited by the pulmonate snails from their remote ancestors, include a feeding device called a *radula.* This structure is rather like an elongate tongue supported by a cartilaginous base and bearing, in most pulmonates, numerous minute chitinous teeth. Pulmonates are spared dental bills because old, damaged teeth are lost, anteriorly, and replaced from behind by new teeth. The radula is located in a mouth region, from which food progresses posteriorly and is processed in a digestive tract. A digestive gland is involved variously in secretion of enzymes and in absorption and storage of nutrients. In ancestors of the gastropods, the anus emptied into the posterior mantle cavity, as noted above. A two-chambered heart was present. A nervous system boasted a prominent collar around the anterior part of the digestive tract, from which arose a pair of nerves that extended back into the foot and a nerve (visceral) loop, which innervated the visceral mass.

A strange thing happened in the evolutionary history of the gastropod line. In fact, if it hadn't happened, we wouldn't have gastropods at all, but would, instead, probably consider them to be monoplacophorans, limpet-shaped mollusks in which the head is anterior and the main mantle cavity posterior, as described above. Monoplacophorans have a long fossil history, and presently are found in some deep-sea areas. It seems that in some monoplacophoran-like ancestor of the gastropods that a phenomenon called *torsion* took place, in which the upper body parts, including the mantle and posterior mantle cavity, rotated 180° with respect to the more ventral parts of the body. This placed the gills and openings for excretory and digestive tract discharge in an anterior position, above and behind the head. Torsion also caused the digestive tract to form a loop, beginning and terminating anteriorly. Another result of torsion was the twisting of the visceral nerve loop into a figure-eight configuration. What the advantages may have been of this rearrangement of body parts has been discussed at length, but no explanation has achieved consensus among those studying the phenomenon. There is agreement that the new position of the apertures for fecal and excretory wastes was not in the best interests of sanitation. Various solutions have evolved to counteract this problem. Some of these solutions involve the control of water currents in relation to head, gills, and waste discharge. In our pulmonate land snails the problem has been avoided by modifying the mantle cavity into an air-breathing device, more like our own lungs. From this lung-like structure has been derived the name Pulmonata (cf. Spanish *pulmones*, meaning lungs). The lung-like mantle cavity has a breathing pore called a *pneumostome*, which opens to the outside.

External Anatomy

The *aperture* is the opening in a snail's shell through which it may emerge, *anterior* end first. The *posterior* (opposite end) also emerges if the snail is moving about. In locomotion, it uses a muscular foot located on the *ventral* (bottom) side, and moves along in a pathway of its own secreted mucus, commonly called "slime." In early morning, the shiny remains of slime trails often are noted in areas where snails have been moving about during the preceding night. Above the foot, *dorsally*, hidden within the shell, are various internal organs of the visceral mass, which is surmounted by a mantle.

Sensory tentacles, which bear eyes at their anterior tip, arise from the head anteriorly. All but one species of New Mexico land snails have two pairs of tentacles--the sole exception being a tiny snail, rare in the state, *Carychium exiguum.* New Mexico's pulmonate aquatic snails, on the other hand, have only one pair of tentacles. When the animal is fully extended, a collar is observed around the edge of the aperture. This is the edge of the mantle, which, posterior to the collar, is hidden from view. In New Mexico slugs, however, which lack an external shell, the mantle is seen as a sort of beret perched atop the animal in the anterior one-third of its body. The mantle secretes the shell, which consists of several layers. The outermost is mainly of the organic, noncalcareous compound conchiolin. It is often pigmented--commonly some kind of brownish color in New Mexico land snails. The periostracum may be rubbed off (exfoliated) in older shells of living animals or in shells remaining after the living occupant has died.

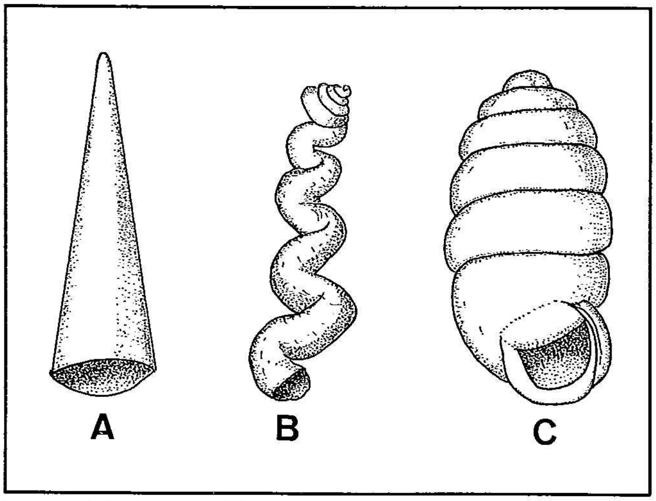

Figure 1.A, Cone, which may never have existed as a shell form in phylogeny of the gastropods, but can serve as a model for understanding development of the gastropod shell, as suggested by Ellis (1926). B, Likewise, shells of the marine worm shells (family Vermetidae) provide a model for a shell with loosely coiled cone. C, Tightly coiled shell (family Pupillidae) typical of many of the land snails of New Mexico.

The Shell

A model suggested by Ellis (1926:15) in his book *British Snails* elucidates the structure of snail shells. Ellis compared the shell to a hollow, elongate cone (Fig. 1A) that becomes spirally coiled "for mechanical convenience." The term "helicocone" has been applied to this structure. The uppermost (closed) end of such a helicocone would correspond to the *apex* of a snail shell, while the lowermost, open end would correspond to the *aperture*, a mouth-like opening of the shell. From the apex, the conical tube down-spirals (Fig. 1C). The model is well illustrated by some marine shells called Worm Shells (genus *Vermicularia*), in which lower spirals are coiled loosely and not attached to each other (Fig. 1B). In our land snails, however, down-spiralling takes place around a central axis in such a way that each lower coil overlaps the one above it to some extent. In disc-shaped shells (discoid), each lower coil is progressively much wider than the one above it, thus allowing much of the undersides of the older whorls to be exposed in a wide *umbilicus*, further discussed below. Each coil or spiral is a *whorl*, with each whorl girdling a shell 360°. The oldest whorl is at the apex, and the youngest terminates at the aperture. Most New Mexico land snails hatch from eggs, but a few are born as baby snails. In either case, the minute shell that they already have produced prior to hatching, or birth, comprises the *embryonic shell* (also referred to as *nuclear whorls* or the *protoconch*) of about 1½-2½ minuscule whorls. These whorls comprise the uppermost, closed end of the apex of the cone. The appearance of the embryonic whorls may be noticeably different from that of the later whorls in color and ornamentation and may be of use in identifying some kinds of snails.

(Terms stressed in this and the next paragraph are illustrated in Fig. 2A). The youngest whorl terminates at the aperture, and is called the *body whorl*. It is often more capacious than earlier whorls. It extends around the shell from the outer edge of the aperture back and up 360° to the location on the preceding whorl that is just above the outer lip--where we started. The stack of whorls above the body whorl is referred to as comprising the *spire* of the shell by most authors, and is so-used herein. However, Burch (1962:13), in his widely used handbook of eastern land snails, illustrated the spire as extending from the upper end of the aperture to the apex. The spire can be relatively high or grade to nonexistent in the flattest shells. The continuous spiral groove that marks the junction of one whorl with its neighbor, above or below, is called the *suture*. In practical terms, it is the indented groove that we note between whorls when looking at a shell in apertural or in top view. Sutures may be deeply indented (*impressed*) or more shallow.

If we look at a shell, facing the aperture, the vertical distance from the bottom of the aperture to the apex is commonly called the *height* of the shell, the term we use here, although some prefer to use the term *length* for this dimension. Likewise, still facing the aperture, the greatest distance from one side to the other of the shell is the *width* (the term we use) or *diameter* of the shell. In land snails, the greatest width will be the dimension from the farthest extension outward of the aperture, across the shell 180° to its opposite side. In flat shells, width may be observed most easily from a top view. In some snails, height may be greater than width and in others, width greater than height. This distinction is employed in the taxonomic key (see below) to divide New Mexico land snails into two major groups for purposes of identification.

To return to our model of the shell as a spiraling, hollow cone, we note that in higher, narrower shells the whorls spiral, in succession, around a central axis formed of the inner sides of each whorl. This central axis is called the *columella* (Fig. 2A). The columella (little column) originates as a hollow structure, but in some kinds of shells it may fill with calcareous material later on to form a true column or pillar. In such a shell, a whorl that is sliced apart at any level would show that its inner wall is contributing to the columella. The aperture provides, in effect, such a slice across a whorl, and its columellar wall will be on the side opposite the outer, free lip or wall of the aperture (Fig. 2E). Attached to the columella is the columellar muscle, used in retracting the animal into its shell. The columella may bear various kinds of plaits or lamellae, which aid in attachment of the columellar muscle. The cavity encompassed by the columellar walls of the shell is called an *umbilicus*. In high,

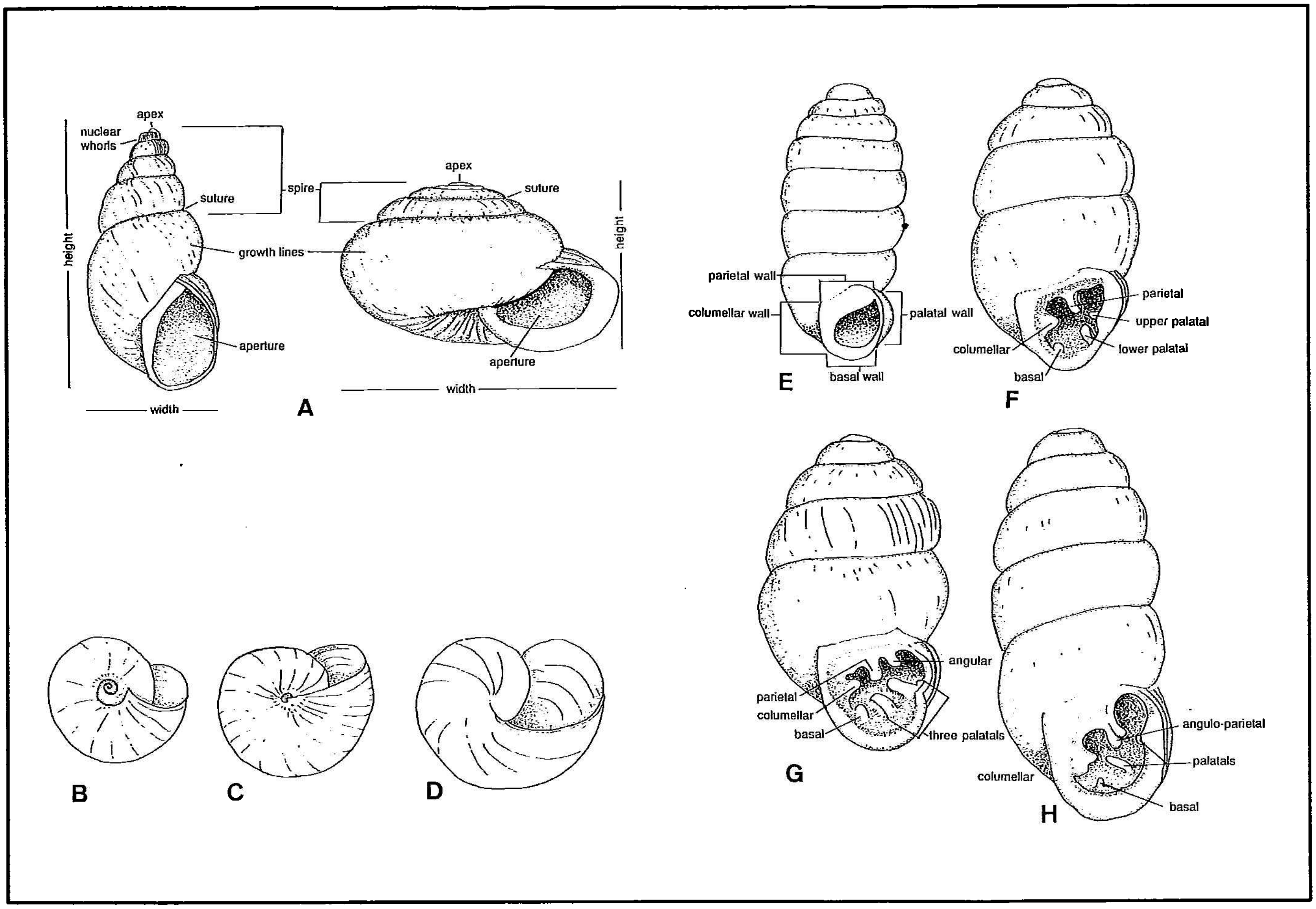

Figure 2. A, Shells showing some general features: Left, the relatively high shell of *Rabdotus durangoanus* (15.8 mm high) and, right, the relatively lower, wider shell of *Ashmunella rhyssa* (16.8 mm wide). B, C, D, Ventral views of three shells showing relative development, or absence of, umbilicus. B, umbilicate (*Zonitoides arboreus*, 5.4 mm wide); C, perforate (*Glyphyalinia indentata*, 5.6 mm wide); and D, imperforate (*Vitrina pellucida alaskana*, 5.9 mm wide). E, Shell of *Pupilla muscorum* showing terminology applied to walls of the aperture. The palatal and basal walls comprise the outer lip and the columellar and parietal walls the inner lip. F, G, H, Diagrams showing terminology applied to teeth (denticles) of pupillid shells. F, *Vertigo elatior* (2.2 mm high); G, *Vertigo ovata* (2.3 mm high); and H, *Gastrocopta procera* (2.2 mm high).

narrow shells, as noted above, the columella tends to be more like a real column, and the umbilicus is highly restricted or obliterated. It is obvious that there cannot be much of a columella in such low, broad shells. It may exist as a short, diminutive structure in the apical whorls, but as whorls soon widen, their columellar walls become separated from each other by increasing distances, so that in such a shell, the umbilicus will become much wider than in high narrow shells. This can be seen in viewing the shell from below. The umbilicus may appear as a deep, well-like hole in shells with narrower umbilici and grade from this morphology to a broad, circular depression in those with wider umbilici, as mentioned above for discoid shells.

Even in shells that have well-developed umbilici, this feature may be partially or entirely obscured from view by the overgrowth of shell material from the adjacent columellar wall. A shell in which there is no such overgrowth is referred to as being *umbilicate*. If the umbilicus is partially covered, perhaps leaving only a small "chink" open, the shell is referred to as being *perforate*. If the columellar wall completely covers over the umbilicus from external view, we have an *imperforate* shell (Fig. 2B-D).

An important part of the shell, insofar as identification is concerned, is the aperture and its related structures. The aperture is sometimes compared to a mouth and its rim to a circular lip, also called the peristome (Fig. 2E). The term *peristome* means literally "around the mouth," and is used to refer to the margin of the aperture, in general, but sometimes is used to imply a margin in which thickening has taken place. In many kinds of shells, part or all of the peristome becomes progressively thickened upon reaching maturity. This thickening is caused by the laying down of calcareous shell material, called *callus*. The wall may be referred to as being *calloused*. A terminology has been developed (Figs. 2E-G) for the aperture, which divides it into four parts. Recalling that the aperture is like the lower opening of a cone, these four parts are, in general, like the top, bottom, and two sides of this opening. The top and inner sides are sometimes termed the inner lip, and the outer and bottom parts, the outer lip. Both the inner and outer lips commonly are subdivided into two regions. The lower part of the inner lip is the *columellar wall*, already discussed. Obliquely or horizontally oriented, above the columellar wall, is the *parietal wall*. In apertures with thin lips, the parietal wall may be nothing more

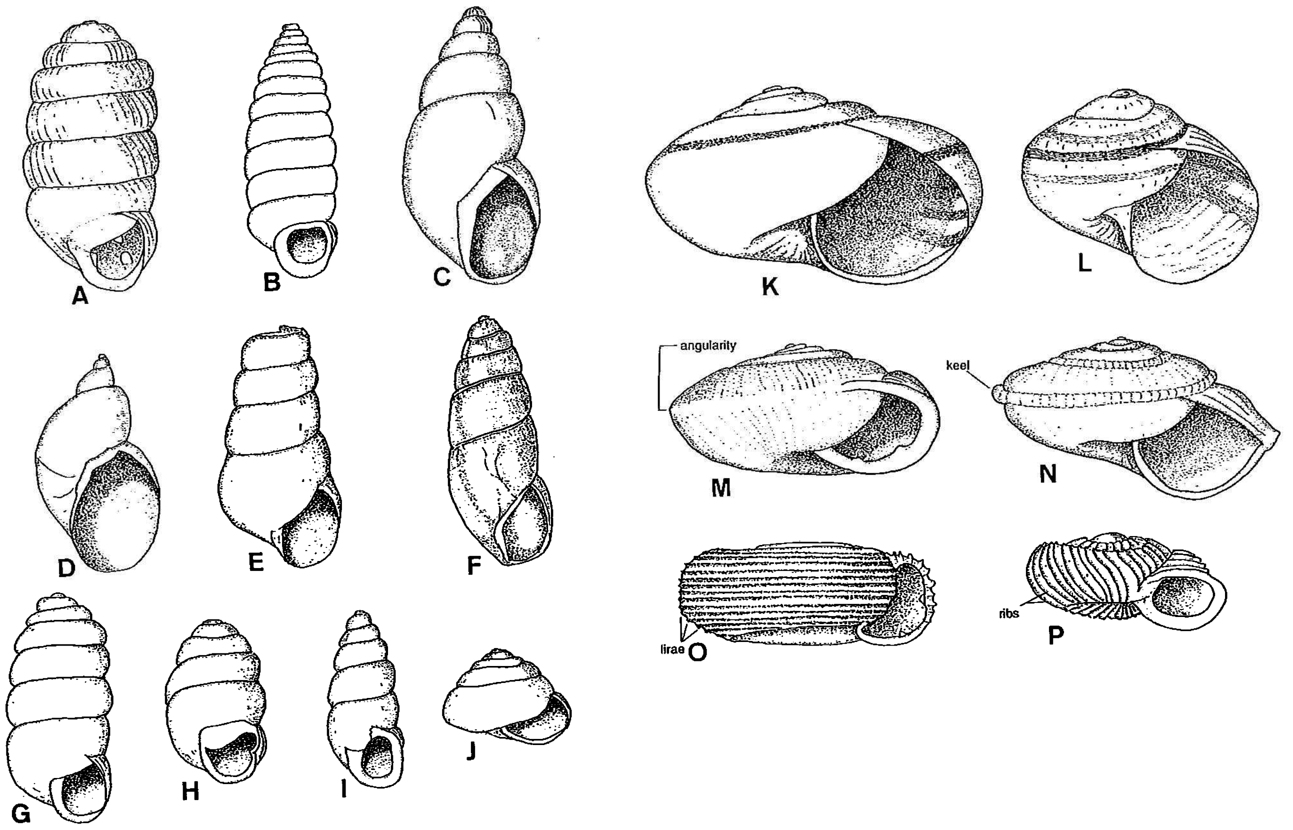

Figure 3. Shell forms and shapes of New Mexico land snails. A, Pupilliform (*Pupilla muscorum*, 3.1 mm high); B, urocoptiform (*Holospira crossei*, 13.6 mm high); C, bulimoid (*Rabdotus durangoanus*, 15.6 mm high); D, succiniform (*Succinea grosvenori*, 12.4 mm high); E, decollate (*Rumina decollata* 14.0 mm high); F, fusiform (*Cionella lubrica*, 6.5 mm high); G, cylindrical (*Columella columella alticola*, 2.7 mm high); H, ovate-conic (generalized *Vertigo* shell not showing teeth); I, elongate-conic (*Pupoides albilabris*, 4.8 mm high); J. dome-shaped (*Euconulus fulvus*, 3.2 mm wide); K, depressed shell (*Sonorella orientis*, 17 mm wide); L, subglobose shell (*Humboldtiana ultima*, 13.5 mm wide); M, angular shell (*Ashmunella organensis*, 14.6 mm wide); N, keeled shell (*Oreohelix metcalfei*, 14.8 mm wide); O, discoid shell showing raised lirae (*Helicodiscus eigenmanni*, 4.5 mm wide); P, shell showing ribs (*Vallonia gracilicosta*, 2.7 mm wide).

than the adjoining part of the body whorl (Fig. 2A, right). However, with thickening of the peristome, the parietal wall becomes more a structure in its own right (Figs. 2A, left, F-H), and in extreme cases (e.g., *Metastoma roemeri*) it may be entirely separated from the body whorl behind it. From the outermost corner of the parietal wall, the entirely free outer lip starts its descent, continues downward, and then curves back towards the columellar wall. The upper part of the outer lip, which is predominantly vertical in orientation is called the *palatal wall.* The bottom part, which is basically horizontal in orientation, is called the *basal wall.* Distinction between the palatal and basal walls may be rather arbitrary.

The thickened (calloused) peristome walls of shells may bear various kinds of small projections. A practical, all-inclusive name for these is *teeth,* which we shall use here. However, some authors call them *denticles* (little teeth), while others use the more complex term *apertural barriers.* Pilsbry (1948:869) noted that teeth found on the columellar wall should, properly, be called folds, and those of the parietal wall should be called lamellae. But, Pilsbry frequently resorted to use of the word "tooth," as well.

Folds and lamellae (terms that we mainly avoid here) are elongate outgrowths of the wall that extend varying distances back into the shell. Casually looking at the aperture, one usually sees only the front end of such a longer structure, so that they also look tooth-like. Lamellae extending back along the palatal or basal wall can be discerned in some cases on the outside of the shell if the wall is sufficiently thin. Some teeth may be located so far back from the aperture that they are not visible at all in apertural view.

Usually, teeth can be allocated as being on one of the subdivisions of the peristomial wall discussed above. Thus, we may have *columellar*, *parietal*, *palatal*, or *basal* teeth (Fig. 2F). A second tooth, located to the outer side of the parietal tooth on the parietal wall is given a special name: *angular tooth* (Fig. 2G). In some snails, the parietal and angular may be combined into a single angulo-parietal tooth (Fig. 2H). Except for the case of the angular, additional teeth are named by adding the adjectives upper and lower and the prefixes supra, infra, sub, or inter. For example, there may be a supracolumellar or subcolumellar tooth or an upper or lower palatal tooth, with an interpalatal tooth between them (Fig. 2H).

We have avoided using the terms *right* and *left* in discussing shell orientation. However, these terms are used to indicate differences in the direction of coiling in snails. Actually, all species of New Mexico land snails typically exhibit what is called right-handed or dextral coiling. In a shell with this type of coiling the outer free lip (palatal wall) of the aperture is located to the viewer's right. In left-handed or sinistral coiling, this lip is located to the left. One common genus of New Mexico aquatic snails (*Physa*) exhibits sinistral coiling. We have found a few atypical, sinistral specimens of land snails, mainly in the genus *Pupilla*. In the snail *Metastoma roemeri*, the last whorl is twisted in such a way as to give a false impression of sinistral coiling.

In the key for families, below, several terms are used (as in Burch, 1962) that refer to a distinctive shell form that is typical of a particular family. The following forms are illustrated in Fig. 3A-D, and include *pupilliform* (for Pupillidae), *urocoptiform* (for Urocoptidae), *bulimoid* (for Bulimulidae), and *succiniform* (for Succineidae). Other, more general terms referring to shell shape (Fig. 3E-J) are also employed such as *decollate*, *fusiform*, *cylindrical*, *ovate-conic*, *elongate-conic*, and *dome-shaped* (this last term in reference to the spire). In discoid shells (Fig. 3O), the body whorl is flattened as seen in apertural view. From such discoid shells, there is a gradation in degree of elevation of the shell from *depressed* (Fig. 3K) to *globose*. Globose shells are almost spherical. No New Mexico land-snail shells reach the extreme of being globose, although several are elevated to the degree indicated in Figure 3L as subglobose. The periphery of the body whorl (as seen in apertural view) may be *rounded*, *angular* or *carinate* (Fig. 3K-N). Carinate shells have a prominent spiral ridge-like cord or *keel*, which surrounds the shell at the point of maximum angularity (Fig. 3N).

The surface of shells may bear various kinds of distinguishing features. Pigmentation of the periostracum gives rise to color patterns that are usually whitish, grayish, or brownish in our species. Some of these pigmentation patterns are useful in identification. Raised or depressed features of the shell surface are referred to as *sculpture* or, occasionally, as *ornamentation*. The most common sculptural features consist of *growth lines* (Fig. 3A). More strongly developed ridges, which are oriented like, and often originate as, growth lines are termed *ribs* (Fig. 3P). Ribs are found in numerous kinds of New Mexico land snails. In their orientation, ribs may range from oblique to vertical. Raised lines that are parallel to the plane of coiling or of the sutures, i.e., are spirally oriented, are called *lirae* (Fig. 3O). Our only species that clearly exhibit lirae are *Helicodiscus eigenmanni*, *Oreohelix barbata*, and *Oreohelix pilsbryi*, although high magnification may reveal faint lirae in other species. All the above sculptural types are raised features. In contrast, there may be incised, shallow grooves on the surface of the shell. Incised spiral grooves are called *striae*. However, in our species, such minute grooves are parallel to the growth lines, and are well developed only in the genera *Glyphyalinia* and *Nesovitrea* in the family Zonitidae (Fig. 2B-C).

USE OF KEYS FOR LAND SNAILS OF NEW MEXICO

The identifying of New Mexico land snails could be approached in several ways. The use of shell characters is a traditional approach, and the one mainly employed here. In some guides to southwestern plants, altitudinal zonation has been employed in characterizing plant communities and as an aid in identifying species. Such an approach will be incorporated here, in some instances, using the Life Zone scheme, discussed earlier. Another approach that is useful in categorizing and identifying New Mexico land snails is provided by their patterns of distribution. In many instances a species is restricted to (=is endemic to) a particular mountain range or group of ranges. This is especially applicable to larger species inhabiting the southern half of the state, where such endemism is marked. For example, a snail of the genus *Sonorella*, known to come from the Doña Ana Mountains will almost surely prove to be *Sonorella todseni*. Various combinations of the above approaches will be employed, herein, wherever they seem useful.

A key to the families of land snails found in New Mexico is provided below. In cases where the family comprises more than one species, an additional key for that family is provided after the general key to families--"A Key to Genera and Species." In most cases these individual keys for families take identification to the level of species or subspecies. In cases where only one New Mexico genus or species occurs in a family, the name of the species is indicated in "A Key to Families." In the key, at some points, explanatory comments are interposed between statements. It is hoped that most of the terms encountered will have been covered in the foregoing discussion and in illustrations in Figures 2 and 3.

In the dichotomous keys, one simply commences with number 1, chooses 1a or 1b, and then proceeds as directed, either to another number or to a taxon name, which may be family, genus, species, or subspecies, depending on the key that is used.

A KEY TO FAMILIES

1a Animal with externally visible shell; commonly called "snails" 2

1b Animal with no externally visible shell (New Mexico species do, however, have a small vestigial shell buried in the fleshy, dorsal mantle); commonly called "slugs" 28

2a Mature shell higher than wide 3

2b Mature shell wider than high 11

3a Mature shell >10 mm in height 4

3b Mature shell <10 mm in height 7

4a Upper whorls of mature shells broken off. This distinctive condition is referred to as being decollate (Fig. 3E) and in New Mexico is exhibited only by this species, which has been introduced in areas of human activity, especially in lawns and gardens. . . . . Subulinidae: *Rumina decollata* (p. 64)

4b Shells not decollate 5

5a Height of aperture <1/3 height of shell; aperture with thickened (calloused) peristome. Uniquely among New Mexico land snails, aperture and its peristome are separated from older (preceding) whorls by a distinct "neck." The distinctive shell form of this family has been referred to as "urocoptiform" (Fig. 3B) . . . . . . Urocoptidae (p. 18)

5b Height of aperture >1/3 height of shell; peristome not thickened nor separated from preceding whorls by a "neck" 6

6a Height of aperture is 60% or less of height of entire shell; shell variously mottled with grayish or light-brownish pigment; two oldest (embryonic) whorls with close-set, equidistant vertical ribs; shells of this form have been referred to as "bulimoid" (Fig. 3C) . . . . Bulimulidae (p. 18)

6b Height of aperture is more than 60% of height of the entire shell; shell not mottled with gray or brown; no ribs on embryonic whorls; shells of this family have been referred to as being "succiniform" (Fig. 3D) . . . . . Succineidae (p. 19)

7a Shells lacking both thickened peristome and teeth; brownish periostracum 8

7b Columellar, palatal, and basal walls of peristome thickened, with the peristome bearing one or more teeth in most species; periostracum whitish, grayish, or brownish 9

8a Shell easily recognized, even in the field, by its highly glossy, light-brown periostracum; shell-shape fusiform (Fig. 3F); mature shell 5.0-7.5 mm in height . . . . Cionellidae (Cochlicopidae) (p. 25)

8b Shell with numerous, low growth lines, not markedly glossy; cylindrical shell shape (Fig. 3G); mature shell 2.5-3.0 mm in height. Pupillidae (in part): . . . . *Columella columella alticola* (p. 34)

9a Shell white, minute, 2.0 mm or less in height, with a distinctive single tooth located at the top of the columellar wall at its juncture with the parietal wall. There is only one species in this family in New Mexico, and it seems to be rare. . . . . Carychiidae: *Carychium exiguum* (p. 25)

9b Shell 1.7-5.0 mm in height; periostracum whitish to grayish to brownish. Shells pupilliform (Fig. 3A), ranging from cylindrical to ovate- or elongate-conic in shape. Teeth are present in many species (Figs. 2F-H), but not with a single tooth, located as in 9a 10

The following two subfamilies sometimes are given family status.

10a Shell minute; not over 2.5 mm in height; brownish; often with low, close-set growth lines; ovate-conic shell shape (Fig. 2G), with at least 4 teeth around the peristome in New Mexico species . . . . Pupillidae (subfamily Vertigininae): *Vertigo* (p. 17)

10b Not with the above combination of characters. This is a subfamily with numerous species, some widespread and common in New Mexico . . . . Pupillidae (subfamily Pupillinae) (p. 14)

11a Mature shell 10 mm or more in width 12

11b Mature shell 8 mm or less in width 16

12a Mature shell >18 mm in height (may reach 25-30 mm); with some kind of brownish banding, involving 3 or more bands 13

12b Mature shell <18 mm in height; usually with some brownish pigmentation; some with brownish bands 14

13a Largest land snail in state; reaching 30 mm in both width and height; shell imperforate; introduced from Europe; usually found in urban or suburban areas . . . . Helicidae: *Helix aspersa* (p. 65)

13b A native snail found only in the Guadalupe Mountains along the New Mexico/Texas border; larger shells perforate, but never imperforate (Fig. 3L) . . . . Humboldtianidae: *Humboldtiana ultima* (p. 62)

14a In mature shell, walls of peristome (usually excluding the parietal) thickened to form a well-defined, solid lip, often paler in color than remainder of shell, and often bearing one or more teeth (Fig. 3M) . . . . Polygyridae (p. 20)

14b Peristome not thickened in mature shell; no teeth present 15

15a Shell with a single brown band that contrasts strikingly with lighter color of remainder of shell; band begins on third whorl and continues to lip of body whorl, which is rounded, peripherally, not angular (Fig. 3K) . . . . Helminthoglyptidae: *Sonorella* (p. 24)

15b Shell without single, simple, brown band, although there may be 2 or more bands, variously broken or fused, or large blotches, or entire shell brownish in color. Shells range from slightly angular to carinate (Fig. 3N) on body whorl . . . . Oreohelicidae (p. 23)

16a Fresh or well-preserved shells exhibiting some kind of raised sculpture. This may take the form of lirae or ribs (see discussion of shell features above, and Figures 3O-P); shell not thin and glossy 17

16b Fresh or well-preserved shells relatively smooth, without well-defined, raised sculpture; shells often thin and glossy 22

17a Shell with well-developed spiral lirae (up to 20 or more on body whorl) (Fig. 3O) . . . . Helicodiscidae (in part): *Helicodiscus eigenmanni* (p. 40)

17b Shell with well-developed, raised ribs 18

18a Mature shell >3.5 mm in width 19

18b Mature shell 3.5 mm or less in width 20

19a Mature shell 5-7 mm in width. In New Mexico, these are montane species of the Transition Life Zone and above . . . . Discidae (p. 19)

19b Mature shell 3.8-4.8 mm in width; found in relatively arid (desert) habitats of Lower and Upper Sonoran Life Zones in New Mexico . . . . *Thysanophoridae* (in part): *Thysanophora hornii* (p. 60)

20a Peristome flared (expanded) somewhat like the mouth of a horn (bugle); usually slightly reflected and much thickened in some species 21

20b Peristome not flared, reflected, or thickened . . . . Punctidae (in part): *Paralaoma caputspinulae* and Charopidae: *Radiodiscus millecostatus* (p. 18)

21a Ribs relatively widely spaced (ca. 0.1 mm apart); umbilicus relatively deep and narrow, its width contained more than 3 times in width of shell. (Fig. 3P) .... Valloniidae (except *Vallonia pulchella*) (p. 17)

21b Ribs closely spaced (considerably less than 0.1 mm); umbilicus relatively wide and flat, its width contained less than 3 times in shell width .... Zonitidae (in part): *Striatura meridionalis* (p. 51)

22a Mature shell with only 2 or 3 whorls, body whorl greatly expanded; shells delicate, easily crushed, translucent, usually with pale greenish tint (Fig. 2D). .... Vitrinidae: *Vitrina pellucida alaskana* (p. 51)

22b Mature shell with more than 2 or 3 whorls, and body whorl not notably expanded; shells not whitish-translucent or greenish. 23

23a Mature shell dome shaped (Fig. 3J) in profile, glossy and brownish; umbilicus barely perforate (just a slit) or imperforate. .... Euconuliidae: *Euconulus fulvus* (p. 50)

23b Mature shell not dome shaped; umbilicus well developed. 24

24a Peristome flared (expanded), slightly reflected and thickened. .... Valloniidae (in part): *Vallonia pulchella* (p. 64)

24b Peristome not flared, reflected, or thickened 25

25a Shell <2.0 mm in width; periostracum smooth, slightly glossy, and brownish .... Punctidae (in part): *Punctum minutissimum* (p. 39)

25b Shell width >2.0 mm; periostracum various colors 26

26a Shell 2-3 mm in width (discussed under respective families in key, below) .... Helicodiscidae (in part): *Helicodiscus singleyanus* or Zonitidae (in part): *Hawaiia minuscula* (p. 19)

26b Shell >3 mm in width 27

27a Shell depressed, without spire; flat; opaque, grayish in color .. *Thysanophoridae* (in part): *Microphysula ingersolli* (p. 61)

27b Shell at least slightly elevated; wiith low to well-developed spire, glossy, some translucent; some with incised grooves on shell .... Zonitidae (in part) (p. 19)

28a Slugs in which mantle has fingerprint-like concentric ridges; a keel extends dorsally from posterior end 2/3 of distance to mantle, and pneumostome is located in posterior half of mantle .... Limacidae (p. 20)

28b Slugs in which mantle lacks fingerprint-like concentric ridges, in which there is no posterior, dorsal keel, and in which the pneumostome is in the anterior half of the mantle .... Arionidae (p. 20)

A KEY TO GENERA AND SPECIES
Pupillidae
Subfamily Pupillinae

1a Shell cylindrical or with upper whorls wider than lower ones; periostracum light brownish, with 0-3 teeth; without ribs .... Genus *Pupilla* 2

1b Shell without the above combination (1a) of characteristics 6

2a Upper whorls (except embryonic ones) wider than lower ones, giving shell a top-heavy appearance; usually with 3 teeth, a species of northwestern New Mexico ....*Pupilla syngenes* (p. 26)

2b Upper whorls not wider than lower ones 3

3a Peristome with no teeth or with only one or two small (tubercular) teeth on parietal and/or columellar wall 4

3b Peristome with 3 teeth (columellar, parietal and lower palatal) 5

4a Shell with no teeth in specimens that we have seen in New Mexico; peristome thin, with no thickening callous deposit; shell glossy brown . . . . *Pupilla hebes* (p. 26)

4b Shell with or without tubercular columellar and/or parietal teeth; peristome with a thick, light-colored callous deposit; prominent crest behind palatal wall of aperture . . . . *Pupilla muscorum* (p. 26)

5a Parietal tooth long and crescent shaped when viewed from below; crest behind palatal lip well developed; southern New Mexico mountains . . . . *Pupilla sonorana* (p. 27)

5b Parietal tooth short, straight, its back part sloping downward, not crescent-shaped; crest behind palatal lip moderately developed; a common species in most New Mexico mountains . . . . *Pupilla blandi* (p. 25)

6a Shell without teeth; species of Lower and Upper Sonoran Zones . . . . Genus *Pupoides* 7

6b Shell with 3 or more teeth . . . . Genus *Gastrocopta* 8

7a Shell elongate-conic (Fig. 3I); peristome greatly thickened with whitish callous material (hence, the name *albilabris*); without well-developed ribs. . . . . *Pupoides albilabris* (p. 27)

7b Shell cylindrical (Fig. 3G); without greatly thickened peristome; ribs moderately to strongly developed. Ribs are more strongly developed in *Pupoides hordaceus* (p. 27) of north-central and northwestern New Mexico and less well developed in *Pupoides inornatus* (p. 27) of northeastern New Mexico. It is possible that the two taxa are subspecies of one species.

Notes concerning *Gastrocopta*, below: Pilsbry (1948:874) treated the genus *Gastrocopta* as comprising several subgenera, five of which occur in New Mexico. In most species of *Gastrocopta*, the "tooth" of the parietal apertural wall actually consists of a combined angular and parietal tooth (angulo-parietal). In many species, this dual combination can be discerned in inspecting the tooth. However, in the subgenera *Vertigopsis* and *Staurotrema*, an angular tooth is small or lacking and the resulting parietal tooth is simple. In the subgenus *Albinula*, on the other hand, two elements are clearly observable in the angulo-parietal complex, which descends a third or more of the height of the aperture. Members of the subgenus *Gastrocopta* are recognized by their cylindrical shell shape, usually brownish color, and an angulo-parietal tooth that has a bifid appearance because of the hybrid origin as angular and parietal. Members of the subgenus *Immersidens* have a complex dentition. Pilsbry (1948:874) described the parietal-wall denticles in this subgenus as follows: "the angular lamella is united with the parietal at the inner end of the former, the two diverging forward, and together shaped like . . . a reversed Y."

8a Parietal wall with a single, simple tooth with an angular tooth component greatly reduced or absent; periostracum whitish to grayish . . . . Subgenus *Vertigopsis* 9

8b Parietal-wall tooth clearly comprised of 2 combined components: parietal and angular teeth (angulo-parietal) 11

9a Shell bearing 3 or more teeth on a well-developed callus inside the palatal and basal walls of the peristome. . . . . *Gastrocopta pentodon* (p. 29)

The nominal subspecies (*G. p. pentodon*) is cylindrical and similar to *G. pilsbryana* (below) except for development of the callus. The subspecies *G. pentodon tappaniana* is more conic-ovate, bears 4 or more teeth on the combined palatal and basal walls, and may be extinct in New Mexico.

9b Shell bearing 2 or 3 teeth on the moderately developed callus of the palatal plus basal walls of the peristome 10

10a Shell >2.5 mm in height; 4 teeth (columellar, parietal, palatal, and basal) arranged as though at the ends of a cross . . . . Subgenus *Staurotrema*: *Gastrocopta quadridens* (p. 30)

10b Shell <2 mm in height; usually 5 (sometimes 4) teeth; not cruciform in arrangement as in 10a . . . . *Gastrocopta pilsbryana* (p. 29)

11a Shell whitish to grayish; ovate-conic; 2 palatal teeth arise from a thick, white palatal callus . . . . Subgenus *Albinula* 12

11b Shell pale gray to tan; cylindrical; basal and palatal teeth deeply set back from aperture instead of on an apertural callus 15

12a Shell reaching 3.5-4.5 mm in height, thus, the largest of North American Gastrocoptas . . . . *Gastrocopta armifera* 13

12b Shell <3.0 mm in height 14

13a Combined angulo-parietal tooth complex descending to about 1/3 of aperture height . . . . *Gastrocopta armifera armifera* (p. 28)

13b Combined angulo-parietal tooth complex massive; descending to about 2/3 of aperture height, filling much of the aperture; a subspecies of the Sacramento Mountains . . . . *Gastrocopta armifera ruidosensis* (p. 28)

14a Shell 2.0-2.5 mm in height; massive angulo-parietal tooth complex descending to about 2/3 of apertural height, and filling much of aperture . . . . *Gastrocopta contracta* (p. 28)

14b Shell <2 mm in height; angulo-parietal complex descending about halfway of apertural height, and resembling an upside-down letter Y when observed from below . . . . *Gastrocopta holzingeri* (p. 29)

15a Angular and parietal teeth united behind (away from) aperture, but diverging forward, when viewed from below. Other teeth are located far back in the aperture, some not, or barely, visible in apertural view . . . Subgenus *Immersidens* 16

15b Angular and parietal not divergent from each other; joined to produce a bifid appearance; other teeth located behind peristomial callus, but not so deeply as in *Immersidens* (15a), so that they are clearly seen in apertural view (Fig. 2H) . . . . Subgenus *Gastrocopta* 19

The most distinctive of the species of *Immersidens* is the most common and most widespread species--*ashmuni*. In other species it is necessary to tilt shells so that one can observe the pattern of the angulo-parietal complex from below and note whether the back part of the parietal part of the complex is straight or curved strongly towards the outer (palatal) lip of the aperture.

16a Inner end (i.e., the end away from the aperture) of the parietal lamella portion of the angulo-parietal complex, sharply curved towards the outer (palatal) lip side of the peristome 17

16b Inner end of parietal portion of angulo-parietal complex rather straight, and not sharply curved outward, as in 16a 18

17a In apertural view, a massive angulo-parietal complex fills much of the aperture, descending about 3/4 of the height of the aperture; other teeth not, or barely, observable; parietal peristome is separated from whorl behind it, producing a neck-like structure and slightly flared peristome . . . . *Gastrocopta ashmuni* (p. 30)

17b Angulo-parietal complex descending to about half the height of the aperture; other teeth also observable in apertural view; parietal peristome firmly attached to surface of whorl behind it . . . . *Gastrocopta cochisensis* (p. 30)

18a Shell >2.0 mm in height, often reaching 2.5 mm; angular branch of angulo-parietal complex much smaller than parietal branch and diverging mainly above it onto parietal wall . . . . *Gastrocopta prototypus* (p. 30)

18b Shell <2.0 mm in height; angular and parietal branches about the same size . . . . *Gastrocopta dalliana* (p. 31)

19a Shell usually 2.5 mm or more in height; peristome thickly calloused within; shell brownish 20

19b Shell usually <2.5 mm, often <2.0 mm, in height; peristome thin, not calloused within; shell whitish to light tan . . . . *Gastrocopta pellucida* (p. 31)

20a Angular and parietal components diverging from each other at tip of the angulo-parietal complex, producing an X-shaped effect; upper part of palatal callus thinned . . . . *Gastrocopta procera* (p. 31)

20b Angulo-parietal complex appearing as one sinuous denticle, not divergent at the lower tip; upper part of palatal wall callus not noticeably thinned . . . . *Gastrocopta cristata* (p. 31)

Pupillidae
Subfamily Vertigininae

1a Shell cylindrical; peristome thin, without callus or teeth and not expanded; fine ribs present . . . . *Columella columella alticola* (p. 34)

1b Mature shell not cylindrical; peristome thickened on all sides, including parietal wall, and bearing varying numbers of teeth 2

2a Minute shell (<1.8 mm in height) with strongly indented area (sinus) in outer (palatal) lip of peristome, below which there are no teeth. Elsewhere, there are 2 teeth on the columellar wall, a parietal and upper palatal tooth. In New Mexico, found only in the southwestern mountains . . . . *Vertigo hinkleyi* (p. 33)

2b Shell without above (2a) characteristics 3

3a Peristome with 6 or more teeth 4

3b Peristome with fewer than 6 (usually 5) teeth 5

4a Shell minute (<1.8 mm in height), typically with 6 strongly developed teeth (a mouthful!): columellar, parietal, angular, upper and lower palatal, and basal. Possibly extinct in New Mexico . . . . *Vertigo milium* (p. 32)

4b Shell >2 mm in height; with same distribution of 6 teeth as in 4a, but several accessory teeth may be present. Aperture not appearing so congested with teeth as in *V. milium*. Rare in New Mexico, at present; mainly near springs . . . . *Vertigo ovata* (p. 32)

5a Shell >2 mm in height, smooth and glossy brown 6

5b Shell <2 mm in height, brownish, but finely set with minute riblets. Usually 5 teeth are present, variously distributed (see species account), but always with a columellar, a parietal, and 2 palatals. An angular or a basal (but not both) may be present in New Mexico specimens . . . . *Vertigo gouldii* (p. 32)

6a Peristome strongly calloused, with marked indentation (sinus) in outer (palatal) lip; small basal tooth present. Species is rare in state and found at higher elevations . . . . *Vertigo elatior* (p. 33)

6b Peristome only moderately thickened, with weak indentation in outer (palatal) lip; basal tooth lacking. This species is especially common in Canadian and Hudsonian Life Zones in New Mexico . . . . *Vertigo modesta ingersolli* (p. 33)

Valloniidae

1a Surface of shell smooth, without well-developed ribs; apparently introduced into New Mexico from eastern states; mainly found in urban and suburban areas . . . . *Vallonia pulchella* (p. 64)

1b Surface of shell with well-developed, widely spaced ribs 2

2a Width of mature shell from 2.5 to 3.0 mm 3

2b Width of mature shell 2.0 mm or less 4

The characters indicated for 3a and 3b below do not allow for species determination on immature shells. It is possible that *V. gracilicosta* and *V. cyclophorella* are actually the same species or that there is hybridization between the two species in some cases. A situation such as this could explain the difficulty encountered in allocating some populations to species, as in the taxon *Vallonia sonorana* of the Big Hatchet Mountains (not included in this key) and specimens from the Oscura Mountains.

3a Mature shell with peristome thickly calloused except for the short parietal wall . . . . *Vallonia gracilicosta* (p. 34)

3b Mature shell with peristome thin, and not calloused .... *Vallonia cyclophorella* (p. 34)

4a Mature shell with peristome thickly calloused except for the short parietal wall; a species mainly of northeastern New Mexico .... *Vallonia parvula* (p. 34)

4b Mature shell with peristome thin and not calloused; a species of Upper Sonoran and Transition Life Zones in the southern half of the state .... *Vallonia perspectiva* (p. 34)

Urocoptidae

1a Body whorl twisted so as to become necklike behind aperture, which is in sinistral position (on lower left side of shell as viewed); a strong, fold-like tooth within right margin of peristome; shell not ribbed .... *Metastoma roemeri* (p. 35)

1b Body whorl not twisted; aperture in dextral position (on lower *right* side of shell); no tooth on right side of aperture; shells ribbed to various degrees 2

2a Whorls in upper 1/3 of shell reduced in size so as to produce an apical point; entire shell strongly ribbed; found only on Bishops Cap Mountain, Doña Ana Co. .... *Coelostemma pyrgonasta* (p. 63)

2b Shell elongate-conic; upper part not markedly sharp pointed; variously ribbed; found in various mountain ranges in southern New Mexico, as follows:
(1) Eastern foothills of Black Range, including Cuchillo Mountains .... *Holospira cockerelli* (p. 36)
(2) Big Hatchet Mountains and associated, lower mountains, Hidalgo Co. .... *Holospira crossei* (p. 36)
(3) Howells Ridge, Grant Co. .... *Holospira metcalfi* (p. 37)
(4) Guadalupe Mountains, Eddy Co. .... *Holospira montivaga* (p. 36)

Bulimulidae

1a Shell relatively large, being >20 mm in height with fully mature shells nearing 30 mm .... *Rabdotus dealbatus neomexicanus* (p. 38)

1b Shell relatively small; <20 mm in height, with fully mature shells about 16 mm in height or only about half the height of the above (1a) taxon .... *Rabdotus durangoanus* (p. 38)

Punctidae and Charopidae

1a Shell <2 mm in width; without well-developed ribs; periostracum light brown and smooth .... *Punctum minutissimum* (p. 39)

1b Shell 2 mm or more in width; with well-developed ribs 2

2a Ribs almost vertical on whorls, close set, but clearly defined with sharp edges .... *Radiodiscus millecostatus* (p. 39)

2b Ribs oblique and sinuous on whorls, appearing to be enlarged growth lines; without sharp edges .... *Paralaoma caputspinulae* (p. 39)

Helicodiscidae

1a Mature shell >3.5 mm in width; with well-developed spiral lirae encircling shell .... *Helicodiscus eigenmanni* (p. 40)

1b Mature shell <3.5 mm in width; smooth, with no spiral lirae .... *Helicodiscus singleyanus* (p. 40)

There is no difficulty in separating shells of the above 2 species, but problems often are encountered in trying to separate *H. singleyanus* from *Hawaiia minuscula*. Fresh shells of both species are translucent with pale tannish tint. However, many shells found are old, weathered, or fossils, and may be bleached and opaque. Growth lines are more evident in *H. minuscula*, being numerous, closely set, and producing an effect that has been compared to woven silk threads. Growth lines in *H.singleyanus* are more obscure, and often do not affect overall appearance of the shell, which is glossy, even when fossilized. In *H. singleyanus*, the umbilicus is shallower and wider, contained less than 3 times in width of the shell. In *H. minuscula*, the umbilicus is deeper and narrower, contained about 3 times or over in shell width. In side view, the spire of *H. singleyanus* rises only slightly above the level of the top of the body whorl, whereas in *H. minuscula*, it rises perceptibly more to form a low dome.

Discidae

1a Shell strongly ribbed on both upper and lower surfaces . . . . *Discus whitneyi* (p. 40)

1b Shell with ribs moderately developed above and very weakly developed below . . . . *Discus shimekii* (p. 40)

The differences between the above 2 species of *Discus* are subtle. Shells of *D. shimekii* seem glossier, probably because of less development of ribbing and many specimens have an olivaceous tint. Pilsbry noted (1948:603, 618) that in *D. whitneyi*, umbilical width is contained from 2.4 to 2.8 times in shell width, and in *D. shimekii*, 3.7 to 4 times. Even with casual inspection, the umbilicus appears wider in *D. whitneyi*. In *D. whitneyi*, also, the body whorl is less capacious, more angular, and the sutures more deeply impressed than in *D. shimekii*. *Discus shimekii* occurs in higher mountains in northern New Mexico (south to Mount Taylor and the Manzano Mountains), while *D. whitneyi* occurs over a broad elevation range in mountains throughout the state.

Succineidae

Shells of *Oxyloma retusum* can be distinguished from those of other species by their greater height, of 12 mm or more, and the high, narrow aperture, which reaches ca. 70% of shell height. In other species of succineids in the state, shell height is <12 mm and apertural height only 50-60% of shell height. Shell characters are inadequate to determine species in the genera *Succinea* and *Catinella*, and characters of the genitalia have been used instead in making species determinations in these genera. Wu (1993) has illustrated some of these characters for species of New Mexico . . . . (p. 47)

Zonitidae

1a Mature shell 4.5 mm or more in width; fresh shells glossy 2

1b Mature shell <3.5 mm in width; fresh shells not very glossy because of numerous growth lines or ribs 5

2a Mature shell >10 mm in diameter; in urban areas . . . . *Oxychilus draparnaudi* (p. 65)

2b Mature shell <7mm in diameter; mainly in non-urban areas 3

3a Fresh shell glossy and with brownish periostracum; without incised grooves . . . . *Zonitoides arboreus* (p. 51)

3b Fresh shell *very* glossy with clear to whitish (never brownish) periostracum. These are the only New Mexico land snails to have well-defined incised grooves (indented below the shell surface). Grooves are parallel to the growth lines 4

4a Shell perforate (i.e., umbilicus reduced to a slit as it is mainly covered over by the columellar wall of the body whorl); aperture lunate (i.e., wider than high) . . . . *Glyphyalinia indentata* (p. 50)

4b Shell umbilicate (i.e., umbilicus well-developed and observable); aperture rounded (about as wide as high) . . . . *Nesovitrea hammonis electrina* (p. 50)

5a Shell with numerous, closely set riblets; umbilicus shallow, flat and wide; body whorl slightly expanded. Shell mottled with various colors: white, gray, and brown hues; several adjoining ribs may be white . . . . *Striatura meridionalis* (p. 51)

5b Shell without riblets, but with close-set growth lines (like woven silk threads); umbilicus narrow and deep; shell light tan, not mottled; body whorl not expanded. Further information is provided under *Helicodiscus singleyanus*, above . . . . *Hawaiia minuscula* (p. 50)

Arionidae and Limacidae

1a Slug; pneumostome in anterior half of right side of mantle; no posterior mid-dorsal keel; dark bands on mantle and posteriorly on body; no concentric ridges on mantle .... Arionidae: *Arion fasciatus* (p. 65)

1b Slug; pneumostome in posterior half of right side of mantle; posterior mid-dorsal keel; pattern of fingerprint-like concentric ridges on mantle: .... Limacidae 2

2a Large slug; over 30 mm in length when extended; with coloration pattern other than uniform gray; introduced species 3

2b Small slug, <30 mm in length when extended, grayish in color; native species .... Genus *Deroceras* 4

3a Slug 50-60 mm long; with dark lengthwise bands dorsally; in urban areas .... *Lehmannia valentiana* (p. 65)

3b Slug 70-100 mm long; background color dusky yellowish to greenish, mottled with yellow patches; tentacles steel blue in color; mucus yellow .... *Limax flavus* (p. 65)

4a A small slug of the higher parts of the Black Range and Mogollon Mountains .... *Deroceras heterura* (p. 51)

4b A widespread, small, grayish slug, occurring from urban areas and river valleys at lower elevations up into mountains; in damp habitats .... *Deroceras laeve* (p. 51)

Polygyridae

1a V-shaped tooth present on parietal wall; occurs in lower Pecos Valley in New Mexico and introduced in some urban areas in southern New Mexico .... Genera *Linisa* (pp. 52 and 64) and *Polygyra* (p. 65)

Linisa texasiana, until recently assigned to *Polygyra*, is known from urban and natural areas in the Pecos Valley, *Polygyra septemvolva* only from one residence in Carlsbad, at present. *Linisa texasiana* has three well-developed teeth in the outer lip, is rounded peripherally, and has a narrower umbilicus, <25% of shell width. *Polygyra septemvolva* has no teeth in the outer lip, is angular peripherally, and has a wider umbilicus, ca. 40% of shell width.

1b Parietal tooth absent or, if present, not V-shaped. Species of New Mexico mountains .... Genus *Ashmunella*

Species of *Ashmunella* often are identified best by referring to mountain ranges in which they are endemic. In the key below, such distributional criteria, as well as shell characters, are employed. Species are grouped in the same geographic categories used with the species accounts below.

Species of Northern New Mexico

1a Mature shell toothless; a species of the Jemez and Nacimiento Mountains .... *Ashmunella ashmuni* (p. 53)

1b Mature shell with a tooth in parietal, palatal, and basal positions; a species of the southernmost Sangre de Cristo Mountains .... *Ashmunella thomsoniana* (p. 52)

Species of Southern New Mexico, East of the Tularosa Basin

1a Shell relatively elevated with well-developed spire; palatal tooth absent and other teeth absent or poorly developed 2

1b Shell slightly elevated or with almost no spire; parietal, palatal, and basal teeth all well developed; species of Guadalupe and Cornudas Mountains 4

2a Usually 2 low (twinned) basal teeth present; species of Capitan, Patos, Carrizo Mountains, and Lone Mountain, Lincoln Co. .... *Ashmunella pseudodonta* (p. 53)

2b Basal tooth absent or one small tooth present; species of Sierra Blanca and Sacramento Mountains (as living) .... *Ashmunella rhyssa* 3

3a Shell relatively smooth, larger (14-20 mm wide); subspecies of the Sacramento Mountains . . . . *Ashmunella rhyssa rhyssa* (p. 54)

3b Shell ribbed, smaller (12-17 mm wide); subspecies of the Sierra Blanca Mountains and Nogal Peak area . . . . *Ashmunella rhyssa altissima* (p. 54)

4a Shell carinate (keeled); spire moderately low, but evident; with single parietal tooth . . . . *Ashmunella carlsbadensis* (p. 54)

4b Body whorl shoulder angular; shell not carinate; spire very low, almost nonexistent; with two simple, unconnected parietal teeth . . . . *Ashmunella amblya cornudasensis* (p. 55)

Species of Southern New Mexico between the Rio Grande Valley and Tularosa Basin

1a Shell heavily ribbed . . . . *Ashmunella salinasensis* (p. 55)

1b Shell not heavily ribbed 2

2a Parietal teeth fused into a square-shaped plaque that occupies most of the parietal wall *Ashmunella pasonis pasonis* (p. 56)

2b Parietal teeth not forming a plaque on parietal wall 3

3a Species of the San Andres and Caballo Mountains 4

3b Species of the Organ Mountains 7

4a Shell tan, very glossy, sharply angular at about 2/3 height of body whorl; with shell smoothly curved, above and below angularity, to give lens-like profile; umbilicus relatively narrow, contained over 4 times in shell width; a species of Goat Mountain area, southern San Andres Mountains . . . . *Ashmunella harrisi* (p. 55)

4b Shell light tan, glossy, angular only at shoulder of body whorl; both bottom and top of shell flattened, with very short spire; umbilicus relatively broad, contained less than 4 times in shell width . . . . *Ashmunella kochii* 5

5a Subspecies of the Caballo Mountains . . . . *Ashmunella kochii caballoensis* (p. 55)

5b Subspecies of the San Andres Mountains 6

6a Shell 18.5 mm or more in width; upper parietal tooth rudimentary or absent . . . . *Ashmunella kochii kochii* (p. 55)

6b Shell <18.5 mm in width; an upper parietal tooth present and well developed . . . . *Ashmunella kochii sanandresensis* (p. 55)

7a Shell dark brown with rough surface; almost carinate peripherally; single, strong, sinuous parietal tooth . . . . *Ashmunella todseni* (p. 56)

7b Body whorl not approaching carinate condition, but only angular or rounded, not dark brown nor with sinuous parietal tooth 8

8a Shell moderately elevated and body whorl rounded; parietal and outer lip teeth rudimentary or absent . . . . *Ashmunella organensis* (p. 56)

8b Shell depressed; low spire; body whorl shoulder angular; well-developed palatal, two basal, and lower and upper parietal teeth, which are joined to the right in some shells . . . . *Ashmunella auriculata* (p. 56)

Species of Southern New Mexico, West of the Rio Grande Valley

1a Species of the San Mateo or Mogollon Mountains or Black Range 2

1b Species of isolated ranges of southwestern New Mexico in Luna, and in southern Hidalgo and Doña Ana Counties 6

2a Aperture with several teeth; shells depressed 3

2b Aperture toothless; shells relatively elevated 4

3a Shell with 4 teeth; parietal, upper palatal, and 2 basal teeth; with representatives in Mogollon and southern San Mateo Mountains, and in central Black Range . . . . *Ashmunella tetrodon* (p. 57)

The *A. tetrodon* complex is in need of further study. Some populations from the southwestern Mogollon Mountains, described as subspecies of *tetrodon* by Pilsbry and Ferriss (1915), have fewer or no teeth, and may be hybrids between *A. tetrodon* and *A. mogollonensis*.

3b Shell with 3 teeth, lacking a parietal tooth, but with upper palatal and 2 basal teeth; species of western canyons of the Mogollon Mountains . . . . *Ashmunella danielsi* (p. 59)

4a Shell relatively depressed; weakly to strongly carinate, with fine to coarse granulation; species of southern Black Range . . . . *Ashmunella cockerelli* (p. 57)

Pilsbry and Ferriss (1917) recognized 3 subspecies of *A. cockerelli*: (1) the nominal (=same name as species) subspecies, found in the southwestern part of the range, is strongly carinate and coarsely granulose; (2) *argenticola*, to the north in the Silver Creek drainage, carinate, but finely granulose; and (3) *perobtusa*, from southeastern slopes of the range, finely granulose, and body whorl, peripherally, more angular than carinate.

4b Shell relatively elevated; not carinate or granulose 5

5a A species of the Mogollon Mountains and westward to the Blue Mountains of Arizona . . . . *Ashmunella mogollonensis* (p. 58)

5b Species of the Black Range . . . . *Ashmunella mendax; A. binneyi* (p. 58)

We see no distinguishing differences between shells of *A. mendax* and *A. binneyi*. We retain them as separate species on the basis of slight differences in anatomy of the genitalia reported by Pilsbry (1940:945,946).

6a Species of the Big Hatchet and nearby mountains 7

6b Species not of the Big Hatchet Mountains area 8

7a Shell smooth and glossy; no thickened parietal callus; periphery of body whorl weakly angular . . . . *Ashmunella mearnsii* (p. 60)

7b Shell granulose, rough-textured, not glossy; thickened parietal wall of peristome detached from the adjacent body whorl wall to the left; carinate . . . . *Ashmunella hebardi* (p. 60)

There may be hybridization between *A. mearnsii* and *A. hebardi*, as intermediate forms have been found.

8a Shell with only one parietal tooth 9

8b Shell with upper and lower parietal teeth 10

9a Shells carinate; a species of the Florida Mountains, Luna Co. . . . . *Ashmunella walkeri* (p. 59)

9b Shells angular (not carinate); a species of the Animas Mountains, southern Hidalgo Co. . . . *Ashmunella animasensis* (p. 60)

10a A species of Mount Riley of southern Doña Ana Co. . . . . *Ashmunella rileyensis* (p. 59)

10b A species of Cooke Peak, Luna Co. . . . . *Ashmunella macromphala* (p. 59)

Thysanophoridae

1a Shell 3.8-4.8 mm in width; elevated, with well-developed ribs; brownish periostracum; Lower and Upper Sonoran Life Zones . . . . . . *Thysanophora hornii* (p. 60)

1b Shell 4.5-5.5 mm in width; not elevated; flat with almost no spire; without ribs; whitish to grayish periostracum; Transition and higher Life Zones . . . . . . *Microphysula ingersolli* (p. 61)

Oreohelicidae

1a Embryonic shell of about 1.5 whorls with strongly developed, sharply defined radial riblets; species of the Big Hatchet Mountains area . . . . . . Genus *Radiocentrum* 15

1b Embryonic shell of 2.0-2.5 whorls, with well-developed growth lines, but not with the crisply defined radial riblets of *Radiocentrum* (1a); includes all living New Mexico oreohelicids except those of the Big Hatchet Mountains area . . . . . . Genus *Oreohelix* 2

2a Species found in northern New Mexico north of U.S. Highway 60 or of a line from Clovis to Quemado 3

2b Species found in New Mexico south of U.S. Highway 60 or of a line from Clovis to Quemado 5

3a A species of the Zuñi area in Little Colorado River drainage of extreme western New Mexico . . . *Oreohelix houghi* (p. 46)

3b Not a species of the Zuñi area of western New Mexico 4

4a Shell width usually >17 mm; shell rounded peripherally, usually with 2 well-defined, dark-brown bands; shell surface relatively smooth . . . . . . *Oreohelix strigosa depressa* (p. 41)

4b Shell width usually <17 mm; shell angular peripherally; variously pigmented from whitish to brown (brown blotches, but seldom with 2 brown bands); growth lines strongly developed, producing rough shell surface (See also 6b below, as this species occurs both north and south of U.S. Highway 60.) . . . . . . *Oreohelix neomexicana* (p. 46)

5a Species east of the Rio Grande Valley 6

5b Species west of the Rio Grande Valley 7

6a Shell weakly angular; spire dome-shaped; sutures poorly impressed; occurs in the Sierra Blanca Mountains . . . . . . *Oreohelix nogalensis* (p. 42)

6b Shell sharply angular to carinate; spire comprised of "stair-stepped" whorls with sutures deeply impressed (also includes characters indicated in 4b, above); living in the Oscura, Gallinas, and Manzano Mountains and fossil elsewhere . . . . . . *Oreohelix neomexicana* (p. 46)

7a Shell small, depressed, <7 mm in height; fresh shells with several spiral fringes of cuticular hairs; a species of the Mogollon Mountains in New Mexico . . . . . . *Oreohelix barbata* (p. 47)

7b Shell depressed to elevated, but >7 mm in height; lacking fringes of cuticular hairs 8

8a Species of the San Mateo and Mogollon Mountains and Black Range 9

8b Species not of the above ranges (8a) 12

9a Shell elevated; mature shell over 12 mm in height; rounded to weakly angular peripherally; usually well-developed brown bands present; shell relatively smooth . . . . . . *Oreohelix subrudis* (p. 42)

Most shells keying to 9a will be *O. subrudis*, which occurs in all three ranges noted in 8a, above. However, a poorly known and dubious species *Oreohelix swopei*, with a restricted distribution in the northern Black Range, will key out here, also.

9b Shell depressed, mature shell 12 mm or less in height; body whorl carinate or angular peripherally 10

10a Shell with several distinctive, strongly developed spiral ridges (lirae); species of Mineral Creek drainage in the northern Black Range .... *Oreohelix pilsbryi* (p. 42)

10b Shell without strongly developed spiral ridges 11

11a Shell carinate and with strongly developed growth ridges; pigmentation varied, whitish to brownish (brown blotches or bands may be present) .... subspecies of *Oreohelix metcalfei* of the main Black Range (p. 43)

11b Shell angular and relatively smooth; a brownish band consistently present: subspecies of *Oreohelix metcalfei* of the northeastern foothills of the Black Range .... *O. m. hermosensis* (p. 43) and *O. m. cuchillensis* (p. 44)

12a Species of Socorro and Catron Counties 13

12b Species of Grant and Luna Counties 14

13a A species of the Magdalena Mountains; mature shells ca. 16 mm or less in width; fresh shells light brown with dark-brown bands .... *Oreohelix magdalenae* (p. 45)

13b A species of the southern margin of the San Agustin Plains; mature shells over 16 mm in width, some over 20 mm; fresh shells very light brown with tannish bands .... *Oreohelix litoralis* (p. 45)

14a A species of the eastern Pinos Altos Mountains, Grant Co.; shell moderately depressed and weakly keeled peripherally .... *Oreohelix confragosa* (p. 45)

14b Species of the Florida and Tres Hermanas Mountains and the Sierra Rica, probably extinct in all three ranges; shell moderately elevated, angular peripherally .... *Oreohelix florida* (p. 45)

15a Shell moderately elevated, rounded to moderately angular peripherally, no lirae present .... *Radiocentrum hachetanum* (p. 47)

15b Shell moderately depressed; carinate peripherally with top of the prominent keel still evident as strong ridge bordering older whorls peripherally; 2 or 3 spiral ridges (lirae) usually present on body whorl below keel .... *Radiocentrum ferrissi* (p. 47)

Helminthoglyptidae

With their single, spiral, brown band on a shell background of lighter color, shells of species and subspecies in the genus *Sonorella* greatly resemble each other. Taxonomic discrimination requires dissection and study of features of the genitalia. The key below is based solely on geographic distribution.

1a Species from east of the Rio Grande Valley 2

1b Species from west of the Rio Grande Valley 3

2a A species of the Doña Ana Mountains, Doña Ana Co. .... *Sonorella todseni* (p. 62)

2b A species of the Organ, San Andres, and Oscura Mountains .... *Sonorella orientis* (p. 62)

It is possible that a population of *S. metcalfi*, a species of the Franklin Mountains, El Paso Co., Texas, occurs in the southernmost foothills of the Organ Mountains.

3a Species of the Animas Mountains, southern Hidalgo Co. .... *Sonorella animasensis* (p. 62)

3b Species of mountains of southwestern New Mexico, exclusive of the Animas Mountains . . . . . . *Sonorella hachitana* (p. 61)

The type locality of the nominal subspecies of *S. hachitana* is from Big Hatchet Peak. Other subspecies have been named from the Florida Mountains (*flora*) and Peloncillo Mountains (*peloncillensis*). Sonorellas also have been noted or reported in other mountains (Tres Hermanas, Carrizalillo, and Pyramid), but their taxonomic status has not been ascertained.

ORDER BASOMMATOPHORA
Family Carychiidae
Genus *Carychium*

Carychium exiguum (T. Say, 1822, as *Pupa*). Journal of the Academy of Natural Sciences of Philadelphia, 2:375. T.L. (=Type Locality here and in subsequent accounts): Philadelphia, Pennsylvania. (obese thorn)

General Distribution--The species extends from the maritime provinces of southeastern Canada, westward to Colorado, and southward to New Mexico in the west and Alabama in the east.

New Mexico Distribution--Living specimens have been taken only along the Tularosa River in Otero Co. at the U.S. National Fish Hatchery and 1.2 miles south, near the village of Mescalero, at elevations from ca. 6,650 to 6,800 ft. Pilsbry (1948:1053) reported specimens from stream drift of the Mimbres River near Deming; likely, they were fossil shells.

Habitat--Although a "land snail," *C. exiguum* is a member of the Order Basommatophora, comprising mainly aquatic snails. It prefers damp habitats like those in the marshy area along the Tularosa River near Mescalero. It might be sought in similar habitats elsewhere in New Mexico.

Paleontology--Fossils show that the species occurred previously in the Tularosa Valley at lower altitude to around 5,000 ft, probably until floodplain sediments, along a formerly marshy Tularosa River there, were entrenched in the last century. Ashbaugh and Metcalf found *C. exiguum* in spring-related deposits at Keen Spring in the Tularosa Basin, Otero Co., and near Placitas, Doña Ana Co. (1986:8). Numerous fossils have been recovered from latest Pleistocene alluvial deposits in the foothills of the Manzanita Mountains, southeast of Albuquerque. Several hundred fossil specimens were collected by A. G. Ruthven (UMMZ 69751 and 115838) in Fresnal Canyon at ca. 6,000 ft west of High Rolls, Otero Co. These and other fossil records suggest that the reduction in riparian and marshy wetlands in New Mexico also has reduced greatly the habitat of *Carychium exiguum.*

ORDER STYLOMMATOPHORA
Family Cionellidae (Cochlicopidae)
Genus *Cionella* (*Cochlicopa*)

Cionella (Cochlicopa) lubrica, (O. F. Müller, 1774, as *Helix*). *Vermium terrestrium et fluviatilium, seu animalium infusoriorum, helminthicorum, et testaceorum, non marinorum, succincta historia, Testacea,* p. 104. T.L.: presumed to be in Denmark. (glossy pillar)

Opinions have differed as to whether the generic name *Cochlicopa* Férussac (1821) or *Cionella* Jeffreys (1829) and the derived family names Cochlicopidae or Cionellidae should be employed. At issue has been whether the generic name *Cochlicopa* is valid. The arguments marshalled against its validity by Kennard (1942) seem convincing. They were accepted by Pilsbry (1948:1045-1047), who reluctantly recommended usage of *Cionella* Jeffreys "snatched from the graveyard of synonymy." Bequaert and Miller (1973:193), on the other hand, defended retention of *Cochlicopa.* Both usages have been employed in the American literature of the past 50 years. In the second edition of the listing of common and scientific names of mollusks, Turgeon (in prep.) utilizes *Cionella,* which will, perhaps, resolve the problem and stabilize the nomenclature.

General Distribution--Excluding the southeastern United States and California, *Cionella lubrica* is found from Alaska to northern México, and in the Palearctic region (Europe and northern Asia) as well.

New Mexico Distribution and Habitat--The species is found in forested montane habitats throughout the state, generally above 6,500-ft elevation. It occurs sparingly in forest-deficient mountains, such as the Big Hatchet Mountains, probably finding such habitat marginal.

Family Pupillidae
Genus *Pupilla*

Pupilla blandi, E. S. Morse, 1865. Annals of the Lyceum of Natural History of New York, 8:5, Fig. 8. T.L.: riparian drift of the Missouri River near site of Fort Berthold, McLean Co., North Dakota. (Rocky Mountain column)

General Distribution--This is a snail of the Rocky Mountain region from Trans-Pecos Texas, New Mexico, and Arizona, northward into southern Canada.

New Mexico Distribution--In the western part of the state, *Pupilla blandi* is found in the forested zone of mountains from the Mogollon Mountains and Black Range northward. It is common in all forested mountains of the central part of the state, southeastward to the Sacramento Mountains. In the northeast, it is taken along valleys draining eastward from the Sangre de Cristo Mountains. In the isolated mountains in the northeast, the species is of scattered occurrence, and not as common as *P. muscorum.*

Habitat--Most commonly, *Pupilla blandi* is found higher than 7,000 ft in forested zones of the above mountain ranges. It also occurs at lower elevations along the eastern slopes of the Sangre de Cristo Mountains, in grasslands and bordering stream valleys, as along a small tributary of Cimarron Creek south of Springer.

Paleontology--*Pupilla blandi* is often abundant in Quaternary fossil deposits in New Mexico. Numerous records show that the species flourished at lower elevations at times during the Pleistocene. It is especially common in Pleistocene sediments along the Rio Grande and Pecos River Valleys in the southern part of the state. Ashbaugh and Metcalf (1986) found it a common species in Pleistocene, spring-related deposits near Placitas, Doña Ana Co.; at Keen Spring in the Tularosa Basin; and in Nash Draw, Eddy Co. All these areas are xeric habitats that would be inimical to the species today.

Pupilla muscorum (C. Linnaeus, 1758, as *Turbo*). *Systema Naturae, seu Reyna tria Naturae systematica proposita, per classes, ordines, genera et species,* Edition 10, p. 767. T.L.: Europe, without precise locality given, but holotype from Sweden. (widespread column)

General Distribution--This is a Holarctic species found in Europe and Asia, in North America from Alaska south into the northern conterminous United States, and south to New Mexico and Arizona in the Rocky Mountains.

Variation and New Mexico Distribution--Two forms of *P. muscorum* occur in New Mexico. The larger, more typical form occurs in the higher mountains from the Sierra Blanca Mountains in Lincoln Co. northward to the Sangre de Cristo and San Juan Mountains.

Pilsbry described (1914) a form, *xerobia*, from Duran Butte, immediately south of Duran, Torrance Co. As he noted later (Pilsbry, 1948:935), this "is a small, compact form which I took at one time to be a subspecies . . . . Similar shells occur in numerous Colorado localities, with intermediate sizes connecting with ordinary *muscorum*, so that it is apparently to be regarded as an arid station hunger form rather than a true race." The small *xerobia* form still occurs on Duran Butte and is found from that area discontinuously on mountains and mesas northeastward in New Mexico to Colfax and Union Counties. Its small size is surely not a direct ontogenetic result of unfavorable habitat, as implied in Pilsbry's term "hunger form," but more likely genetically based, because specimens are uniformly small over most of northeastern New Mexico, even including the higher forested elevations of Sierra Grande and Johnson Mesa.

On the basis of the New Mexico material, one could make a case for considering *xerobia* a subspecies of *P. muscorum*. However, as Pilsbry noted above, if similar small forms are found in other regions and have presumably evolved separately in several such regions, then the use of trinomials might lead to unnecessary confusion. Also, with a species having such a broad, Holarctic distribution, it seems especially prudent to be cautious in partitioning the taxon into subspecies.

The small *xerobia* form occurs mainly on isolated mountains and mesas in northeastern New Mexico. In most of this area, at present, there is no possibility of intergrading with populations in the Sangre de Cristo Mountains to the west, because of the intervening lowlands of the Canadian River Valley. In the extreme northern part of the state, however, there seems to be evidence of intergradation in the higher country associated with Raton Mesa and eastward, where *P. muscorum* extends along the basaltic mesas (Hunter Mesa, Mesa de Maya) eastward to Black Mesa in northwestern Cimarron Co., Oklahoma.

Habitat--The larger, more typical form is very much a species of montane forests, mainly in the Canadian Life Zone. It reaches elevations in excess of 10,000 ft. The smaller *xerobia* form occurs in varied habitats from the relatively arid Upper Sonoran Zone represented by Duran Butte, with only sparse pinyon-juniper stands, up to the Transition Zone habitats of Sierra Grande and some of the mesas of the northern borderlands.

Paleontology--In southern New Mexico, *Pupilla muscorum* is common in Pleistocene deposits at elevations lower (at 4,000 to 5,000 ft) than where it occurs today. At times in the Pleistocene, it must have had a much wider distribution. In contrast to its present montane preferences, in Pleistocene deposits a robust form of *P. muscorum* is often associated with marshy and spring-related habitats, as noted by Ashbaugh and Metcalf (1986:11).

Pupilla hebes (C. F. Ancy, 1881, as *Pupa*). Le Naturaliste, 3:389. T.L.: White Pine Co., Nevada. (crestless column)

General Distribution--The species has been reported from the mountains of various western states, except California, and it has been reported also from northern Chihuahua, México. Bequaert and Miller (1973:180-181) recorded it from numerous localities in Arizona where it is widespread. Colorado and New Mexico are on the eastern periphery of its range.

New Mexico Distribution--Pilsbry (1948:936) reported the species from "Magdalena Mt., Socorro Co." Hoff (1962:57) recorded it from Pecos Baldy in Mora Co. at 11,900 ft, and from Lake Peak, Santa Fe Co., at 12,000 ft. He suggested: "The occurrence of this species at high elevations may explain the relatively few records for New Mexico." Our collections from the Magdalena Mountains and Lake Peak have not revealed this species. We have taken specimens from two localities in the Zuñi Mountains in Cibola and McKinley Counties and from two localities in the Shuree Lakes area in the Sangre de Cristo Mountains, Colfax Co. In New Mexico, it seems to occur only in the north-central and northwestern parts of the state, where further collections probably will reveal additional populations.

Habitat--In the Zuñi Mountains, *P. hebes* was taken at elevations of 7,475 ft by D. W. Taylor and by us at 8,000 ft in forested montane habitats. The latter habitat consisted of a lush, wet meadow near Ojo Redondo Spring. It has been collected from similar habitats in the Sangre de Cristo Mountains.

Pupilla syngenes (H. A. Pilsbry, 1890, as *Pupa*). The Nautilus, 4:3, 39, Pl. 1, Fig. 7. T.L.: Arizona, with precise locality not given. (top-heavy column)

General Distribution--This species has been recorded from Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming. Bequaert and Miller (1973:61) regarded it as a representative of their Rocky Mountain Molluscan Province.

New Mexico Distribution and Habitat--Pilsbry (1948:940) recorded *P. syngenes* from San Rafael, Valencia (now Cibola) Co. The collection was made in the 1890s by E. H. Ashmun. We have taken the species at two localities in the Zuñi Mountains.

Our localities are in Zuñi and Bluewater Canyons at 7,200-

ft and 7,150-ft elevations, respectively. In Zuñi Canyon, specimens were found on a north-facing slope of a reentrant of the canyon. The slope was strewn heavily with basaltic talus, and shells were taken from deep leaf litter, mainly of Gambel Oak leaves. The localities are arid--in contrast to the higher montane meadows at Ojo Redondo in the Zuñi Mountains, where *P. hebes* has been collected. The specimens collected in the Zuñi Mountains are the only ones taken in our survey. They are in the size range considered "very long" by Pilsbry (1948:940), the largest reaching a height of 4.2 mm with ca. 10 whorls. It appears that *P. syngenes* is a species more widespread in Arizona, which extends only into the west-central part of New Mexico.

Pupilla sonorana (V. Sterki, 1899, as *Pupa*). The Nautilus, 12:128. T.L.: Whiteoaks, Lincoln Co., New Mexico. (three-tooth column)

General and New Mexico Distribution--*Pupilla sonorana* is a quintessential New Mexican pupillid, as most records are from this state. It occurs in southern mountains, west to east: Big Hatchet, Organ, San Andres, Oscura, Jicarilla, Carrizo, Capitan, Sacramento, and Guadalupe Mountains. The above distribution suggests that it evolved in the mountains surrounding the Tularosa Basin. The species occurs (living) in the Guadalupe Mountains of Texas and as a fossil in the Sierra Diablo and Franklin Mountains of Texas.

Habitat--*Pupilla sonorana* is the only member of its genus in the Big Hatchet, Organ, San Andres, and Jicarilla Mountains, where it occurs from the Upper Sonoran Zone to the mountain tops. In the Oscura Mountains and in the higher mountains east of the Tularosa Basin, it occurs with *P. blandi* mainly in forested habitats of the Transition and Canadian Life Zones. Specimens (UMMZ 109934 and 109936) from the localities listed by Pilsbry (1948:929) from San Miguel and Mora counties do not seem to be *P. sonorana*.

Remarks--In the Sacramento, Capitan, and Carrizo Mountains, where *P. sonorana* and *P. blandi* occur together, their shells are separated rather easily (see key, above). The smaller size and crescentic parietal tooth of *P. sonorana* are distinctive. It seems necessary to emphasize that *P. sonorana* and *P. blandi* are quite distinct species and show no evidence of intergradation, inasmuch as Bequaert and Miller (1973:50) and Fullington (1979:106) suggested that they might be conspecific. Fullington reported *P. blandi* from the Guadalupe Mountains of Texas, but we have not observed it in our collections from that range in either New Mexico or Texas, except as a fossil in Pleistocene hillslope colluvial deposits.

Some shells in one lot of *P. sonorana* observed exhibit whorls that increase in width, dorsally, as in *P. syngenes*, but shells have the denticulation of *P. sonorana*, and are much smaller than shells of *P. syngenes*.

Genus *Pupoides*

Pupoides albilabris (C. B. Adams, 1841, as *Pupa*). American Journal of Science, 40:271. No precise T.L. (white-lip dagger)

General Distribution--Pilsbry noted (1948:923) that *P. albilabris* "occurs in all the states from Arizona and Colorado eastward, but never at high elevations."

New Mexico Distribution and Habitat--*Pupoides albilabris* is widespread in southern and eastern New Mexico, but it is probably underrepresented in collections because of the lack of collecting at lower elevations. *Pupoides albilabris* is one of the few native New Mexico land snails that are tolerant of conditions of the Lower Sonoran Life Zone. In the eastern and southern parts of the state, it also extends into the Upper Sonoran Zone foothills, but is not found at elevations above the Upper Sonoran Zone. *Pupoides albilabris* may be found in brushy areas under stones or in leaf litter. In the southern part of the state, it may occur under stems of dead yuccas and dead, detached caudices of sotol (*Dasylirion*).

Pupoides hordaceus (W. M. Gabb, 1866, as *Pupa*.) American Journal of Conchology, 2:331. T.L.: Fort Grant, at the junction of the San Pedro River and Aravaipa Creek, Pinal Co., Arizona. (ribbed dagger)

Pupoides hordaceus and *P. inornatus* (below) are columnar in shape and have regularly spaced riblets, which are less developed in *P. inornatus*. Shells of *P. hordaceus* are slightly more slender than those of *P. inornatus,* and its aperture is smaller in relation to the rest of the shell. The differences are slight, and it is possible that the two taxa are conspecific and should be treated only as subspecies (in which case, *P. hordaceus*, having priority, would become the specific name). Clear evidence for intergradation is not available. Pilsbry (1948:925-926) allocated specimens from near Las Vegas to both *P. hordaceus* and *P. inornatus*. It is possible that they were drift or fossil shells of different proveniences. Since shells attributable to the two species occur already in the Pleistocene, this argues for retaining them as separate, full species.

In our collections, we have found *P. hordaceus* to be a common fossil in Pleistocene sediments from the eastern foothills of the Guadalupe Mountains westward to southwestern New Mexico. The species is especially characteristic of Pleistocene deposits of the Rio Grande Valley, from Doña Ana Co. northward to Rio Arriba Co.

General Distribution--This species (or subspecies) is probably restricted to Arizona, western Colorado, New Mexico, and Utah.

New Mexico Distribution--In New Mexico, *P. hordaceus* may be characterized as a snail of the Upper Sonoran Zone, ranging from the central New Mexico highlands northwestward.

Habitat--This species has been taken both in broken country and in areas of low gradient in pinyon-juniper woodlands of the Upper Sonoran Life Zone. All localities are in relatively xeric habitats. At Echo Amphitheater, Rio Arriba Co., living specimens were found under dead juniper branches. In other places, they were taken in collections of leaf litter from brushy habitats. Some of our specimens of *P. hordaceus* are shells taken from anthills of *Pogonomyrmex* sp.

Pupoides inornatus E. G. Vanatta, 1915. The Nautilus, 29:95. T.L.: Drift of White River, Washington (now Shannon) Co., South Dakota. (Rocky Mountain dagger)

General Distribution--East of the Rocky Mountains: southwestern South Dakota, eastern Wyoming, western Nebraska, eastern Colorado, and northeastern New Mexico.

New Mexico Distribution--We have taken this species in the high plains of northeastern New Mexico, from near Las Vegas, to the northeastern corner of the state.

Habitat--Our collections are from areas of rocky outcrop, including Cretaceous limestone and the caprock of the Miocene Pliocene Ogallala Formation. Specimens also were found associated with outcrops of Quaternary basalts.

Remarks--We have found Pleistocene fossils of *P. inornatus* from the Pecos River Valley in Chaves Co. and from the eastern slopes of the Sacramento Mountains, indicating that the species ranged farther to the south in times past. These fossil occurrences support recognition of it as a full species, distinct from *P. hordaceus* as discussed above.

Genus *Gastrocopta*
Subgenus *Albinula*

Gastrocopta armifera armifera (T. Say, 1821, as *Pupa*). Journal of the Academy of Natural Sciences of Philadelphia, 2:162. T.L.: Germantown, Pennsylvania. (T.L. selected by Pilsbry, 1948:875). (armed snaggletooth)

Gastrocopta armifera ruidosensis (T.D.A. Cockerell, 1899, as *Bifidaria*). The Nautilus, 13:36. T.L.: Ruidoso, Lincoln Co., New Mexico. (Ruidoso snaggletooth)

This species is a giant among the members of its genus, reaching heights of 4.5 mm. In the typical subspecies, the angulo-parietal is relatively small and exhibits a furrow along the line of fusion of the angular and parietal, the tips of which are unfused and divergent from each other. In *G. a. ruidosensis*, the angulo-parietal is more massive, its two elements show a more intimate fusion, and there are no divergent tips.

As noted by Hubricht (1972:74-76), the columellar denticle is distinctively different in the two subspecies--in *G. a. armifera* resembling "an inverted 'Y', being branched below" while in *G. a. ruidosensis* it "lacks the forward and vertical lobes and the backward lobe is expanded into a broad plate." Hubricht also noted that the shell of *G. a. ruidosensis* is slightly smaller and less ovoid than in the typical subspecies.

Hubricht (1972:75,76) has treated *G. a. ruidosensis* as a full species, noting: "*G. ruidosensis* is found living in a small area in central New Mexico, but occurs as a Pleistocene fossil from western Kansas to central Texas." Hubricht has so mapped *ruidosensis* in his work of 1985 (Map 51), showing it only as a fossil in West Texas. On the other hand, he maps *G. armifera* as a living species in West Texas (Map 44), although of very scattered occurrence. We point out this situation in West Texas because it is the reverse of that prevailing in the Sacramento Mountains of New Mexico, where the living form is *ruidosensis*. All Pleistocene fossils from a number of localities in New Mexico, including the Sacramento Mountains, are ascribable to the typical *armifera* form.

We follow Pilsbry (1948:877) in treating *ruidosensis* as only a subspecies of *G. armifera*.

General Distribution--The species is found in most of the eastern United States, westward to New Mexico and Colorado, and in southern Canada, westward to Alberta.

New Mexico Distribution--The typical subspecies, *G. a. armifera*, is found in northeastern New Mexico. We have found it at various places along the eastern foothills and along the Pecos River Valley in the southern foothills of the Sangre de Cristo Mountains. Specimens collected by T. D. A. Cockerell along "Rocky ledges along the Gallinas River near Las Vegas" (ANSP 79647) in 1900 still had intact epiphragms in 1977. It occurs southward along the Pecos Valley to near Puerto de Luna and along the Cimarron River Valley in the extreme northeastern part of the state.

The subspecies *G. a. ruidosensis* occurs in the Sacramento Mountains, where the type specimen was obtained from an anthill at Ruidoso. Apparently, the subspecies is restricted to this mountain range at present, although, as noted above, Hubricht (1985) mapped fossil records in states east of New Mexico.

Habitat--In northeastern New Mexico, we have found *G. armifera armifera* on brushy hillsides and low scarps bordering river valleys. It has been found in riparian brushy woodland along the Pecos River Valley from near Villanueva to near Puerto de Luna. In the Sacramento Mountains, *G. a. ruidosensis* has been taken at a number of places in the Transition Life Zone along canyons in forested areas. Most of our specimens are from Tularosa and Peñasco Canyons, where we have concentrated our collecting in this range.

Remarks--*Gastrocopta armifera* is one of several species of land snails of more eastern distribution, which extended its range in the Pleistocene (or early Holocene) as far west as Arizona. There are Pleistocene records from central and western New Mexico also.

The most abundant assemblage of fossil *G. a. armifera* that we have seen from New Mexico was collected by Dr. John Appelgarth from an archaeological excavation in the Pecos River Valley, 9 miles NNW of Santa Rosa, Guadalupe Co. These and other fossil specimens indicate that the species must have been especially common along the Pecos Valley in the past.

Gastrocopta contracta (T. Say, 1822, as *Pupa*). Journal of the Academy of Natural Sciences of Philadelphia, 2:374. T.L.: Occoquan, Virginia. (bottleneck snaggletooth)

General Distribution--*Gastrocopta contracta* is distributed generally over the eastern half of the United States, westward to the Plains states. Hubricht (1985:Map 42) mapped it as occurring in Texas, west to Val Verde Co. It has been recorded also from southern Canada and México.

New Mexico Distribution--In New Mexico, this snail is known only from the Guadalupe and Sacramento Mountains. These populations are separated widely from the nearest ones in central Texas and northeastern México.

Gastrocopta contracta has been taken as a Quaternary fossil in southeastern New Mexico (Leonard, Frye, and Glass, 1975) and in Pleistocene deposits in the Guadalupe Mountains of Texas, a few miles from New Mexico. This indicates that the species is not a newcomer to southeastern New Mexico.

Gastrocopta holzingeri (V. Sterki, 1889, as *Pupa*). The Nautilus, 3:37, 96, 119. T.L.: Will Co., Illinois. (lambda snaggletooth)

General Distribution--*Gastrocopta holzingeri* extends from the northern Appalachian region westward to the Plains states and north to Canada. Hubricht (1985:Map 48) mapped it from many counties in Oklahoma, including the Panhandle, and Metcalf (1984a:57) took it in Cimarron Co., Oklahoma, in the westernmost Panhandle; from there its range extends into northeastern New Mexico.

New Mexico Distribution--This species was found living in northeastern New Mexico, mainly along the Cimarron River Canyon and associated mesas in the extreme northern part of the state, on Sierra Grande, and along the Mora River valley on the eastern slope of the Sangre de Cristo Mountains. T. D. A. Cockerell collected it in 1903 in Gallinas Canyon near Las Vegas (ANSP 11617). A specimen (ANSP 83042) is indicated as being collected by E. H. Ashmun in the Oscura Mountains, Socorro Co.

Habitat--In the areas noted above, *G. holzingeri* was found in leaf litter in wooded and brushy areas along canyon walls, and in montane forests as on Sierra Grande.

Paleontology--*Gastrocopta holzingeri* has been taken in Pleistocene deposits along the Rio Grande Valley in Doña Ana Co. indicating that its range extended farther to the southwest in times past.

Subgenus *Vertigopsis*

Gastrocopta pentodon (T. Say, 1822, as *Vertigo*). Journal of the Academy of Natural Sciences of Philadelphia, 2:376. T.L.: Pennsylvania, without precise locality. (comb snaggletooth)

Pilsbry observed (1948:888) that *Gastrocopta pentodon* "is found over a greater area than any other North American *Gastrocopta*." It also appears to be among the most taxonomically troublesome of North American Gastrocoptas, perhaps because of such an extensive range. In 1906, Vanatta and Pilsbry attempted to resolve the problem with a publication that included 53 figures! All attempts show that there is a highly variable taxon (or taxa) involved, which, at one extreme, exhibits larger, more ovoid shells (1.7-2.0 mm x 1.1-1.2 mm) and, at the other extreme, exhibits a more cylindrical, smaller shell (1.5-1.8 mm x 0.8-1.1 mm). Many authors have assigned the smaller, more cylindric shells to *G. pentodon* (Say) and the larger, more ovoid ones to *G. tappaniana* (C. B. Adams). However, W. J. Clench reexamined the types of *G. tappaniana* and selected a lectotype (1965:106) that was of the smaller, more cylindric *pentodon* morphology. Thus, the name *tappaniana* seems unavailable for the more ovoid shells, but no one has started to apply a different name. In his comprehensive work (1985:9), Hubricht retains the name *tappaniana*, using it as a species name. Neck (1990) reports it as a species from the Texas Panhandle.

Bequaert and Miller (1973:89), unlike Hubricht (1985), concluded that the forms *pentodon* and *tappaniana* were two extremes of a continuum across which intergradation was so gradual that no demarcation could be made between two species. They wrote "the senior author reached the conclusion that it is impossible to recognize consistently two biological species," and recognized only *G. pentodon* (which has priority). Ashbaugh and Metcalf (1986:10) followed the recommendation of Bequaert and Miller and assigned all fossil specimens of this complex from some spring-related deposits in southern New Mexico to *pentodon*, although many were definitely of the large, ovoid, shell shape typical of traditional "*tappaniana*."

It may be that the two shell morphologies are related to habitat and that they represent only ecophenotypes. The more ovoid, "*tappaniana*" form is found in damper, often marshy, habitats, whereas *pentodon* is a form of drier habitats. Baker (1939:100-101), who treated the two as separate species, noted that "*Gastrocopta tappaniana* is found beneath pieces of wood, logs, and damp debris in wet places such as floodplains, moist woodlands and swamp edges, while *Gastrocopta pentodon* prefers drier situations."

So far, living representatives of the moisture-loving, more ovoid, larger *"tappaniana"* form have not been found in New Mexico. However, it occurs as a fossil in spring-related Pleistocene deposits in Eddy, Otero, Lincoln, Doña Ana, and Socorro Counties. Further investigation of the few remaining marshy habitats at low elevations may reveal it still to be extant in the state.

The fact that the most slender, cylindrical representatives of the *G. pentodon* spectrum, in size and shell morphology, approach specimens of *Gastrocopta pilsbryana* (V. Sterki) presents another complication. Pilsbry (1948:891) noted similarity in shells of the two species, but separated them on the basis of: 1) fewer denticles (four or five) in *pilsbryana* and often more than five in *pentodon* and 2) the presence of an internal, rimlike callus upon which the teeth of *G. pentodon* are borne, a character supposedly lacking in thin-lipped *G. pilsbryana*. We note, however, that specimens presumably of *G. pilsbryana* from more eastern mountains in New Mexico (Sacramento and Guadalupe Mountains and the isolated mountains of the northeastern part of the state) have a distinct callus and corresponding external crest behind the outer lip, as in the case of *G. pentodon*. We are undecided whether these should be considered a variant of *G. pilsbryana* or whether *pilsbryana* is another variant of *pentodon*. At present, and pending further work, we prefer to retain, conservatively, the name *pilsbryana* for New Mexico montane representatives of this complex, and include living *pentodon* in the state list with a query.

Gastrocopta pilsbryana (V. Sterki, 1890, as *Pupa*). The Nautilus, 3:123. T.L.: "Colorado River," presumably in Arizona. (montane snaggletooth)

General and New Mexico Distribution--*Gastrocopta pilsbryana*, as discussed in the preceding account, is very much a southwestern mountain snail, found mainly in Arizona and New Mexico, extending north into southern Utah and Colorado and south to Chihuahua, México. It occurs throughout New Mexico in forested mountains.

Habitat--*Gastrocopta pilsbryana* occurs at elevations as low as the uppermost Upper Sonoran Zone, as in the relatively arid Big Hatchet Mountains. It extends upward through the Transition and Canadian Life Zones. Pilsbry (1948:891) noted, as we have, that in New Mexico and Arizona "hundreds of specimens can often be obtained by sifting."

Remarks--A subspecies, *G. p. amissidens*, Pilsbry, 1934, was described from Mahan Mountain in Coconino Co., Arizona. It differs from typical *G. pilsbryana* in lacking a basal denticle. Such forms may occur in New Mexico also. As they are not geographically separable, they do not seem to be true subspecies, but simply another variant within populations of this species, whose taxonomic complexities were discussed above, and which ultimately may prove to be a subspecies of *G. pentodon*.

Subgenus *Staurotrema*

Gastrocopta quadridens H. A. Pilsbry, 1916. Manual of Conchology, 24:57, Pl. 10, Figs. 7, 10. T.L.: Capitan Mountains, Lincoln Co., New Mexico. (cross snaggletooth)

General and New Mexico Distribution--Like *G. pilsbryana*, the present species is a snail of southwestern mountains, but it is neither so widespread nor so abundant in collections as is *G. pilsbryana*. It occurs in mountains of eastern and northern Arizona and north into southern Utah. In New Mexico, *G. quadridens* occurs in mountains of the western and central parts of the state from the Sacramento and Mogollon Mountains, northward. The type locality is in the Capitan Mountains, and is one of the southeasternmost records for the species.

Habitat--*Gastrocopta quadridens* is absent from many montane collections in the state and apparently does not occur at all in some mountain ranges within the circumference of its range. Often, when found, it is represented by only a few specimens, although it has proven to be abundant at a few localities. Along Sandia Crest it is a common snail, apparently finding this open-forest habitat with calcareous bedrock especially favorable. In contrast, we found numerous specimens in dense forest in the Capitan Mountains, where the bedrock is igneous.

Remarks--Formerly, *G. quadridens* may have been much more widespread in New Mexico. It has not been found living in the Caballo Mountains, although it is a common fossil in Pleistocene slope deposits. Perhaps it once enjoyed conditions in these mountains of limestone bedrock somewhat similar to those on Sandia Crest where it now flourishes.

Subgenus *Immersidens*

Gastrocopta ashmuni (V. Sterki, 1898, as *Bifidaria*). The Nautilus, 12:49. T.L.: Santa Rita Mountains, Santa Cruz Co., Arizona (T.L. selected by Bequaert and Miller, 1973:159). (sluice snaggletooth)

General and New Mexico Distribution--This southwestern species occurs in New Mexico, Arizona, and Trans-Pecos Texas in the United States and in Chihuahua and Sonora in México (collected at six localities in Sonora by Naranjo-García, 1991:168). In New Mexico, it is preeminently a species of the Upper Sonoran Zone of the southern part of the state. It has been taken as far north as Salinas Peak, Sierra Co.; the San Mateo Mountains, Socorro Co.; and the Zuñi Mountains and Mount Taylor area, Cibola Co. Rev. E. H. Ashmun, himself, collected it near Grants and San Rafael, Cibola Co. (ANSP 47453 and 79459).

Habitat--*Gastrocopta ashmuni* is common in lower, fairly arid mountains, such as the San Andres, Caballo, Florida, and Big Hatchet Mountains. It often occurs together with *Gastrocopta pellucida* (see below) in collections in such mountains. It has been obtained by collecting and searching through leaf litter from under shrubs and trees that occur in lower, arid mountains.

Gastrocopta cochisensis (H. A. Pilsbry and J. H. Ferriss, 1910, as *Bifidaria*). Proceedings of the Academy of Natural Sciences of Philadelphia, 1910:139, Figs. 32, 33. T.L.: Tanner (Garden) Canyon, Huachuca Mountains, Cochise Co., Arizona. (Apache snaggletooth)

General Distribution--This is a snail probably with its center of distribution in México, as it has been reported from Sinaloa, Sonora, and Chihuahua. It also has been reported by Bequaert and Miller (1973:163-164) from numerous stations in southern Arizona, but barely seems to enter New Mexico.

New Mexico Distribution--The only New Mexico records for the species are from the Animas Mountains (Metcalf, 1976). Nine specimens were taken in Indian Creek Canyon and a single specimen from the north slope of Animas Peak. Probably, *G. cochisensis* is fairly common in the Animas Mountains. It seems likely that the species occurs in the Peloncillo Mountains to the west of the Animas Mountains, but, to date, it has not been found in collections from that more arid range.

Habitat--The Indian Creek collection came from leaf litter in a wooded canyon at 5,800-ft elevation. The Animas Peak specimen was taken at 7,300-ft elevation, from soil and leaf litter filling the interstices of igneous rock talus.

Gastrocopta prototypus (H. A. Pilsbry, 1899, as *Bifidaria*). Proceedings of the Academy of Natural Sciences of Philadelphia, 51:400. T.L.: Huingo, near Lago de Cuitzco, 40 km NW of Morelia, Michoacán, México. (Sonoran snaggletooth)

General Distribution--United States specimens of *G. prototypus* were assigned previously to *G. oligobasodon* (Pilsbry and Ferriss, 1910). Bequaert and Miller (1973:164-165) synonymized *G. oligobasodon* with *G. prototypus* of México, where the species is widespread. It has been reported from Michoacán and Jalisco and we have taken it in Durango and Coahuila. It also occurs in Guatemala (Bequaert and Miller, 1973:54-55).Populations in southern Arizona and southwestern New Mexico are on the northern periphery of its range.

New Mexico Distribution--Pilsbry reported (1948:901) "*G. oligobasodon*" only from river drift: along the Mimbres River near Swartz and Deming, and along the Rio Grande near Mesilla. The village of Swartz is in the southern foothills of the Black Range, where *G. prototypus* may occur, although we have not collected it there. Fossils have been found at ca. 5,250-ft elevation along Trujillo Canyon, 4 mi. south of Hillsboro in the southeastern foothills of the Black Range. We have taken it, living, only in the Mogollon Mountains, along Rain Canyon in the southwestern part and along the West Fork of the Gila River in the central part of the range. However, it seems likely that the species occurs in other ranges in southwestern New Mexico.

Habitat--The locality in Rain Canyon is at 5,800-ft elevation. The collection was made in a riparian fringe forest along the creek and at the base of the canyon walls. Specimens occurred in litter, predominantly of oak leaves, from among angular igneous stones. Along the West Fork, Gila River the species also occurred in riparian woods at ca. 5,600 ft.

Gastrocopta dalliana dalliana (V. Sterki, 1898, as *Bifidaria*). The Nautilus, 12:91. T.L.: Ephraim Canyon in Nogales, Santa Cruz Co., Arizona. (shortneck snaggletooth)

General Distribution--*Gastrocopta dalliana* comprises two subspecies, *dalliana* and *bilamellata*, as recognized by Bequaert and Miller (1973:165-169). The species ranges widely in southern Arizona and adjacent Sonora, México, and it has been reported from Chihuahua and Baja California Territorio Sur in México.

New Mexico Distribution and Habitat--In New Mexico, this species has been taken only in Indian Creek Canyon, at 5,900-ft elevation on the northern flank of Animas Peak in Hidalgo Co. Two specimens were taken in leaf litter collected along the wooded canyon.

Subgenus *Gastrocopta*

Gastrocopta procera (A. A. Gould, 1840, as *Pupa*). Boston Journal of Natural History, 3:401; 4:359. T.L.: Baltimore, Maryland. (wing snaggletooth)

General Distribution--*Gastrocopta procera* is found in most of the eastern United States. It is rare in the southeastern states, but widespread in Texas and Oklahoma to the east of New Mexico. According to Bequaert and Miller (1973:170-171), the species probably does not occur as a native, living species in Arizona at this time, although populations of introduced snails have been found. Bequaert and Miller failed to find it as a fossil in Arizona, *in situ*. However, specimens found in river drift in various parts of the state are presumably of fossil provenience, indicating that the species once ranged west to Arizona. *Gastrocopta procera* is, then, one of several species that once extended westward across New Mexico into Arizona, but now extend no farther than central or eastern New Mexico.

New Mexico Distribution--Most records of *G. procera* are from along scarps of the Ogallala Formation in eastern New Mexico, from Eddy Co. northward to Union Co. An isolated population occurs in the Sacramento Mountains, and there is a specimen (UMMZ 67950) indicated as being from the Oscura Mountains, Socorro Co.

Habitat--The areas mentioned above are very different with respect to habitat. The Ogallala scarp is low and arid, supporting mainly forbs, shrubs, and a few small trees such as junipers and oaks. The habitat of *G. procera* in the Sacramento Mountains, on the other hand, is montane forest of the Transition Zone. Specimens have been taken along several canyons in the range. With tolerance of such diverse habitats, it is surprising that the species is not more common at present.

In New Mexico, *G. procera* is more widespread as a Pleistocene fossil than as a living species. There are fossil occurrences in the Rio Grande Valley west of its present range and, as mentioned above, at one time the species probably occurred entirely across New Mexico and into Arizona.

Gastrocopta cristata (H. A. Pilsbry and E. G. Vanatta, 1900, as *Bifidaria procera cristata*). Proceedings of the Academy of Natural Sciences of Philadelphia, 52:595, Pl. 22, Figs. 4, 5. T.L.: Camp Verde, Yavapai Co., Arizona. (crested snaggletooth)

General Distribution--Most records are from the Great Plains and southwestern United States, from Kansas to Texas, and west to Arizona, where Bequaert and Miller (1973:169) found it to be common in the southern half of the state.

New Mexico Distribution--This is a species of lower elevations, usually found along stream valleys. In the Rio Grande Valley, it occurs at least as far north as Sierra Co. (excluding urban records) and fossils have been taken as far north as San Juan Pueblo, Rio Arriba Co. It occurs in southeastern New Mexico in the Pecos River Valley and along Pecos River tributaries such as the Rio Felix. The species was collected in a "cienega at base of Capitan Mountains" by E. H. Ashmun (USNM 152373). The species has been taken at scattered localities in northeastern New Mexico, as along Tramperos and Perico Creeks in Union Co. and along a tributary of Cimarron Creek south of Springer. It also has been taken as a fossil along tributaries of the Canadian River system in San Miguel Co. In southwestern New Mexico it occurs along the lower Gila River Valley of the state.

Habitat--This is, perhaps, the best example of a floodplain species in the New Mexico malacofauna. It occurs under stones or branches in leaf litter in timbered areas. The species often occurs in association with cottonwood groves along the floodplains, but strictly avoids habitats dominated by *Tamarix*, which likely indicates that its habitat has been reduced greatly since introduction of salt cedar.

Perhaps *G. cristata* finds urban habitats in cities along the Rio Grande and Pecos River Valleys similar, or even superior, to its natural habitat. It is common in regularly watered parks and lawns, where there are shrubs to provide shelter and leaf litter.

Gastrocopta pellucida (L. Pfeiffer, 1841, as *Pupa*). *Symbolae ad Historiuim Heliciorum*, i, p. 46. T.L.: Cuba, without more precise locality. (slim snaggletooth)

The species *Gastrocopta pellucida* was described from

Cuba. Pilsbry (1948:913-916) considered that the West Indies representatives belonged to the nominal subspecies, and that "the mainland forms belonged to: 1) *G. p. hordeacella* (Pilsbry, 1890), with type locality designated as New Braunfels, Comal Co., Texas, and 2) *G. p. parvidens* (Sterki, 1899), with type locality at Jerome, Yavapai Co., Arizona. Pilsbry (1948:916) reported *G. p. parvidens* from Pecos River drift at Pecos, San Miguel Co., New Mexico, and from the Jemez Mountains near Valle Grande, Santa Fe Co. Surely, the latter record is in error because this is a snail of low elevations. After studying specimens of these subspecies, Bequaert and Miller concluded (1973:81): "We are unable to separate *pellucida* and *hordeacella*, except by locality, and follow B. A. Branson et al. (1966:149) in synonymizing both *G. p. hordeacella* and *G. p. parvidens* with *G. pellucida*." This recommendation is followed here.

General and New Mexico Distribution--*Gastrocopta pellucida* is a species of the West Indies and southern United States, extending from Florida to California and southward into México.

New Mexico Distribution--It is common in the Lower and Upper Sonoran Life Zones in southern and eastern New Mexico. In the eastern part of the state, it is a typical species along the Ogallala Caprock escarpment.

Habitat--This is one of the few New Mexico species that occur in the Lower Sonoran Zone of the Chihuahuan Desert, where it may be found on slopes and bajadas under shelter such as large stones, fallen yucca stems, or caudices of sotol (*Dasylirion*). It is frequent in the Upper Sonoran Zone of mountains in the southern part of the state. Many specimens were recovered from localities in the San Andres Mountains where *G. pellucida* was the most common species taken in a survey of that range (Metcalf, 1984b). It also was abundant in leaf-litter samples taken in the Big Hatchet Mountains.

Remarks--*Gastrocopta pellucida* is a common fossil in southern and eastern New Mexico, especially in alluvial sediments along the Rio Grande and Pecos River Valleys.

Subfamily Vertigininae

In the literature of recent years, this group may be treated as a family or considered a subfamily, Vertigininae, under the family Pupillidae, as we do here,

Genus *Vertigo*

Vertigo milium (A. A. Gould, 1840, as *Pupa*). Boston Journal of Natural History, 3:402. T.L.: Oak Island, Chelsea, near Boston, Massachusetts. (blade vertigo)

Vertigo milium occurs throughout the eastern United States from Maine to Florida and westward to North Dakota and Texas. In Arizona, Bequaert and Miller (1973:182) cite only two collections as modern records, these made by Pilsbry and Ferriss in the first decade of the century in the Huachuca and Chiricahua Mountains, the latter collection represented by only one shell.

Vertigo milium is not known as living in New Mexico; it is a marsh-associated species that may be found with more systematic searching of such habitats in the state. Ashbaugh and Metcalf (1986:9) found it in deposits associated with Pleistocene springs in Lincoln and Eddy Counties. There are a number of other fossil records of the species in New Mexico.

Vertigo ovata Say, 1822. Journal of the Academy of Natural Sciences of Philadelphia, 2:375. T.L.: Philadelphia, Pennsylvania (selected by H. A. Pilsbry, 1919). (ovate vertigo)

Bequaert and Miller (1973:183) indicated that Say described this species in the genus *Pupa*. In the description it is listed as *P. ovata*, but under the genus *Vertigo*, and another species under the same heading, is listed as *V. pentodon*. It appears that the "*P.*" was simply an error.

General Distribution--*Vertigo ovata* is a widespread species. It occurs in Alaska and much of Canada; and it has been recorded from Maine to Florida, and westward to California and Washington. However, in the Southwest, records are scattered widely, as indicated in maps for Oklahoma and Texas by Hubricht (1985:Map 67). Neck (1990) recorded it living in the Texas Panhandle. Bequaert and Miller (1973:183) recognized only six modern records for Arizona; four of these lots were collected by Pilsbry before 1920.

New Mexico Distribution and Habitat--We have collected live specimens only from the environs of Blue Springs, south of Carlsbad in Eddy Co., but other marshy or spring-brook areas at low elevations may reveal the species. *Vertigo ovata* lives within a few meters of the brook issuing from Blue Springs, where it occurs under shelter of dead tree-branches and on damp soil.

Remarks--The scarcity of records of living populations of *V. ovata* in the Southwest is in marked contrast to the fossil record. In both Arizona and New Mexico, there are numerous records from Pleistocene and Holocene deposits. Ashbaugh and Metcalf (1986:10) found the species in spring-related deposits in Eddy, Lincoln, and Doña Ana Counties. It is especially common in Holocene deposits along the lower Tularosa River, Otero Co., and still may occur along the marshy area that extends a few miles southward from Mescalero.

The reduction in populations of *V. ovata* follows the pattern of several species that were associated with marshy habitats, especially those depending on discharge from springs. Holocene warming, exacerbated in the past century by entrenchment of streamside marshes, drainage of wetlands, and other human developments have reduced greatly the habitat available for such species.

Vertigo gouldii (A. Binney, 1843, as *Pupa*). Proceedings of Boston Society of Natural History, 1:105. No precise T.L. selected. (variable vertigo)

This is the most common species of *Vertigo* in New Mexico. It is highly variable in regard to dentition and, for this reason, several subspecies or variants have been described. Bequaert and Miller (1973) recognized several of these (tooth formula in parentheses): *basidens* (0 angular, 1 parietal, 1 columellar, 1 basal, 2 palatals), *arizonensis* (1 angular, 1 parietal, 1 columellar, 0 basal, 2 palatals), *inserta* (1 angular, 1 parietal, 1 columellar, 1 basal, 2 palatals), and *coloradensis* (0 angular, 1 parietal, 1 columellar, 0 basal and 2 palatals).

It appears that the above forms cannot be regarded as geographically valid subspecies because two or three of them may occur together in a population. Bequaert and Miller observed (1973:184): "Even in our limited experience, a population of *V. gouldii* is seldom in Arizona of one type of teeth." For example, shells of the *inserta*, *arizonensis*, and *basidens* types were taken, all in one collection, from along Eagle Creek in the Sacramento Mountains, New Mexico. We are not employing here the above names for New Mexico material, deeming these variants to be without any clear-cut, cohesive, geographical ranges, and, in many cases, only intrapopulational. Hubricht (1985:11) also treats the taxon only at the species level.

Nevertheless, there are some broad patterns in regard to the different dentitional forms. The *arizonensis* form was indicated by Bequaert and Miller (1973:186) as the most common variant in Arizona, and this is also true for southern and central New Mexico. The majority of shells from New Mexico have an angular and a parietal. The *coloradensis* form, with no angular, is common only in the San Juan and Sangre de Cristo Mountains in the north.

General Distribution--*Vertigo gouldii* is found in two regions at present. As indicated by Hubricht (1985:Map 75), it occurs in the northeastern quadrant of the United States, but it is represented only by fossils in the Great Plains states. It occurs again in the Rocky Mountain states, as a common species. It also occurs in Canada in the southeastern provinces, in the Rocky Mountains, and in northwestern Chihuahua, México.

New Mexico Distribution and Habitat--In New Mexico, *V. gouldii* is widespread, found in the forested zones of most mountains of the state. It is a snail of the Transition and Canadian Life Zones, extending to lower elevations than its congener and common habitat associate, *V. modesta ingersolli*. Conversely, *V. m. ingersolli* gains ascendancy at higher elevations, whereas *gouldii* becomes rarer as elevation increases.

Vertigo modesta ingersolli (T.D.A. Cockerell, 1891, as *Pupa ingersolli*). British Naturalist 1891:101. T.L.: "San Juan District" (=San Juan Co.), Colorado. (cross vertigo)

In revising the Vertigos of Arizona, Bequaert and Miller (1973:189) placed several kinds in the synonymy of *V. modesta ingersolli*. These include 1) *V. concinnula* T.D.A. Cockerell, 1897 (described as *V. coloradensis* form *concinnula*) and 2) *V. m. insculpta* H. A. Pilsbry, 1919.

Pilsbry (1948:989) had considered *V. m. insculpta* to occur in the Black Range of New Mexico, but noted that "there is a certain amount of intergradation" between *V. m. insculpta* and *V. concinnula* in regard to size and length of palatal folds. These were features that he was using to separate the two species. Our observations indicate that there is only one *Vertigo* larger than *V. gouldii* in montane forests of the Black Range. The assignment of Pilsbry's two taxa to *V. m. ingersolli*, as done by Bequaert and Miller, seems to resolve the problem posed by Pilsbry, and to be consonant with observations made in other parts of New Mexico.

General Distribution--In his survey of land snails of the eastern United States, Hubricht (1985:12, Map 76) found no living *V. m. modesta* (Say, 1824) and noted "All of the definite records I have seen are of Pleistocene fossils, but it has been reported from the New England states. A primarily Canadian species." The species *modesta* occurs as far north as Greenland and Alaska and also in northern Asia and Europe. It seems, then, that in the United States the *modesta* complex is found mainly in the western mountain states, extending from Canada south to New Mexico and Arizona. Pilsbry (1948:982) noted this also: "The typical *modesta* replaced in the Rocky Mountain system and California by various weakly differentiated races."

New Mexico Distribution and Habitat--In New Mexico, this species is found in high mountains from the Sacramento Mountains, Black Range, and Mogollon Mountains northward. It does not occur in the uppermost Upper Sonoran Zone as does *V. gouldii*, and prefers habitats from the Upper Transition Zone to the Hudsonian Zone. It is found in forests of these zones in leaf litter of deciduous trees (mainly aspen) and under stones, dead logs, and branches.

Vertigo elatior V. Sterki, 1894 (as *Vertigo ventricosa* var. *elatior*). Eighth Annual Report of the Ohio State Academy of Science, 1900, p. 33. T.L.: Fulton Co., Illinois. (tapered vertigo)

General Distribution--*Vertigo elatior* seems to be widespread in southern Canada, having been reported from British Columbia to Ontario. Its range extends into the northern United States from Maine to North Dakota, and makes an intrusion southward, along the Rocky Mountains into New Mexico. In Arizona, it is known as a Pleistocene fossil.

New Mexico Distribution and Habitat--*Vertigo elatior* is of rare occurrence in New Mexico. It is a species of high montane forests, and we have taken it in the Sacramento, Jemez, Zuñi, and Sangre de Cristo Mountains. It was reported from the Oscura Mountains, Socorro Co., by Pilsbry (1948:956). As a species of more northern affinities, it seems likely that it is in a marginal situation, so far south, and may be something of a Pleistocene relict of scattered occurrence. This argument seems strengthened by the occurrence of fossil shells at lower elevations in southern New Mexico and Arizona. Alison Simcox collected a fine suite of fossil shells of this species in Holocene sediments in the Sacramento Mountains near Cloudcroft.

Vertigo hinkleyi H. A. Pilsbry, 1921. Manual of Conchology, 26:234, Pl. 6, Figs. 12-16. T.L.: Cave Canyon, Huachuca Mountains, Arizona. (heart vertigo)

General and New Mexico Distribution--There are few records of this species. Bequaert and Miller (1973:182) found it in several canyons in the Huachuca and Dos Cabezas Mountains of southeastern Arizona. Pilsbry (1953:164) reported it from the Sierra de la Breña in northwestern Chihuahua, México. Metcalf (1976:410,411) recorded it from two stations in the Animas Mountains, Hildago Co., New Mexico. Thus, the species seems to be of rather circumscribed distribution, unless it is more widespread in México than present records show.

Habitat--*Vertigo hinkleyi* was taken with *Gastrocopta* *cochisensis* (see above) at two localities in the Animas Mountains. Four specimens were taken in leaf litter along Indian Creek Canyon and twelve specimens were taken on the north slope of Animas Peak, in soil and leaf litter that filled interstices of igneous-rock talus.

Genus *Columella*

Columella columella alticola (E. Ingersoll, 1875, as *Pupilla alticola*). Bulletin of the U.S. Geological and Geographical Survey of the Territories, 1:128. T.L.: Cunningham Gulch, San Juan Co., Colorado. (mellow column)

New Mexico Distribution--Pilsbry (1948:1004) reported this species from Willow Creek in the Mogollon Mountains (collected by Ferriss and Daniels) and from La Belle, near Elizabethtown in Taos Co. (collected by Rev. E. H. Ashmun). We have collected this species in widely separated mountains in New Mexico: Sangre de Cristo (Colfax, San Miguel, and Santa Fe Counties), Jemez (Sandoval Co.), Capitan (Lincoln Co.), Sierra Blanca (Lincoln and Otero counties), Salinas Peak (Sierra Co.), and Mogollon (Catron Co.). It was taken in damp leaf-litter in densely wooded, shady ravines of montane forests.

Family Valloniidae

Genus *Vallonia*

Vallonia parvula V. Sterki, 1893. Manual of Conchology, 8:254; Pl. 32, Figs. 23-26. T.L.: Joliet, Illinois. (trumpet vallonia)

General Distribution--Hubricht (1985:Map 28) mapped *V. parvula* as occurring from New York westward to South Dakota and southwestward to Oklahoma and Texas. It is common from Illinois westward to eastern Kansas and Oklahoma.

New Mexico Distribution--*Vallonia parvula* is found only in eastern New Mexico. In the northeastern part, this snail is less common than *V. gracilicosta*, but it has been taken at numerous localities from the eastern foothills of the Sangre de Cristo Mountains, eastward to Oklahoma. An isolated population of living *V. parvula* has been found along the Peñasco River Valley in the eastern foothills of the Sacramento Mountains. This isolated occurrence could be the result of human introduction. However, the following occurrences of *V. parvula* indicate that the species has inhabited the area for a long period of time: 1) a fossil (collected by D. W. Taylor) in Holocene sediments along the Rio Felix, not far to the northeast of the Peñasco Valley locality and 2) as a Pleistocene fossil in spring-related deposits at Nash Draw east of Carlsbad (Ashbaugh and Metcalf, 1986:12). Thus, it seems likely that the Peñasco Valley population is a relict of a previous, more widespread distribution of *V. parvula*.

Habitat--*Vallonia gracilicosta* (see below) has been found in both upland and riparian habitats in Cimarron Co., Oklahoma, and adjacent New Mexico. It was common especially under shrubs along canyon walls and on bluffs. *Vallonia parvula*, on the other hand, showed a preference for riparian habitats, although it extended headward along canyon floors for considerable distances. It showed a similar preference for riparian habitats, westward, where it extends to the foothills of the Sangre de Cristo Mountains.

Vallonia perspectiva V. Sterki, 1893. Manual of Conchology, 8:257, Pl. 33, Figs. 39-45. T.L.: Woodville, Jackson Co., Alabama. (T.L. selected by Pilsbry, 1948:1034.) (thin-lip vallonia)

General Distribution--Hubricht (1985:Map 33) has recorded this species as widely scattered in the eastern United States. There are few records from the southeastern states, although the type locality is in Alabama. The species seems to be more of a southwestern than an eastern element. As Bequaert and Miller (1973:97) wrote, "Its main continuous range is even now in Arizona, New Mexico, and Trans-Pecos Texas, where it lives from 3,500 to 8,700 feet elevation. Elsewhere the records are erratic and somewhat uncertain . . . ."

New Mexico Distribution and Habitat--*Vallonia perspectiva* is more common in the southern and central parts of New Mexico, and less common northward. It occurs widely in mountains in the Upper Sonoran and Transition Zones, tolerating fairly xeric habitats where there is adequate leaf litter, as along canyons and rocky scarps. It is common in such southern mountains as the Big Hatchet, Florida, Organ, and San Andres Mountains and the Black Range. In the Big Hatchet Mountains, it occurs with the less common *Vallonia sonorana* on the north-facing timbered slope below Hacheta Grande.

Vallonia cyclophorella V. Sterki, 1892. The Nautilus, 5:101. T.L.: Westcliffe, Custer Co., Colorado. (silky vallonia)

Vallonia gracilicosta O. Reinhardt, 1883. Sitzungs-Berichte, Gesellschaft Naturforschunde Freunde Berlin, p 42. T.L.: Little Missouri River, North Dakota, probably near Medora, Billings Co., according to Pilsbry (1948:1030). (multirib vallonia)

In regard to general distribution, *V. cyclophorella* and *V. gracilicosta* are mainly western species. As Pilsbry (1948:1036) noted: "*V. cyclophorella* is by far the most generally distributed *Vallonia* of the mountain states." It is confined to the Rocky Mountains westward, except for a few records from the western Dakotas and Texas Panhandle. *Vallonia gracilicosta* is a species more of the eastern foothills region. Of interest is the distributional map of *V. gracilicosta* for the eastern United States, assembled by Hubricht (1985:Map 31) in which numerous fossil localities for the species are indicated for the Plains states and eastward from Kansas to Illinois and Indiana (the prairie peninsula effect?). These records indicate an extensive former range for the species in a region where it no longer occurs. Records of living specimens are mapped for the Northeast (Maine, Massachusetts, and New York) and, after a great hiatus, for Iowa, Minnesota, and the Dakotas. All northern records seem to be those previously ascribed to *V. albula* Sterki, 1893.

Hubricht (1985:7) synonymized *V. albula* with *V. gracilicosta*, which seems a prudent measure. In fact, Pilsbry (1948:1032) wrote: "in the mountain states it is often not easy to decide between *albula* and *gracilicosta* . . ." and "I am leaving some of our lots from Colorado and other mountain states undecided; . . ." Whereas, it seems wise to abandon *albula*, a cautionary note is sounded and a new problem may be broached by Pilsbry's observation in the same paragraph that "*V. albula* is somewhat intermediate between *gracilicosta* and *cyclophorella* . . . ." This opens a question as to whether "*albula*" might represent hybrids or intergrades between two species or subspecies, *gracilicosta* and *cyclophorella*.

Vallonia gracilicosta occurs widely in northeastern New Mexico, where it is probably the most common land snail. In most places, it is associated with broken terrain, as along the Ogallala Caprock escarpment, the Cimarron River Canyon, basaltic flows and basalt-capped mesas, and in all the isolated northeastern mountains. It extends from the Oklahoma State Line to at least the Sangre de Cristo Mountains. Towards the south, the species becomes less widespread and, east of the Sacramento Mountains, it is restricted to a few localities along the Ogalalla Formation scarp, usually on north-facing slopes.

Shells attributable to both *gracilicosta* and *cyclophorella* are widespread in the Sacramento Mountains. Along canyons, *V. gracilicosta* extends to lower, more arid elevations at about 5,400 ft. At higher elevations, *V. gracilicosta* seems to prefer floodplains of the mountain canyons, whereas *V. cyclophorella* is more common on adjacent wooded, often rocky, canyon slopes. Occurrence of these two Vallonias sympatrically in the Sacramento Mountains argues for considering them as separate species rather than subspecies of each other. However, it is possible that they could behave differently elsewhere, as in the north-central mountains where intermediate forms occur in some places, like those that Pilsbry (1948:1032) allocated to *V. albula*. Another population with puzzling, intermediate characteristics occurs in the Big Hatchet Mountains and is treated below as a separate species, *V. sonorana*, for practicality.

West of the Rio Grande Valley occurrences of *V. gracilicosta* seem to be scattered. To the north, *V. gracilicosta* occurs in the Zuñi Mountains and Mount Taylor areas and along stream valleys in extreme northern San Juan Co. (Los Pinos, Animas, and La Plata Rivers). Southward, populations have been found in the valley of the Gila River.

Paleontology--*Vallonia gracilicosta* occurs as a Pleistocene fossil westward across the southern part of New Mexico and into Arizona, where Bequaert and Miller (1973:193) reported it as a fossil, but not living. It seems to have become extinct in the former western part of its range during the Holocene. *Vallonia cyclophorella*, by contrast, is a widespread living species in Arizona.

> ***Vallonia sonorana*** H. A. Pilsbry, 1915. Proceedings of the Academy of Natural Sciences of Philadelphia, 67:345, Fig. 5. T.L.: Summit of Big Hatchet Mountain (=Hacheta Grande), Hidalgo Co., New Mexico.

Vallonia sonorana has had a checkered taxonomic career. Pilsbry and Daniels collected it in the Big Hatchet Mountains on an expedition in 1910. Pilsbry (1915) later described the species. In his 1948 monograph (p. 1033), Pilsbry relegated *V. sonorana* to the synonymy of *V. albula*, discussed above. As construed by Pilsbry, *V. albula* appeared to have something of an intermediate morphology between that of *V. cyclophorella* and *V. gracilicosta*, which also seemed to be the case with *V. sonorana*. It is in the size range of these two species. As shown in Pilsbry's (1948: Fig. 552) illustrations, some specimens exhibit the thin lip characteristic of *V. cyclophorella* and others, the thickened lip of *V. gracilicosta*. Our specimens tend more toward the *cyclophorella* thinner-lip form.

Bequaert and Miller (1973:63) assigned *V. sonorana* to the synonymy of *V. gracilicosta*. This may prove to be the most judicious allocation, especially because *V. gracilicosta* occurs as a fossil in the area of the Big Hatchet Mountains. Numerous fossil specimens, for example, have been taken in Pleistocene deposits of U-Bar Cave, south of the Big Hatchets, and from the Little Hatchet Mountains to the northwest.

Because of its puzzling intermediacy between *cyclophorella* and *gracilicosta*, we elect to retain the species in *V. sonorana*, where originally placed, until its status becomes clearer.

New Mexico Distribution and Habitat--This species is known only from the Big Hatchet Mountains. Pilsbry and Daniels took it from the summit of Hacheta Grande. We have taken it at several localities at the base of cliffs on the north face of Hatcheta Grande, where it was found in leaf litter mainly of Gambel Oak and in a mountainside woodland of oak and tall pinyons and juniper. The habitat is rather xeric and is assignable to the Upper Sonoran Life Zone.

Family Urocoptidae

In his monograph of 1946, Pilsbry retained all species in the family Urocoptidae from the United States in the genus *Holospira*, while designating several subgenera. Subsequent authors have been more inclined to elevate these and other subgenera to generic rank. Herein, we have followed the recommendations of Thompson (1974, 1988) in regard to generic and subgeneric rankings.

Genus *Metastoma*

> ***Metastoma roemeri*** (L. Pfeiffer, 1848, as *Cylindrella*). *Monographia Heliceorum viventium sistens descriptiones systematicas et criticas omnium huius familiae generum et specierum hodie cognitarum*, 2:382. T.L.: Near New Braunfels, Comal Co., Texas. (distorted metastoma)

General Distribution--*Metastoma roemeri* is the only urocoptid occurring in New Mexico that is not a local endemic. Its range extends from the Balcones Escarpment area of Texas westward to the Hueco and Franklin Mountains, El Paso Co., and into southern New Mexico.

New Mexico Distribution--*Metastoma roemeri* occurs in some mountains of southern New Mexico east of the Rio Grande Valley. The westernmost records are from the San Andres Mountains. It also may occur in the northern prolongation of the Franklin Mountains into southern Doña Ana Co., New Mexico, because it is found in this range a short distance south in Texas. It has been taken in fossil form in probable Pleistocene sediments excavated from Conkling's Cave on the east side of

Bishops Cap Mountain, a few miles to the north of the northernmost Franklin Mountains. It occurs in the southwestern part of the Sacramento Mountains in canyons leading into the Tularosa Basin. Pilsbry (1946:115) reported the species from Alamo Canyon, and we have taken it in Dog Canyon. Pilsbry (1946:115) also reported it from the Guadalupe Mountains, New Mexico; however, this locality seems to be just south of the Texas State Line (Hoff, 1961; Metcalf, 1970:35). We have, nevertheless, taken *M. roemeri* in the Guadalupe Mountains in New Mexico, where it occurs northward at least to the Carlsbad Cavern area.

Habitat--All the above records are from mountains of calcareous bedrock, especially where there are massive limestone outcrops. The species is an obligate calciphile, not found in areas of igneous rock. It tolerates the uppermost Lower Sonoran Life Zone, but probably is more a denizen of the Upper Sonoran. Generally, it is found in lower, arid mountains or in the foothills of higher ranges, as in the case of the Sacramento and Guadalupe Mountains. In both ranges, it seems to be found most commonly along brushy canyon walls--occurring under stones, dead yucca stems, dead caudices of sotol, and also in accumulations of limestone talus.

The remaining urocoptids of New Mexico are narrowly endemic, being confined to a single mountain range or adjacent ranges.

Genus Holospira
Subgenus *Bostrichocentrum*

Holospira montivaga H. A. Pilsbry, 1946. Academy of Natural Sciences of Philadelphia Monograph, 3(II) 1:123 Fig. 61. T.L.: given as southeast of Orange, Otero Co., New Mexico, but the type locality actually seems to be just south of the state line in Culberson Co., Texas. (vagabond holospira)

General and New Mexico Distribution--This species is restricted to the Guadalupe Mountains of Texas and New Mexico. Pilsbry and Ferriss collected the type while exploring the western flank of the range along the New Mexico-Texas border in 1922, but the type locality is apparently on the Texas side of the state line (Hoff, 1961:54; Metcalf, 1970:35; Wahl and Metcalf, 1982:43). We have taken the species in Black and Devil's Den Canyons in the Guadalupe Mountains, New Mexico.

Habitat--The type locality is on the fairly exposed, arid, western slope of the Guadalupe Mountains. The species occurs in such habitats and also in the more mesic, higher parts of the range, especially in wooded canyons. Living specimens were found along ledges on the walls of Devil's Den Canyon at ca. 6,950 ft among ponderosa and pinyon pines and Gambel and live oaks.

Remarks--Several other species of *Holospira* and a subspecies "form" of *H. montivaga* (*H. m. brevoria* Pilsbry, 1946) have been described from the Guadalupe Mountains in Texas. Fullington (1979:98) suggested that these taxa "probably should be synonymized under the earliest named *H. m. montivaga*." We follow his recommendation here in regard to variants in this complex found in New Mexico.

Holospira cockerelli W. H. Dall 1897. The Nautilus, 11:61. T.L.: drift debris of Rio Grande at Mesilla, Doña Ana Co., New Mexico. (Cockerell holospira)

Considered as synonym of the above: *Holospira regis* Pilsbry and Cockerell, 1905. Proceedings of the Academy of Natural Sciences of Philadelphia, 57:218, Pl. 26, Fig. 7. T.L.: near Kingston, Sierra Co., New Mexico.

The type of *H. cockerelli* was taken from Rio Grande drift at Mesilla, Doña Ana Co. Pilsbry (1946:126) supposed that "Probably the type specimen, found in flood-débris of the Rio Grande, was washed down from the region around Kingston or northward, where the species is abundant." This is a reasonable assumption, because there is no other known source for a *Holospira* upstream from Mesilla. However, the riverine journey is long--some 80 miles along the approximate course of the streams from Kingston to Mesilla.

With *H. cockerelli*, then, the type locality is known, but it is outside the range of the species as subsequently understood. With *H. regis*, on the other hand, the type locality is vague, being given as "near Kingston." Our own searching along the Percha Creek Valley in which Kingston is situated has not revealed any Holospiras, but a few specimens were found along Carbonate Creek, about 3 miles north of Kingston.

Pilsbry (1946:125-126) recorded *H. regis* only from the type lot, but reported *H. cockerelli* from several localities along the eastern side of the Black Range from "near Kingston" northward to the Cuchillo Mountains. Apparently, he detected little difference between the two species, noting only that "*H. cockerelli* differs from the related *H. regis* chiefly by the smoothness of the intermediate whorls." We find this character to be variable within populations. Given the minor differences between the two taxa, reports of both species as occurring "near Kingston," and the fact that the name *H. cockerelli* has priority, it seems that the case for recognizing *H. regis* as a separate species is weak, and we treat it here as a synonym of *H. cockerelli.*

Distribution and Habitat--As an obligate calciphile, *H. cockerelli* is found only in the eastern foothills complex of the Black Range, where limestone and other calcareous rocks occur. Its northernmost known record is in the Cuchillo Mountains, a small arid range east of the Black Range. There are limestone cliffs in the southern part of the Cuchillo range, where J. H. Ferriss collected *H. cockerelli* in 1915. Pilsbry and Ferriss also collected *H. cockerelli* farther south near Hermosa in the Palomas Creek Valley. We found it fairly common there at several sites along canyon walls, well timbered with pine and oak. Probably *H. cockerelli* occurs in other areas of calcareous bedrock in the Black Range foothills between recorded localities in the Palomas and Carbonate Creek Valleys.

Holospira crossei W. H. Dall, 1895. Proceedings of the U.S. National Museum, 18:4. T.L.: top of Hacheta Grande, Big Hatchet Mountains, Hidalgo Co., New Mexico. (Cross holospira).

Considered as a synonym of the above: *H. bilamellata* Dall, 1895. Proceedings of the U.S. National Museum, 18:4. T.L.: Big Hatchet Mountains, Hidalgo Co., New Mexico, with several "forms" listed and discussed in Pilsbry (1946:129-134).

Dr. Edgar A. Mearns collected Holospiras in the Big Hatchet Mountains during his 1892 survey of the United States - México boundary. His party used a burro pack-train to ascend Hacheta Grande, highest peak in the range, from an easterly direction. In 1910, H. A. Pilsbry and L. E. Daniels spent a week in the Big Hatchets, greatly augmenting the number of museum specimens of Holospiras from that range. Pilsbry noted (1946:128) that several thousand shells were collected.

Pilsbry (1915:334-344) devoted considerable study to the Holospiras that had been collected in the Big Hatchets by the above expeditions. He named several new forms in his publication, indicated above, and noted on p. 128 of his 1946 monograph that "The Hacheta holospiras belong, if we accept the criterion of intergradation, to only one species, for which the prior name is *H. crossei*. Between this species and *H. bilamellata* there is a perfect series of intergrades in size, sculpture and number of whorls . . . ." He noted that variation was great among populations in different parts of the range, but that intergrades also were found involving these variants. Pilsbry settled on recognizing two species, *crossei* and *bilamellata*. It appears that these were the two extremes of the spectrum of variation, discussed above, since he noted (1946:128): "For our present purpose we consider the smallest form (*crossei*) and the largest (*bilamellata*) as species, ranking the others as subspecies, though in some cases they are more distinct than these two are from one another."

It seems clear that Pilsbry realized that he was dealing with morphological variants and not with discrete noninterbreeding species, or even with geographically identifiable subspecies. The assignment of names to such morphologically distinguishable forms may, of course, be useful in an informal context, but hardly advisable from a formal, biosystematic point of view. From that standpoint, it seems best to assign the Big Hatchet Holospiras to the single species, *H. crossei*, which has line priority over *H. bilamellata*. In our collections from the Big Hatchets, we, too, have been impressed by the exhibited pattern of diversity, and, like Pilsbry, note that within populations there are intermediates between smallest and largest specimens.

Distribution--As indicated above, *H. crossei* is an endemic of the Big Hatchet Mountains complex. Its range extends southward along a series of lower, linear, limestone hills to a small isolated mountain west of the northern end of the Alamo Hueco Mountains. In 1985, living specimens were taken in limestone talus on the north-facing slope of this mountain (NE 1/4, sec. 36, T32S, R16W).

Habitat--In higher reaches of the Big Hatchet Mountains, Holospiras are very common, where, as noted above, Pilsbry and Daniels collected several thousand specimens. This could be done today, as well. During a November 1988 visit, we were impressed by the large number of empty shells present along the northern cliff face of Hacheta Grande. *Holospira crossei* lives both on wooded slopes and in exposed locations. This latter tolerance is reflected in two of the subspecific names used by Pilsbry for Big Hatchet Holospiras: *heliophila* and *insolita*.

Holospira metcalfi F. G. Thompson, 1974. Southwestern Naturalist, 19:53, Fig. 1. T.L.: Howells Ridge, Little Hatchet Mountains, Grant Co., New Mexico. (Metcalf holospira)

In his description (1974) of this species, Thompson stressed that the species was related closely to the *Holospira* complex of the Big Hatchet Mountains, which are located to the southeast of the Little Hatchets. In comparing the present species with *Holospira bilamellata*, (considered a synonym of *H. crossei* in the preceding account, of the Big Hatchets, he noted:

> They are similar in most aspects, but differ conspicuously in shape, the depth of the suture and the contour of the whorls. They are allopatric in distribution. The limestone outcrops occupied by the two species are interrupted by igneous intrusions and alluvial deposits which are ecologically intolerable to species of this subfamily. Because of the isolation of the two taxa from each other and because of the absence of intergrading populations, I treat them as separate species though their interrelationship is close.

Distribution and Habitat--*Holospira metcalfi* has a very limited range, being endemic to Howells Ridge at the northern end of the Little Hatchet Mountains. Since much of the Little Hatchet range is of igneous bedrock, the habitat would be inimical to this calciphile elsewhere in the range. Howells Ridge is a southeast-northwest linear escarpment, about 6 miles long and less than 1 mile wide. The base of the range is about 5,000 ft in elevation and about 5,700 ft at the summit. Most of the ridge is capped by a massive, marine-reef limestone of the U-Bar Formation of Lower Cretaceous age. Cliffs of this limestone commonly reach heights of 60-80 ft along the crest of the ridge. The habitat was discussed by Metcalf and Smartt (1974:58-59) as follows:

> Snails were found mainly under large stones at the base of the cliffs, especially in areas that supported what seemed to be a slightly more mesic vegetation. That is, in contrast to the sparsely vegetated lower slopes of the ridge, the areas directly below the cliffs supported a few small trees and shrubs:. . . . A few mosses and ferns occurred and grasses and herbaceous plants were more numerous in a narrow zone immediately below the cliffs. The U Bar Cliffs are perpendicular and reach heights of 60-80 feet. The area along the northeastern base of the cliffs is, consequently, shaded for much of the afternoon. Possibly water from summer freshets spills down the bare rock to water the area below.

Populations of *H. metcalfi* were limited to the narrow, slightly more mesic strip just below the cliffs. Living specimens often occurred in aggregations of from three to ten individuals under and around the edges of large stones, and were taken at three localities.

Remarks--*Holospira metcalfi*, insofar as is known, is restricted to the very narrow area at the base of the U-Bar limestone cliffs, discussed above, along a few miles of Howells

Ridge. The precarious nature of the population was emphasized in the title of our 1974 paper: "Gastropods of Howells Ridge, Grant Co., New Mexico: a fauna in the process of extinction?".

Genus *Coelostemma*

Coelostemma (Goniapex) pyrgonasta F. G. Thompson, 1988. Bulletin of the Florida State Museum, Biological Sciences, 33:92 Figs. 12-14. T.L.: Bishops Cap Mountain, Doña Ana Co., New Mexico. (bishop tubeshell)

Thompson (1988) placed this species in a genus formerly known in México, but new to the United States. The species is endemic to Bishops Cap Mountain, a pyramidal peak located between Las Cruces in Doña Ana Co., New Mexico, and El Paso, Texas. It can be seen as a salient feature a few miles to the east of Interstate Highway 10. Specimens of *C. pyrgonasta* have been found in the eastern, western, and northern parts of the mountain; thus they seem to be distributed widely in this small range. Bishops Cap is a low, arid mountain, reaching 5,419 ft in elevation. The vegetation consists of xeric-adapted species of the Chihuahuan Desert, predominantly creosote bush. Specimens of this species were found under limestone blocks below cliffs. Metcalf was with Dr. Fred G. Thompson when the types were collected and learned that this urocoptid apparently prefers to live under large stones, which required his strength and skill to lift. Living specimens were scattered in occurrence, not concentrated in small pockets as was the case with *H. metcalfi* on Howells Ridge, discussed above. The area occupied by *C. pyrogonasta* is greater than that occupied by *H. metcalfi*, but is nevertheless quite small--only about 3 or 4 square miles.

Family Bulimulidae
Genus *Rabdotus*

Rabdotus dealbatus neomexicanus (H. A. Pilsbry, 1946, as *Bulimulus*). Academy of Natural Sciences of Philadelphia Monograph, 3(II)1:13, Fig. 4:e,f. T.L.: at Burke's (=Burke) Spring, west slope of San Andreas (=Andres) Mountains, Doña Ana Co., New Mexico. (whitewashed rabdotus)

Taxonomically, the situation with this species is complex in the area treated here. Pilsbry (1946:13,19) considered that two bulimulid species existed in southern New Mexico: 1) *Bulimulus pasonis* Pilsbry, with type locality in the Franklin Mountains, Texas, which he recognized also from the Sacramento and Guadalupe Mountains of southern New Mexico and adjacent Texas, and 2) *Bulimulus dealbatus neomexicanus* Pilsbry, a subspecies of the widespread species, *B. dealbatus*, which ranges from Kansas southward into México. Pilsbry designated the type locality of *neomexicanus* as Burke's Spring (environs) in the San Andres Mountains and reported it also from the Sacramento and Guadalupe Mountains. As represented in the above mountain ranges, shells of the two taxa differ greatly, *B. d. neomexicanus* being more robust and thick-shelled, reaching some 30 mm in height and 19 mm in width, whereas *B. pasonis* is a more gracile form, reaching only about 17 mm in height and 9 mm in width.

In a revision of some North American bulimulids, Pratt (1974:24-25) elevated the subgenus *Rabdotus* to generic status. He also synonymized *B. pasonis* Pilsbry with *B. durangoanus* (von Martens), with type locality in Durango, México. He relegated *durangoanus* to subspecific status under *B. dealbatus*, noting that the two kinds intergraded in places in Texas and México. In addition, he deemed the subspecies *neomexicanus* as not sufficiently different from the nominal subspecies to require recognition. Thus, in the point of view of Pratt's report, the two kinds of bulimulids in the San Andres, Sacramento, and Guadalupe Mountains become *Rabdotus dealbatus dealbatus* (Say) and *R. dealbatus durangoanus* (von Martens). This creates an unusual situation in which two subspecies of *R. dealbatus* coexist in the three ranges without intergradation, which is an awkward, although not impossible, state of affairs. Because of a seeming lack of detailed information about the supposed intergradation between the *durangoanus* and *dealbatus* forms in México, we will retain, conservatively, the name used by Pilsbry for the large form in New Mexico: *R. d. neomexicanus*, and treat *R. durangoanus* as a full species.

General and New Mexico Distribution--The species *R. dealbatus* is found in the south-central United States: east to Alabama, Tennessee, and Kentucky; north to Kansas and Missouri; west to New Mexico; and it also occurs in northern México. The subspecies, *R. d. neomexicanus*, as recognized here, is restricted to southern New Mexico and the Guadalupe Mountains of Texas. It might be sought in the Delaware Mountains of Texas, as well. In New Mexico, this subspecies is found in the San Andres, Sacramento, and Guadalupe Mountains.

Habitat--This subspecies is found only in areas of calcareous bedrock. It occurs widely in the San Andres Mountains south of the igneous-rock area in the Salinas Peak complex. However, in the extreme southern end of the range, it is replaced by *R. durangoanus*. It also occurs to the east in the Oscura Mountains. In the Sacramento Mountains, *R. d. neomexicanus* occurs on the eastern slope and up to about 7,650 ft in the central part of the range. It is replaced by *R. durangoanus* on the southwestern slopes of the range, as in Dog Canyon. Similarly, in the Guadalupe Mountains, the larger *R. d. neomexicanus* is more widespread and *R. durangoanus* is restricted to slopes of the western part of the range.

Paleontology--Fossil specimens of this species have been found at several localities in Pleistocene sediments along canyons in the Sacramento Mountains. They closely resemble those in populations inhabiting the mountains today, indicating that the species has been there for a long period of time. Slightly to the west of the presently known range of the species, Metcalf (1967:47) reported a few poorly preserved specimens of a *Rabdotus* from Pleistocene sediments in the foothills of the Robledo Mountains, north of Las Cruces, Doña Ana Co., New Mexico. Tentatively, these specimens were assigned to *R. dealbatus*..

Rabdotus durangoanus (E. von Martens, 1893, as *Bulimulus*). *Biologia Centrali-Americana*, p. 246, Pl. 15, Fig. 11, 11a. T.L.: Villa Lerdo, State of Durango, México.

General Distribution--The distributional center for *R. durangoanus* seems to be in northern México. The type locality is in the State of Durango, where we have collected it. Also, it occurs in some low mountain ranges with calcareous bedrock to the south of Ciudad Juárez, Chihuahua, and in the Juárez Mountains themselves. It occurs in the Franklin Mountains, El Paso Co., Texas, and specimens from there were described as *Bulimulus pasonis* by Pilsbry (1946).

New Mexico Distribution--In New Mexico, we have taken this species in the Howells Ridge portion of the Little Hatchet Mountains. After a considerable hiatus, it occurs again in the southernmost San Andres Mountains. Across the Tularosa Basin, it occurs in the southwestern part of the Sacramento Mountains. It probably occurs in the southwestern part of the Guadalupe Mountains in New Mexico, but records so far have been only from nearby Texas.

Habitat--In all the above New Mexico habitats, *R. durangoanus* is definitely an inhabitant of the Upper Sonoran Zone and has not been found in the Transition Zone, in contrast to *R. dealbatus neomexicanus*. It tolerates xeric conditions. Our records are from along canyon walls or fairly steep foothill slopes of the mountains noted above. In such habitat, specimens have been found in limestone talus or under dead yucca stems and dead caudices of sotol, where they are sometimes attached to the underside of a stone or attached to plant material.

Family Punctidae

The family Punctidae and the following three families have been included often in the family Endodontidae. We follow Solem (1983:47), who elevated several subfamilies of the Endodontidae to family status.

Genus *Punctum*

This genus contains the smallest discoid snails in the New Mexico land-snail fauna. Adult shells generally range in diameter from 1.1 to 2.2 mm. The taxonomic allocation of these minute gastropods is difficult and our identifications, below, are tentative.

> ***Punctum minutissimum*** (I. Lea, 1841, as *Helix*). Transactions of the American Philosophical Society 9:17. T.L.: vicinity of Cincinnati, Ohio. (small spot)

A minute *Punctum* widespread in the higher mountains of New Mexico clearly belongs to the *P. minutissimum* group of Pilsbry (1948:644). This group comprises *P. blandinum* of Tennessee, *P. minutissimum* of the eastern United States, *P. californicum* of the western United States, and *P. randolphi* of the Pacific Northwest. New Mexico is located in an intermediate zone in which some malacologists have assigned the local minute *Punctum* to *minutissimum* and others to *californicum*. Baker (1930:9) reported a *Punctum* from the Sacramento Mountains as being very close to *minutissimum*. On the other hand, J. C. Bequaert (pers. comm.) considered specimens found in the Guadalupe Mountains of Texas, a few miles from New Mexico, to pertain to *P. californicum*; and Bequaert and Miller (1973:81) considered only *californicum*, of this group, to be living in Arizona. Our observations indicate that the minute *Punctum* of New Mexico is of the same species as the one in Arizona. It is, in fact, similar to the specimen illustrated by Pilsbry (1948:Fig. 355) as *P. californicum*, from the Dragoon Mountains of southeastern Arizona. Dr. Barry Roth, who is studying Punctums of the west-coast states, has suggested (in litt., 23 June 1990), however, that the specimen noted from the Dragoon Mountains appears different from *P. californicum* of California and that it may be a new or, at least, different species. Given this considerable uncertainty, we conservatively assign the New Mexico material to *P. minutissimum*, indicating that it is, at least, in the *minutissimum* group of Pilsbry (1948:644).

Genus *Paralaoma*

> ***Paralaoma caputspinulae*** (L. A. Reeve, 1852, as *Helix*). *Conchologia Iconica,* Vol. 7. T.L.: New Zealand. (pinhead spot)

This species has been assigned to various taxa in the literature. It long ago was allocated to *Punctum conspectum* (Bland, 1865). Roth (1985, 1986) referred it to *Punctum (Toltecia) pusillum* (Lowe, 1831), but later (1987b:95-96) transferred it to *Paralaoma caputspinulae* (Reeve, 1852). In New Mexico, *P. caputspinulae* is common in Three Rivers Canyon on the west side of Sierra Blanca Peak, Lincoln Co., where the species is found along a creek in rich leaf litter under heavy shade of a well-developed riparian forest. Elsewhere in our survey, it has been found only at 8,400 ft on the west side of Lake Peak in the Sangre de Cristo Mountains, Santa Fe Co. This distributional pattern is puzzling. Although Pilsbry (1948:652) recorded *Punctum conspectum* from Willow Creek in the Mogollon Mountains, Catron Co., we have not found it in that area. Bequaert and Miller (1973:153) listed *Punctum conspectum* for Arizona, only on the basis of literature citations that recorded it from the southeastern and from several mountains in the northeastern parts of the state.

Family Charopidae

Genus *Radiodiscus*

> ***Radiodiscus millecostatus*** H. A. Pilsbry and J. H. Ferriss, 1906. Proceedings of the Academy of Natural Sciences of Philadelphia, 58:154, Fig. 10. T.L.: Carr Canyon, Huachuca Mountains, Cochise Co., Arizona. (ribbed pinwheel)

Although records are scattered, it seems that the center of distribution for *Radiodiscus millecostatus* is in México, where it has been reported as far south as Michoacán and Tamaulipas. It occurs in Chihuahua, and we have collected specimens in Coahuila. It appears that New Mexico and Arizona are on the northern periphery of the range of this species. In New Mexico Pilsbry (1948:657) reported *R. millecostatus* from Willow Creek in the Mogollon Mountains, Catron Co., in which range we also took it in leaf litter from 7,200- to 9,650-ft elevation. In the Magdalena Mountains, we took it near the summit at 10,280 ft in aspen forest. In the Sacramento-Sierra Blanca complex, we collected it along canyons from 6,800 to 10,800 ft.

Family Helicodiscidae
Genus *Helicodiscus*
Subgenus *Helicodiscus*

Helicodiscus eigenmanni H. A. Pilsbry, 1900. The Nautilus, 14:41. T.L.: Beaver Cave, near San Marcos, Comal Co., Texas. (Mexican coil)

Helicodiscus eigenmanni bears considerable resemblance to *H. parallelus* (Say, 1817). Bequaert and Miller (1973:152) speculated that perhaps *H. eigenmanni* is only a southwestern subspecies of *H. parallelus*. Pilsbry (1948:630), on the other hand, championed a specific status for *H. eigenmanni*, noting: "This fine species is easily recognized by its large size, the shell in all stages of growth being much more robust than *H. parallelus*." Hubricht (1985:Maps 180,185) treated *H. eigenmanni* and *H. parallelus* as distinct species and mapped them as allopatric to each other. In Texas, he showed *H. eigenmanni* as occurring in the central and western parts of the state and *H. paralellus* only in some easternmost counties. To the west, *H. eigenmanni* extends to Arizona and also into northern México.

New Mexico Distribution and Habitat--In New Mexico, *H. eigenmanni* is widespread, found in mountains throughout the state, mainly in the Upper Sonoran and Transition Life Zones. It occurs in rocky areas in foothills and lower elevations of mountains, where there is some development of woodlands sufficient to produce leaf litter in which specimens commonly are ensconced. It is found consistently in leaf litter from the elevations noted, but only in low numbers, typically comprising less than 5% of specimens taken in a collection.

Subgenus *Hebetodiscus*

Helicodiscus singleyanus (H. A. Pilsbry, 1889, as *Zonites*). Proceedings of the Academy of Natural Sciences of Philadelphia, 41:84. T.L.: New Braunfels, Comal Co., Texas. (smooth coil)

Seddon and Holyoak (1993:329) noted that *Helicodiscus scintilla* Lowe, 1852, is a senior synonym of *H. singleyanus*, and recommended that the case should be referred to the International Commission on Zoological Nomenclature, with a view to preserving use of the name *singleyanus*.

Helicodiscus singleyanus is one of several small species in the genus *Helicodiscus* that are confusingly similar to each other; it is possible that more than one occur in New Mexico. Hubricht, who has studied this genus extensively, mapped (1985) three other members of the genus as living in Texas. Hubricht also mapped (Map 179) *H. singleyanus* as occurring both living and fossil across Texas and into southeastern New Mexico, with other records to the east of Texas.

New Mexico Distribution and Habitat--*Helicodiscus singleyanus* has been taken at lower elevations in the southern and eastern parts of New Mexico; it occurs mainly in hilly country in both the Lower and Upper Sonoran Life Zones. It is found commonly under stones or in leaf litter below the scarp of the Ogallala Caprock in eastern New Mexico. It occurs in rock talus along canyon walls and hillslopes of the arid lower mountains of the south-central and southwestern parts of the state. *Helicodiscus singleyanus* is a common fossil in both Pleistocene and Holocene deposits of river and arroyo floodplains in southern New Mexico.

Family Discidae
Genus *Discus*

Discus whitneyi (W. Newcomb, 1864, as *Helix*). Proceedings of the California Academy of Sciences, 3:118. T.L.: near Lake Tahoe, California. (forest disc)

Snails of this taxon long have been assigned to *Discus cronkhitei* (Newcomb, 1865). A recent reexamination of types by Roth (1987a) showed *D. whitneyi* and *D. cronkhitei* to be conspecific. *D. whitneyi* has priority.

General Distribution--*Discus whitneyi* is distributed widely, occurring from Alaska and much of Canada, southward into the northern half of the conterminous United States, and farther to the south along the mountains of the West to southern Arizona and northwestern Chihuahua, México. In the Plains states, the species presently is known to live only as far south as South Dakota, but its range extended southward to Texas in the Pleistocene (Hubricht, 1985:Map 171).

New Mexico Distribution--*Discus whitneyi* occurs widely in New Mexico mountains. It is the only *Discus* in the southern part of the state, whereas *D. shimekii* (see below) is a species of higher elevations of the northern mountains. In New Mexico, *D. whitneyi* does not descend much below the Transition Life Zone, although it descends lower in Arizona, even to the low, arid mountains of Organ Pipe National Monument (Dillon, 1980).

Discus shimekii (H. A. Pilsbry, 1890, as *Zonites*). The Nautilus, 4:3. T.L.: Iowa City, Iowa, as a Pleistocene fossil. (striate disc)

General Distribution--*Discus shimekii* occurs in western North America in Canada, and south to northern California, Arizona, and New Mexico. Like *D. whitneyi*, it occurred as a Pleistocene species in the Great Plains region, but not so far to the south as in the case of *D. whitneyi*.

New Mexico Distribution--*Discus shimekii* occurs at higher elevations in the northern mountains of New Mexico, and as far south as the Sandia and Manzano Mountains and Mount Taylor. Although the species was reported by Pilsbry (1948:619) from the San Mateo and Black Ranges west of the Rio Grande Valley, in their original report on these ranges Pilsbry and Ferriss (1917:102) assigned disc shells only to *Pyramidula cronkhitei* (=*Discus whitneyi*, above). We have found only *D. whitneyi* in these ranges. *Discus shimekii* is a species of the Canadian Life Zone and above, to treeline. In a transect on the west side of Mount Taylor, it was found above 10,000 ft and in another transect, on the west wide of Lake Peak in the Sangre de Cristo Mountains, it occurred above 8,400 ft (Dillon and Metcalf, this volume). In both cases, *D. whitneyi* occurred at lower elevations in the transect. We have found separation to species (*D. whitneyi* or *D. shimekii*) to be difficult for some populations in the 7,500-9,000 ft elevation in northern New Mexico. Possibly hybridization is involved, or perhaps the presence of two species together may cause confusion in identification. *Discus shimekii* is, perhaps, a Pleistocene relict in the southernmost Rocky Mountains, in New Mexico and in Arizona, where Bequaert and Miller (1973:151) recorded it from only three stations, all at high elevations.

Family Oreohelicidae

Formerly, all members of this family were placed in the genus *Oreohelix*, which comprised two subgenera, *Oreohelix* and *Radiocentrum*. *Radiocentrum* shells differ from those of *Oreohelix* in having, on the first 1½ whorls, distinctive, well-defined radial riblets parallel with the growth lines. Pilsbry (1939:541) described these as "delicate, retractive radial rib-striae."

There are also differences in the genitalia of the two groups. Members of *Oreohelix* are live-bearing snails, whereas those of *Radiocentrum* are egg-layers. Babrakzai, Miller, and Ward (1975:10) deemed the differences between these groups to be deserving of generic recognition and elevated *Radiocentrum* to a full genus.

It has been customary to place the family Oreohelicidae in the superfamily Helicacea (or Helicoidea), which includes the large New Mexican snails of the genera *Sonorella* and *Humboldtiana* and the introduced *Helix*. However, Emberton (1991) has recommended allying the Oreohelicidae with the family Discidae. This phylogenetic arrangement has been followed here. Emberton's interpretation was based on an analysis of anatomical structures, although he pointed out (1991:221) the importance of also applying molecular methods in the construction of land-snail phylogenies. Until such molecular information is available and is applied, phylogenies may continue to be somewhat speculative and subject to differences in interpretation. One wonders, then, if the oreohelicids have found their true phylogenetic home with this relocation or if other shifts await them.

Genus *Oreohelix*

Snails of this genus are called "mountainsnails" (Turgeon, 1988:141-142). The name is appropriate because, from northern New Mexico and Arizona northward in the Rocky Mountains, they are the major large, casually observed, land snails.

Species of *Oreohelix*, with large elevated shells, occur in the mountains of northern New Mexico, in the Sierra Blanca-Nogal Peak complex to the southeast, and in the San Mateo Mountains-Black Range-Mogollon Mountains complex to the southwest. In the literature, those from the northern part of the state, south to the Sandia Mountains, have been assigned to *O. strigosa depressa* (Cockerell); those from Sierra Blanca-Nogal Peak, to *O. strigosa nogalensis* Pilsbry, and those from the San Mateo Mountains-Black Range-Mogollon Mountains, to *Oreohelix subrudis* (Reeve). Brandauer (1988) analyzed populations of *O. strigosa* and *O. subrudis* from throughout the range of the genus in Colorado and concluded that the two species could not be separated, taxonomically, in that state. She assigned Colorado "*subrudis*" to *O. strigosa*.

We are reluctant to follow the procedure of Brandauer regarding New Mexico *strigosa* and *subrudis* for several reasons, including: 1) lack of a thorough study of the genus in New Mexico; 2) an electrophoretic analysis by Rees (1988) showing differences between *strigosa* and *subrudis* in Colorado, and unpublished electrophoretic data suggesting some differences between them in New Mexico; and 3) in New Mexico, unlike the situation in Colorado where there appear be no clearly discernible geographic ranges attributable to each of the two forms, the species have been considered as occupying definite, allopatric ranges (as outlined above).

Oreohelix strigosa depressa (T.D.A. Cockerell, 1890, as *Patula*). The Nautilus, 3:102. T.L.: a canyon near Durango, La Plata Co., Colorado. (Rocky mountainsnail)

General Distribution--Pilsbry (1939:Fig. 296) mapped *O. strigosa strigosa* (Gould) as occurring in southern British Columbia, Washington, northernmost Oregon, northern Idaho, and western Montana. He mapped *O. s. depressa* as occurring from western Wyoming and southeastern Idaho, southward to northern Arizona and New Mexico. Thus, as considered by Pilsbry, both of these major subspecies of *O. strigosa* are widely distributed.

New Mexico Distribution--We have found *O. s. depressa* generally distributed in the two major mountain masses of north-central New Mexico--the Sangre de Cristo and the Jemez Mountains, east and west of the Rio Grande Rift Valley, respectively. It has been collected by Smartt in the Sandia Mountains, where it exists seemingly only as a localized population. Smartt also has acquired specimens of *O. s. depressa* (NMMNH 98) from the Chuska Mountains, San Juan Co., probably from Beautiful Mountain in the boundary area of Arizona and northwestern New Mexico. These 4 specimens (3 fresh and 1 faded) were collected in summer, 1987. Pilsbry (1939:431) assigned specimens of *Oreohelix* from "5 miles east of Zuñi, McKinley Co.," in the west-central part of New Mexico to *O. s. depressa*. However, specimens that we have from the Zuñi area are *O. houghi* Marshall. The rather arid habitat there is surely not that normally chosen by *O. s. depressa*. We have not collected *O. s. depressa* from east of the Sangre de Cristo Mountains, but Pilsbry (1939:431) reported it from Folsom, Union Co., this based on a lot of 12 shells collected by E. B. Howard in 1931 (ANSP 156440).

Habitat--For such a wide-ranging snail as *O. s. depressa*, any generalization about habitat is difficult. It occupies habitats from the Transition to Hudsonian Life Zones. Hoff (1962:53) wrote "Specimens were taken only at elevations where considerable moisture occurs in soil and litter and it is suggested that inadequate moisture may be an important factor determining the lower limit of range in elevation." Hoff (pp. 52-53) reported finding the specimens living under bark and stones and "on ground and litter." On Pecos Baldy, at 11,800 ft, he found it "under rocks in open woods at timberline." In a few cases, we have found it in igneous-rock talus at lower elevations of the Transition Zone.

Oreohelix nogalensis H. A. Pilsbry, 1939. Academy of Natural of Sciences of Philadelphia Monograph, 3(I) 1:442, Fig. 293. T.L.: Water Canyon on the west slope of Nogal Peak, Lincoln Co., New Mexico.

Pilsbry (1939:442) noted that the relatively high spire and narrow umbilicus of this snail had suggested to him that it was allied with *O. subrudis*. Instead, dissection of the genitalia showed it to be a member of the *O. strigosa* group, to which Pilsbry assigned it as a new subspecies. In light of the still-prevailing uncertainly about the identity and relationships of *strigosa* and *subrudis*, it would appear that further taxonomic evaluation is in order. Tentatively, we treat this isolated population of large *Oreohelix* as a full species.

Distribution and Habitat--*Oreohelix nogalensis* is known living only from the Sierra Blanca-Nogal Peak complex (=Sierra Blanca Mountains) of Lincoln Co., some 150 mi south of the nearest occurrence of *O. strigosa depressa* in the southern Sangre de Cristo Mountains. Specimens have been taken in canyon habitats above 7,000-ft elevation. In Water Canyon, Pilsbry (1939:442) noted that "It lives on steep, leafy slopes with very little rock, near the canyon bed, the trees mostly maple; higher, close under the peak, it was taken among aspens." It occurs in more open habitat in the pine-oak woodland surrounding Nogal Peak.

Paleontology--Well-preserved fossils of *O. nogalensis* have been found in rubbly Pleistocene deposits along the Rio Bonito Valley at 5,500-ft elevation, about 4.4 miles southeast of Lincoln and some 28 miles east of the crest of the Sierra Blanca Mountains. Here, snails were apparently living on a limestone slope in rubble. Clearly, in the Pleistocene, the range of *O. nogalensis* extended a greater distance to the east and to lower elevations than at present. This fossil evidence of its relatively venerable occupation of the Sierra Blanca Mountains area provides an additional motive for treating it as a full species.

Oreohelix subrudis (L. A. Reeve, 1854, as *Helix*). *Conchologia Iconica,* 7, Pl. 198, Fig. 1390 a, b. T.L.: unknown. (subalpine mountainsnail)

Distribution--Pilsbry (1939:Fig. 312) mapped *O. subrudis* as occurring from the area of southeastern British Columbia; southwestern Alberta; northeastern Washington; northern Idaho, and northwestern Montana southward along the Rocky Mountains to Wyoming, Utah, and Colorado. After a hiatus of some 250 miles, an isolated outlying group of *subrudis* was mapped in the southwestern quadrant of New Mexico and in adjacent Arizona. In New Mexico, we have taken *O. subrudis* in the San Mateo Mountains, Black Range, and Mogollon Mountains, including mountains west of the San Francisco River Valley. Further work may show that this southern group would be best assigned to a different species, as done above for *Oreohelix nogalensis*. If such action were to seem judicious, the name *apache* Pilsbry and Ferris, 1919, is available. This taxon was taken in Apache Co., Arizona, and was considered a "form" of *O. subrudis* by Pilsbry (1939:488). However, the situation is complicated by the introduction of a name *meridionalis* as a subspecies of *Oreohelix strigosa* for an oreohelicid from the same area by Pilsbry and Ferriss (1919:324).

Habitat--*Oreohelix subrudis* has been taken in a wide range of habitats. It occurs from the higher peaks of the Mogollon Mountains, Catron Co., in forests of the Canadian Life Zone, downward to arid slopes in the Upper Sonoran Life Zone, where it inhabits igneous-rock talus. In the Black Range, it is widespread in the higher forests, occurring in areas of both limestone and igneous bedrock. It has been taken only in the southern part of the San Mateo Mountains, occurring in rhyolitic talus, which is widespread in this area.

Paleontology--*Oreohelix subrudis* is a common fossil in the eastern foothills of the Black Range, in areas of calcareous bedrock. Many fossils were observed in a road-cut on the northwest side of Apache Hill, ca. 0.5 mile northwest of Lake Valley (a ghost town) and about 7 miles east of the crest of the Black Range. Fossils also were numerous in salient exposures ca. 2.5 miles northeast of Kingston.

Oreohelix swopei H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:93, Pl. 9, Figs. 2, 3-3b, 13; Text-fig. 3. T.L.: Head of Morgan Creek Canyon, northern Black Range, Sierra Co., New Mexico. (Morgan Creek mountainsnail)

Distribution and Habitat--This enigmatic species was considered by the above authors to have shells similar to those of *Oreohelix strigosa depressa*. However, characters of the genitalia did not conform to those of *O. s. depressa*, prompting the authors to place it in a new species. The snail was taken on the Pilsbry and Ferriss expedition to the Black Range in 1915--in a few canyons in the northern part of the range, on both the eastern and western slopes: Morgan, Diamond Creek, and Black Canyons. In 1989, Smartt collected specimens of *O. swopei* in Turkey Run Canyon in the northern Black Range. They were not abundant or easy to find. Clearly, *O. swopei* is a species that requires further evaluation in regard to taxonomy and distribution, especially as to how it might relate to *O. strigosa depressa* or to *O. subrudis*.

Oreohelix pilsbryi J. H. Ferriss, 1917. The Nautilus, 30:102. T.L.: Oliver's mine on Mineral Creek, 5-6 miles above Chloride, Sierra Co., New Mexico. (Mineral Creek mountainsnail)

Pilsbry noted (1939:514) that this snail, bearing his patronym, was "closely related to *O. metcalfei*"; however, he retained it as a full species because of its distinctive shell features: the strong sculpture and higher shell with smaller umbilicus than in the *O. metcalfei* group, discussed below.

Distribution and Habitat--The species has been reported only from the T.L., above. According to Raymond Schmidt of Chloride, there was a mining settlement called "Rounderville" on the floor of Mineral Creek Canyon (a few apple trees still persist there). A Mr. Oliver lived in Rounderville at one time and mined in the near vicinity; hence, sometimes the term "Oliver's mine" was used. There were several mines around Rounderville, including the Dreadnaught Mine, still easily located and indicated on the Winston 7-1/2 USGS Topographic Quadrangle. As often is the case in a mining zone hereabouts, there are limestone strata within the predominantly igneous-bedrock sequence, these limestone strata associated with a mineralization zone.

About 0.35 mile south of the Dreadnaught Mine, at ca. 6,750-ft elevation, the thin limestone strata are cut through by erosive action of Mineral Creek. In 1987, we found *O. pilsbryi* occurring abundantly there, but the area of its occurrence was quite small, no more than 100 ft along the northeast-facing outcrop where Mineral Creek makes a right-angle bend. In 1988 Smartt discovered a second population about 1/4 mi. up-slope from the first locality, noted above. This was also an area of limestone outcrop that was north-facing, and supported a stand of Gambel Oaks. If these two localities comprise the entire range of the species, it is very limited, indeed. A search of the entire length of Mineral Creek (we have not seen all of it) and of Dry Creek Canyon, immediately to the north, should be undertaken. We did not find *O. pilsbryi* along Chloride Canyon, the next canyon to the south, nor in the steep hilly country south of the Dreadnaught Mine, which we traversed in reaching Mineral Creek from Chloride Canyon.

Oreohelix metcalfei Cockerell Complex of the Black Range

This is a complex of related oreohelicids with relatively depressed shells, often carinate and variously ornamented. Species in the complex occur in the Black Range and some of its associated foothills. Possibly, *O. pilsbryi*, discussed above, also belongs to this complex. It is likely that some race or species of the complex occurs in most parts of the higher Black Range where there is limestone. These species are strict calciphiles, in contrast to *O. subrudis* of the same range, which tolerates areas of igneous bedrock. In the Black Range areas of limestone bedrock occur discontinuously, and it appears that a situation comparable to an island archipelago exists. In the southern part of the Black Range, these "limestone islands" are much larger, and outcrops of limestone strata may continue for several uninterrupted miles as in the higher parts of the southwestern slopes of the range. To the north, areas of limestone outcrop become smaller and more isolated, as in the case of the type locality of *O. pilsbryi*, discussed above. Limestone strata are fairly continuous along the eastern foothills of the Black Range. However, much of this country is seemingly too arid to support populations of snails of the *O. metcalfei* complex at present. There is, however, ample fossil evidence of their former occurrence in this calcareous foothill zone, which likely served as a north-south corridor for dispersal of members of the calciphile *O. metcalfei* complex, during times equivalent to Pleistocene glaciations. One might visualize an increasing isolation and fragmentation of populations during interglacials, including the Holocene, which promoted speciation of a number of weakly differentiated races within various of the "limestone islands" in the range. Evolution in the group may involve multiple episodes of fragmentation and rejoining of populations, especially during the Pleistocene.

Racial variability, such as that indicated in the preceding paragraph, is reflected in the various subspecific taxa of *O. metcalfei* erected by Pilsbry and Ferriss (1917), after their malacological survey of the Black Range in 1915. Using similar criteria, additional subspecies could be described from other "limestone island" areas in the range. It seems prudent, while conserving the taxa of Pilsbry and Ferriss for convenience of discussion, not to burden the literature with additional subspecific epithets at this time. Instead, what is needed is a thorough survey, using such modern tools as may be appropriate to try to bring some synthesizing order into the existing taxonomic situation. Given the insular nature of populations of *O. metcalfei* in the Black Range, it seems that this also would involve an interesting application of theoretical island biogeography, as applied to an inland area.

Below, we list the subspecies of *O. metcalfei* named from the Black Range, together with brief comments. We list them from south to north, suggesting that the larger limestone areas of the southern end of the range might be hypothesized as a source area within the archipelago of limestone islands proposed above.

> ***Oreohelix metcalfei acutidiscus*** H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:98, Pl. 8, Figs. 4, 4a. T.L.: given by the authors (Pilsbry and Ferriss, 1917:106) as "A limestone ledge, 20 minutes' walk down the mountain east from the camp on the saddle of Sawyer Peak." Sawyer Peak is a prominent peak, the highest in the southern part of the range, Sierra Co., New Mexico.

Smartt collected specimens of this subspecies in 1989 about 0.5 mi east of Sawyer Peak in Trujillo Canyon.

> ***Oreohelix metcalfei concentrica*** H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:97, Pl. 8, Figs. 1-1d; Pl. 9, Fig. 10. T.L.: Above the "Box" on Silver Creek Canyon, on the north side of the canyon, Black Range, Grant Co., New Mexico.

Distribution and Habitat--This subspecies inhabits the extensive limestone-bedrock area around the head of the Silver Creek Canyon complex on the west side of Sawyer Peak, and continues southward. Pilsbry and Ferriss (1917:97) reported it from the south end of the range near Grand Central Mine (=Royal John Mine, we suppose), from the next two gulches north of the mine, and on the west side of Sawyer Peak. They noted minor variations in color and sculpture of shells at these various localities. Occurring over such an extensive area, it appears that *O. m. concentrica* is the most widespread of the named subspecies of *O. metcalfei* in the Black Range.

We found flourishing populations of *O. m. concentrica* along Forest Road 523, where it crosses both Silver Creek and Rustlers Canyons, and we also found it living at several places in the vicinity of the Royal John Mine at the southern end of the Black Range.

> ***Oreohelix metcalfei radiata*** H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:97, Pl. 8, Figs. 2, 2a, 3, 3c, 6, 6a; Pl. 9, Fig. 11. T.L.: an outcrop of limestone on the east side of Spring Creek, where a small ravine enters from the east (Spring Creek is a southeastern tributary of Iron Creek) on the western slope of the Black Range, Grant Co., New Mexico.

Distribution and Habitat--*Oreohelix metcalfei radiata* occurs along the canyons of Iron and Spring Creeks, the next complex north of the Silver Creek Canyon complex. It is probably much less widespread than *concentrica*, although the extent of its range to the north of Iron Creek Canyon is not known. We have found it living along both Iron Creek and Spring Creek Canyons.

> ***Oreohelix metcalfei metcalfei*** T. D. A. Cockerell, 1905. The Nautilus, 18:113. T.L.: indicated as "mountains near Kingston," Sierra Co., New Mexico. (Black Range mountainsnail)

The type of the nominal subspecies was collected by O. B. Metcalfe, who was associated with the agricultural college (now New Mexico State University) at Las Cruces, and who did considerable botanical and some incidental malacological collecting in the region in the early 1900s.

Distribution and Habitat--Living specimens of *O. m. metcalfei* have not been found in the immediate environs of Kingston, although fossils were found just to the east along Percha Creek Canyon. However, *Oreohelix* of the *metcalfei* complex are often found where there are limestone outcrops, as occur to the southwest and northwest of Kingston. The T.L. is vague, but it seems reasonable to view the nominal subspecies as an inhabitant of the canyons of the extensive upper Percha Creek system, to the north and south of Kingston.

> ***Oreohelix metcalfei hermosensis*** H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:98, Pl. 9, Figs. 4-4b, 12; T.L.: near Hermosa in Palomas Creek Canyon, eastern slope of the Black Range, Sierra Co., New Mexico.

Distribution and Habitat--We found *O. m. hermosensis* still living in the vicinity of the T.L. in rock rubble along Palomas Creek Canyon, east of the site of the former village of Hermosa, in what had been an active mining district. Here, the canyon enters the foothills region of calcareous bedrock, the rock type favored by this calciphile group. We found *Holospira cockerelli*, discussed above, occurring with this *Oreohelix*.

We have not seen any representatives of the *O. metcalfei* group from the upper canyons of Las Animas and Seco Creeks, situated between canyons of the Percha and Palomas Creek systems. Perhaps in these canyons, which are difficult of access, there are forms of this complex that are intergradational between *O. m. metcalfei* to the south and *O. m. hermosensis* to the north.

> ***Oreohelix metcalfei cuchillensis*** H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:99, Pl. 9, Figs. 1-1b. T.L.: southern end of the Cuchillo Mountains, Sierra Co., New Mexico.

Distribution and Habitat--Despite the aridity of the southern Cuchillo Mountains, specimens of *O. m. cuchillensis* were found in abundance at the time that J. H. Ferriss collected there in 1915; a lot of more than 200 specimens is mentioned (Pilsbry and Ferriss, 1917:99). We made several attempts to search the southern Cuchillo range, but were unable to do so. Thus, we do not know the present status of this population, seemingly of small extent areally. We found a few old, badly weathered shells of *O. m. cuchillensis* in the northern end of the Cuchillo Mountains. We also found fossils of this species in Pleistocene sediments in the northern Cuchillos, indicating that it is a relatively ancient occupant of the range.

Species of *Oreohelix* peripheral to the Black Range

In the accounts above, the Black Range and its eastern foothills have been proposed as being a center of evolution for members of the *O. metcalfei* complex. Metcalf (1974:99) and Crews and Metcalf (1982:262) proposed that, from such a center, there was a dispersal of members of this complex to other mountains of the region. Such a scenario had already been set by Pilsbry (1939:513) in recognizing the subspecies *O. metcalfei florida* in mountains to the south of the Black Range.

In the following section, several species occurring in mountains peripheral to the Black Range are treated. Whether or not they may conform to a model of dispersal from a Black Range center of origin remains to be tested.

There was apparently dispersal of *O. florida* to several mountain ranges to the south and of *O. caballoensis* eastward to the Caballo Mountains, with subsequent extinction of the taxa in these southern and eastern ranges. Dispersal was more successful to the Pinos Altos Mountains to the west (*O. confragosa*) and to the Magdalena Mountains and the area of the San Agustin Plains to the north (*O. magdalenae* and *O. litoralis*). (Note, however, reservations indicated under account of *O. magdalenae*, below.) Metcalf (1974:99) and Crews and Metcalf (1982:262) noted that, except for *O. confragosa*, all these peripheral species have shell features that might be considered as primitive within the *O. metcalfei* complex. A general picture, then, might be visualized in which there was an early dispersal to these peripheral areas of a fairly primitive stage of *O. metcalfei*, rather like existing *O. m. hermosensis* and *O. m. cuchillensis* of the northeastern foothills of the Black Range. Subsequently, as noted, the more primitive peripheral forms suffered extinctions related probably to climatic deterioration during the Holocene, but also in part, perhaps, to the natural extinction process to be expected on small islands. However, in the higher, more extensive, and more mesic "heartland" of the group in the Black Range, *O. metcalfei* continued to evolve and speciate into the variants recognized there today as subspecies, and which are treated above. Instead of this dispersalist model, one could, of course, contrive a vicariance model to explain the distributional patterns.

Oreohelix confragosa A. L. Metcalf, 1974. The Nautilus, 88:96, Figs. 4-7, 9, 11. T.L.: north-facing wall of Willow Springs Canyon, 0.3 mile WSW of west side of ruins of Georgetown, Grant Co., New Mexico. (Pinos Altos mountainsnail)

Distribution and Habitat--This species occurs in the Pinos Altos Mountains, across the Mimbres River Valley from the "stronghold" of the *Oreohelix metcalfei* complex in the southern Black Range. As suggested above, it may belong to that complex, but be an outlying member, which speciated in the Pinos Altos Mountains.

Living specimens of *O. confragosa* have been taken only at the type locality, southwest of the ghost town of Georgetown, below massive limestone outcrops. Snails were living under flat limestone rocks derived from the cliffs above and strewing the slope below. Here, at 6,700-ft elevation, the canyon wall supported a pinyon-juniper-Gambel Oak association of trees. It seems likely that search in other areas of limestone outcrops in the eastern Pinos Altos Mountains might reveal further populations of this or closely allied species.

Oreohelix florida H. A. Pilsbry, 1939. Academy of Natural Sciences of Philadelphia Monograph, 3(I)1:513. T.L.: near the "central peak" (probably Baldy Peak) of the Florida Mountains on the west side, Luna Co., New Mexico. (Florida mountainsnail)

Pilsbry first reported (1915:349) this taxon as "*Oreohelix strigosa* var.". In his description, Pilsbry (1939) made it a subspecies of *Oreohelix metcalfei*. Metcalf (1974:98) raised *florida* to the status of full species. Even in 1915, Pilsbry had reported (p. 349) that only "Two broken and very old 'bones' were found . . . " at the type locality, presumably on Baldy Peak in the Florida Mountains. Baldy Peak, a high, isolated, massive limestone outcrop, may have been the last refuge of the species. In 1970, Metcalf found only a few weathered fragments on the north side of Baldy Peak, as has Richard D. Worthington in 1996. Collections made in this century suggest that *O. florida* is no longer living. As a fossil, it occurs in the Florida, Santa Rita, and Tres Hermanas Mountains, the Apache Hills, and on the lower, northern side of Cooke Peak near the ghost town of Cooke (or Cook).

Oreohelix litoralis C. R. Crews and A. L. Metcalf, 1982. Proceedings of the Biological Society of Washington, 95:256, Figs. 1A-C, 2A, 3A. T.L.: Sec. 1, T. 6 S, R. 12 W, at 6,900-ft elevation, south side of San Agustin Plains, Catron Co., New Mexico.

Distribution and Habitat--As known presently, *O. litoralis* is limited to certain areas of outcrop of rhyolitic rocks around the southern edge of former Pleistocene Lake San Agustin. Here, it is found in crevices in the rocks and in rock rubble of wave-cut cliffs. The localities are on the southern margin of the San Agustin Plains at an elevation of ca. 6,900 ft. The area is grassland with sparse shrubs, in contrast to the forested habitats observed in association with most occurrences of *Oreohelix*.

Remarks--Populations of *O. litoralis* were discovered by Dr. Robert H. Weber, New Mexico Bureau of Mines and Mineral Resources, in the course of his investigations on former pluvial Lake San Agustin. Dr. Weber collected this species at seven sites around the southern former shore of the lake. One of these localities was on what had been an island in the lake for a period of time. Lorna L. M. Scarbrough has found fossil specimens of *O. litoralis* in sediments excavated from Bat Cave, also near the southern margin of the ancient lake.

A single specimen of a weathered *Oreohelix* was taken in conifer forest just under the summit of Eagle Peak in the Tularosa Mountains, southwest of the San Agustin Plains. This specimen may appertain to *O. litoralis* (a very provisional identification). Search at several localities on Eagle Peak failed to reveal additional specimens.

Oreohelix magdalenae H. A. Pilsbry, 1939. Academy of Natural Sciences of Philadelphia Monograph, 3(I)1:515, Fig. 336b. The T.L. is recorded simply as "Magdalena, Socorro Co." As the environs of the town of Magdalena, itself, do not seem to provide likely habitat for this species, we suppose that the type locality was, instead, in the nearby Magdalena Mountains to the east of the town. (Magdalena mountainsnail)

Distribution and Habitat--The Magdalena Mountains are an isolated range, reaching 10,783-ft elevation on South Baldy Peak, with considerable forest at higher elevations. *Oreohelix magdalenae* seems to occur widely in the range, above elevations of 7,000 ft. We have taken it at several localities. Along North Fork Canyon, a branch of Water Canyon, we found it at 7,320 ft on a north-facing slope near the bottom of the canyon, living under loose, igneous stones in thick leaf litter from deciduous trees. It has been taken in coniferous forest as high as 9,850 ft on North Baldy Peak.

Pilsbry (1939:515) named this snail as a subspecies of *O. socorroensis* (discussed below). Metcalf (1974:99) and Crews and Metcalf (1982:259) treated it as a full species, as we do here. In our opinion, the larger, rounded shell of *O. magdalenae*, with its well-developed color bands, bears little resemblance to the small, carinate, sparsely pigmented shell that is the type of *O. s. socorroensis*. Thus, it seems judicious to consider *magdalenae* as a full species, typical of and confined to the Magdalena Mountains. Crews and Metcalf (1982:262) compared *O. magdalenae* with *O. litoralis*, which occurs to the west. They considered the two species to be closely related, but found minor differences between them in shell and soft anatomy. They suggested that these species were outlying members of the large *Oreohelix metcalfei* complex. As a cautionary note, however, it should be pointed out that both *O. magdalenae* and *O. litoralis* thrive in areas of igneous bedrock, whereas members of the *O. metcalfei* group, to the south, seem to be obligate calciphiles. The two northern species could, then, reasonably be considered as comprising a group of their own.

Additional Species of *Oreohelix*

At a time equivalent to the latest Pleistocene glaciation, it seems likely that most of the mountains in southern New Mexico were inhabited by oreohelicid snails (*Oreohelix* and *Radiocentrum*). Fossils from many mountains with calcareous bedrock seem to confirm this. (Molluscan fossils are not found in mountains with igneous bedrock in New Mexico.) The mountains bordering the Rio Grande Rift on the west, plus the Caballo Mountains, would have harbored representatives of the groups discussed in the preceding sections. Eastward, in addition to *Oreohelix nogalensis* of the Sierra Blanca Mountains, discussed above, there occurs a small species, *O. neomexicana.*

> ***Oreohelix neomexicana*** H. A. Pilsbry, 1905. Proceedings of the Academy of Natural Sciences of Philadelphia, 57:282, Pl. 11, Figs. 8, 9; Pl. 19, Fig. 9; Pl. 25, Fig. 59. T.L.: Canyon Diablo near Rowe, San Miguel Co., New Mexico.

Oreohelix neomexicana was originally described (Pilsbry, 1905) as a subspecies of *O. yavapai*; the nominal subspecies of which occurs in north-central Arizona. Herein, we elevate *neomexicana* to species status on the basis of conchological differences already listed by Pilsbry (1939:520) and because of the geographical separation of more than 200 miles between known populations of *yavapai* and *neomexicana.* We also relegate *O. y. compactula* Cockerell, August 1905, and *O. socorroensis* Pilsbry, 1905, to the synonymy of *O. neomexicana*, Pilsbry, May 1905. The name *socorroensis* has page precedence (p 279) over *neomexicana* (p 282) in Pilsbry (1905). However, acting as first revisers (Ride et al., 1985:53), we 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 Co." in its description, wherein Pilsbry noted that he was unable to locate the type locality, and that the collector of the type series was unknown. We also are unable to identify any "Negra Mts." in New Mexico. From its appearance, we suspect that the type of *socorroensis* is a fossil.

As shown by Crews (1981, unpubl. M.S. thesis, University of Texas, El Paso), *O. neomexicana* is found, living, from north-central New Mexico, in foothill regions of the southern Sangre de Cristo and Jemez Mountains, southward through the Sandia and Manzano Mountains, Gallinas Peak in northwestern Lincoln Co., the Oscura Mountains of Socorro Co., and recently a small living population has been found in Arcente Canyon ca. 4.7 road-miles S of High Rolls at 7,200 ft elevation in the southwestern Sacramento Mountains, Otero Co. Pilsbry (1939:520) reported it from near Grants, Cibola Co., but we have been unable to find any *Oreohelix* in that area, including Mount Taylor.

Habitat--*Oreohelix neomexicana* has been taken near Montezuma in the southeastern foothills of the Sangre de Cristo Mountains, in scant cover under loose stones alongside a paved road. In the Sandia Mountains, it occupies a variety of habitats from lush forested canyons on the east side of the range to the environmentally extreme conditions of Sandia Crest, where a dwarfed form occurs abundantly. On the Crest, it occurs under limestone rocks. In the Manzano Mountains, it was found under single stones in areas of rich leaf litter; on Gallinas Peak, it occurs in igneous-rock talus associated with rock glaciers (Blagbrough, 1991:837). In the Oscura Mountains, a range with much calcareous bedrock, it has been collected on the west side below North Oscura Peak and from another locality on the west side two miles north of South Oscura Peak. Thus, the species seems to tolerate a broad variety of habitats in mountains where it still exists. Despite this ability, it has gone extinct over much of the southern part of its former range, apparently during the Holocene, as indicated below.

Oreohelix neomexicana varies greatly in size from mountain range to range, and even within ranges, as exemplified in the Sandia Mountains. Pilsbry (1939:416) discussed the great diversity in size that may occur within a given species of *Oreohelix*, even over short distances. He noted that there may be significant variation in shell size even within the same colony. Similarly, Henderson (1924:110) wrote concerning *Oreohelix* in Colorado: "It is not at all uncommon to find a colony in which those individuals living under the best cover are large and robust, while those at the edges where cover is scant are dwarfed."

Paleontology--*Oreohelix neomexicana* is widespread as a fossil in colluvial and alluvial deposits in the Sacramento Mountains. Fossils from alluvial deposits along the Tularosa River have been dated as being of Holocene age. However, a living population has been found only at the one site noted above. Fossils of *O. neomexicana* also occur southeastward from the Sacramento Mountains, in the Guadalupe Mountains into Texas. West of the Sacramento Mountains, it is found as a fossil in the San Andres Mountains and, to the south, in the Hueco and Franklin Mountains of Texas.

> ***Oreohelix houghi*** W. B. Marshall, 1929. Proceedings of the U.S. National Museum, 76(5):2, Pl. 1, Figs. 7-10. T.L.: Heber, Navajo Co., Arizona. (Diablo mountainsnail)

Distribution--*Oreohelix houghi* is a species mainly of east-central Arizona. Bequaert and Miller (1973:127-128) recorded it from eastern Coconino Co., eastward to the area of St. Johns and Springerville in Apache Co. Pilsbry (1939:516) referred to it as being a species of the Little Colorado River Valley. The Zuñi and Carrizo Wash Valleys are northeastern branches of the Little Colorado Valley. It is not surprising, then, that *O. houghi* follows these valleys headward into New Mexico. We have specimens from about 4 miles east of Zuñi. Pilsbry assigned (1939:431) specimens from 5 miles east of Zuñi to *Oreohelix strigosa depressa.* However, it seems likely that these specimens were really *O. houghi.* Courtesy of Mr. Dick Duman, we also have obtained specimens from south of Zuñi, in Valencia Co., in the area of Cibola Canyon, which drains into the Zuñi River Canyon. Still farther south, Rebecca Smith-Sealy has found *O. houghi* along Carrizo Wash, 3 miles east of the Arizona border, near NM Highway 191 in Catron Co. This is one of several species of land snails, more widespread in eastern Arizona, which barely enter western New Mexico.

> ***Oreohelix barbata*** H. A. Pilsbry, 1905. Proceedings of the Academy of Natural Sciences of Philadelphia, 57:279, Pl. 25, Figs. 57, 58; Pl. 19, Fig. 5; Pl. 22, Fig. 6. T.L.: According to Bequaert and Miller (1973:129) the T.L. is in the Chiricahua Mountains of Cochise Co., Arizona, in Cave Creek Canyon near Winn Falls. (bearded mountainsnail)

Oreohelix barbata has been reported from the Chiricahua Mountains of Arizona and the Mogollon Mountains of New Mexico. In the Mogollon Mountains, the species occurs in southwestern canyons of the range, at least from Little Dry Creek Canyon northwestward to Whitewater Creek Canyon, and then northeastward at least to Willow Creek Canyon. We have found it along creeks at the bottom of such canyons in riparian forest. Here, it occurs in rock rubble where there is also an abundance of leaf litter from deciduous trees. The distribution of this species in the Mogollon and Chiricahua Mountains is reminiscent of that of *Gastrocopta prototypus*, discussed above, and could suggest a distributional history involving either vicariance or migration.

Genus *Radiocentrum*

The genus *Radiocentrum* differs from *Oreohelix* in that its first 1½ (embryonic) whorls bear sharply defined radial ribs and the animal is egg-laying, rather than live-bearing, as in *Oreohelix*. There are a number of species of the genus in southeastern Arizona and in northwestern Chihuahua, but New Mexico is inhabited presently by only two species of the genus. This is a genus with a fossil record extending back to Cretaceous time in western North America. Probably, it has inhabited New Mexico during most or all of the Cenozoic.

> ***Radiocentrum hachetanum*** (H. A. Pilsbry, 1915, as *Oreohelix*). Proceedings of the Academy of Natural Scieces of Philadelphia, 67:330, Pl. 6, Figs. 1-1d, 6; Text-Fig. 4a. T.L.: summit of Hacheta Grande, Big Hatchet Mountains, Hidalgo Co., New Mexico. (Hacheta mountainsnail)

> ***Radiocentrum ferrissi*** (H. A. Pilsbry, 1915, as *Oreohelix*). Proceedings of the Academy of Natural Sciences of Philadelphia, 67:332, Pl. 6, Figs. 4-5d; Text-fig. 4b. T.L.: at "Station 3" (see below) in the Big Hatchet Mountains, Hidalgo Co., New Mexico. (fringed mountainsnail)

To avoid repetition, shells of the two species of *Radiocentrum* from the Big Hatchet Mountains are compared together, but they differ conchologically in numerous respects (see Key).

Distribution and Habitat--From the collections of Pilsbry and L. E. Daniels in 1910 and of ourselves, it appears that *R. hachetanum* is a species of the higher areas of the Big Hatchet complex. Pilsbry found it on and around the summit of Hacheta Grande, the highest peak in the range. We have found it in a fairly mesic habitat on the north face of Hacheta Grande and on the northeastern slope of North Hatchet Peak.

Radiocentrum ferrissi, on the other hand, was taken by Pilsbry and Daniels at lower elevations in the more arid, southern part of the Big Hatchet Mountains. He described the type locality as follows (Pilsbry, 1915:333):

> Our Station 3 is on ledges of high cliffs facing the mouth of Sheridan Canyon, and especially on a bench about half-way up. Here Ferriss's *Oreohelix* lives on an almost inaccessible cliff looking out over the mesa into Mexico. There is little vegetation on the ledges. . . . The *Oreohelix* colony is of small extent; the ledges where they were observed living are probably not over a couple of square rods in area, with perhaps an equal area on the talus below the cliffs, where dead shells were found. These estimates are from memory, as I neglected to note the figures at the time.

Pilsbry goes on to note that the only other locality where *R. ferrissi* was found was on the east side of Teocalli Butte--a low, elongate mountain on the southwestern periphery of the range. He noted (p. 333) that this locality was "more restricted, and if possible more arid" than the type locality.

Pilsbry described a subspecies for each of the two living species, based on dead shell materials collected in the Big Hatchet Mountains. In each case, he assumed that the subspecies had gone extinct; these comprised *R. hachetanum cadaver* and *R. ferrissi morticinum*. Both of these sepulchral subspecies were found and described from the same station (Pilsbry's No. 5) on the north side of a peak located southwest of Hacheta Grande, which Pilsbry called Daniels Mountain in honor of his field companion.

We have seen fossils of both *R. hachetanum* and *R. ferrissi* in sediments on the east slope of North Hatchet Peak, and have not seen fossils of *hachetanum* elsewhere. *Radiocentrum ferrissi*, on the other hand, seems to have been adept at long-distance travel (for a snail) during the Pleistocene. Fossils of *R. ferrissi* are common in Pleistocene deposits in U-Bar Cave, located in a small limestone mountain outlying the Big Hatchet Range to the south (and west of the northern Alamo Hueco Mountains). Fossils have been taken also on Howells Ridge, in the northern Little Hatchet Mountains. Most unexpectedly of all, is the occurrence of Pleistocene fossils that appear attributable to *R. ferrissi* at several localities in the Franklin Mountains of El Paso Co., Texas, 110 miles to the east of the Big Hatchet Mountains. In Vinton Canyon in the northern Franklin Mountains, *R. ferrissi* occurs in Pleistocene deposits together with *Oreohelix neomexicana*, discussed above.

Family Succineidae

The identification of succineids is notoriously difficult because the shells of many species are similar, even those of different genera. Characteristics of the reproductive organs generally have been used to differentiate species taxonomically. This being the case, the true identity of type specimens, most consisting of shells only, is often in question. For species described in the 1800s or early 1900s, this poses a serious taxonomic problem, sometimes exacerbated by lack of precise data as to where type material actually was collected; for example, as in *S. avara* and *S. grosvenori*, discussed below.

There are numerous older records of succineids from New Mexico in the literature. Unfortunately, the problems noted above render these records taxonomically unreliable for the most part. However, studies by Franzen (1971, 1982) and, most recently, an annotated listing of succineids from New Mexico by Wu (1993), have contributed towards a better understanding of succineids in the state.

Genus *Oxyloma*

Oxyloma retusum (I. Lea, 1834, as *Succinea*). Transactions of the American Philosophical Society, 5:117, Pl. 19, Fig. 86. T.L. Ohio near Cincinnati. (blunt ambersnail)

Wu (1993:93) assigned living specimens of an *Oxyloma* found in the area of Mescalero, Otero Co., to *O. retusum*. The species occurs along the banks of the Tularosa River. Numerous specimens have been observed in a park along the river in the town of Mescalero. It also occurs near the fish hatchery at the west side of Mescalero and up Tularosa Canyon, probably to near the headsprings of the Tularosa River. The floodplain and stream in this section support a lush growth of moisture-loving and aquatic plants, such as cattails, sedges, rushes, and watercress. Especially important to *O. retusa*_seem to be the emergent leaves and stems of watercress (*Nasturtium officinale*), which flourishes in the stream. These snails are found commonly on watercress and other plants overhanging the water, or not far away. The floodplain is marshy in some places. Judging by the nature of exposed Holocene sediments, this marshy habitat must have continued downstream from Mescalero for some 15 miles to the level of the Tularosa Basin before stream entrenchment took place in the last century. Fossil *Oxyloma* shells are common in such sediments. *Oxyloma retusum* is not found upstream from the Tularosa River headsprings, where marshes and lush, riparian, vegetation abruptly terminate at present.

In New Mexico, we have seen living *Oxyloma* only from this short segment of the Tularosa River Valley; however, Dr. Raymond W. Neck recently informed us of finding Oxylomas along Fresnal Canyon, above High Rolls, Otero Co. *Oxyloma retusum* may occur in other marshy, riparian habitats in the Sacramento Mountains. Remaining marshy or wetland habitats in New Mexico, where other rare species also may persevere, should be sought out and given further attention. *Oxyloma* fossil specimens found in various parts of New Mexico indicate that the genus was more common in previous times than at present.

Genus *Succinea*

Succinea luteola A. A. Gould, 1848. Proceedings of the Boston Society of Natural History, 3:37. T. L.: Bequaert and Miller discuss the T.L. (1973:155): "Texas, without more precise locality; W.G. Binney's (1885:497) listing of 10 shells (at U.S. Nat. Mus. No. 39757) from Corpus Christi as 'type original lot,' seems to preempt Pilsbry and Ferriss' (1906:158) selection of Galveston as T.L.; R. I. Johnson (1961:106) mentions syntypes at Mus. Comp. Zool., but does not select a holotype or a T.L." (Mexico ambersnail)

General and New Mexico Distribution--Hubricht (1985:Map 123) mapped this species as occurring in the Gulf Coastal states from the Florida Panhandle to Texas. However, most records are from Texas, where it is common in the southern two-thirds of the state. This species extends up the Rio Grande and Pecos River Valleys into West Texas and, in the case of the Rio Grande Valley, into southern New Mexico (probably also in the Pecos River Valley, but this has not been confirmed).

Habitat--In the Mesilla Valley, Doña Ana Co., we have found *S. luteola* living along irrigation ditches, where the snails were located on the wet banks of canals only a few inches above the water line, a habitat they often share with the basommatophoran snail *Fossaria bulimoides*.

Succinea vaginacontorta C. B. Lee, 1951. University of Michigan Museum of Zoology, Occasional Papers, 533:1-7, Pl. 2, Fig. 1. T.L.: Meade Co., Kansas.

Dr. Dorothea Franzen dissected specimens of a succineid, which Metcalf had collected from near Romeroville, San Miguel Co., New Mexico, and assigned them to *S. vaginacontorta* (1971:137). Wu (1993:94) assigned specimens from Colfax Co. (1 locality) and Union Co. (2 localities) to this species. These determinations suggest that *S. vaginacontorta* is a species of northeastern New Mexico. As understood by Franzen (1971:141), *S. vaginacontorta* is a "xerophilous" species, ranging from South Dakota to Texas and New Mexico in the High Plains and Rocky Mountain foothills.

Hubricht (1985:15; Map 117) placed *S. vaginacontorta* in the synonymy of *S. indiana* Pilsbry, 1905, and mapped the High Plains records noted by Franzen, apparently including the record from Romeroville, as pertaining to *S. indiana*. Neck also recorded (1990) *S. indiana* from the Texas Panhandle. Some problems with this employment of *S: indiana* are suggested by Hubricht's map, because its type locality is in Posey Co., Indiana, whereas nearest records to the type locality are in Central Alabama, south-central Arkansas, and southwestern Missouri. It seems more conservative, at this time, to use the name *vaginacontorta*, a species with its T.L. in the High Plains, for the western populations considered here.

Succinea grosvenori I. Lea, 1864. Proceedings of the Academy of Natural Sciences of Philadelphia, 16:109. T.L. As summarized by Bequaert and Miller (1973:156): "described from Santa Rita Valley, Kansas, and Alexandria, Louisiana; no precise T.L. selected so far." (Santa Rita ambersnail)

The epithet *grosvenori* often has been applied to relatively small succineids from the Great Plains and southern Rocky Mountains states. Pilsbry (1948:821) listed it in New Mexico from near Las Vegas, the San Andres Mountains, Tularosa (Otero Co.), and "Grant" (presumably Grants in Cibola Co.).

Leonard listed it as an exceedingly common late Cenozoic fossil in his studies of eastern New Mexico (Leonard and Frye, 1975; Leonard, Frye, and Glass 1975). Wu (1993:94; Figs. 14, 15) recorded *S. grosvenori* from xeric habitat of the Lower Sonoran Life Zone in Doña Ana Co., and illustrated genitalia of a specimen. There has been, then, a strong tendency to assign New Mexico succineids, especially from lower, more xeric habitats, to *S. grosvenori*.

Hubricht described (1961) *Succinea solastra* from Hidalgo Co., Texas, and mapped it (1985:Map 130) from various localities in southern Texas. He observed (1961:32) that characters of the genitalia in *S. solastra* were not distinguishable from those of snails that he allocated to *S. grosvenori*, thus making only a weak case for considering *S. solastra* as a valid species, distinct from *grosvenori*, which has almost a century of nomenclatural priority. Hubricht (1963:135) studied succineids from Alexandria, Louisiana, one of the T.L.s given for *Succinea grosvenori*, and found specimens that he assigned to that species. He noted (1985:15) that *S. grosvenori* could be identified by use of characters of the genitalia; however, he also noted that the species "has been used in the past as a catchall for any succineid which could not be as readily identified as some other species."

Succineids from New Mexico also have been ascribed to *Succinea avara* Say, 1824. The T.L. of *S. avara* is given by Say simply as "Northwest Territory." Despite the inadequate information concerning the type locality and the fact that the type consists only of an empty shell, the name has been applied widely to North American succineids. Pilsbry (1948:838) reported it from New Mexico and Arizona in "mountains throughout the states." Franzen (1982) assigned succineids from collections made by Metcalf in southern and extreme northeastern New Mexico to *S. avara*. This included five southern localities that ranged from arid basins of the Chihuahuan Desert (Lower Sonoran Life Zone) up to forested canyons in the Sacramento Mountains (Transition Zone). Four collection localities in northeastern New Mexico were from the Upper Sonoran Zone. Franzen's study involved a careful analysis of shell proportions, reproductive, and other soft anatomy, and radulae. We deem it unfortunate that she chose to use the ambiguous name *Succinea avara*. Franzen's rationale for doing this apparently relied on similarity of the New Mexico material seen by her to published figures (Pilsbry, 1948:Fig. 442, B,C) of succineids from Arizona, which Pilsbry assigned to *S. avara*. Considering the dubious background of *avara*, this allocation seems to have had little justification. It seems judicious to follow Turgeon (in prep.), who recommends that the name *avara* no longer be applied to any succineid taxon.

To compound problems involved with use of the name *avara*, Hubricht (1983:16-18) placed it in the genus *Catinella*, considering it to be conspecific with *C. vermeta*, discussed below.

Unfortunately, the taxon *grosvenori* is only slightly less ambiguous than *avara*. The "type localities" of *grosvenori*, themselves, are ambiguous, because two are listed. Of these, Alexandria, Louisiana, is clearly identifiable, but the location of "Santa Rita Valley, Kansas" is not. There seems to be no place of this name in the present or former confines of the state of Kansas. Possibly it refers to the present Salado River Valley of Socorro Co., New Mexico, as a village originally known as Santa Rita (now Riley) was located there. The Santa Rita mining complex of Grant Co. is not in a valley location.

Ambiguities abound, but what is quite clear is that there is at least one succineid that is common at the lower elevations of southern New Mexico and Trans-Pecos Texas. It seems likely that only one xeric-tolerant species is represented. The name *grosvenori* is suggested here out of deference to custom, but it is also clear that this succineid deserves further study.

Succinea forsheyi I. Lea, 1864. Proceedings of the Academy of Natural Sciences of Philadelphia, :109. T.L. Rutersville, Texas. (spotted ambersnail)

Wu (1993:93) assigned some succineids from northeastern New Mexico to *Succinea concordialis* Gould, 1848. However, Hubricht (1974:33) determined that the types (4 remaining out of an original 5 specimens) of *S. concordialis* actually pertained to *Pseudosuccinea columella*, an aquatic to semiaquatic lymnaeid snail. Hubricht (1974:33) concluded that the name *S. forsheyi* must be used for the snail which has been known as *S. concordialis*", because *forsheyi* was the next available synonym, temporally, for the kind of snail that had long been assigned to *S. concordialis*. The T.L. of *forsheyi* is Rutersville, Texas, about halfway between Houston and Austin. As mapped by Hubricht (1985:Map 119), *S. forsheyi* is mainly a species of Texas, northward and northeastward to Nebraska, Iowa, and Illinois, with scattered records in the southeastern states. He mapped it as occurring in the Texas Panhandle and southwestern Kansas, areas not far from northeastern New Mexico.

Wu reported (1993:93) this species from three localities in northeastern New Mexico, two in Quay, and one in San Miguel Co. Specimens were taken along streams, a typical habitat for *S. forsheyi*.

Genus *Catinella*

Catinella vermeta (T. Say, 1829, as *Succinea*). New Harmony Disseminator, 2:230. T.L.: New Harmony, Posey Co., Indiana. (suboval ambersnail)

As noted above, Hubricht (1983:16-18) transferred *Succinea avara* Say, 1824, to the genus *Catinella*, and synonymized it with *C. vermeta* Say, 1829, which became a junior synonym. In taking this action, Hubricht assumed that the T.L. "Northwest Territory" given by Say (1824) for *S. avara* referred to Minnesota only. He further suggested that there were only 3 species of succineids in Minnesota, as that was what his collecting there had revealed. Of these 3, the one that had a shell morphology closest to the type specimen of *avara* was a *Catinella* of the kind that he had previously considered to be *C. vermeta*. The presence of "dirt and slime" on the type shell also was used in making the allocation of *avara* to *Catinella*.

There is a good chance that Hubricht was correct in all this. However, the argument relies to some extent on hypothesis. This being the case, it seems that it would have been more prudent simply to have allowed the name *avara* to wither away (see account of *Succinea grosvenori,* above), while retaining *vermeta,* which had come into general usage. In recent papers we see *C. vermeta* being used by Wu (1993:91) for New Mexico material, whereas Spamer (1993:51) has used *C. avara* for shells from the Grand Canyon area of Arizona.

New Mexico Distribution--Wu (1993:91) has reported *Catinella vermeta* from several northeastern and north-central counties in New Mexico: Union, Colfax, Mora, San Miguel, and Rio Arriba. He also recorded it from Doña Ana Co., from along the Rio Grande floodplain, 0.9 mile south of Radium Springs. It also has been collected from 7 miles NNW of Radium Springs, where it has been found attached to fallen branches in a cottonwood grove alongside the Rio Grande.

Dr. Dorothea Franzen has dissected some succineids collected by Metcalf from the locality NNW of Radium Springs and from San Simon Cienega, Hidalgo Co. She has assigned these specimens to *C. vermeta.* In addition to the assignments made to *C. vermeta,* Wu (1993:91,93) listed two other records, which he assigned to "*Catinella* sp. 1" (4 specimens from Union Co.) and "Catinella sp. 2" (1 specimen from Otero Co.). Hubricht (1985) does not map any species of *Catinella* other than *Catinella avara* (considered by him, as noted above, to be a prior synonym of *C. vermeta*) as occurring any closer to New Mexico than eastern Oklahoma.

Family Helicarionidae
Genus *Euconulus*

Euconulus fulvus (O. F. Müller, 1774, as *Helix*). Vermium etc. (see *Cionella lubrica* for full citation), 2:56. T.L.: Fridrichsdal, Denmark. (brown hive)

General Distribution--This species has an exceedingly broad range, including much of the Palearctic (Europe and northern Asia) and Nearctic (North America) zoogeographic regions. In the New World, it ranges from Alaska, Canada, and Greenland south to the conterminous United States, where it is found in the northeastern quadrant and in western states. It is not found in the Great Plains region at present, but occurs as a Pleistocene fossil from Nebraska and Iowa, south to northern Texas (Hubricht, 1985:Map 331).

New Mexico Distribution and Habitat--*Euconulus fulvus* is widespread and common in all the forested mountains that reach into the Transition Zone. Collections of leaf litter from the Transition and Canadian Life Zones commonly contain this species.

Family Zonitidae
Genus *Glyphyalinia*

Glyphyalinia indentata (T. Say, 1823, as *Helix*). Journal of the Academy of Natural Sciences of Philadelphia, 2:372. T.L.: vicinity of Philadelphia, Pennsylvania. (carved glyph)

In much of the older literature, this species is assigned to the genus *Retinella,* with *Glyphyalinia* treated as a subgenus. Southwestern representatives are ascribed often to the subspecies *paucilirata* (Morelet, 1851), with type locality in Guatemala. As currently recognized, *Glyphyalinia indentata* is a widespread species, occurring from southeastern Canada southward through much of the United States and México, and at least to Guatemala.

Naranjo-García (1991: Table 1) collected it at 15 localities in Sonora, México. Hubricht (1985:24) has suggested that *G. indentata* actually may comprise a complex of several species. *Glyphyalinia indentata* is widespread in New Mexico. Consistently, shells occur in collections made in montane habitats, from the upper part of the Upper Sonoran Zone up into the Canadian Zone.

Genus *Nesovitrea*

Nesovitrea hammonis electrina (A. A. Gould, 1841, as *Helix*). Report on the Invertebrata of Massachusetts, comprising the Mollusca, Annelida and Radiata, p. 183, Fig. 111. T.L.: shores of Fresh Pond, Cambridge, Massachusetts. (amber glass)

General Description--The name *electrina* has been used at the species level for North American representatives of this taxon in much of the literature. Bequaert and Miller (1973:145) considered the species *hammonis* to include both Palearctic and Nearctic representatives. They retained the name *electrina* for Nearctic populations, but relegated it to subspecific level. So construed, *N. hammonis* is exceedingly widespread, occurring in the Palearctic from Iceland and the British Isles, through northern Eurasia to Japan and Kamchatka, with the *electrina* subspecies found from Alaska southward to the northern half of the conterminous states, and southward in the Rocky Mountains to New Mexico and northern Arizona.

New Mexico Distribution and Habitat--*Nesovitrea hammonis electrina* is mainly a species of higher mountains of the northern part of the state. It occurs to the southwest at high elevations in the Mogollon Mountains. It has been found living in Madden Canyon in the Sierra Blanca-Sacramento Mountains complex, and has been found as a fossil at several localities in and near these mountains, including the Keen Spring area in the Tularosa Basin. In the northeastern part of the state, it occurs as far east as Sierra Grande, where it is found on the upper slopes of this isolated mountain. It reasonably could be regarded as one of a number of species that extended southward along the Rocky Mountains in past times and, at present, may be a Pleistocene relict, towards the south. The species occurs in leaf litter and under or alongside stones and logs, usually were soil is moist.

Genus *Hawaiia*

Hawaiia minuscula (A. Binney, 1841, as *Helix*). Boston Journal of Natural History 3:435. T.L.: Ohio. (T.L. designated by Pilsbry, 1946:421-422). (minute gem)

A subspecies, *Hawaiia minuscula neomexicana* (Cockerell and Pilsbry, 1900, as *Zonitoides*) was described from the

Dripping Spring area on the western flank of the Organ Mountains. This subspecies may deserve specific status (Dr. William L. Pratt, pers. comm.). Pending publication of Dr. Pratt's studies, here we employ the name *minuscula*.

General Distribution--This minute snail is widespread, occurring from Alaska and Canada in North America south to Costa Rica in Central America. It has been introduced widely elsewhere, and it was from such an introduced population in Hawaii that the generic name was derived.

New Mexico Distribution and Habitat--As treated here, *Hawaiia minuscula* is a common snail in New Mexico, widespread both geographically and altitudinally. Its broad altitudinal range lends credence to the possibility (suggested above) that two species may be present in the state. It is found along the Rio Grande and Pecos River Valleys in cottonwood groves and urban lawns and parks. In mountains, it extends from the Upper Sonoran Zone as high as the Canadian Life Zone, although it is most common in the Transition Zone. It occurs consistently, but in low numbers, in collections of leaf litter taken in montane habitats.

Genus *Zonitoides*

Zonitoides arboreus (T. Say, 1816, as *Helix*). (Nicholson's) American Edition, British Encyclopedia Vol. 2, Art. Conchology, species No. 2, Pl. 4, Fig. 4. No precise T.L. (quick gloss)

General Distribution--This is a widespread species in North America. It extends across southern Canada from British Columbia to Newfoundland, and southward across the conterminous United States and México to Central America.

New Mexico Distribution and Habitat--*Zonitoides arboreus* is widespread in New Mexico. As the name *arboreus* suggests, it is associated with trees, and is found in most of the state's forested mountains. It is especially typical of the Transition and Canadian Life Zones, and collections of leaf litter from these zones usually contain shells of the species. In some areas where other species are scarce, as in the mountains surrounding the San Agustin Plains, *Z. arboreus* may be the only species found at a collection site. On the other hand, there is a puzzling absence of *Z. arboreus* in the San Andres and Organ Mountains (Metcalf, 1984b), although Transition Zone habitat is present in parts of these mountains. However, the species is common in the Sierra Blanca - Sacramento Mountains complex just across the Tularosa Basin to the east. *Zonitoides arboreus* also has become established in some urban areas. It is found as a Pleistocene fossil along the Rio Grande and Pecos River valleys, indicating it was more widespread at lower elevations in the past than at present.

Genus *Striatura*

Striatura meridionalis (H. A. Pilsbry and J. H. Ferriss, 1906, as *Vitrea*). Proceedings of the Academy of Natural Sciences of Philadelphia, 58:152. T.L.: drift of Guadalupe River above New Braunfels, Comal Co., Texas. (median striate)

As the specific name *meridionalis* suggests, this is a southern species in the United States, occurring from the southeastern to the southwestern states and southward into México. In New Mexico, this species is found in forested habitats throughout the Transition and Canadian Life Zones.

Family Vitrinidae
Genus *Vitrina*

Vitrina pellucida alaskana W. H. Dall, 1905. Land and Fresh Water Mollusca, Harriman Alaska Expedition, 13:37. T.L.: Carson Valley, Churchill Co., Nevada. (western glass-snail)

General Distribution--This species generally has been reported in the American literature as *Vitrina alaskana*. Bequaert and Miller (1973:147) ascertained that "*V. alaskana* agrees in shell and genitalia with Old World *V. pellucida* (O. F. Müller, 1774), of which it is the American subspecies." Thus construed, *V. pellucida* is of Holarctic distribution. The subspecies *alaskana* occurs in the western Nearctic region from Alaska south to California, Arizona, and New Mexico.

New Mexico Distribution and Habitat--*Vitrina pellucida alaskana* is found in higher mountains in New Mexico from the Sacramento-Sierra Blanca complex and the Mogollon Mountains northward. It is typical of the Canadian and Hudsonian Life Zones in New Mexico mountains. Live specimens are found usually in association with low vegetation such as sedges and grasses, in damp montane meadows, and along streams and other bodies of water.

Family Limacidae
Genus *Deroceras*

The native slugs of New Mexico comprise only two species, both in the genus *Deroceras*. In addition, there are some introduced Eurasian species of limacid slugs that occur in urban areas, discussed in a later section.

Deroceras laeve (O. F. Müller, 1774, as *Limax*). *Vermium* etc. (see *Cionella lubrica* for full citation), 2:2. T.L.: Fridrichsdal, Denmark. (meadow slug)

Deroceras laeve is a Holarctic species found throughout much of North America, occurring widely in New Mexico. At lower elevations, it is found in cultivated and urban areas and in marshy areas of river floodplains. In mountains, it occurs mainly around springs and along streams and other bodies of water. It is especially typical of wet montane meadows, sharing this habitat with *Vitrina p. alaskana*, discussed above.

Deroceras heterura Pilsbry, 1944. The Nautilus, 58:15. T.L.: west side of north summit of Sawyer Peak, Black Range, Grant Co., New Mexico. (marsh slug)

Pilsbry (1948:562) deemed populations of *Deroceras* from the higher elevations of the Mogollon Mountains and the Black

Range as belonging to this distinct, endemic species and not to the more widespread *D. laeve*. He wrote: "*D. heterura* occurred . . . near the summit trail of the Black Range in the splendid forest at about 8000 to 9000 feet, from Sawyer Peak to Morgan Creek, a distance of over 20 miles as the crow flies, and much more as the snail-hunter walks." He also recorded it from along Willow Creek in the Mogollon Mountains.

From study of the soft anatomy, Pilsbry (1944, 1948) concluded that *D. heterura* was a relict of an early invasion into North America of *Krynickillus*, a mainly Eurasian subgenus of *Deroceras*. He speculated that the subgenus *Deroceras*, to which *D. laeve* belongs, had entered North America at a later time and subsequently had spread far and wide. There has been relatively little interest in taxonomy and biogeography of the family Limacidae in North America, perhaps because the fauna is not so diverse and salient as in the Old World. Thus, to our knowledge, further assessment of Pilsbry's views of *D. heterura* as an interesting and rather ancient relict has not been made.

Family Polygyridae

> ***Linisa texasiana*** (S. Moricand, 1833, as *Helix*). Mémoires de la Société de Physique et d'Histoire Naturelle de Genève, 6:538, Pl. 1, Fig. 2. T.L.: Moricand gave the T.L. as "Mexique, dans le province de Texas." Pilsbry (1940:618) suggested that the type was likely from the vicinity of Brownsville, Texas. (Texas liptooth)

A recent systematic revision of the Polygyridae by Emberton (1995) allocates species traditionally placed in the large genus *Polygyra* among several genera. Consequently, the species long known as *Polygyra texasiana* is placed in the genus *Linisa*.

Pilsbry (1940) recognized two subspecies of *L. texasiana* as valid: the nominal subspecies and *L. texasiana texasensis* Pilsbry, 1902. He assigned western representatives of the complex to *L. t. texasensis*. Hubricht (1985:37) did not recognize the subspecies *texasensis*, and we follow him in referring specimens only to the species level.

General Distribution--This is a species of the south-central United States and northeastern México. Hubricht (1985: Map 373) mapped it as occurring living from western Alabama to western Texas and from southernmost Kansas southward through most of Texas. He indicated its present occurrence in western Texas as scattered, and he mapped a number of fossil occurrences in the Llano Estacado and Pecos River Valley of Texas.

New Mexico Distribution--We have found fossils of *L. texasiana* at a number of localities in the Pecos River Valley, from the Roswell area southward. Apparently, it was a common inhabitant of the valley in the past. Hubricht also indicated a fossil occurrence for *L. texasiana* in Chaves Co. (1985: Map 373). This record, like that of Pilsbry (1940:620), is presumably based on the record by Cockerell (1905:69) of fossil material from deposits along South Spring Creek near Roswell. In the Pecos River Valley, there is at least one population of *L. texasiana* still living, which was discovered by Dr. Dwight W. Taylor in 1981 in Bitter Lake National Wildlife Refuge, east of Roswell. Given the former, more widespread occurrence of the species in the Pecos Valley, the population at Bitter Lake Refuge appears to be relict.

Habitat--The habitat at Bitter Lake Refuge is a low-lying, damp, seepage area along and near the Pecos River floodplain. Such habitats were likely common in the lower Pecos Valley in New Mexico before agricultural development took place. Specimens of *L. texasiana* have been collected in urban areas in Carlsbad and Artesia, New Mexico, and El Paso, Texas.

Genus *Ashmunella*

The name *Ashmunella* is a patronym honoring The Reverend E. H. Ashmun, a 19th-century clergyman and amateur malacologist, who lived for a time in New Mexico. Reverend Ashmun was discussed above.

Bequaert and Miller (1973:19) have referred to Arizona as "the land of *Sonorella*." Similarly, it seems appropriate to refer to New Mexico as the "land of *Ashmunella*." The center of distribution for the genus, as mapped by Bequaert and Miller (1973:Fig. 5), lies approximately along the southern Rio Grande Valley. The genus extends from north-central New Mexico southward into Chihuahua, México (southern extent not known), and from the Davis Mountains of West Texas westward to the Huachuca Mountains of southeastern Arizona.

Because there is no significant information available about the phylogenetic position of species within the genus *Ashmunella*, we elect simply to list them by geographical regions, north to south and east to west, much as Pilsbry did in his monograph of North American land Mollusca (1940). In most cases, knowing the geographic provenience of a specimen of *Ashmunella* will readily allow one to establish its taxonomic identity, because the majority of species are endemic to a single mountain range or complex of ranges.

Species of Northern New Mexico

> ***Ashmunella thomsoniana*** (C. F. Ancey, 1887, as *Helix*). Conchologist's Exchange, 2:64. T.L.: Santa Fe Canyon, Santa Fe Co., New Mexico. (Sangre de Cristo woodlandsnail)

The early taxonomic history of this species, the first land snail to be described from New Mexico, is discussed in the section, above, concerning early history of New Mexico malacology.

The northernmost representatives of the genus *Ashmunella* consist of a pair of species: *A. ashmuni* on the west side of the Rio Grande Rift Valley and *A. thomsoniana* on the east side.

The zoologist T.D.A. Cockerell, who was active in the Las Vegas area around the turn of the century, made collections of *A. thomsoniana* and named several variants of the species. Pilsbry (1940:921-922) recognized two subspecies among living populations of *A. thomsoniana*: the nominal subspecies, with its type locality in Santa Fe Canyon, and *A. t. porterae* (Pilsbry and Cockerell, 1899), with type locality in Sapello Canyon, at 8,000 ft on the eastern side of the Sangre de Cristo range. Pilsbry may have envisioned these to comprise an eastern and a western subspecies, but he did not make a case for this. The main criteria used in separating the two subspecies appear to have been slightly larger size and more consistent presence of a bifid basal tooth in *A. t. porterae*. However, Pilsbry, himself, questioned the usefulness of shell size in *A. thomsoniana* as a taxonomic character (1940:921): "Whether size is of racial significance . . . seems to me doubtful; it may be that larger size is a response to longer humid seasons higher up." Moreover, Cockerell and Cooper (1902:109) concluded that "the character of the basal tooth, whether double or single, is highly variable, and not to be relied on to separate races." Thus, it seems that neither of the two differentiating characters--shell size and presence or absence of a bifid tooth--was considered very important or consistent, even by these earlier workers. It is possible that a detailed study might show the validity of recognizing two subspecies of *A. thomsoniana*; but lacking such evidence, it seems wisest to refrain from such partitioning. This position is reinforced by noting that Cockerell also described a subspecies, *A. t. cooperae*, 1901, which Pilsbry (1940:921) noted was intermediate between *A. t. thomsoniana* and *A. t. porterae* in regard to shell diameter.

Distribution--*Ashmunella thomsoniana* occupies only the southernmost tip of the Sangre de Cristo Mountains, approximately south of the northern boundary of San Miguel Co. (as if the boundary extended westward across the range). It is not known what factor, or factors, prevent its occurrence farther north in the range into what appears to be very similar habitat.

Habitat--Most collections of *A. thomsoniana* have been taken along forested canyons like those northeast of Santa Fe. In upper Pecos Canyon, these snails may be seen crawling about after summer showers, even in campgrounds frequented by humans. Here, it is likely to be observed especially along the margin of the narrow floodplain and base of the flanking forested slopes.

The species has been observed as far down the Pecos Valley as Villanueva State Park, at 5,750 ft, where it occurs under riparian shrubs and small trees on the Pecos River floodplain. At Montezuma, in the eastern foothills of the Sangre de Cristo range, the species occurs in talus immediately east of an abandoned smelter, at an elevation of ca. 6,800 ft.

Paleontology--Pilsbry (1940:919) synonymized a fossil species, *A. antiqua* Cockerell, 1901, from Pleistocene deposits near Las Vegas, with *A. t. porterae*. Another fossil taxon, *A. t. pecosensis* Cockerell, 1903, was described from a deposit at "Valle Ranch, Pecos," based on a single specimen. We also have collected fossils of *A. thomsoniana* of probable Pleistocene age along Pecos Canyon near Pecos.

Ashmunella ashmuni (W. H. Dall, 1898, as *Polygyra*). Proceedings of the U.S. National Museum, 19:342. T.L.: near Bland in the Jemez Mountains, Sandoval Co., New Mexico. (Jemez woodlandsnail)

Pilsbry (1940:922-923) recognized two subspecies of *A. ashmuni*, the nominal subspecies, with type locality near Bland, and *A. a. robusta* Pilsbry, 1905. The type of this latter subspecies was collected by Rev. E. H. Ashmun, himself, and was referred earlier to the Arizona species *A. chiricahuana* Dall, 1896. Later, Pilsbry (1905:233) placed this snail in *A. a. robusta*. The type locality of *robusta* is imprecise, being somewhere in the Jemez Mountains, apparently between Bland and Jemez Springs. Pilsbry (1940:924) noted that *robusta* occurred at elevations higher than the nominal subspecies. It seems likely that *A. a. robusta* is only a higher-elevation ecophenotype of *A. ashmuni*, and not deserving of subspecific recognition. It is clear that shell size is influenced by conditions prevailing at different elevations in a number of species of *Ashmunella*, and this is most likely the case here. Generally, progressively larger shells are found at higher elevations, at least to around 8,000 ft, above which the trend may reverse.

Distribution--This *Ashmunella* is a denizen of the Jemez Mountains region. It has been taken from Santa Clara Canyon on the northeast to Bland on the southeast, across the Jemez range to the Jemez Springs area, and then northwestward to the Nacimiento Mountains. It is, then, one of the more widespread Ashmunellas, areally, and is the northwesternmost representative of the genus.

Habitat--Most collections of this species have been from forested canyons, as at Bland and in Santa Clara and Frijoles Canyons. After summer rains, the snails may be seen on paths near the creek in Frijoles Canyon, Bandelier National Monument. It occurs at Bland in rock talus, and in the Nacimiento Mountains it can be found in association with limestone outcrops along the Rio de las Vacas and Rio Caballo. *Ashmunella ashmuni* also occurs in Joaquin Canyon, in red granite talus along the Guadalupe fork of the Jemez River.

Species of Southern New Mexico, East of the Tularosa Basin

Ashmunella pseudodonta (W. H. Dall, 1897, as *Polygyra*). Proceedings of the U.S. National Museum 19:343. T.L.: Capitan Mountains, White Oaks, Lincoln Co., New Mexico. (Capitan woodlandsnail)

Pilsbry (1940:924-925) recognized two subspecies of *Ashmunella pseudodonta*, the nominal subspecies with type locality listed as "Capitan Mountains, White Oaks, Lincoln Co., at 7500 feet (E. H. Ashmun)" and *A. pseudodonta capitanensis*, with type locality "Near Baldonado Springs, Capitan Mountains, Lincoln Co., altitude 8200 feet (E.H. Ashmun)." If Reverend Ashmun collected the type of nominal subspecies near White Oaks, it is likely that it would have been from Carrizo Peak, to the south of White Oaks, or possibly from Patos Mountain to the southeast. In Ashmun's time, both of these mountains probably were considered as part of the more easterly located Capitan Mountains. We have been unable to locate Baldonado Springs.

Supposedly, *A. p. capitanensis* differed from the nominal subspecies in its larger size and lesser development of dentition. We have seen collections of *A. pseudodonta* from Lone and Carrizo Peaks and Patos Mountain on the west, to the Capitan Mountains on the east, and failed to find any shell characteristics that show a geographic pattern suggestive of the presence of two subspecies. Shell size varies greatly, but this seems related to such factors as elevation and slope exposure, discussed above. Two lots collected in the area of Capitan Pass, from within ca.

0.7 mile of each other, differ by about 4.5 mm in mean diameter (14.5 vs 19.0 mm). Dentition is highly variable, ranging from toothless specimens to those with one or two low basal denticles and a short parietal tooth. Many shells from Patos Mountain, to the west, closely resemble shells from the eastern end of Capitan Mountain, near Pine Lodge, in both size and development of dentition. These localities are near the eastern and western limits of the range of the species, and their similarity seems to illustrate well the inadvisability of partitioning *A. pseudodonta* into subspecies. Therefore, we treat it here at the species level only.

Distribution and Habitat--The Lone Peak-Carrizo Peak-Patos Mountain-Capitan Mountain complex is composed of igneous rock, which has produced large amounts of talus especially on the upper and northern slopes of the Capitan Mountains. Blagbrough (1991) interpreted the talus and associated rock glaciers as being of Pleistocene periglacial origin. All our collections of *A. pseudodonta* have been from talus accumulations. At the eastern end of Capitan Mountain, specimens occur in a talus accumulation at the lower end of Forest Trail 64, at ca. 6,200 ft elevation, north of the Pine Lodge settlement. The species seems to thrive even at these lower elevations if talus is present.

Ashmunella rhyssa rhyssa (W. H. Dall, 1897, as *Polygyra*). The Nautilus, 11:2. T.L.: according to Pilsbry (1940:926), "Ashmun did not state just where he collected the type lot of *A. rhyssa*, but presumably it was somewhere on the eastern flank of Sierra Blanca Peak, above the town of Ruidoso." (Sierra Blanca woodlandsnail)

Ashmunella rhyssa altissima (T. D. A. Cockerell, 1898, as *Polygyra*). The Nautilus, 12:76. T.L.: summit of Sierra Blanca Peak, Otero Co., New Mexico.

Numerous species and subspecies of living and fossil Ashmunellas have been described from the Sierra Blanca Mountains (a complex of mountains extending from Nogal Peak southward to Sierra Blanca Peak), and beyond these to include the Sacramento Mountains. In his 1940 monograph, Pilsbry recognized three species and a number of subspecies as inhabiting this mountain complex. In a revision of the Ashmunellas of this area, Stern (1973) reduced the number of taxa to one species, *A. rhyssa*, with the two subspecies indicated above. Stern considered the nominal subspecies as occurring throughout the Sacramento Mountains and northward to the lower south, east, and west slopes of Sierra Blanca Peak. However, on Sierra Blanca's slopes around 8,000 - 9,000 ft, Stern detected evidence of intergradation between the two subspecies, with *A. r. altissima* occurring on the uppermost slopes (its type locality, atop the summit). *Ashmunella rhyssa altissima* occurs on the northern slopes of Sierra Blanca and northward in the Sierra Blanca Mountains to the Nogal Peak area, where it is common along Bonito and Nogal Canyons and other canyons in the northern part of this range.

In his analysis of *A. rhyssa*, Stern saw clear evidences of the relationship between elevation and shell size, mentioned in connection with other species of *Ashmunella*, above. In Peñasco Canyon, on the eastern slope of the Sacramento Mountains, size was analyzed for collections taken at 300-ft intervals from 6,000- to 9,300-ft elevation. A population at 7,200-ft elevation attained maximum size. Size gradually and progressively decreased above and below this elevation (Stern, 1973: Fig. 11). A similar 300-ft interval transect, from 9,600 to 12,000 ft in the Sierra Blanca Peak area, showed a general decrease in shell size with increase in elevation (Stern, 1973: Fig. 10).

Distribution and Habitat--*Ashmunella rhyssa rhyssa* is widespread in the Sacramento Mountains, both areally and altitudinally. It is especially common along canyons, occurring as low as 5,750-ft altitude, being found in limestone talus at lower elevations. At higher elevations, in the Canadian Life Zone, the species may be found throughout the forests. For instance, persons picnicking or camping in the recreation areas around Cloudcroft during summer months commonly note this snail crawling about. Our subjective assessment is that this species attains the greatest population density of any *Ashmunella* in New Mexico in the high forests of the Sacramento Mountains.

In general, *A. r. rhyssa* is associated with the limestone terrane of the Sacramento Mountains and *A. r. altissima*, with the igneous bedrock of the Sierra Blanca Mountains from the northern Sierra Blanca to the Nogal Peak areas. There are exceptions to this generality, however; for example, *A. r. rhyssa* is found along the lower part of Three Rivers Canyon in an area of igneous rock.

Ashmunella rhyssa altissima tolerates the highest summits of Sierra Blanca and Nogal Peaks, the former being almost 6,500 ft higher than the lowest elevations inhabited by the species. At these very high altitudes, above tree line, snails find shelter in rock talus, much as their relatives do at the lowest elevations. Numerous collections of *A. r. altissima* have been made also along canyons in the Sierra Blanca Mountains, where colonies often are found along streams under willows and other small trees or (unfortunately for the malacologist) in nettle patches.

Paleontology--Pleistocene fossils show that in the past *A. r. altissima* extended southward into the northern Sacramento Mountains at least as far as upper Tularosa Canyon, westward in the Tularosa Basin at least to Keen Spring (Ashbaugh and Metcalf, 1986:13), and as far east as 4.4 miles SE and 4 miles NW of Lincoln, along Bonito and Salazar Canyons, respectively.

Fossils of *A. r. rhyssa* have been found to the south, in the Guadalupe Mountains, where the species does not live at this time. Fossils have been noted in Pine Spring Canyon in the Guadalupe Mountains of Texas. In the Guadalupe Mountains foothills in Eddy Co., fossils of *A. r. rhyssa* have been taken ca. 8 miles west of Malaga in sediments along the Black River and along Rocky Arroyo Canyon at ca. 3,500 ft, about 1 mile SW of Rocky Arroyo Cemetery. The above records indicate a more widespread distribution of *A. rhyssa* in the past, to both the southeast and west, and to lower elevations than at present.

Several presumed variants of *A. rhyssa* occur in calcareous Quaternary sediments of the Sacramento Mountains. None of these has been given taxonomic recognition. However, a number of different species of Pleistocene Ashmunellas from the Sacramento Mountains have been described by Metcalf (1973).

Ashmunella carlsbadensis H. A. Pilsbry, 1932. The Nautilus, 46:19. T.L.: according to Pilsbry (1940:978): "A cave in Dark Canyon, southwest of Carlsbad, from the surface to a depth of two feet." (Guadalupe woodlandsnail)

E. B. Howard, who was excavating fossiliferous deposits in the above cave, obtained the type of *A. carlsbadensis*, which is almost surely a fossil, probably of Pleistocene age.

Ashmunella carlsbadensis occurs as a living species in the Guadalupe Mountains, New Mexico, from McKittrick Canyon, along and just south of the New Mexico-Texas boundary, northward along the Guadalupe Mountain escarpment. Most collections have been taken along the lower slopes of canyon walls, where talus and deep leaf litter have accumulated. In isolated populations, the range of the species also extends northeastward into the arid foothills of the Guadalupe Mountains, where it has been reported from Carlsbad Caverns National Park by Webb (1974). Smartt has found it in the foothills west of Carlsbad at ca. 3,610-ft elevation.

Ashmunella amblya cornudasensis J. Vagvolgyi, 1974. Proceedings of the Biological Society of Washington, 87:143, Pl. 1, Figs. 2, 2a. T.L.: Wind Mountain of the Cornudas Mountains group, Otero Co., New Mexico.

This species was named as a subspecies of *A. kochii* Clapp by Vagvolgyi (1974:143), who described the taxon. At that time, the species *A. kochii* was considered to include a large *Ashmunella* of the southernmost Guadalupe Mountains in Texas, *A. kochii amblya*, although the type locality of *A. kochii kochii* was in the San Andres Mountains, Doña Ana Co., New Mexico. Subsequently, Metcalf and Smartt (1977:861) elevated *A. amblya* to species status, recognizing two subspecies: the nominal subspecies of the Guadalupe Mountains, Texas, and *A. amblya cornudasensis*.

New Mexico Distribution and Habitat--*Ashmunella amblya cornudasensis* is found on mountains of the Cornudas group, having been taken on Chatfield, Flattop, and Wind Mountains. These peaks rise some 2,000 ft above the surrounding plain, forming a prominent cluster when viewed to the north from the El Paso-Carlsbad highway. They comprise a small group of "montane islands," which invite studies of insular biogeography. Genetic studies of the several isolated populations of *A. a. cornudasensis* might prove of interest. Some peaks, such as Wind Mountain, are especially conical and steep sided. We assume that the species occurs on other mountains in the group, in addition to those already collected from, and noted above. In the arid Cornudas Mountains, *A. a. cornudasensis* appears to be restricted to accumulations of igneous-rock talus, the bedrock of the mountains. Here, woody plants consist of shrubs and some low junipers and live oaks, which provide sparse leaf litter.

Species of Southern New Mexico between the Rio Grande and Tularosa Basin

Ashmunella salinasensis J. Vagvolgyi, 1974. Proceedings of the Biological Society of Washington, 87:154, Pl. 1, Fig. 9. T.L.: Salinas Peak, San Andres Mountains, Socorro Co., New Mexico. (Salinas Peak woodlandsnail)

In his description of *A. salinasensis*, Vagvolgyi (1974:156) emphasized that its shell features are similar to those of *A. rhyssa altissima*, which, as noted above, was more widespread in the Pleistocene and occurred on the Tularosa Basin floor at Keen Spring. It seems probable that the Salinas Peak species may have arisen from a propagule of *A. r. altissima*. Perhaps it should be considered a subspecies of *A. rhyssa*.

Distribution and Habitat--*Ashmunella salinasensis* has been taken only in talus accumulations of igneous rock on the higher, northern slopes of Salinas Peak. We found it to be abundant where trees grew within or alongside the areas of talus.

Ashmunella kochii kochii G. H. Clapp, 1908. The Nautilus, 22:77, Pl. 8, Figs. 1-3. T.L.: Black Mountain, locally called Black Brushy Mountain, in the southern San Andres Mountains, Doña Ana Co., New Mexico. (San Andres woodlandsnail)

Ashmunella kochii sanandresensis J. Vagvolgyi, 1974. Proceedings of the Biological Society of Washington, 87:145, Pl. 1, Fig. 3, 3a. T.L.: western slope of San Andres Peak, Doña Ana Co., New Mexico.

Ashmunella kochii caballoensis J. Vagvolgyi, 1974. Proceedings of the Biological Society of Washington, 87:148, Pl. 1, Fig. 4, 4a. T.L.: Brushy Mountain, in the Caballo Mountains, Sierra Co., New Mexico.

The history of the *A. kochii* complex is confusing, because of the former assignment of shells from the Guadalupe Mountains, Texas, and the Cornudas Mountains, New Mexico, to *A. kochii*. As noted above, Metcalf and Smartt (1977:861) placed these in the species *A. amblya*. We further considered *A. kochii* to comprise the three subspecies indicated above: 1) the nominal race from Black Brushy and Goat Mountains in the San Andres Mountains; 2) *A. k. sanandresensis* Vagvolgyi, 1974, from San Andres Peak, immediately north of Black Brushy Mountain; and 3) *A. k. caballoensis* Vagvolgyi, 1974, from the Caballo Mountains west of the San Andres Mountains. The subspecies *A. kochii caballoensis* has been taken living only on Brushy Mountain in the central part of the Caballo range. Fossils indicate that *A. k. caballoensis* was more widespread at lower elevations of the Caballo Mountains during the Pleistocene. In the Holocene, it seemingly has suffered restriction of range to the most favorable remaining habitats, in talus at higher elevations and on north-facing canyon slopes of Brushy Mountain.

Populations of the Caballo and San Andres Mountains subspecies of *A. kochii* have been found in limestone talus, which provides the main available shelter in these semiarid mountains.

Ashmunella harrisi A. L. Metcalf and R. A. Smartt, 1977. Proceedings of the Biological Society of Washington, 90:851. T.L.: east side of Goat Mountain in the southern San Andres Mountains, Doña Ana Co., New Mexico. (Goat Mountain woodlandsnail)

Ashmunella harrisi was named in honor of Dr. Arthur H. Harris, University of Texas at El Paso, who first collected specimens of the species.

Ashmunella harrisi occurs in two unnamed canyons on the east side of Goat Mountain in the southeastern part of the San Andres Mountains (see Metcalf and Smartt, 1977:866, Fig. 6). Along Bear Canyon south of Goat Mountain, *A. harrisi* hybridizes with *A. pasonis pasonis* Drake. A cline grading from one species to the other is shown in four collections taken along the south-facing wall of Bear Canyon. At the easternmost of these localities (Metcalf and Smartt, 1977: Fig. 6), shells are close to those of *A. harrisi* at or near its type locality on the east side of Goat Mountain. To the west, shell characters of *A. p. pasonis* become progressively more evident in populations and, at Bear Canyon's upper end, shells are indistinguishable from *A. p. pasonis* found elsewhere. Like other Ashmunellas of the southern San Andres Mountains, *A. harrisi* has been taken only in accumulations of limestone talus.

Ashmunella pasonis pasonis (R. J. Drake, 1951, as *Polygyra*). Revista de la Sociedad Malacológica "Carlos de la Torre," 8:44. T.L.: Vinton Canyon, in the northern Franklin Mountains, El Paso Co., Texas. (Franklin Mountain woodlandsnail)

Ashmunella pasonis pasonis is exceptional in several ways: in shell features, in occupying two widely separated mountain ranges, and in seemingly hybridizing with two other species of *Ashmunella*. It has the most elaborate dentitional development of any of the known Ashmunellas. In this respect, Dr. Robert Drake, its discoverer and author, was reminded of a *Polygyra*; he originally placed it in that genus (1951), but transferred it to *Ashmunella* in a later paper (Drake, 1952).

Fossils in the Franklin Mountains of El Paso Co., Texas, provide good evidence that *A. p. pasonis* evolved from an ancestor like the subspecies, *A. pasonis polygyroidea* Vagvolgyi (Metcalf and Smartt, 1977:862). The *polygyroidea* subspecies occurs as a fossil throughout the Franklin Mountains, and still lives in the central part of the range. We assume that at some time after *A. pasonis pasonis* arose from an *A. p. polygyroidea*-like ancestor, it dispersed northward into the southern part of the San Andres Mountains of New Mexico, where it occurs in two areas. In the more northern area, *A. p. pasonis* occurs at least from Hembrillo, Lost Man and Dead Man Canyons south to Mayberry Canyon, and it hybridizes with *A. kochii sanandresensis* in the northern part of San Andres Peak. *Ashmunella p. pasonis* occurs in upper Little San Nicholas Canyon in the south, but it does not hybridize with *A. k. kochii* there. In the southern area, it also occurs on Black Mountain, and on its north slope, which is the south wall of Bear Canyon, it hybridizes with *A. harrisi*, as noted above (Metcalf and Smartt, 1977:866-868).

Because *A. p. pasonis* is able to hybridize with two other species of *Ashmunella* of the San Andres Mountains, this surely suggests that most of the group of Ashmunellas of the San Andres-Organ-Franklin Mountains chain, with depressed shell morphology, are closely related. Genetic analysis of the relationships within this complex should prove especially interesting.

Throughout its range in the San Andres Mountains, *Ashmunella p. pasonis* has been found only in accumulations of limestone talus.

Ashmunella auriculata J. Vagvolgyi, 1974. Proceedings of the Biological Society of Washington, 87:150, Pl. 1, Fig. 5, 5a. T.L.: given as Boulder Canyon in the southern Organ Mountains (but see below).

Distribution--The canyon commonly called Boulder Canyon is at the extreme southern end of the Organ Mountains, where we have found only *A. organensis* (collected on the west wall of the canyon). It appears that there is an error in Vagvolgyi's placing the type locality of *A. auriculata* in Boulder Canyon. To our knowledge, *A. auriculata* occurs in the Organ Mountains from lower Fillmore Canyon northward. It is the species of the Organ Needles area and northward to Baylor Peak. In Fillmore Canyon, it has not been taken above the "Narrows." *Ashmunella organensis* replaces it to the south and to the southeast around Organ Peak (including uppermost Fillmore Canyon).

Habitat--In Fillmore Canyon and on Baylor Peak, *A. auriculata* inhabits rhyolitic talus, where mounds of angular, reddish stones are numerous. In the area of the Organ Needles, it must accommodate to a monzonitic rock-type that does not fracture into angular stones, but instead weathers into rounded rocks that do not produce the mounds of talus, full of interstices, typical of rhyolitic talus. Colonies of *A. auriculata* are less readily located in the monzonitic Organ Needles area than to the north or south, and may not be as numerous.

Ashmunella todseni A. L. Metcalf and R. A. Smartt, 1977. Proceedings of the Biological Society of Washington, 90:854, Pl. 1, Figs. b,e. T.L.: Maple Canyon, northeastern Organ Mountains, Doña Ana Co., New Mexico. (Maple Canyon woodlandsnail)

Ashmunella todseni has the most restricted occurrence of the three species of *Ashmunella* inhabiting the Organ Mountains. It has been taken only in the northeastern part of the mountains, in Maple and Texas Canyons, the upper branches of which are juxtaposed on opposing sides of a ridge. It may possibly occur in the southeastern part of the range. That area was inaccessible to us because of military restrictions. *Ashmunella todseni* inhabits rhyolitic talus in the canyons noted, and it is abundant at the type locality in a prominent talus accumulation on the east side of the eastern branch of Maple Canyon. *Ashmunella todseni* has not been found to intergrade or hybridize with the other Ashmunellas of the Organ Mountains.

Ashmunella organensis H. A. Pilsbry, 1936. The Nautilus, 49:101. T.L.: western slope of the Organ Mountains, above Dripping Spring from 7,000 to 7,500 ft (estimated), Doña Ana Co., New Mexico. (Organ Mountain woodlandsnail)

Distribution--*Ashmunella organensis* inhabits the southern part of the Organ Mountains, from upper Fillmore Canyon southward to Finley and Boulder Canyons. The type locality is in Ice Canyon, to the south of Fillmore Canyon. The species also extends northeastward into Rock Springs Canyon, where it occurs between the ranges of *A. auriculata* to the northwest and *A. todseni* to the east. It is broadly distributed, altitudinally, occurring as high as 8,200 ft or higher on Organ Peak and as low as 5,370 ft in the southern end of the Organ Mountains.

Habitat--Throughout its range in the Organ Mountains, *A. organensis* is an inhabitant of igneous-rock talus--in most cases of rhyolitic rock. This is true even in the higher, forested parts of the range, which approximate the Transition Life Zone. In the lower elevations of the southern end of the range, it is rather surprising to find this same *Ashmunella* living in isolated talus accumulations exposed to the sun, and in a habitat of markedly xeric character.

Among populations of *A. organensis*, there is marked variation in size, shape, coloration, and thickness of shell (Metcalf, 1984b:38). These characteristics are intergradational among populations and are related to elevation. The largest shells taken were at 7,900 ft and the smallest shells, at 6,300 ft. Means and extremes in shell diameter, for a sample of 10 shells from these and an intermediate population, are as follows (in mm): 7,900 ft, 15.2 mm (14.9-16.2 mm); 7,350 ft, 14.3 mm (13.6-15.2 mm); 6,300 ft, 11.5 mm (11.0-12.1 mm).

Species of Southern New Mexico, West of the Rio Grande

Ashmunella tetrodon tetrodon H. A. Pilsbry and J. H. Ferriss, 1915. The Nautilus, 29:15,29, Pl. 1, Figs. 1-3a. T.L.: Dry Creek Canyon, southwestern Mogollon Mountains, in and above the "Box" from 6,000 to 7,000 ft, Catron Co., New Mexico. (Dry Creek woodlandsnail)

Ashmunella tetrodon mutator H. A. Pilsbry and J. H. Ferriss, 1915. The Nautilus, 29:31, Pl. 1, Figs. 3-6. T.L.: Dry Creek Canyon, southwestern Mogollon Mountains, Catron Co., New Mexico.

Ashmunella tetrodon inermis H. A. Pilsbry and J. H. Ferriss, 1915. The Nautilus, 29:33, Pl. 1, Fig. 7. T.L.: Dry Creek Canyon, southwestern Mogollon Mountains, Catron Co., New Mexico.

Ashmunella tetrodon animorum H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:89, Pl. 7, Figs. 2, 2b. T.L.: at Holden's Spring, Black Range, Sierra Co., New Mexico.

Ashmunella tetrodon fragilis H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:89, Pl. 7, Figs. 1, 1b. T.L.: Cave Creek Canyon in the eastern foothills of the Black Range, along a wagon road north from Hillsboro to Hermosa, from a talus accumulation (slide) on a hillside, Sierra Co., New Mexico.

Distribution--We have listed the above subspecies of *A. tetrodon* to reflect the present situation according to the published literature. This would recognize races of *A. tetrodon* in three widely separated areas: 1) in the southwestern Mogollon Mountains; 2) in the Black Range, mainly at higher elevations in the northern part of the range, but with one seemingly isolated population (*A. t. fragilis*) in the eastern foothills; and 3) in the southern part of the San Mateo Mountains, Socorro, and Sierra Counties. When he worked with this complex, Pilsbry (who with James Ferriss named all its subspecies) visualized that further collecting would reveal populations that would connect the subspecies geographically. Thus, he noted (1940:939) that *A. tetrodon* "may be expected to occur widely in the central and eastern Mogollons, still unexplored." As it turned out, however, only *A. mogollonensis* appears to occur in the central and eastern Mogollons, leaving the three groups of putative *A. tetrodon* widely separated.

An analysis of the systematics of the *A. tetrodon* complex is much needed. The outcome of such a study cannot be predicted firmly, of course; but it appears likely that the number of subspecies might be reduced and the number of species, increased. It is probable that the three representatives of so-called "*A. tetrodon*" from the Mogollon and San Mateo Mountains and the Black Range may prove to be separate species that have evolved convergently in regard to shell morphology. It is possible, however, that these taxa may, instead, be separated derivatives of a common ancestral *tetrodon*, formerly widespread in west-central New Mexico. It is almost surely the case that three subspecies cannot be substantiated as occurring in a short segment of Dry Creek Canyon in the southwestern Mogollon Mountains, as listed above. One possibility that could explain the situation is that this segment of the canyon is a zone of hybridization between *A. tetrodon* and *A. mogollonensis*. Although we see some evidence to suggest it, sufficient collecting has not been done to support or reject this hypothesis.

Habitat--In the Mogollon Mountains, *A. tetrodon* appears to be limited to deep canyons. Along creek bottoms of these narrow canyons, deciduous trees produce an abundant leaf litter where snails occur under and around stones and logs. Presumably they could not exist, at present, on the relatively arid, steep ridges that separate canyons such as Dry Creek Canyon from Sheridan and Little Dry Creek Canyons to the west and east. In the San Mateo Mountains and northern Black Range, on the other hand, so-called "tetrodon" is a snail of the higher forests of the ranges, where it most commonly is associated with accumulations of talus of igneous rocks.

The isolated population named *Ashmunella tetrodon fragilis* by Pilsbry and Ferris (1917) also occurs in igneous rock-talus on a north-facing canyon wall at the lowermost end of Cave Creek Canyon, north of Hillsboro, Sierra Co. Apparently specimens of *A. t. fragilis* had not been observed or collected at the T.L. between 1915, when Ferriss found it there, and 1995, eighty years later, when we were able to visit the locality, and found the snail still inhabiting the talus slide.

Ashmunella cockerelli cockerelli H. A. Pilsbry and J. H. Ferriss, 1917, Proceedings of the Academy of Natural Sciences of Philadelphia, 69:90, Pl. 7, Figs. 3, 3a, 3b, 4, 9; Pl. 10, Fig. 2. T.L.: ravine up the trail to Sawyer Peak from Grand Central Mine, southwestern Black Range, Grant Co., New Mexico. (Black Range woodlandsnail)

Ashmunella cockerelli argenticola H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:91, Pl. 7, Fig. 5. T.L.: Silver Creek Canyon just below the "Box" where the trail makes a detour on the steep northern slopes between 8,000 and 8,500 ft, southwestern Black Range, Grant Co., New Mexico.

Ashmunella cockerelli perobtusa H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:91, Pl. 7, Fig. 7, 7a; Pl. 10, Fig. 4. T.L.: about 2 miles east of the trail from Sawyer Peak to Grand Central Mine and at a somewhat higher level than the mine, southeastern Black Range, Grant Co., New Mexico.

We have listed the three subspecies of *A. cockerelli* as they were set forth originally by Pilsbry and Ferriss in their paper of 1917. No work has been done subsequently to clarify the taxonomic status of the subspecies. It is clear that there is variation among populations of this species, but whether it is great enough, and shows a pattern with sufficient geographic consistency, to warrant the retention of subspecific partitioning is not clear to us at this time. A basic problem involving calciphile snails of the Black Range arises from the fact that limestone outcrops are discontinuous, and this leads to insularity of populations. Thus, there might well be other fairly distinctive variants of the *A. cockerelli* complex on "limestone islands" not yet collected or analyzed. The same problem prevails with the *Oreohelix metcalfei* complex, discussed hereafter.

Distribution and Habitat--In May 1987, we collected *A. c. cockerelli* at several places around Royal John Mine, which we suppose to be the Grand Central Mine of Pilsbry and Ferriss (1917). We found flourishing colonies of *A. c. argenticola* along Forest Road 523 where it crosses Silver Creek Canyon, and a bit farther north where it crosses and terminates near Rustler's Canyon--a northern tributary of Silver Creek Canyon.

The habitat of *A. c. cockerelli* around the Royal John Mine is open woodland, verging on semiarid. We found snails living in limestone talus in sheltered, undisturbed areas. The habitat in which we collected *A. c. argenticola* was higher in elevation and more mesic. Here, along the scenic head canyons of the Silver Creek system, the forest encroaches closely onto the canyon floors. There is a rich mixture of leaf litter amidst loose limestone rocks, which, when overturned, revealed an abundance of land snails.

We did not attempt to locate the type locality of *A. c. perobtusa* because Pilsbry and Ferriss were uncertain of its exact location, noting (1917:91) that ". . . one of the authors was lost when he found this colony . . . ."

In summary, it appears that members of the *A. cockerelli* complex still occur widely in the southern part of the Black Range.

Ashmunella binneyi H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:91, Pl. 7, Fig. 8; Pl. 10, Fig. 5. T.L.: in upper Silver Creek Canyon above the "Box" at ca. 8,500-ft elevation; southwestern Black Range, Grant Co., New Mexico. (Silver Creek woodlandsnail)

Ashmunella mendax H. A. Pilsbry and J. H. Ferriss, 1917. Proceedings of the Academy of Natural Sciences of Philadelphia, 69:92, Pl. 7, Figs. 6-6b; Pl.10, Fig. 1. T.L.: south side of Iron Creek, above the mouth of Spring Creek, southwestern part of the Black Range, Grant Co., New Mexico. (Iron Creek woodlandsnail)

Shells of *A. binneyi* and *A. mendax* are similar in their elevated, edentulous morphology. The two taxa are probably closely related and possibly conspecific. In view of these affinities, here they are treated together. They are retained as separate species only on the basis of Pilsbry's (1940:945) report of differences in genital anatomy between the two species.

Distribution and Habitat--Our collections confirm Pilsbry's observation (1940:946) that *A. mendax* was widespread in the Black Range, whereas *A. binneyi* was much more localized. *Ashmunella mendax* appears to tolerate lower elevations, even occurring along wooded canyons down into the Upper Sonoran-Transition Zone boundary. Pilsbry took it at ca. 6,250 ft in a garden in the village of Kingston and we have seen it living at slightly lower elevations, to the east. It also extends down to at least 6,680 ft along Gallinas Canyon on the west side of the range. Although a "canyon snail" at lower elevations, it is more widespread in the forested zone of higher elevations. Pilsbry (1940:946) wrote, "This snail has a remarkable range, from about 5500 to over 9000 feet." As in the case of several wide-ranging species already discussed, shell size varies in relation to elevation and probably to other environmental factors. Thus, shells of the more humid, higher forests are larger than those from the lower more xeric canyons.

Ashmunella binneyi, as understood by Pilsbry (1940:945), was a local endemic found only on the west side of the Black Range along a 2-mile, north-south distance at 8,000-8,500 ft in the upper ends of Silver, Bull Top, and Spring Creek Canyons. Spring Creek is a tributary of Iron Creek, along which is the type locality of *A. mendax*. It would be useful to study this area to see if there is intergradation or hybridization between the two species. We did not find either species in lowermost Spring Creek Canyon, although *A. binneyi* occurs higher up in the canyon. Perhaps there is a real (although narrow) distributional hiatus between the two taxa in that area.

Ashmunella mogollonensis H. A. Pilsbry, 1905 (as a subspecies of *A. chiricahuana*). Proceedings of the Academy of Sciences of Philadelphia, 57:252, Pl. 16, Fig. 102. T.L.: Whitewater Creek Canyon about 1-1/2 miles due east of Mogollon Peak, 9,000-ft elevation, Mogollon Mountains, Catron Co., New Mexico. On recent maps, a White Creek is shown draining eastward from Mogollon Baldy Peak and into the West Fork Gila River. Presumably, the T.L. was along this creek, which would be at an elevation of ca. 8,800 ft, at 1½ miles east of Mogollon Baldy. (Mogollon woodlandsnail).

Distribution and Habitat--This species occurs around all the higher, central mountains of the Mogollon massif and is common in the upper canyons of the Gila River system. It descends along Silver Creek Canyon to about 7,000 ft, near the town of Mogollon, and descends to about 5,600 ft along Whitewater (*not* White) Canyon in the Catwalk area 5 miles northeast of Glenwood. It has been recorded also from the Blue Mountains, Greenlee Co., Arizona (Pilsbry 1940:944).

At low elevations in the canyons south of Whitewater Creek Canyon, *A. mogollonensis* is replaced by members of the *A. tetrodon--A. danielsi* complex. However, in some places it occurs with *A. tetrodon*, as along Little Dry Creek Canyon. It has been taken as far north as Negrito Creek Canyon, near the northern end of the Mogollon Mountains. In summary, *A. mogollonensis* is the most widespread *Ashmunella* in New Mexico, areally, after *A. rhyssa* of the Sacramento Mountains-Sierra Blanca area. Although more common in the high forests of the Mogollon Mountains, it tolerates a wide range of elevations from at least 5,600 to 10,000 ft.

Ashmunella danielsi danielsi H. A. Pilsbry and J. H. Ferriss, 1915. The Nautilus, 29:34, Pl. 2, Fig. 1. T.L.: Cave Spring Canyon, ca. 7,000-ft elevation, western Mogollon Mountains, Catron Co., New Mexico. (Whitewater Creek woodlandsnail)

Ashmunella danielsi dispar H. A. Pilsbry and J. H. Ferriss, 1915. The Nautilus, 29:41, Pl. 2, Fig. 2. T.L.: at ca. 7,500 ft in Little Whitewater Creek Canyon east of Glenwood, western Mogollon Mountains, Catron Co., New Mexico.

It seems probable that *A. danielsi* does not need to be split into two subspecies. Their differences are minor, as indicated in their descriptions and as ascertained from paratypes inspected. *Ashmunella d. dispar* has a smaller, thicker shell, features that likely are related to environmental differences.

We have listed the two subspecies here to reflect the present situation in the literature. The entire complex of smaller Ashmunellas in the southwestern part of the Mogollon Mountains needs further analysis and assessment. It is likely that each major canyon extending at least from Rain Canyon northwesterly around to Little Whitewater Canyon has some member of the *tetrodon-danielsi* group. There are such representatives at least in Rain, Little Dry, Dry, and Sheridan Canyons, plus the two canyons listed above for *A. danielsi*. At present, this complex includes shells with four well-developed teeth; those with no teeth at all; and those, like *danielsi*, with three teeth. Analysis of this group would, no doubt, also involve the problem of *A. tetrodon* from the Black Range and San Mateo Mountains (as discussed above). It is possible that *A. tetrodon tetrodon* and *A. danielsi danielsi* ultimately might prove to be subspecies of the same species with existence of intergrading forms between the two. The major differences between them, insofar as shells are concerned, is the presence of a strong parietal tooth in *A. tetrodon tetrodon* and its complete absence in *A. danielsi* sspp.

Distribution and Habitat--We have collected *A. danielsi* only in Little Whitewater Creek Canyon (type locality of *A. d. dispar*). We assume that the canyon referred to as Cave Spring Canyon by Pilsbry and Ferriss (1915), which is the type locality of the nominal subspecies, is the canyon below Cave Spring. It is referred to as Shelton Canyon on modern maps, and is the next major canyon south of Little Whitewater Creek Canyon. In his account, Pilsbry (1940:942) described Cave Spring Canyon as being *north* of Little Whitewater Creek; but all other aspects of the description clearly show that it was actually *south* and not north. In Little Whitewater Canyon, we collected *A. danielsi dispar* on a wooded, north-facing slope in igneous rock in talus, moss covered in places, containing damp leaf litter in interstices among the stones.

Ashmunella rileyensis A. L. Metcalf and P. A. Hurley, 1971. The Nautilus, 84:120, Figs. 1, 2. T.L.: from the talus at head of southwest draining ravine on the west side of Mount Riley (northeast--see below), Doña Ana Co., New Mexico. (Mount Riley woodlandsnail)

Distribution and Habitat--Distributionally, *Ashmunella rileyensis* has one of the more restricted ranges of New Mexico land snails. It is found only on two small mountains that are surrounded by the La Mesa Plain, west of the Rio Grande Valley in southernmost New Mexico. On USGS topographic maps, the two mountains are designated, collectively, as "Mount Riley," but geologists at the University of Texas at El Paso, working in the area, have used the name "Mount Cox" to refer to the southwestern mountain, reserving the name "Mount Riley" for the northeastern one, which actually comprises two interconnected peaks. From western El Paso, Texas, these mountains appear as three low peaks on the western horizon. The Mount Riley complex is entirely of igneous, mainly rhyolitic rock. *Ashmunella rileyensis* is found only in long, linear mounds of rhyolitic talus that radiate downslope from the higher peaks of the Mount Riley complex. Only a few living specimens were found in this arid habitat (Metcalf and Hurley, 1971).

Ashmunella macromphala J. Vagvolgyi, 1974. Proceedings of the Biological Society of Washington, 87:152, Pl. 1, Fig. 7; Fig. 5a. T.L.: Cooke (=Cooks) Peak, Luna Co., New Mexico. (Cook's Peak woodlandsnail)

Distribution and Habitat--Like *A. rileyensis*, just discussed, *A. macromphala* is a species of very restricted occurrence, having been found only on Cooke Peak--a salient, isolated, 8,400-ft peak south of the southern end of the Black Range and north of Deming, New Mexico. Vagvolgyi (1974:153) described the habitat where he collected the species as follows: "We collected the snails on the very steep northern slope of the peak, at about 6,900-7,000 ft. of elevation, at the edge of 2 huge rock slides, from under the rocks and the debris accumulated between them. Groups of oak bordered the rock slides, providing food and shelter for the snails."

In 1988 we collected specimens in rock slides like those described by Vagvolgyi. We also collected a few fossils of *A. macromphala* in sediments at the "ghost village" of Cook (or Cooke) at the northern base of Cooke Peak.

Ashmunella walkeri Ferriss, 1904. The Nautilus, 18:53. T.L.: in rock talus near the middle of the west side of the Florida Mountains, Luna Co., New Mexico. (Florida Mountain woodlandsnail)

Distribution and Habitat--This is another of the southwestern New Mexico Ashmunellas with a restricted distribution, known from only a few localities in the Florida Mountains. We have taken it in a small elongate spill of limestone talus on the northwestern slope of Baldy Peak in the central and highest part of the Florida range. This likely may be the type locality indicated by Ferriss (see above). We also have taken it in igneous rock talus in a narrow canyon on the north side of South Peak, about 2 miles southwest of Baldy Peak. The species has not been found in the northern end of the Florida Mountains. It appears that the Florida Mountains presently do not offer much suitable habitat for *A. walkeri*. This may also have been the case with *Oreohelix florida*, which, we suggest below, likely has become extinct in the range.

> ***Ashmunella mearnsii*** (W. H. Dall, 1895, as *Polygyra*). Proceedings of the U.S. National Museum 18:2. T.L.: The type was collected by Dr. E. A. Mearns on his 1892 ascent of Hacheta Grande (=Big Hatchet Peak). Pilsbry (1915:329) suggested that the type locality was probably near Mearns' camp on a peak southeast of Hacheta Grande (this peak called "Daniels Peak" by Pilsbry--his collecting locality Number 5). In any event, the T.L. is near or on Hacheta Grande. (Big Hatchet woodlandsnail)

> ***Ashmunella hebardi*** H. A. Pilsbry and E. G. Vanatta, 1923. The Nautilus, 36:119. T.L.: northwestern slope of Big Hatchet Peak at about 7,600-ft elevation in a broad canyon, Hidalgo Co., New Mexico. (Hacheta Grande woodlandsnail)

Distribution and Habitat--*Ashmunella mearnsii* seems to be widespread in the Big Hatchet Mountain complex. We have taken it, living, at about 5,500-ft elevation as far south as a small mountain west of the northern end of the Alamo Hueco Mountains (NE ¼, sec. 36, of T 32 S, R 16 W). A number of living specimens were found on the north-facing slope of this small mountain north of the area of U-Bar Cave. Likely, it occurs in other, similar foothills of the southern Big Hatchet range in T 32 S, R 15 W. It has been taken from several localities in the higher, central part of the Big Hatchet range, where it occurs in both talus and thick leaf litter, especially below north-facing cliffs supporting good stands of Gambel oak. Also, we have taken it in limestone talus as far north as the northeastern slope of North Hatchet Peak. In addition, it occurs as a fossil in: 1) Pleistocene sediments excavated by Dr. A. H. Harris in U-Bar Cave, mentioned above, and 2) hill-slope colluvial deposits on the north side of Howells Ridge in the Little Hatchet Mountains. It seems, then, that the Pleistocene range of the species was relatively extensive, spreading some 30 miles from the U-Bar Cave area to the Little Hatchet Mountains, but, we suppose, not continuously.

Ashmunella hebardi, on the other hand, appears to be a local endemic of the Big Hatchet Peak area. We have collected it near what must be the type locality on the south side of Chainey Canyon (a broad canyon, as indicated in the description of the T.L.) on the northwestern, precipitous slope of Hacheta Grande. Here, it occurs under loose stones below cliffs in an area of unusually tall pinyon pines.

We do not know how far *A. hebardi* extends to the west along the south side of Chainey Canyon. Collecting in the area for one day, we moved to the east and upward along the cliffs, insofar as possible. Progressing eastward from an area where there were shells that appeared to be "good *hebardi*," we first found shells that were intermediate between *hebardi* and *mearnsii* and, still farther along, encountered shells that seemed to be "good *mearnsii*." All of this transition from one shell type to another occurred within 0.3 mile and several hundred feet, altitudinally. It is not clear to us, at this time, whether *A. mearnsii* and *A. hebardi* should be regarded as intergrading subspecies or as hybridizing full species.

Extremes of the two taxa appear quite distinct. *Ashmunella hebardi* shells differ from those of *A. mearnsii* in being larger, carinate rather than angular, having a dull, granular surface rather than the smooth, glossy surface of *A. mearnsii*, and having a thicker parietal callus, which is more raised, marginally, from the body whorl.

In the Big Hatchet Mountains, we found no fossils that would elucidate problems about the relationship of *A. hebardi* and *A. mearnsii*, but we hardly have searched for them at this time. A few specimens found were judged likely to be fossils that had washed or fallen down from cliffs on the northwestern face of Hacheta Grande. Somewhat disconcertingly, these snails had greatly reduced dentition, suggesting the existence, at least in the past, of still another variant in the *mearnsii-hebardi* complex!

> ***Ashmunella animasensis*** J. Vagvolgyi, 1974. Proceedings of the Biological Society of Washington, 87:153, Pl. 1, Fig. 8. T.L.: Animas Peak, Hidalgo Co., New Mexico. (Animas Peak woodlandsnail)

Distribution and Habitat--Like most of the Ashmunellas of southwestern New Mexico, this species is restricted to a single "montane island," the Animas Mountains. It has been taken around Animas Peak only at higher elevations. We took a number of specimens in an extensive field of igneous talus on the north side of Animas Peak at about 7,500-ft elevation. Vagvolgyi (1974:154) collected the species on the west side of the peak, noting that the locality was ". . . somewhat below the summit, at an estimated elevation of 7,500-8,000 ft. Pine, oak and juniper grew in abundance on the slope, indicating a fair amount of precipitation."

Family Thysanophoridae
Genus *Thysanophora*

> ***Thysanophora hornii*** (W. M. Gabb, 1866, as *Helix*). American Journal of Conchology, 2:330, Pl. 21, Fig. 5. T.L.: In Arizona. According to Bequaert and Miller (1973:135): "T. L.: old Fort Grant, at junction of Aravaipa (misspelled "Arivapa") Creek and San Pedro Riv, Pinal Co.; now a marked Site, 8 mi N by 5 mi W of Mammoth." (southwestern fringed-snail)

Distribution--The genus *Thysanophora* seems to be of Neotropical origin. *Thysanophora hornii* is widespread in México, including Baja California, and extends northward into Texas, Arizona, and New Mexico. We have taken it as far north as Sierra Co. in New Mexico.

Thysanophora hornii fully deserves to be called a "desert snail." It is typical of the Lower and Upper Sonoran Life Zones, being one of the few New Mexico land snails occurring in the Lower Sonoran Zone, outside of the floodplains of stream valleys. It is especially characteristic of the low, arid mountains of the southern part of the state. It occurs where there is some cover, such as rock rubble and talus, leaf litter, or under the dead stalks of yuccas or dead caudices of sotoles (*Dasylirion*).

Paleontology--Bequaert and Miller (1973:56) remarked on the rarity of *T. hornii* in fossil deposits examined in their work in Arizona. However, in New Mexico, it has been taken at a number of fossil localities in deposits of both Holocene and Pleistocene age. It is the most common species taken from fossil deposits of Pleistocene age excavated from U-Bar Cave, Hildago Co., by Dr. A. H. Harris, whose efforts have also supplied Pleistocene fossils of this species from Dry Cave, Eddy Co. Both caves are in the Lower Sonoran Life Zone.

Genus *Microphysula*

Microphysula ingersolli (T. Bland, 1875, as *Helix*). Annals of the Lyceum of Natural History of New York, 11:151. T.L.: Bequaert and Miller (1973:136) write: "T.L.: not selected thus far; described from Howardsville, San Juan Co., and other Stations in SW Colorado, at 9,300 to 11,000 ft." (spruce snail)

Distribution--This is a species of the Rocky Mountains and Pacific Northwest, known from British Columbia southward to New Mexico and Arizona. In New Mexico, *M. ingersolli* is typical of the Canadian Life Zone and upward to timberline. It is most common in the mountains of the north-central part of the state, these providing large areas of its favored habitat. To the south, it is found in the higher elevations of the Mogollon Mountains, Black Range, and the Sacramento Mountains-Sierra Blanca complex. It was taken by Hoff (1962:54) in habitats described as "8400 feet, in debris of alder stump," "8500 feet, mixed litter of aspen, spruce, and fir," and "10,300 feet, under rocks and in a wet rotting log, spruce-fir forest."

Family Helminthoglyptidae
Genus *Sonorella*

The stronghold of *Sonorella* is from the Grand Canyon area of Arizona, southeastward across Arizona, and into northeastern Sonora, México. The genus also occurs, but with far fewer species, in southwestern and south-central New Mexico, Trans-Pecos Texas, and northern Chihuahua.

Walter B. Miller's extensive studies of this genus led him to recognize four "complexes" (Bequaert and Miller, 1973:111), which he did not deem as being equivalent to subgenera. The two complexes of Miller that are present in New Mexico are indicated below.

Sonorella hachitana Complex

Sonorella hachitana hachitana (W. H. Dall, 1896, as *Epiphragmophora*). Proceedings of the U.S. National Museum, 18:2. T.L.: Big Hatchet Peak (=Hacheta Grande), Hidalgo Co., New Mexico. (New Mexico talussnail)

As recognized by Pilsbry (1939:273-278), *Sonorella hachitana* would be a species more widespread than what is usual for species of *Sonorella*. In addition to the nominal subspecies from the Big Hatchet Mountains and the subspecies listed below, Pilsbry recognized *S. h. orientis*, which has subsequently been elevated to a full species. It is likely that further analysis of soft anatomy or other taxonomic approaches might result in partitioning the *hachitana* complex into still further species. For convenience at present, all New Mexico Sonorellas west of the Rio Grande, are placed in the species *S. hachitana*, except for *S. animasensis* from the Animas Mountains.

In addition to published records (noted below) from the Big Hatchet, Florida, Carrizalillo, and Peloncillo Mountains, fresh (dead) shells have been collected from Pyramid Peak, south of Lordsburg, by Metcalf, and fresh shells and one living specimen from the Tres Hermanas Mountains by Dr. Richard Worthington. Fossil shells have been found in Pleistocene deposits of the Tres Hermanas Mountains and Howells Ridge of the Little Hatchet Mountains. In light of this, it seems likely that most mountains of southwestern New Mexico were inhabited by Sonorellas in the Pleistocene.

Distribution and Habitat--Concerning distribution of *S. h. hachitana* in the Big Hatchet Mountains, Pilsbry (1939:274) noted: "It was found most abundant at our station 7, on a hill about 1 1/8 miles south southeast of Big Hatchet Peak, where there is some shade in the largest group of pinyon pines in the mountains, under large stones on the steep slope near the summit, at about 7400 to 7500 feet." We found it at about these same elevations on the wooded northern face of Big Hatchet Peak, also under tall pinyon pines. Pilsbry (1939:275) also listed the nominal subspecies from the Carrizalillo Mountains on the basis of "bones" collected there by E. A. Mearns during the boundary survey in 1892.

Sonorella hachitana flora H. A. Pilsbry and J. H. Ferriss, 1915. Proceedings of the Academy of Natural Sciences of Philadelphia, 67:347, Pl. 5, Figs. 3-3c, Text-figs. F,G. T.L.: west side of Florida Mountains in "Spring Canyon," Luna Co., New Mexico.

This subspecies is endemic to the Florida Mountains. It appears to be distributed generally throughout the range, as we have acquired collections of the large shells of this species from various parts of the range.

Sonorella hachitana peloncillensis H. A. Pilsbry and J. H. Ferriss, 1915. Proceedings of the Academy of Natural Sciences of Philadelphia, 67:349, Text-figs. 6A-E. T.L.: Skull Canyon, Peloncillo Mountains, Hidalgo Co., New Mexico.

In addition to the type material of *S. h. peloncillensis* from Skull Canyon, Pilsbry (1939:277) noted that an immature shell in the U.S. National Museum from "Doubtful Canyon," in the

Peloncillo Mountains, seemed to belong to this subspecies. We have not found this snail in our searches of Skeleton and Clanton Canyons to the south of Skull Canyon. Thus, it would seem to be restricted to the Skull Canyon area.

Sonorella orientis H. A. Pilsbry, 1936. The Nautilus, 49:110. T.L.: at Dripping Spring, Organ Mountains, Doña Ana Co., New Mexico. (Organ Mountain talussnail)

Pilsbry (1905:257) first allocated this species to *Sonorella hachitana*. Later (1936), he assigned it to the new subspecies *orientis*. Pilsbry (1939:277-278) assigned specimens from the Organ and San Andres Mountains, New Mexico, and from Sierra Blanca Peak, Hudspeth Co., Texas, to *S. hachitana orientis*. Bequaert and Miller (1973:125) raised *orientis* to species rank. Because the Sierra Blanca, Texas, population is separated from the New Mexico populations by almost 100 miles, it seems likely that further study may show them to be specifically distinct, leaving *S. orientis* as an endemic of the Organ, San Andres, and Oscura Mountains.

Distribution and Habitat--In the Organ Mountains, *S. orientis* is widespread and common, associated with various kinds of igneous rock talus, chiefly rhyolitic and monzonitic. Metcalf (1984b:Table 2) found it at 20 of 25 localities collected, and at elevations ranging from ca. 4,900 to 7,900 ft. *Sonorella orientis* seems less common in the San Andres Mountains where it was found at only 4 out of 25 localities sampled (Metcalf, 1984b:Table 1). In the San Andres chain, igneous rock talus is confined to the area of Salinas Peak, where the species was taken in forested habitat. It also was found in limestone talus at several localities south from Salinas Peak to San Andres Peak in xeric habitat supporting only shrubs and a few low trees.

Smartt has collected shells from the Oscura Mountains that are probably attributable to this species. This range, predominantly of limestone, parallels, to the east, the northern part of the San Andres Mountains in the northern part of the Tularosa Basin.

Sonorella metcalfi W. B. Miller 1976. The Nautilus, 90:70, Figs. 1, 4. T.L.: Fusselman Canyon, Franklin Mountains, El Paso Co., Texas. (Franklin Mountain talussnail)

Sonorella metcalfi is mainly a species of the Franklin Mountains in Texas, to the south of the Organ Mountains (Metcalf and Johnson, 1971). However, Miller (1976:71) also assigned to this species some specimens from the head of Finley Canyon in the southern Organ Mountains, at about 6,000-ft elevation. This is arid habitat of the Upper Sonoran Life Zone. The snails are restricted to mounds of rhyolitic talus in the Finley Canyon area.

Similar mounds from Finley Canyon southward in the southernmost Organ Mountains yield shells, probably of this species. However, it is not known precisely how *S. metcalfi* and *S. orientis* are related, distributionally, in the southern Organ Mountains.

Sonorella todseni Miller, 1976. The Nautilus, 90:71, Figs. 2, 4. T.L.: northwestern slope of Doña Ana Peak, Doña Ana Mountains, Doña Ana Co., New Mexico. *Sonorella todseni*, as well as *Ashmunella todseni*, were named in honor of Dr. Thomas K. Todsen, Las Cruces, New Mexico, who first collected them. (Doña Ana talussnail)

Distribution and Habitat--*Sonorella todseni* is the most restricted, distributionally, of New Mexico Sonorellas. It is endemic to the Doña Ana Mountains, a small, arid range of igneous rock at the southern end of the Jornada del Muerto and north of Las Cruces. Within the range, to this time, the species has been taken only at the type locality on the north-facing slope of Doña Ana Peak, in an area of igneous rock talus under a sparse growth of live oaks and xeric-adapted shrubs. The types were collected after summer rains, when they were active. Specimens did not seem very common, and further investigation is advisable to better ascertain the size of the population.

Sonorella binneyi Complex

Sonorella animasensis H. A. Pilsbry, 1939. Academy of Natural Sciences of Philadelphia Monograph, 3(I)1:322, Figs. 190, 191. T.L.: above Black Bill Spring, Animas Mountains, Hidalgo Co., New Mexico. (Animas talussnail)

Sonorella animasensis is an eastern outlier of a subgroup of Sonorellas (*S. binneyi* complex) centered in Arizona (Bequaert and Miller, 1973:111,118-121). In this and some other respects, the land-snail fauna of the Animas Mountains shows affinity with that of southeastern Arizona.

Distribution and Habitat--This species is endemic to the Animas Mountains. In addition to the type locality (the only locality listed by Pilsbry in the description of the species), we have taken it in Indian Creek Canyon in the northern part of the range and on the northern slope of Animas Peak. Pilsbry's (1939:323) habitat description specified: "It occurs in deciduous forest on the steep sides of the canyon above the spring, under volcanic rock (andesite?), at from 6500 to 7000 feet, the forest above that being pine." Our collections were also from rock rubble and talus on steep slopes.

Family Humboldtianidae
Genus *Humboldtiana*

This is mainly a genus of México, extending from the Transverse Volcanic Belt in the region of México, D.F., northwestward, along the central highlands of the country, where it occurs in both lower and higher mountain ranges. The range of the genus continues northwest across the mountains of the central part of Trans-Pecos Texas, and barely into southeastern New Mexico.

Humboldtiana ultima H. A. Pilsbry, 1927. Proceedings of the Academy of Natural Sciences of Philadelphia, 79:184, Figs. 6, 12; Pl. 12, Figs. 12-14; Pl. 13, Fig. 4. T.L.: Pilsbry indicated in his description that he collected *Humboldtiana ultima* in the Guadalupe Mountains in the area of the Texas - New Mexico border at his Stations 240 and 241, with the type locality at Station 241. His field notes (Metcalf, 1970:29) show that Station 241 was in

Pine Spring Canyon, Texas, in the southeastern part of the Guadalupe Mountains. (northern threeband)

Distribution and Habitat–*Humboldtiana ultima* has been taken in the Guadalupe Mountains of Texas and New Mexico and, according to Fullington (1979:96), occurs in the Sierra Diablo Mountains of Hudspeth Co., Texas. In New Mexico, it has been taken in canyons of the Guadalupe Mountains as far north as Dark Canyon (Wahl and Metcalf, 1982:43). In Devil's Den and Dark Canyons, it has been found living in a mixture of rock rubble and leaf litter of deciduous trees, but not in talus accumulations as is the case with many larger land snails of the region. At the locality in Dark Canyon, it appeared to be living in a colony, and was found at the base of steep cliffs, on a gentle slope where large oak trees provided leaf litter some 2 or 3 inches thick. The snails were found under the leaves on slightly damp soil.

SPECIES OR SUBSPECIES THAT APPEAR TO BE OF RESTRICTED OCCURRENCE IN NEW MEXICO

From our observations of New Mexico land snails we discern certain species or subspecies that are of restricted distribution, and may or may not be threatened or endangered. It seems useful to identify these. They are indicated below, with no attempt to assign them to more formal categories.

A. Endemic species or subspecies known only from small to medium-sized isolated mountains in the southern part of the state:

1. ***Vallonia sonorana*** Pilsbry occurs only in the area of Big Hatchet Peak, Big Hatchet Mountains, Hidalgo Co.; however, it is quite possibly synonymous with *Vallonia gracilicosta*, and not a true species itself.
2. ***Holospira metcalfi*** Thompson is known only from the north face of Howells Ridge at the base of massive cliffs.
3. ***Coelostemma pyrgonasta*** Thompson is known only from Bishops Cap Mountain, Doña Ana Co. It seems fairly widespread within this small complex of limestone mountains.
4. ***Ashmunella amblya cornudasensis*** Vagvolgyi is found in the Cornudas Mountain complex of southern Otero Co. Specimens have been taken on Chatfield, Wind and Flat Top Mountains, all in igneous talus accumulations. The species probably occurs in two or three other mountains of the group.
5. ***Ashmunella harrisi*** Metcalf and Smartt is known only from canyons on the east side of Goat Mountain in the southeastern San Andres Mountains, Doña Ana Co., where living specimens are exceedingly scarce. It hybridizes with *Ashmunela pasonis pasonis* (Drake) in eastern Bear Canyon, south of Goat Mountain.
6. ***Ashmunella todseni*** Metcalf and Smartt has been taken only in Maple and Texas Canyons in the Organ Mountains, Doña Ana Co., but may also occur in the malacologically unexplored southeastern part of the range.
7. ***Ashmunella tetrodon fragilis*** Pilsbry and Ferriss is known only from a rock slide north of Hillsboro, Sierra Co. We were able to confirm its perseverance there in January 1995, 80 years after its discovery. It seemingly occurs in a very small area.
8. ***Ashmunella rileyensis*** Metcalf and Hurley is restricted to Mount Riley and nearby Mount Cox in southern Doña Ana Co. It occurs sparingly in rhyolitic talus in these mountains.
9. ***Ashmunella macromphala*** Vagvolgyi is reported only from the higher parts of Cooke (Cooks) Peak, Luna Co.
10. ***Ashmunella walkeri*** Ferriss has been taken, so far, only around Baldy Peak and on South Peak in the Florida Mountains.
11. ***Ashmunella hebardi*** Pilsbry and Vanatta is known only from the south wall of Chainey Canyon in the western part of the Big Hatchet Mountains, Hidalgo Co. Its relationship (whether subspecies or distinct species?) to *Ashmunella mearnsii* of the same range is unclear.
12. ***Ashmunella animasensis*** Vagvolgyi is recorded only from the vicinity of Animas Peak, Hidalgo Co.
13. ***Oreohelix metcalfei cuchillensis*** Pilsbry and Ferriss is reported living only from the south end of the Cuchillo Mountains, Sierra Co. We were unable to gain access to this area, and do not know its current status.
14. ***Radiocentrum ferrissi*** (Pilsbry) has been taken, living, so far as we know, only at two localities in the southern Big Hatchet Mountains (Pilsbry, 1915:333).
15. ***Sonorella hachitana peloncillensis*** Pilsbry and Ferriss has been reported only from the type locality in Skull Canyon, Peloncillo Mountains, Hidalgo Co.
16. ***Sonorella animasensis*** Pilsbry occurs only in the Animas Mountains, Hidalgo Co.
17. ***Sonorella todseni*** Miller is known only from the type locality in the Doña Ana Mountains, Doña Ana Co. No doubt, the species is restricted to this small, low group of mountains.

B. Species of restricted occurrence within a relatively large mountain range or in more than one range:

1. ***Oreohelix nogalensis*** Pilsbry is presently restricted to the Sierra Blanca Mountains (Sierra Blanca-Nogal Peak) of Lincoln and Otero Counties.
2. ***Oreohelix pilsbryi*** Ferriss is known only from two localities along Mineral Creek, west of Chloride, Black Range, Sierra Co.
3. ***Oreohelix confragosa*** Metcalf is known from one locality in the eastern part of the Pinos Altos Mountains, Grant Co.
4. ***Oreohelix litoralis*** Crews and Metcalf has been collected at several localities in hills around the

southern edge of the San Agustin Plains, Catron Co.

5. ***Sonorella metcalfi*** Miller has been reported in New Mexico (somewhat tentatively) from the southernmost Organ Mountains; however, it is fairly widespread to the south in the Franklin Mountains, El Paso Co., Texas.
6. ***Humboldtiana ultima*** Pilsbry is known only from the southern Guadalupe Mountains of New Mexico, but also occurs to the south in the Guadalupe Mountains and Sierra Diablo of Texas.

C. In categories C and D are species of restricted occurrence in New Mexico, but occurring elsewere as well. In C are species restricted to limited areas of mesic habitat:

1. ***Carychium exiguum*** (Say) is known at present in New Mexico only from along the Tularosa River Valley, near the Tularosa River from the village of Mescalero upstream to the headsprings of the river. It occurs widely in other parts of the United States.
2. ***Oxyloma retusum*** (Lea) has much the same distribution as the previous species, occurring from the headsprings of the Tularosa River, downstream as far as the village of Mescalero, and also along Fresnal Canyon above High Rolls (Sacramento Mountains), according to Raymond W. Neck (pers. comm.).
3. ***Vertigo ovata*** (Say) is common as a fossil in springbrook and other aquatic-related deposits in the state. Populations of living snails are rare, presumably because much of its preferred marsh-type habitat has disappeared. It is found living below Blue Springs, Eddy Co., and may occur elsewhere in similar habitats.
4. ***Linisa texasiana*** (Moricand) is widespread in Texas, but only known in natural habitat in New Mexico from moist areas in Bitter Lakes National Wildlife Refuge, east of Roswell, Chaves Co. It occurs as an introduced species in some urban areas, as in Artesia and Carlsbad.

D. As in C, but in drier, montane habitats:

1. ***Gastrocopta cochisensis*** (Pilsbry and Ferriss)
2. ***Gastrocopta dalliana dalliana*** (Sterki)
3. ***Vertigo hinkleyi*** Pilsbry
4. ***Vertigo elatior*** Sterki

The first three species above are found in Arizona and México. In New Mexico, to date, they are known only from the Animas Mountains, Hidalgo Co. *Vertigo elatior* is a montane species of northern affinities.

In summary, it appears that the Animas and Big Hatchet Mountains are especially notable for the number of endemic species of restricted occurrences. The small segment of the Tularosa River Valley, along the Tularosa River between the village of Mescalero and the headsprings, also harbors two species of restricted occurrence in New Mexico. The various isolated mountains of Doña Ana Co. have a rather impressive number of endemic species.

SPECIES NOT NATIVE TO NEW MEXICO

All species below, except *Vallonia pulchella* and *Polygyra septemvolva*, have been introduced from Europe--several from the Mediterranean region. The latter seem to be species especially pre-adapted for dispersal overseas by human agencies, and they now occur widely in various temperate parts of the world where they have been introduced.

Vallonia pulchella (Müller, 1774). (lovely vallonia)

This widespread species is native to temperate Eurasia, North Africa, and eastern North America. Pilsbry (1948:1024) considered it to be native as far west as Kentucky and Missouri, but noted already that it had been introduced into many places farther west, including Texas, the mountains states, and California. This tiny snail seems to be an especially successful adventitious species. It occurs in large numbers in urban areas and thrives in garden and lawn edges and flower beds, around the bases of shrubs, and in backyards. Pilsbry (1948:1024) quoted a report of impressive numbers found in gardens "in the heart of Brooklyn." Similarly, we have found large numbers in the heart of Albuquerque, as around the New Mexico Museum of Natural History. It occurs along the Santa Fe River in Santa Fe. The species is abundant under shrubs and foliage on the campuses of New Mexico State University, Las Cruces, and New Mexico Institute of Mining and Technology, Socorro. It also has been taken in Aztec, Mountainair, Portales, Hobbs, Artesia, High Rolls, Silver City, Carlsbad, and Deming. In fact, it probably occurs in most towns and cities of the state. In addition, it seems more inclined than most introduced species to establish itself outside towns and cities. Fresh shells have been taken in drift of the Gallinas River at Montezuma (San Miguel Co.). It has been found living along Bluewater Canyon 6 miles east of Bluewater Lake (Cibola Co.). Farther south, it has been found along the Tularosa River in Otero Co., and in Grant Co. at several localities along the Gila River and near Mangas Spring.

Cecilioides acirula (Müller, 1774). (blind awlsnail)

This minute species, of European origin, has been found in El Paso, Texas, very near the New Mexico state line. It is highly likely that it occurs in adjacent urban habitats in New Mexico as well. It can be expected in other urban areas in the Rio Grande Valley of southern New Mexico.

Rumina decollata (Linnaeus, 1758). (decollate snail)

Rumina decollata is native to the Mediterranean area. It has been introduced widely in the Americas. In the United States it occurs mainly in the more southern states. In New Mexico, we have found it in Albuquerque, Portales, Socorro, Roswell, Lovington, High Rolls, Alamogordo, Silver City, Hobbs, and Carlsbad. No doubt, it occurs in other cities in the southern two-thirds of the state.

Arion fasciatus (Nilsson, 1823). (orange-banded arion)

Slugs taken along the floodplain of the Pecos River about 1½ miles north of the town of Pecos, along the Gallinas River Valley, San Miguel Co., and along the Santa Fe River in Santa Fe, seem to conform to this species, which is native to and widespread in Europe. Specimens have dark bands along the anterior end and the sides of the mantle, rising above the pneumostome and fading out posteriorly. Two parallel dark bands extend from behind the mantle posteriorly along the sides of the body to its posterior end. A median dorsal line of tubercles are larger and paler in color than tubercles lateral to them. The spermatheca has a long tapered sac. All these are characters that differentiate *A. fasciatus* from the congeneric species *Arion hortensis* according to Quick (1960:130). Both species have been introduced into the United States. Specimens taken in Santa Fe are smaller than those taken at other localities noted.

Oxychilus draparnaudi (H. Beck, 1837). (black-bodied glass snail)

This species is native to western Europe, and has been introduced into the United States. We have found living specimens along the Santa Fe River in Santa Fe and in Las Vegas and Carlsbad. Adult shells range 10-12 mm in diameter, and the living animal is of a striking blue-black color, characters that separate this species from the related *Oxychilus cellarius* (Müller).

Limax flavus (Linnaeus, 1758). (yellow gardenslug)

This species usually has been relegated to the genus *Limax*, with *Limacus* considered to be a subgenus of *Limax*. However, in some, mainly European, publications, *Limacus* has been elevated to a full species. Bequaert and Miller (1973:148) recorded *Limax flavus* from several counties in Arizona. We have found it only along the floodplain of the Gila River in Grant Co. at two localities: (1) north of the Gila River bridge between Gila and Cliff and (2) 3 miles NE of Red Rock. (SE¼, NW¼, SE¼, sec. 21, T 18 S, R 18 W) Probably it occurs elsewhere between these localities along the Gila River Valley. Specimens from the second locality, when observed in late March 1993, were of various sizes and were of a dusky greenish background color.They were found under rotting logs in areas thickly grown to Cow Parsnip (*Heracleum lanatum*), the plants about a foot high at that time. The slugs were often found aggregated together, a behavior that has been discussed for the species by Chelazzi et al. (1988).

Lehmannia valentiana (A.E.J. d'A. de Férussac, 1821). (threeband gardenslug)

This species often has been referred to *Lehmannia poirieri* (Mabille, 1883) in the American literature; however, Bequaert and Miller assigned specimens from Arizona to *L. valentiana*. The type locality is Valencia, Spain, and it seems to be native to the western Mediterranean region. It has been widely introduced to other parts of the world, including the United States. It is known from El Paso and Albuquerque, and likely occurs in other urban areas in the Rio Grande Valley.

Polygyra septemvolva Say, 1818. (Florida flatcoil)

This polygyrid is a native of the southeastern United States, occurring mainly in Florida and along the Gulf Coast, west to coastal Texas (Hubricht, 1985:Map 365). It has been disseminated by horticultural practices, as seems to be the case in Carlsbad, where it was found at a residence with many ornamental plants. It also has been found in El Paso, Texas, and might be expected in urban areas in New Mexico contiguous with El Paso.

Helix aspersa O. F. Müller, 1774. (brown gardensnail)

Helix aspersa is of European origin. In Europe it is more common towards the south, and this also is true of the United States. It has been found in several urban areas in New Mexico: Santa Fe, Albuquerque, Tijeras, Socorro, Hobbs, High Rolls, Las Cruces, Silver City, and Carlsbad. It doubtless occurs in other populated areas. This *escargot* seems to be establishing itself in yards, gardens, and at least one campground on the eastern slope of the Sandia Mountains at ca. 7,000-7,500 ft. One author (Smartt) was contending with a thriving population of the aptly named "brown gardensnail" in his own vegetable garden in the summer of 1997.

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LAND SNAILS OF NEW MEXICO FROM AN HISTORICAL ZOOGEOGRAPHIC POINT OF VIEW

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ABSTRACT: This abstract briefly notes the following generalities, inasmuch as a summary section is included. Efforts to delineate zoogeographic provinces for land snails of the southwestern United States and for New Mexico, in particular, are discussed and evaluated; minor modifications are proposed. A history is presented of geological, paleoclimatic, and paleontological aspects that seem to have been related to the New Mexico land-snail fauna, past and present, extending from the Late Mesozoic to the Quaternary. From this analysis, a model is proposed concerning Cenozoic historical zoogeography of the New Mexico land-snail fauna.

INTRODUCTION

A Symposium of the American Malacological Union and Western Society of Malacologists, held in 1989 in honor of Dr. Walter B. Miller, stimulated my interest in the zoogeography of land snails of New Mexico. The topic seemed apropos on such an occasion because Bequaert and Miller (1973) essentially initiated, and went far in analyzing, southwestern land-snail zoogeography. Herein is a discussion of some historical aspects of the zoogeography of the land-snail fauna of New Mexico.

ZOOGEOGRAPHIC DIVISIONS AND PROVINCES OF WESTERN LAND SNAILS

William G. Binney (1885:18-26) summarized his views concerning zoogeography of North American land snails, proposing three major "provinces": Eastern, Central, and Pacific. In the United States, his Eastern Province extended from the Atlantic coast to the Rocky Mountains, the Central Province from the Rocky Mountains to the Sierra Nevada, and the Pacific Province from the Sierra Nevada to the Pacific Ocean. He subdivided the Pacific Province into more northern Oregonian and more southern Californian Regions.

Henderson (1931) recognized (see Fig. 1A) only two major geographic subdivisions in the land-snail fauna of the United States: an Eastern Division, essentially the same as Binney's Eastern Province, and a Western Division, incorporating Binney's Central and Pacific Provinces. Henderson retained Binney's Oregonian and Californian Regions, although referring to them as provinces, and extended the Californian eastward to incorporate southwesternmost Arizona. He subdivided Binney's Central Province into the following three provinces: 1) To the northwest, a Washingtonian Province was recognized east of the Oregonian Province. 2) A southwestern Province was defined, including Arizona, except for the southwestern part (noted above) and New Mexico, except for the eastern part (placed in the Eastern Division). 3) Henderson relegated the remainder of Binney's Central Province to a Rocky Mountain Province, which

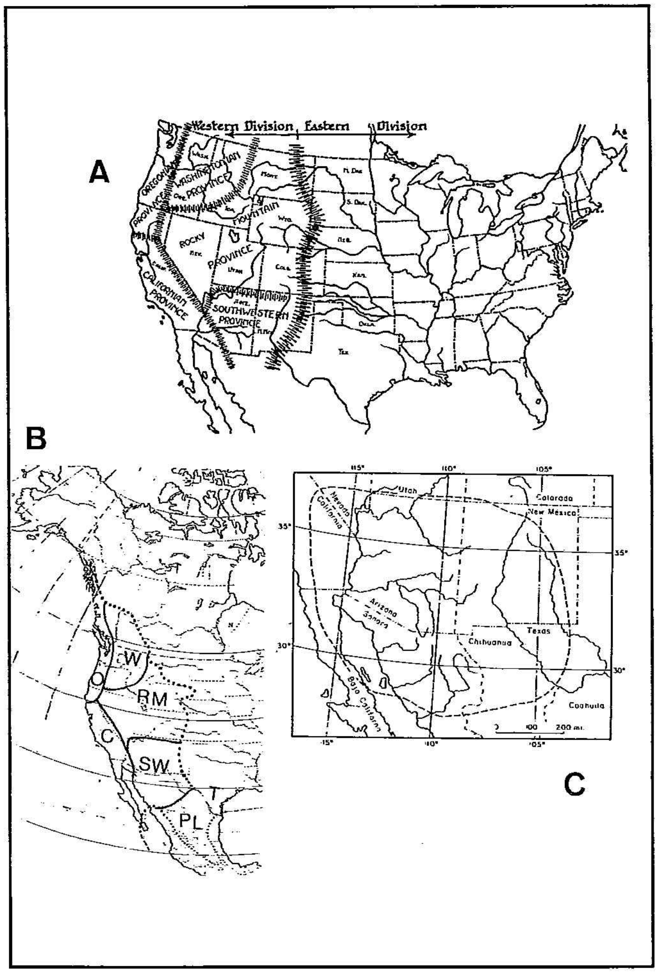

Figure 1.Molluscan provinces of western United States proposed by Junius Henderson (1931: Fig. 1). B, Molluscan provinces of western United States proposed by Henry A. Pilsbry (1948: Fig. 1). Abbreviations indicate the following provinces: O=Oregonian, C=Californian, W=Washingtonian, RM=Rocky Mountain, SW=Southwestern, T=Texan, and PL=Mexican Plateau. C, Boundaries of the Southwestern Molluscan Province proposed by Joseph C. Bequaert and Walter B. Miller (1973: Fig. 1; by permission of The University of Arizona Press).

he delimited southward along the Utah-Arizona and Colorado-New Mexico borders.

Pilsbry (1948:XL-XLI) adopted (see Fig. 1B) the basic terminology and boundary definitions of Henderson (1931). However, he suggested existence of a Texas Province, without defining its boundaries. Pilsbry extended Henderson's Southwestern Province eastward to include most of Trans-Pecos Texas, and southward into México to incorporate most of Sonora and Chihuahua. South of the Southwestern Province, he mapped a Mexican Plateau Province (1948:Fig. 1). In New Mexico, Pilsbry showed the Eastern Division as extending less far to the west than in the rather generalized map of Henderson (1931:Fig.1).

Bequaert and Miller (1973) also retained the basic scheme of Henderson (1931, Fig. 1C), recognizing a Western Division that they subdivided into Oregon-Washington, California, Rocky Mountain, and Southwestern Provinces. However, the boundary between the California and Southwestern Provinces was moved back to the west to include, in the latter province, arid southeastern California, southernmost Nevada, and the northwesternmost part of the Mexican State of Baja California Norte. They assigned (p. 7) "northeast New Mexico" to the Rocky Mountain Province. Thus, in the latest application of the by-now traditional land-snail zoogeographic subdivisions, New Mexico is partitioned among the Eastern Division and the Southwestern and Rocky Mountain Provinces of the Western Division.

Further consideration of the applicability of these divisions and provinces to New Mexico is undertaken in the Discussion section, hereafter.

THE LATER MESOZOIC

In attempting to trace a history of the land snails of New Mexico, it is probably justifiable to speculate about conditions as far back as the Mesozoic. Although there are almost no Mesozoic land snails reported from the state, there are Cretaceous records from other western states and Canadian provinces, and some of these pertain to families presently or formerly found in New Mexico. It is likely that the long-continued geologic activity of the Cordilleran region, especially the effects of: 1) a succession of magmatic arcs, already active in the Mesozoic, and 2) the presence of Cretaceous epicontinental (epeiric) seas has played a major role in determining the nature and distribution of the land-snail fauna of the general region, and of New Mexico in particular.

Jurassic Mountains of Arizona

Already during most or all of the Jurassic Period, a magmatic arc crossed Arizona south of a northwest-southeast trending line from Parker to Tucson to the southeastern corner of the state, according to Tosdal et al. (1989:Fig. 4). These authors (p. 428) interpreted magmatic activity in the early Jurassic to have formed "a volcanic province comparable to the Neogene Central Andes of South America or the Tertiary Sierra Madre Occidental of Mexico." Busby-Spera (1988) compared the early Jurassic arc to that of present-day Central America. A paleolatitudinal and climatic model of Dickinson (1989:Fig. 9) indicates that Arizona would have been at a paleolatitude of some 20° N in the Early Jurassic, or at about the latitude of the present Transverse Volcanic Belt of México, which may be somewhat analogous, biotically, to these early Jurassic volcanic mountains. Tosdal et al. (1989:428) found evidences of transport and deposition of clastic sediments derived from these mountains by "streams or rivers," which suggests that the mountains received considerable precipitation, and were likely mesic and forested, especially on their Pacific coastal side.

Further evidence of Jurassic mountains is provided by Lipman and Hagstrum (1992), who discussed four volcanic calderas in southeastern Arizona, three of which are in the Huachuca Mountains area, and seem to span a time from mid-to-late Jurassic. The calderas were large (one being 8 x 16 km), produced extensive ash-flow sheets, and some may have produced resurgent domes. These and other evidences suggest volcanic mountains of considerable height. Probably, long after their eruptive stages, they continued to produce a mountainous landscape.

It is not known what kinds of land snails might have inhabited such Jurassic mountains, in Arizona or elsewhere along the Jurassic magmatic arc. However, given the existence of such a fauna, it seems likely that there could have been ancestral links between it and the Cordilleran fauna that is known from Cretaceous fossils. Perhaps there already existed ancestral Jurassic roots of faunas that eventually would be described as typical of the modern Southwestern, California, and Oregon-Washington Molluscan Provinces, noted above. The latter two provinces, in their maritime locations, more likely may have conserved elements of ancient, Mesozoic Cordilleran faunas than did areas of the Cordilleran interior, with less equable climates.

Early Cretaceous: Southern New Mexico and Southeastern Arizona

In the latest Jurassic and continuing on into the Early Cretaceous, southeastern Arizona and southern New Mexico were affected by a kind of geologic activity, different from that discussed above. At that time, rifting, related to the opening of the Gulf of Mexico, extended northwestward therefrom, forming the Chihuahua Trough. Seager and Mack (1986:671) discussed Late Jurassic rocks of marine origin in the subsurface in the Las Cruces area, indicating that by then an arm of the Gulf of Mexico had already extended up the Chihuahua Trough to southern New Mexico. In the Early Cretaceous, this sea extended across southern New Mexico from near Las Cruces to the Big Hatchet Mountains and on into southeastern Arizona, where its northwesternmost extension occupied the much-studied Bisbee Basin. Mack et al. (1988:136,140) referred to the "Chihuahua/Bisbee basin" as being an "Early Cretaceous rift basin," bordered on the north by a rift shoulder, a feature defined and discussed by Bilodeau and Lindberg (1983). The rift shoulder was a source of sediments deposited in the rift basin to the south. The nature of these sediments indicates presence of exposures of Paleozoic sedimentary and Precambrian crystalline rocks along the rift shoulder highlands (Mack et al., 1988:140).

These highlands seem to have incorporated rift faults oriented roughly perpendicular to those of the present Rio Grande rift valley. The rift shoulder highlands continued westward, with or without interruptions, into Arizona as the "Mogollon Highlands," as mapped by Bilodeau and Lindberg (1983:Fig. 6). Dickinson (1989:8) depicted the Mogollon Highlands as Early Cretaceous features, consisting of a zone of steep, faulted scarps associated with rifting north of the Bisbee Basin. On their northern flank, he visualized these highlands as sloping more gently toward the region of the present Colorado Plateau. It would appear that during the Early Cretaceous a landscape persisted, which was dominated by mountains or highlands bordering a sea--the sea, in this case, being an arm of the Atlantic rather than the Pacific Ocean as during the earlier Jurassic situation, discussed above.

Deposition in the Early Cretaceous rift basin in southwestern New Mexico continued during most of Early Cretaceous time, but, as described by Mack et al. (1988:140) "Late Albian and early Cenomanian was a transitional time between the rift and foreland basins. The rift shoulder was onlapped by the Sarten and Beartooth Formations . . . derived from the northwest." These authors further noted (p. 140) that "the rift shoulder that separated southwestern New Mexico from the Midcontinent foreland basin in Aptian, Albian and early Cenomanian time was not a significant barrier by middle to late Cenomanian and . . . the foreland basin occupied virtually all of New Mexico." Thus, the wearing down of the rift shoulder allowed incursion of the Cretaceous epeiric sea from the east, establishing the conditions that would characterize the Late Cretaceous of New Mexico.

The Late Cretaceous Epeiric Sea

The Late Cretaceous epeiric (epicontinental) sea stretched from the northern to the southern margin of North America as a broad seaway covering much of the region of today's Great Plains and Rocky Mountains. In the northern United States, the sea extended as far east as western Iowa and Minnesota and as far west as western Montana (Rice and Shurr, 1983; Witzke, et al., 1983). To the south, most parts of the Gulf Coast states were inundated, with the sea extending across Texas and New Mexico and into Arizona during maximal stages. To the south, much of México was covered by the sea (Enos, 1983).

The epeiric sea was subject to recurrent transgressive and regressive cycles. Witzke et al. (1983) recognized five major cycles in the northern United States as did Molenaar (1983) in the area of New Mexico and Arizona. Molenaar found that the earliest transgression (late Cenomanian to early Turonian) was also the most extensive (his Fig. 7), extending westward approximately to a diagonal drawn from the northwestern to southeastern corners of Arizona. Except possibly for a small area in the extreme southwestern corner, and for any mountaintops that became islands, all of New Mexico would have been covered by this transgression of the sea. With its regression (later Turonian), the southwest quadrant of the state was exposed. In succeeding cycles, transgressions extended successively less far to the southwest and regressions successively farther to the northeast. The fifth transgression extended only about as far as a diagonal drawn from the northwestern to the southeastern corners of New Mexico, and, in a final regression, the sea withdrew from northeastern New Mexico in Campanian to Maestrichian time of the latest Cretaceous (Molenaar, 1983:Fig. 10).

In southwestern New Mexico and southeastern Arizona, regressions were related to a return of tectonic uplift in the western part of a retroarc foreland region where compressional orogenesis was taking place. In this regard, Mack (1987:512) noted: "Erosion of the orogen produced a great volume of siliciclastic sediment that spread eastward, southeastward, and northeastward across the former rift basin and onlapped the former rift shoulder." That is to say that the later Cretaceous sea in southwestern New Mexico was a repository of clastics derived from an orogenic source that existed farther to the west. Such an orogenic belt in Arizona is also involved in the model of Cumella, who wrote (1983:196): "I suggest that the movement of the Late Cretaceous shoreline in the San Juan Basin area was controlled primarily by tectonism in southeastern Arizona. . . ." Cather (1991:272) summarized evidence indicating that paleocurrent and provenance data from the Mesaverde Group of Late Cretaceous age "throughout much of New Mexico favor derivation from orogenic areas in southern Arizona and southwestern New Mexico." In the same general area in southeastern Arizona where Jurassic volcanoes had developed, Lipman and Sawyer (1985) reported identification of a number of late Cretaceous calderas with an age range of ca. 70-75 Ma. They also noted a likely caldera in this age range near Hillsboro, Sierra Co., New Mexico, which they compared to the Crater Lake volcano of northern California.

It appears, then, that in the Late Cretaceous, recurrent uplifts and volcanic activity created highlands and mountains in eastern Arizona that would have bordered the epeiric sea, probably producing islands and peninsulas. Throughout the Cretaceous, land snails of montane affinity probably continued to find satisfactory habitats in parts of Arizona, and would have been, as it were, poised to colonize New Mexico as habitat became available. As land emerged from under the epeiric sea, a *tabula rasa* must have been produced, which would have invited terrestrial colonists. In the back-and-forth succession of transgressions and regressions, periods of colonization must have alternated with extinctions caused by inundations. It seems, then, that the first land snails colonizing New Mexican soil during regressions would have come into the southwestern part of the state. It has been stressed, above, that southern Arizona (and adjacent México) seem to have had a long Jurassic and Cretaceous history as a mountainous or highland region--these highlands often being coastal in location. Thus, any colonists repopulating southwestern New México probably included species adapted to coastal habitats of the epeiric sea as well as montane species.

Regional Aspects of the Cretaceous and Faunal Implications

Some aspects of the Cretaceous that are of broader regional extent than those discussed above may relate, in a general way, to New Mexico and its fauna. These pertain to the nature of lands west of the epeiric sea (apart from Arizona, discussed above) and to the general isolating effect of the epeiric sea on elements of the North American biota.

The southern end of the Cretaceous magmatic arc and its associated mountains were located in southern California and adjacent México, west of where its Jurassic antecedent had been in Arizona. However, to the north, the Cretaceous arc must have occupied a position similar to that of the Jurassic arc and of the present Sierra Nevada Mountains (Dickinson, 1989:Figs. 4, 5). The Cretaceous magmatic-arc mountains in this region have been termed "a belt of great batholiths" by Hamilton (1988:4). Norris and Webb (1990:85) speculated that these mountains were as high as or higher than the present Sierra Nevada. Hamilton (1988:17) has suggested an analogy of these ancient mountains to parts of the Andes Mountains over 5 km in elevation. Comparison to the Andes also has been suggested by Nilsen (1987:82). There seem to be similarities both in terms of physiography and of plate tectonics. Both ranges have been related to subduction of oceanic plates (Nazca and Farallon) under continent-bearing plates (South American and North American).

Perhaps, then, the Cretaceous magmatic-arc mountains of California were of Andean aspect, and also at a paleolatitude comparable to the Andes of central Chile (Dickinson, 1989:Fig. 9). It appears likely that they were mesic, forested ranges that provided favorable habitats for land snails, at least on their seaward slopes. Such Cordilleran mountains, extending from México to Alaska with probable connections to northeastern Asia at times, must have provided a remarkably long although narrow corridor for occupancy by land snails adapted to montane habitats. As such, these mountains may have been of major significance in the development of a distinctively western North American land-snail fauna during the later Mesozoic. Such a fauna, in a broad sense, also may have had some bearing on the nature of the land-snail fauna of New Mexico, even though removed geographically.

East of the Cretaceous magmatic-arc mountains was a region located in present Nevada and northwestern Utah, which has been termed the "Hinterland" by Armstrong (1972) and most later authors, in contradistinction to the more eastern Cordilleran foreland. Coney and Harms (1984:552-553) interpreted the Hinterland as an "overthickened crustal welt," produced by compressional "crustal telescoping," and suggested that the region might have resembled a "Tibetan or Andean altiplanolike plateau" in the late Mesozoic. The altiplano analogy conforms well with an Andean model for the magmatic-arc mountains to the west. Perhaps the Hinterland was within a rain shadow of the magmatic-arc mountains, as they were probably at that time in a zone of prevailing westerlies (Dickinson, 1989:Fig. 9).

East of the Hinterland belt was the Cordilleran fold and thrust belt (also termed as the overthrust belt, foreland thrust belt, or Sevier thrust belt). This was a remarkably long, sinuous, mountainous belt extending from Alaska southward to the eastern Mojave Desert region of California. Levy and Christie-Blick (1989) indicated that this belt formed within the time-frame of 150-50 Ma and Elison (1991) as between 165- 55 Ma (Early Cretaceous to Eocene in both cases). Thus, in part, it would be time-equivalent to the Laramide Orogeny, discussed below. This belt was caused by intracontinental compression related, at least to some extent, to events involving the boundary of the North American Plate (Elison, 1991:1235). Estimates of minimum crustal shortening in the fold-thrust belt calculated by Levy and Christie-Blick (1989:Table 1) range from 104 to 135 km. Clearly, such horizontal compression must have been converted by folding and thrusting into vertical planes that produced imposing mountain ranges. Such mountains are shown in paleogeographic reconstructions, as for western Montana by Rice and Shurr (1983:Fig. 17) and for central Utah by Ryer and McPhillips (1983:Fig. 14).

Eaton and Nations (1991) summarized studies concerning Cretaceous sediments deposited along the western margin of the Cretaceous sea in southwestern Utah and northern Arizona. They found evidences of deposition by streams flowing east to northeast from the Sevier Thrust Belt mountains, and also by streams flowing north to northeast from the Mogollon Highlands to the south (Eaton and Nations, 1991:Fig. 6). The Sevier and Mogollon highlands, thus, bordered a roughly V-shaped western extension of the sea, which has been termed the "Grand Canyon Bight" (Eaton and Nations, 1991:1). Fluviatile deposition indicated presence of perennial streams (Schmitt et al., 1991), which suggests that the adjacent mountains received considerable precipitation and were probably well vegetated.

It seems likely that the fold-thrust ranges, not too distant from the epeiric sea in Cretaceous time, provided favorable opportunities for land snails. In some ways, it may have been analogous to the present Sierra Madre Oriental of México, also westward from a warm sea. The fold-thrust mountains may have provided a long "highway" offering opportunities for dispersal of land snails, northward or southward. Families with members utilizing such a highway likely may have included the Urocoptidae, Oreohelicidae, and Helminthoglyptidae, known from Cretaceous fossils in the region, and still existing there. Several other families are reported as Cretaceous fossils in the region and may have inhabited the fold-thrust belt west of the epeiric sea, although they now exist to the south or southeast of the Cordilleran region. Included are the families Helicinidae, Cyclophoridae, Subulinidae, and Camaenidae. In the fold-thrust mountains, snails belonging to such families might have found habitats similar to those in the present Sierra Madre Oriental, as suggested above.

Although narrow longitudinally, the sources cited above indicate that the lands west of the epeiric sea provided a variety of habitats in regard to elevation, climate, and vegetation, and presumably supported a correspondingly diverse land-snail fauna, which must have contributed in some ways to producing Late and post-Cretaceous faunas of New Mexico. Unfortunately, the nature of the Late Cretaceous land-snail fauna of New Mexico is not known. Hartman (1981b) referred to *Planorbis chacoensis* Stanton, 1917, as being a terrestrial species, and he reports (pers. comm., 9 July 1992) continuing work on nonmarine Cretaceous mollusks from northwestern New Mexico. A discussion of the taphonomy of nonmarine invertebrates and vertebrates of latest Cretaceous age in the Fruitland and Kirtland Formations has been provided by Hunt (1991), although no specific terrestrial snail taxa are mentioned.

In the Rocky Mountain region, with desiccation of the epeiric sea, the more western area that had been covered by the sea joined with the land to the west and took on its Cordilleran character. That is, Tertiary magmatic, tectonic, and volcanic activities were to produce an environmental and biotic diversity much in contrast to that of the Plains region, which developed to the east. New Mexico, located astride the Cordilleran-Plains interface, surely was colonized by both western and eastern immigrants attracted by the *tabula rasa* presumably produced upon progressive desiccation of the epeiric sea.

As has been recognized in various faunal and floral groups, in sundering North America into eastern and western parts, the Cretaceous epeiric sea acted as a major isolating barrier between biotas. Leopold and MacGinitie (1972:148-149) discussed this in regard to floras. This ancient allopatry, east and west of the epeiric sea, may be reflected dimly in present faunas, although Cretaceous effects have been obscured by some 65 Ma of subsequent Cenozoic history. The eastern part of the sea was to be replaced in the Cenozoic by the Great Plains, which, in their turn, continued to act as a barrier to eastern and western plants and animals that were unable to adapt to the Plains environment.

Henderson (1931:185) and Pilsbry (1948:XLV) related the existence of the epeiric sea to origin of Eastern and Western Divisions in the North American land-snail fauna, with this being variously reinforced by subsequent development of the Great Plains. As noted, these authors allocated easternmost New Mexico (in the Great Plains) to their Eastern Division, and the western, Cordilleran part of the state to a Western Division. Henderson (1931:186) took special note of the role of the Great Plains as a continuing isolating mechanism between eastern and western faunas.

Although diversity of the Plains fauna has fluctuated in the past, as discussed hereafter, it seems never to have been as rich as that in Cordilleran New Mexico, in which many groups have western rather than eastern roots. This could be termed an "Ancient Cordilleran Fauna," and probably included most of the taxa (families or genera) indicated as distinguishing the present Southwestern Molluscan Province (Henderson, 1931; Pilsbry, 1948; Bequaert and Miller, 1973).

Cretaceous Termination

It is probable that a process of post-epeiric sea recolonization of New Mexico by land snails was well under way, from west to east, at the termination of the Cretaceous.

Current models strongly support the hypothesis of a terminal event caused by one or more asteroid or comet-related impacts, one of which impacted as near as the Yucatan region (Hildebrand et al., 1991; Swisher et al., 1992). It is not known what effect such an impact might have had on land snails of the western United States; however, palynological studies provide information concerning the plants with which snails presumably were associated. Tschudy and Tschudy (1986) analyzed pollens occurring across the K/T boundary at outcrops in Montana and Wyoming and in the Raton Basin of Colorado and New Mexico. They concluded (p. 670): "It is clear that the Western Interior terrestrial Cretaceous flora received a profound ecological shock at the K/T boundary." However, despite indications of "massive devastation of plant life," they found no evidence in the western interior region of "total extinction of any key Cretaceous genus. . .". They assumed that there were refugia, which enabled many plant species to survive. Perhaps a similar scenario applies to land snails. Insofar as land snails of K/T time were able to enter dormancy, as do many modern species, this could have pre-adapted them for surviving an "impact winter" of some weeks or months. Wolfe (1991) has suggested, on the basis of paleobotanical evidence from Wyoming, a major bolide impact in early June and a resulting impact winter of less than 2-months duration. If this were the case, and if New Mexico had a subtropical climate with a spring-to-early-summer dry season like that of much of México today, then land snails still might have been in dry-season dormancy at the time of impact.

Tschudy and Tschudy (1986:668) noted that, in sections analyzed in their study, there was a zone above the K/T "boundary clay" that yielded "abundant sapropel and fusinite suggestive of decaying vegetation and fire." Sheehan and Fastovsky (1992:558) have discussed forest-soil food chains based on detritus composed of leaf litter, decaying wood, roots, and branches, and on associated fungi. Among groups utilizing such food resources, they included the gastropods. These authors, and Sheehan and Hansen (1986), contended that detritus feeders probably enjoyed an advantage over those animals, which fed on living plant materials at the time of the terminal Cretaceous event. They pointed out that the death of plants and animals actually may have temporarily increased amounts of food available to detritvores. Land snails might have found that dead vegetation or fungi attracted to decaying plant materials were a source of life-sustaining nutrients during a time of scarcity of living plant food. It is apropos to note Solem's (1979:286) suggestion that ever since the late Paleozoic "Land snails presumably kept contentedly chewing away on dead plant matter." At the level of families of land snails, at least, there seem to have been no identifiable extinctions at the end of the Cretaceous in the Cordilleran region, and some genera reported from the Upper Cretaceous also are recorded in the Tertiary.

LARAMIDE COMPRESSIONAL DEFORMATION

During the latest Cretaceous and early Tertiary (Paleocene to Eocene), there occurred yet another highland or mountain-building episode in New Mexico, the Laramide deformation or orogeny. In Dickinson's model (1989:8-9) the magmatic arc, which had been located along the western edge of the continent during most of the Cretaceous, migrated eastward during Laramide time. This is inferred to have been caused by a flattening of the angle of dip of the subducted Farallon slab, so that melting occurred where the slab penetrated the asthenosphere. Dickinson (1989:9) indicated that Laramide activity in southern Arizona involved folding, thrust-faulting, and general regional uplift, beginning about 80-75 Ma. The arc spread eastward, south and east of the Sevier fold-thrust belt, into Wyoming, Colorado, and New Mexico. Dickinson et al. (1988:1030,1032) suggested that Laramide deformation in southern Colorado and northern New Mexico began 75-65 Ma, and terminated 40-35 Ma. In New Mexico, the magmatic arc spread approximately as far eastward as where mountains occur today. In the northern part of this region, the Laramide orogeny initiated building of antecedents of the present Rocky Mountains, which, in a dramatic turnabout, rose in a region that earlier, in the Cretaceous, had been covered by the epeiric sea.

As described by Dickinson et al. (1988:1024), the entire Cordilleran foreland in the central Rocky Mountain region was "broken up into discrete local basins," which were separated by "strongly emergent" uplifts. As these Laramide highlands developed, it is likely that they gradually became populated with land snails, probably predominately by nearby western, Cordilleran colonists.

Uplifts degraded to contribute sediments (variously of latest Cretaceous, Paleocene, and Eocene age) to nearby basins, thereby leaving indirect evidence of their existence preserved in basin fill. In New Mexico, both larger and smaller basins existed, with the more significant being northeast to southwest: the Raton, Galisteo-El Rito, San Juan, Carthage-La Joya, Baca, Sierra Blanca, and Cutter Sag-Love Ranch Basins (Lucas and Ingersoll, 1981). Some of the sediments filling these basins are fossiliferous. The Raton Basin is notable for its Paleocene floral (leaves and pollen) fossil record. Fossil aquatic snails have been reported from Paleocene beds of the Raton Basin and both aquatic and terrestrial snails from the Paleocene of the San Juan Basin (Cockerell and Henderson, 1912; Cockerell, 1914; Henderson, 1935; Hartman, 1981*a*).

In north-central New Mexico, the broad Brazos-Sangre de Cristo uplift of Laramide age occupied areas approximately located where ranges bearing those same names occur today. Later the Nacimiento-Gallina-Archuleta uplift arose to the west and partitioned off the eastern part of the former San Juan Basin to form the Galisteo-El Rito Basin (Ingersoll et al., 1990:1288). These extensive uplifts already may have harbored the beginnings of what would become the Rocky Mountain molluscan faunal element in northern New Mexico. However, the fauna of such interbasinal uplifts is not known.

PALEOGENE

In the Paleocene and Eocene, the landscape of western and northern New Mexico seems to have been dominated by the uplifts and basins produced by Laramide deformation. Although the persistence of mountains has been stressed herein, it is to be supposed that they rose from low base levels in the earlier Paleogene. At the beginning of the Paleocene, easternmost New Mexico, having emerged above the sea not long before, still would not have risen much above sea level. It seems likely that lowlands and basins elsewhere in the state were also at low elevations. In the western United States, low regional elevation, among other factors, probably contributed to the climatic warmth that generally is ascribed to the early Paleogene up to the mid or late Eocene. By the latest Eocene there are evidences of increased regional elevation, as noted below.

Paleocene-Eocene Biotas

Studies of leaf physiognomy by Wolfe (1978) indicated a Paleocene in which tropical to paratropical rain-forest vegetation occurred widely in North America. Axelrod (1975:291) interpreted the Paleocene climate of the southern United States, in general, as having been mild, frostless, and monsoonal with a summer rainy season. He included the Raton and San Juan Basins of the Paleocene in a grouping of "swampy (coal) basins and broad floodplains at or close to sea level" supporting vegetation of tropical to subtropical requirements, although he found some evidence for more xeric floral communities in hillier areas away from basins and floodplains. Sloan (1994:882) used data from various reports to derive an estimated elevation of the Paleocene-Eocene Green River Lake system in the Utah-Wyoming region of 300 m (985 ft). He estimated that surrounding highlands could have reached an additional 500 m in height, or 800 m (2,625 ft) above sea level.

Berggren and Prothero (1992:5) presented evidences for "an anomalously warm global climate optimum spanning some 4-5 m.y. during the early Eocene.", which was followed by a "gradual, stepwise cooling during the remainder of the Paleogene, . . ." From botanical evidence, Wing et al. (1991:1191) assessed early Eocene (59-50 Ma) climates of the Bighorn Basin of northwestern Wyoming as likely to have been the warmest of the Cenozoic, with estimates of annual average temperatures during this 9-million-year period ranging from 13° to 18°C. In the strata studied, tree ferns, palms, and cycads occurred along with other cold-sensitive plants.

From palynological studies in the Rocky Mountain region, Leopold and MacGinitie (1972:166-167) recognized two moist and two dry subtropical floral phases encompassing most of the Eocene, with a development in the latest Eocene of a dry phase associated with an "essentially temperate flora." A tropical, humid, forested environment has been suggested as characterizing the Eocene San Juan Basin of northwestern New Mexico, based on floras and faunas of the San Jose Formation (Tidwell, et al., 1981; Smith and Lucas, 1991). Fossil palm leaves occur in the Eocene Palm Park Formation in northern Doña Ana Co.

The above assessments suggest that land snails inhabiting Paleocene and early-to-mid Eocene basins must have enjoyed climates like those of present tropical or subtropical lowlands. Inhabitants of nearby uplifts are not known, nor is the nature of the climatic conditions that they encountered at these higher elevations.

The Paleocene and Eocene faunal list of New Mexico land snails is scant. Several taxa of terrestrial and freshwater gastropods were described and reported from the Paleocene of northwestern New Mexico in the late 1800s and early 1900s (White, 1883,1886; Cockerell and Henderson, 1912; Cockerell, 1914, 1915). Hartman (1981*a*) identified the four localities from which these earlier collections were obtained as being in Sandoval Co., one near Cuba and three in the area of Torreon. These and subsequent collections of Paleocene snails seem to have been derived from one mollusk-bearing facies that occurs in the Nacimiento Formation of the Torreonian land-mammal age of the Paleocene in geomagnetic anomaly zone 27 normal, dated at 62 Ma (S. G. Lucas and T. E. Williamson, pers. comm., 6 July 1992). Hartman (1981a:Table 1) provided a useful summary of the species that were reported from the Nacimiento Formation in the early publications, cited above. Some comments concerning taxa comprised in Hartman's list follow:

Helix adipis White, 1886, and *Helix chriacorum* Cockerell, 1914, are small shells of uncertain affinity. Solem (1979:283) suggested that *H. adipis* might be a helminthoglyptid and that *H.*

chriacorum might be a ribbed helicinid. A shell in NMMNH lot PLS-20-92 (uncataloged) conforms well with illustrations of cotypes of *H. adipis* in White (1886:Pl. 5) and Hartman (1981a:Fig. 1). However, the size of the NMMNH specimen (12.0 mm width and 8.5-mm height) is considerably greater than that indicated for specimens depicted by White and Hartman (with 5.0-mm width and 3.0-mm height for the type). This larger size accords well with Solem's suggestion that this species appertains to the Helminthoglyptidae.

The urocoptid snail *Holospira grangeri* Cockerell, 1914, is well represented in collections from the Nacimiento Formation including those recently made by the New Mexico Museum of Natural History (NMMNH Nos. P-15694, P-15695, and P-15697).

In his description of *Polygyra petrochlora*, Cockerell (1914:103) had available only four shells, these from a greenish facies of the Nacimiento Formation, which Cockerell pointed out as differing in color from beds in which other mollusks had been found in the formation. The shells were fragmentary and Cockerell placed them in the genus *Polygyra* with some hesitancy. The thickened, reflected lip figured in Cockerell's Plate 8, Fig. 7, suggests a polygyrid. The dimensions of the type (20-mm width and 14-mm height) are similar to those of larger species of modern *Ashmunella* of New Mexico. *Polygyra petrochlora* may well be an early *Ashmunella*, as this seems reasonable on zoogeographic grounds. However, as pointed out by Cockerell (1914:101), it is not always possible to distinguish between the two genera on the basis of shells alone. Additional, better-preserved specimens of this species are much needed.

Helix nacimientensis White, 1886, was allocated to the genus *Oreohelix*, subgenus *Radiocentrum* by Cockerell (1914:103). *Radiocentrum* has since been elevated to generic status. *Radiocentrum nacimientensis* is the most common Paleocene species contained in collections of the New Mexico Museum of Natural History. A number of well-preserved specimens have been acquired, some with whitish shell material still intact and showing sculpture. In some of these specimens, the typical radial striae on the apical whorls of specimens of *Radiocentrum* are observable, as in NMMNH Nos. P-15678, P-15786, and P-16324. The species is robust. White's (1886) holotype had a width of 42 mm, and several specimens in the NMMNH collections are around 40 mm in width. Widths for 7 specimens from Lot PLS-20-92 (uncataloged) ranged from 28.0 to 41.9 mm with a mean of 33.5 mm. As is the case in many oreohelicids, younger shells are depressed, flattened dorsally, and tend to be carinate peripherally. As whorls are added on older shells, the periphery becomes progressively more angular (by 25-30 mm in width) and then more rounded (by 35-40 mm). Cockerell (1914:103) indicated that the type of his new variety *steini* had a width of 32.5-mm, and differed from typical *nacimientensis* in having a more angular shell. This peripheral angularity seems, as noted above, to be characteristic of shells in the size range of the type of *steini*. Hartman (1981a:945) noted that the type of *steini* was the specimen illustrated by Cockerell (1914:Pl. 8, Figs. 3 and 4). According to Roth (1986:265), D. W. Taylor had suggested that *O. n. steini* was a "New species of Camaenidae." However, Cockerell's Pl. 8, Fig. 4 clearly seems to show the apical sculpture of a *Radiocentrum*.

As pointed out by Cockerell (1914:103), there is much similarity between shells of *Radiocentrum nacimientensis* and of *R. megarche* Cockerell and Henderson, 1912, from Wyoming. The illustrations of *R. megarche* in Russell (1931:Pl. 3) show considerable resemblance to shells of *R. nacimientensis*. This suggests that a single species or species complex of *Radiocentrum* may have been widespread in the Cordilleran region at a time in the Paleocene.

In summary, the Paleocene record seems to present good evidence for the presence of the families Urocoptidae, Oreohelicidae, and Polygyridae in northwestern New Mexico and suggests the possible occurrence of members of the Helicinidae and Helminthoglyptidae.

Eocene records are few and seem to include only specimens of a camaenid snail of the genus *Hodopoeus*. This genus was discussed by Solem (1978), and comprises two named species: *H. hesperarche* (Cockerell, 1914) and *H. crassus* Pilsbry and Cockerell, 1945. The type locality of neither species is known, but may be in New Mexico or western Texas. In New Mexico, specimens of a *Hodopoeus* have been collected from the Regina Member of the San Jose Formation in northwestern New Mexico (NMMNH P-11375) and from the Palm Park Formation in the south-central part of the state (UTEP 12,532). Smith and Lucas (1991:35) considered mammalian fossils from the Regina Member to be of early Eocene (Wasatchian) age and suggested an approximate age for them of 53 Ma.

Clearly, the early Tertiary land-snail fauna must have been much richer in taxa than the above meager records would indicate. It would be informative to have extensive early Tertiary records from nearby states. Roth (1984) and Roth and Megaw (1989) have reported faunas from western Texas and central Chihuahua, México. However, Arizona and Colorado, like New Mexico, have a dearth of records. This is unfortunate, because Arizona was likely a source area of land snails colonizing New Mexico upon recession of the epeiric sea, and Colorado was likely a source of species inhabiting the Rocky Mountains of northern New Mexico.

There are, however, records from Utah, Wyoming, and Montana, which allow inferences about the nature of the early Tertiary fauna of the present central Rocky Mountain region. Some publications of significance to achieving an understanding of early Tertiary faunas in the greater region include the following, arranged from Utah eastward in the Montana-Wyoming region, then southward to Texas and Chihuahua: 1) LaRocque (1960), Paleocene and Eocene strata of Flagstaff Formation, central Utah; 2) Hanley (1976), Eocene Green River and Wasatch Formations, southwestern Wyoming and northwestern Colorado; 3) McKenna, Robinson, and Taylor (1962) and Dorr (1969), Eocene, central western Wyoming; 4) Russell (1931), Eocene, northwestern Wyoming; 5) Roth (1986), Eocene-Oligocene, Bozeman Group, southwestern Montana and summary of regional records; 6) Evanoff and Roth (1992), Evanoff, Prothero, and Lander (1992), Eocene-Early Oligocene, White River Formation, east-central Wyoming; 7) Roth (1984), Eocene-Oligocene, Vieja Group, Trans-Pecos Texas; 8) Roth and Megaw (1989); Megaw, McDowell and Roth (1994), upper Eocene strata, central Chihuahua, México.

Families included in these reports are listed below, using the above numbers to indicate inclusion of family in the report:

Helicinidae - 2, 4
Grangerellidae - 2, 4
Ellobiidae (*Carychium*) - 1, 5
Pupillidae - 1, 5, 6
Valloniidae - 6
Subulinidae - 5
Urocoptidae - 1, 2, 3, 4(?), 6, 8
Bulimulidae - 1, 2, 3, 8
Discidae (*Discus*) - 1, 2, 4
Oreohelicidae - 1(?), 2, 4 , 5, 6
Succineidae - 6
Polygyridae - 2, 4, 6
Zonitidae (*Mesomphix*) - 6
Thysanophoridae (*Microphysula*) - 4
Camaenidae - 1, 7
Ammonitellidae - 5, 6
Helminthoglyptidae - 5, 6, 7, 8
Humboldtianidae - 6

In addition to the above, Roth (1986) also included the following families in his compilation of regional records, citing them only from the regional compilation of Taylor (1975): Strobilopsidae (*Strobilops*), Clausiliidae (genus indet.), charopidae (*Charopa*), and Oleacinidae (genus indet.). Taylor (1975:87) also listed the Vitrinidae (*Vitrina*) from one locality in the Powder River Basin, Wyoming. These records from Taylor (1975) are based on materials from only one or two localities, and in the case of the Oleacinidae, on a single fragmentary shell (Taylor, 1975:441).

Of the above-mentioned families, the Grangerellidae is extinct, and may not have occurred as far south as New Mexico. The Ammonitellidae probably always has been a family of the Pacific Northwest. Of the remaining 21 families, 15 (ca. 70%) still occur in New Mexico, where they likely have been long-time sojourners. These include Ellobiidae, Pupillidae, Valloniidae, Urocoptidae, Bulimulidae, Charopidae (as *Radiocentrum*), Discidae, Succineidae, Polygyridae, Zonitidae (but not *Mesomphix*), Vitrinidae, Thysanophoridae, Oreohelicidae, Humboldtianidae, and Helminthoglyptidae. Representatives of the Helicinidae, Strobilopsidae, Subulinidae, and Oleacinidae occur as near as Texas and/or northern México and there are records of fossil *Strobilops* and of a possible helicinid (Solem, 1979:283--"*Helix*" *chriacorum*) from New Mexico. The camaenids are now known no closer than the West Indies and Costa Rica, although occurring as fossils in New Mexico and elsewhere in the western United States. Whether members of the Clausiliidae ever occurred in the Cordilleran region requires further investigation, given their present American distribution, far to the south, and their being reported from only a single fossil locality in Wyoming (Taylor, 1975:138).

An overall pattern shows that, at the family level, many of the taxa of the Cordilleran Paleocene/Eocene still exist in the general southern Cordilleran area of New Mexico and northern México. To the extent that taxa of the present southern Cordillera descend from earlier progenitors like those discussed above, they might be termed as comprising elements of an "ancient Cordilleran fauna," a term used previously and to be used hereafter.

Eocene-Oligocene Transition

An Eocene-Oligocene boundary age of 36.5 Ma proposed by Berggren et al. (1985:Fig. 4) has been cited widely. More recent analyses by Berggren et al. (1992:40-42) and McIntosh et al. (1992a:462) support, respectively, boundary ages of about 34 and 33.4 Ma.

Various authors concur in the view that Laramide deformation terminated about 38-36 Ma, in the late Eocene. According to Dickinson (1989:9-10), in the Late Eocene to early Oligocene, a "steepening of slab descent beneath the continental block" led to a reversal of Laramide-type conditions, with the magmatic arc sweeping from New Mexico back westward to California from latest Eocene through mid-Miocene time (37-15 Ma), and creating extensional rather than the compressional deformation, which had taken place earlier. Elston (1984:229) has referred to this as an "extensional orogeny," which was marked by episodes of uplift and volcanism from latest Eocene to earliest Miocene.

In some areas, a cessation of tectonism occurred in the late Eocene between the termination of Laramide compressional activity and the beginning of mid-Tertiary extensional deformation--and uplifted areas developed graded erosion surfaces. Such surfaces have been described in Arizona (Dickinson, 1989:9) and in southern Colorado (Epis and Chapin, 1975; Scott, 1975; Dickinson et al., 1988:1035). There have been some suggestions of similar erosional surfaces in cordilleran New Mexico (Smith et al., 1985:306; Dolliver, 1990:73-74). At least in the Laramide Front Range in Colorado, the late Eocene surface developed at a relatively high elevation according to an analysis by Gregory and Chase (1992). These investigators utilized foliar physiognomy of the Florissant fossil flora to calculate a mean annual temperature and an elevation that would have pertained to the paleoflora. They derived a mean annual paleotemperature of ca. 10.7°C and an elevation of 2.4-2.7 km (7,874-8,858 ft), which is near the present elevation for Florissant of 2.5 km (8,202 ft). From analysis of various studies, Wolfe (1992:426) concluded that "the Rocky Mountains in central Colorado and southwestern Montana were near . . . their present altitudes by the latest Eocene." This may well apply to late Eocene New Mexico as well. Where late Eocene surfaces attained such elevations, it would seem that they must have produced conditions inimical not only to subtropical-tropical floras, as shown at Florissant, but also to land snails that had flourished in warmer environments in the earlier Eocene.

Although late Eocene erosional surfaces, like the above, seem to have existed in some places in New Mexico, it appears that in many places fairly intact Laramide landscapes, of marked relief, continued to exist up until late Eocene volcanism commenced. At sites studied in southern New Mexico, Seager and Mack (1986:672) showed that, although active Laramide uplift essentially had ceased by the time of onset of latest Eocene volcanism, Laramide uplifts, themselves, still were exposed and serving as sources of sediments deposited in adjacent basins. In a study of Datil Group volcanics in west-central New Mexico, Cather (1989, 1990) found evidence of the persistence of Laramide uplifts that still were shedding sediments into the Baca Basin up to the time of late Eocene volcanism. Datil Group volcanics ranged in thickness from 1 km, where deposited in basins, to only 300 m where onlapping Laramide uplifts (Cather, 1990:1447). This indicates something of late Laramide topographic relief in that area. Cather noted (1990:1449) that "blocks of Paleozoic limestone, some nearly a kilometer in length" occur in lower Datil Formation debris-flow deposits. This seems to indicate existence of scarps formed on outcrops of Paleozoic sedimentary rocks in foundering Laramide highlands. Cather (1991:273) also found evidence in sediments of Eocene age in the Cub Mountain Formation of the Sierra Blanca Basin of an "unroofing" of Laramide uplifts in that area, which comprised crystalline basement as well as Paleozoic carbonate rocks. It seems likely that uplifts with outcrops and scarps formed on Paleozoic limestones and associated carbonate rocks could have provided especially congenial habitats for land snails, as do the Sacramento Mountains today.

Several authors have recognized a marked climatic shift in North America in the later Eocene towards a cooler, drier mode that was to persist, with some fluctuation, for the remainder of the Tertiary. This was the "terminal Eocene event" of Wolfe (1978:694). In a symposium edited by Prothero and Berggren (1992), several authors explored aspects of the late Eocene and Eocene-Oligocene Transition. In general, evidence was presented suggesting periods of global cooling in the late mid-Eocene and at the time of the Eocene-Oligocene transition (Berggren and Prothero, 1992:1). There is evidence, in some cases, that these periods of cooling were associated with increases in aridity. Using paleosol records from the Badlands of South Dakota, Retallack (1992:382) found evidence for a decrease in precipitation and increase in a more arid-adapted flora between 38 and 30 Ma. Leopold et al. (1992:404, Fig. 20.2), in an examination of palynological data, found evidence in the Rocky Mountain region of Colorado and Wyoming for a shift from mid-Eocene broadleaved evergreen and deciduous forest to a latest Eocene "woody" (non-grassy) savannah. Significant amounts of pollen of Oligocene age in the Rocky Mountain/High Plains region were lacking.

Evanoff et al. (1992), in an analysis of the White River Formation of east-central Wyoming, described a well-defined change in land-snail faunas between the latest Eocene Chadronian and earliest Oligocene Orellan Land Mammal Ages. These authors interpreted (p. 127) Chadronian snails to have lived in a subtropical woodland with seasonal precipitation. Prominent genera were *Ashmunella* and *Skinnerelix*, the latter a humboldtianid genus, described by Evanoff and Roth (1992). Orellan genera, on the other hand, were considered to have inhabited a progressively more open and more arid woodland or "bushland" environment and comprised a fauna of smaller-shelled genera of mixed eastern, northwestern, and southwestern affinities.

It seems likely that the biota of New Mexico, including its molluscan components, was also affected by climatic changes of the Eocene-Oligocene transition much as in other parts of the Rocky Mountain region, discussed above.

Oligocene

According to Elston (1984:229-230), Oligocene extensional activity produced conditions in which low-angle detachment faulting prevailed. He suggested that the region now recognized as the Basin and Range Physiographic Province (including New Mexico except for the Colorado Plateau and the eastern plains) possibly doubled its width during this period, while experiencing uplift of from 1 to 2 km. In this earlier phase of Basin and Range activity, basins were oriented obliquely with relation to present basins of the region, were broader, and were bordered by faults with lower angles than is the case with present basins (Baldridge and Olsen, 1989).

This earlier phase of Basin and Range development must have produced considerable topographic relief. However, such relief was probably dwarfed by the building up of volcanic piles during the time from late Eocene to earlier Miocene, but especially in the Oligocene. Elston (1984:229) noted that in New Mexico "some of the highest mountains of North America, up to 4.3 km high, rose through resurgence of ignimbrite cauldrons and isostatic uplift of underlying plutons." These volcanoes must have been imposing features of the Oligocene landscape, just as are some of today's mountains (Smith et al., 1985:308), which descend from their roots (e.g., Latir Peak, Sierra Blanca, and the San Mateo and Organ Mountains). Volcanic activity affected much of the western and northern part of New Mexico. Smith et al. (1985:293) wrote:

> In Oligocene time, volcanism was widespread in western New Mexico. The southwestern quarter of the state, in particular, became a volcanic highland, consisting of thousands of meters of calc-alkalic lavas and pyroclastic flows. The landscape was dominated by resurgent domes of ash-flow tuff (ignimbrite) cauldrons and by andesitic stratovolcanoes.

In southern New Mexico, McIntosh et al. (1992b) recognized three mid-Tertiary volcanic fields: Sierra Blanca, Boot Heel, and Mogollon-Datil. The latter field was, by far, the most extensive, including some 10 cauldrons occurring from the Las Cruces and Socorro areas on the east to the Mogollon Mountains on the west. Pulses of ignimbrite activity were dated ($^{40}Ar/^{39}Ar$) at between 36.2 and 24.3 Ma within this field (McIntosh et al., 1992b:Fig. 12). Moore et al. (1991:139) reported evidences that volcanic activity occurred in the Sierra Blanca field between ca. 37 and 26 Ma.

Smith et al. (1985:308) noted that the resurgent domes of the Bursum and Emory cauldrons in the present Mogollon Mountains and Black Range, respectively, were the largest cauldrons known in New Mexico and were among the largest in the world. Axelrod and Bailey (1976) discussed a fossil flora preserved in moat sediments of the Emory Cauldron, interpreting it as having a subalpine aspect, which further indicates the lofty heights attained by some of these volcanic mountains. Probably, taxa of land snails that were adapted to such montane forests were also present. Given the sedentary tendency in dispersal, which characterizes land snails, it may be that species ancestral to present denizens of the mountains of west-central New Mexico were already present in these Oligocene-Miocene mountains. A search for land-snail fossils in cauldron moat sediments, might be warranted, although such fossils usually are not found in areas of igneous bedrock.

Ingersoll et al. (1990:Fig. 3) depicted similar conditions in north-central New Mexico. They showed that in the Oligocene-early Miocene period there were three major volcanic fields flanking the Galisteo-El Rito Basin: San Juan to the north, Taos Plateau-Latir to the east, and Espinaso to the south. Here, these volcanic highlands largely replaced or amplified the Brazos-Sangre de Cristo uplift of earlier, Laramide time. Thus, some type of highland seems to have persisted during the Paleogene in north-central New Mexico, and presumably harbored a land-snail fauna more or less ancestral to that of northern New Mexico today.

Oligocene volcanism occurred widely in other parts of the Rocky Mountain region in addition to New Mexico. Volcanism, regional uplift, climatic change, and, probably, other factors must have been to some extent interrelated, with this interrelationship impinging on biotas in the Rocky Mountain region. Leopold and MacGinitie (1972:164) presented palynological evidence for changes in the paleofloras of the Rocky Mountain region from a mid-Eocene analogy with the present flora of southern México and Central America, an early Oligocene analogy with northeastern México, and a Miocene flora whose "primary relationship" was with that of the present Rocky Mountains. In the Western Interior region, Axelrod (1975) found evidence of an increase in a more xeric-adapted flora dominated by sclerophyll, woody plants from the late Eocene into the Oligocene.

Similarly, the Oligocene was probably a time when various groups of land snails of the Western Interior became extinct in the northern part of their range, where some had flourished as far north as Canada during the Cretaceous and Paleocene. This seems to have been the case with such families as: Urocoptidae, Bulimulidae, Humboldtianidae, and Camaenidae, the more tropical helicinids, and the genera *Radiocentrum* and *Ashmunella*.

Evidence of such a change seems to be provided by studies of Pierce and Rasmussen (1992) and Pierce (1992), who have reported land snails from the "Cabbage Patch beds" of southwestern Montana. These beds are, according to Pierce and Rasmussen (1992:Fig. 2), assignable to the Arikareean Land Mammal Age, of the late Oligocene and early Miocene. Land snails were taken at levels of both Oligocene and Miocene age. These beds are especially rich in smaller snails. In the study of Pierce and Rasmussen (1992), 10 species of pupillids were described, including 7 species of *Gastrocopta*, 1 species of *Pupoides* (*Ischnopupoides*), and 2 species of *Vertigo*. Pierce (1992) described a new species in each of the genera *Vallonia*, *Nesovitrea*, *Punctum*, *Polygyroidea*, and *Oreohelix*, and a new succineid. Two new species of *Deroceras* were described. Some shells were assigned questionably to the genus *Monadenia*. Roth and Emberton (1994) reported another fauna of Arikareean age from Montana (Deep River Formation), several families of which were shared with the Cabbage Patch beds (Pupillidae, Valloniidae, Succineidae, and Oreohelicidae), plus the families Discidae, Polygyridae, and Helicinidae. All these families except the last presently occur in New Mexico. These late Oligocene-early Miocene faunas differ significantly from earlier Tertiary faunas of the northern Rocky Mountain region, comprising genera that are mostly characteristic of the region today. As viewed by Pierce (1992:617) "one is struck with the modern aspect of this fauna." He suggested that there had been a "dramatic and relatively swift" change in the nature of snail faunas and climate between late Eocene and late Oligocene, with a cooler and more seasonal climate replacing a subtropical-to-warm-temperate Eocene climate. Roth and Emberton (1994:103) posited a mesic paleoenvironment for the Deep River Formation, with mixed-mesophytic forest. Such a Miocene Holarctic forest has been suggested by various authors, as in Leopold and Macginitie (1972).

Land snails enjoying the warmer Eocene climate in the northern Rocky Mountain region might be considered as representing the "ancient Cordilleran fauna," mentioned above. In New Mexico there seems to have been a persistence of diverse elements of this ancient Cordilleran fauna for varying periods of time, with several persevering there today, mainly in the southern part of the state: Urocoptidae, Bulimulidae, Humboldtianidae, *Radiocentrum*, and *Ashmunella*. Unfortunately, no Oligocene molluscan fossils have been reported from New Mexico. The nearest record seems to be that of a *Humboldtiana* reported from volcanic tuff deposits of Oligocene age in the Indio Mountains, Trans-Pecos Texas (Underwood and Wilson, 1974). Camaenids and the humboldtianid genus *Lysinoe* still persisted as far north as Trans-Pecos Texas in late Eocene to early Oligocene time (Roth, 1984). It seems likely that the Oligocene was a time when a molluscan fauna with tropical-to-subtropical affinity was replaced by one more like that of present New Mexico. That is, New Mexico had an earlier Paleogene fauna of rather tropical aspect but, after the "volcanic smoke" of the Oligocene and earlier Miocene had cleared, a fauna of more modern aspect probably was in place, as exemplified by the Jacona fauna, discussed below.

NEOGENE

Miocene

The Oligocene/Miocene boundary has been ascertained as being at ca. 23.7 Ma by Berggren et al. (1985:1415) and at "about 24 Ma" by Berggren et al. (1992:42).

By mid-Miocene time, magmatic arc-related tectonism had ceased in New Mexico and Arizona. According to a model of Dickinson and Snyder (1979) and Dickinson (1989:11), the absence of a subducted slab and development of the San Andreas transform fault and of lateral shear conditions led to upwelling of mantle beneath the region that had been affected by crustal extension. This resulted in another episode of volcanism (basaltic, bimodal) and of the late, traditionally recognized phase of Basin and Range tectonism. This tectonic activity began by 20 Ma in some areas, according to Baldridge and Olsen (1989:241), who noted that in this present phase of Basin and Range development, basins are narrower, more north-south oriented, and bounded by faults with steeper angles than in the earlier basins, noted above. Basin and Range tectonic activity has continued to the present, at which time the results of such tectonism are seen in much of western New Mexico. Block-faulting has uplifted rocks of many ages, including those associated with some of the processes discussed above, such as Laramide basin fill and earlier-phase Basin and Range volcanics. In north central New Mexico, Ingersoll et al. (1990) noted evidence of the initiation of late-phase Basin and Range block-faulting and activity associated with the Rio Grande Rift in the early to mid-Miocene period, 21-15 Ma. The Santa Fe and Nacimiento blocks were produced east and west, respectively, of the Española Basin (earlier, the Galisteo Basin). Later, in the period 15-8 Ma, the Taos Range became recognizable, north of the Santa Fe block in the area of the former Taos Plateau-Latir-Questa Caldera volcanic field. The Taos Range and Santa Fe Block became integrated into the present Sangre de Cristo Mountains. At the south end of the Nacimiento block, the Jemez volcanic field developed at about 13 Ma and continued on into the Quaternary. In overview, this reconstructed paleogeographical sequence of Ingersoll et al. (1990) indicates persistence of mountains or highlands of one kind or another in north-central New Mexico, from Laramide uplifts through Oligocene-Miocene volcanic fields to Miocene and later block-faulted uplifts, with later ones associated with rifting. It would seem that montane land snails could have found suitable habitats in mountains in this area throughout much of the Cenozoic--at least from the time of extensional deformation onward. Probable descendants of such species are components of the fauna of a Rocky Mountain Molluscan Province, as defined by Henderson (1931).

The above highlands flanked, east and west, a well-defined depression that persisted from Laramide time onward, first as the Galisteo-El Rito Basin, and later as the San Luis-Española Basin in which sediments of the Santa Fe Group would accumulate. Ultimately it became, structurally, a graben of the Rio Grande Rift and, physiographically, the Rio Grande Valley of today. Patterns of Miocene sedimentation in this basin are highly complex, with sediments derived from surrounding highlands of diverse lithologies. At times, sandy eolian sediments were deposited also. Fossil plants are preserved in some of these Miocene sediments in the Rio Grande Valley, and one unit, the Tesuque Formation, has yielded a fauna of land snails.

Through the good offices of Dan Chaney, U.S. National Museum, I have been able to examine fossil gastropods he obtained from the Jacona microfauna. Chaney (1988) indicated that this microfauna occurs in the Pojoaque Member of the Tesuque Formation of the Late Barstovian Land Mammal Age, which is of middle Miocene age. The locality is in Santa Fe Co. in the Rio Grande Rift Valley of north-central New Mexico. The whitish matrix in which the shells occur covers the surface of most shells, fills apertures, umbilici, and hinders identification. Nevertheless, several families of terrestrial snails seem to be recognizable, as follows:

1) Cionellidae. A single shell, consisting only of the apical three whorls, seems to be a *Cionella* of the size of modern *C. lubrica* of New Mexico.

2) Pupillidae. Several shells, some with distinctive rib sculpture preserved, are assignable to the *Pupoides (Ischnopupoides) hordaceus/inornatus* complex, which still occurs in northern New Mexico. One specimen of a large pupillid shows the apertural denticles of *Gastrocopta armifera*. A few specimens, in which denticles are obscured, have the shell shape of *Gastrocopta procera* or *G. cristata* and likely belong to the subgenus *Gastrocopta*. A number of shells show the indented outer lip typical of many Vertigos. Several have the size and shape of *Vertigo milium*. Some larger specimens have the wide shell and apertural shape of *Vertigo ovata*, while some higher, more slender specimens are similar to *Vertigo berryi*. These three Vertigos occur in Pleistocene deposits in New Mexico.

3) Valloniidae. The fauna includes a well-preserved series of *Vallonia* in the size range of *Vallonia cyclophorella* and with the relatively thin lip of that species.

4) Zonitidae. A few minute shells resemble those of *Hawaiia minuscula*. There are other small, discoid shells whose relationships are not clear.

5) Succineidae. There are numerous well-preserved shells of succineids, just as is often the case in collections of Pleistocene age made in New Mexico at lower elevations.

6) Polygyridae. A number of specimens are of a small species of polygyrid, in which mature shells range from 9 to 11 mm in diameter. There is a thickened, reflected lip that is well developed; however, in specimens in which the aperture is cleared of matrix, no parietal or lip denticles are seen. On zoogeographic grounds (as in the case of *Polygyra petrochlora*, discussed above), these fossils might be placed most reasonably in the genus *Ashmunella*. They are small for the genus, but within the size range of *Ashmunella nana* Metcalf and Fullington, 1976, a Pleistocene fossil species from the Guadalupe Mountains of Texas.

7) The most abundant fossils in the assemblage are of a relatively small oreohelicid, reaching some 18 mm in maximum width. Sculpture of the apical whorls is visible on a few specimens. The diameter of individual apical whorls is short, and about the same as that seen in specimens of *Radiocentrum*. However, such short diameters are also typical of shells of the *Oreohelix neomexicana* complex of northern New Mexico. Well-defined radial ribs of the embryonic whorls, such as occur in *Radiocentrum*, are not observable. These could have been eroded away, although it seems more likely that they were never present. As observed on a few, better-preserved shells, embryonic shells seem to comprise about two whorls, as in *Oreohelix*, not the ca. 1.5 whorls comprised in *Radiocentrum*. One well-preserved, small shell displays spiral striae ventrally, as in *O. neomexicana* and some specimens exhibit spiral undulations on the whorls, dorsally, as in this species. These characters seem to argue for assignment of this material to the *Oreohelix neomexicana/yavapai* group rather than to *Radiocentrum*.

Lymnaeid freshwater snails occur with the above terrestrial species indicating a paleoenvironment near water. A warm climate can be inferred from presence of palm wood and fronds in the Pojoaque Member, as well as in the underlying Skull Ridge Member of the Tesuque Formation (Chaney, 1988; Axelrod and Bailey, 1976:238). The latter authors considered the biota of the Skull Creek Member to imply a probably subtropical climate with mild winters. This may have been related to lower elevation, as sediments of the Tesuque Formation have been uplifted some 1200-1500 m, subsequent to deposition, according to Axelrod and Bailey (1976:249).

The fossil land-snail fauna, discussed above, does not include distinctively tropical or subtropical elements, such as the camaenids found in Eocene strata. In fact, the fauna appears much like that of present New Mexico, just as though some major faunal reorganization had taken place between the glimpses afforded by earlier Paleocene and Eocene assemblages and the one afforded by the Jacona, mid-Miocene fauna. Even though the fauna is considered by the authors cited above to have existed in a warm, lowland environment, it is much like the fauna of areas of moderate heights (1525-2135 m/5,000-8,000 ft.) today in New Mexico. Of course, these modern montane snails might be quite happy to occupy a warm, humid habitat, with palms, if one were offered to them nearby, as along a river valley. Similarly, their mid-Miocene antecedents may have accommodated themselves to various habitats at both lower (probably restricted) and higher (probably more widespread) elevations. At present, introduced *Washingtonia* palms survive in the Rio Grande Valley as far north as Truth or Consequences (1290 m/4,240 ft).

It seems that by mid-Miocene time a "Rocky Mountain fauna" was already in existence in northern New Mexico, marked by presence of the genus *Oreohelix*, the "Mountain snails," and of a variety of smaller species that are poorly represented in older Tertiary strata. Roth (1986:260) noted that Miocene land-snail faunas in the western United States were preponderantly composed of genera still living in the same regions.

Pierce and Rasmussen (1989) studied sediments and vertebrate and molluscan fossils from a middle Miocene (early Barstovian) locality in western Montana. They interpreted the mid-Miocene climate there to have become cooler and more seasonal than that of the late Eocene to early Oligocene.

Pliocene

Berggren et al. (1985:1415) supported a Miocene-Pliocene boundary date of ca. 5.3 Ma; Rio et al. (1991) proposed a younger date of ca. 4.93 Ma.

According to studies discussed above and to a review incorporating data from various parts of the world (Cronin and Dowsett, 1991:v-vi), Pliocene climate was still warm relative to succeeding Quaternary climates, although a pattern of global cooling had commenced as early as the latest Eocene. For example, Matthews and Ovenden (1990) analyzed Pliocene pollen records that indicated presence of trees on shores of the Arctic Ocean at 80°N. For the western United States, Thompson (1991:126-127) assembled evidences indicating a milder climatic regime with more effective moisture during the first 4/5 of the Pliocene, which he indicated to be 4.8-2.4 Ma, followed by a cooler, drier interval at 2.4-2.0 Ma and a second, moister and probably warmer interval at 2.0-1.8 Ma. He interpreted (p. 125) evidence from vertebrate paleontology in the Great Plains (mainly, Kansas and Oklahoma) as suggesting an open, grassy savannah with a "subhumid-subtropical" climate in the late Miocene and early Pliocene.

In a study utilizing fossil seeds in deposits of the Miocene Pliocene Ogallala Formation in western Texas, some 60-125 km east of New Mexico, Frye and Leonard (1957:16) found evidence of a "mixed prairie flora, apparently dominated by grasses," although fossil hackberry seeds also were found. In subsequent investigations, their group found sparse, but similar, fossil seed assemblages farther west, in eastern New Mexico. In their investigations in Texas and New Mexico, they found almost no localities with fossil mollusks of Pliocene age, in contrast to their earlier studies carried out farther north, in the High Plains of Kansas. Frye, Leonard, and Glass (1978:12) noted that, after several field seasons studying the Pliocene Ogallala Formation in eastern New Mexico, they had found "only one significant fauna of fossil mollusks." This fauna was from a locality ca. 11.3 km (7.0 mi) south of Clayton, Union Co., which they termed the "Clayton South" locality. This fauna was discussed further by Leonard and Frye (1978).

At Clayton South, they found 1 species of sphaeriid clam, 10 species of pulmonate aquatic snails, and 15 taxa of land snails. The assemblage contained 2 extinct species (*Gastrocopta debilis* and *G. arena*) described and known only from this locality. The fauna included several species commonly associated with grasslands today, including *Gastrocopta cristata*, *Pupoides* spp., and *Hawaiia minuscula*. *Pupilla blandi* occurs in grasslands farther west on the high grasslands or *vegas* near Las Vegas. Two species of succineids were listed. At least one species of succineid, assigned to *Succinea vaginacontorta* by Franzen (1971), is common in prairie habitats of the High Plains today. The presence of *Vertigo milium* suggests habitat marginal to a prairie marsh or pool, presumably inhabited by the aquatic species. Leaf detritus under a grove of trees associated with such a marsh could have been inhabited by *Gastrocopta pilsbryana*, *Euconulus fulvus*, and *Vallonia perspectiva*, which are species common in various habitats in cordilleran New Mexico today. All in all, the habitat seems conformable to a prairie or savannah interpretation, but with ranker grasses than those of the short-grass prairie at the Clayton-South locality today. The habitat of the *vegas* some 175 km to the west, with their taller grasses and greater rainfall, might provide a better present analog.

Another molluscan fauna of Pliocene age has been found in the Rio Grande Valley, in the northwest part of the City of Socorro, Socorro Co. The fauna occurs in sediments below a volcanic-ash deposit. It comprises only *Pupilla blandi*, *Vallonia gracilicosta*, *Discus whitneyi*, succineids, and *Zonitoides arboreus*. All of these are kinds (although the succineids are not assigned to a species) that occur in faunas of younger, Pleistocene age along the Rio Grande Valley, and all occur in New Mexico today. This suggests considerable long-term conservatism in regard to the land-snail fauna of the Rio Grande Valley.

THE QUATERNARY

Compared to the paucity of fossil land-snail localities in Tertiary sediments in New Mexico, Quaternary localities are relatively numerous. However, precise chronological control is usually lacking. On the eastern plains and in intermontane basins of Cordilleran New Mexico, fossil shells usually occur in alluvial deposits related to former aquatic habitats such as marshes, ponds, lakes, springs, and streams. In montane areas, fossils are found both in alluvial and colluvial deposits, these latter occurring on mountain slopes, often along the walls of canyons.

Throughout New Mexico, it appears that there was a depression of life zones to elevations lower than those prevailing at present, during times equivalent to the latest Wisconsin glaciation, and presumably during earlier glaciations as well. During such times, ranges of several species of land snails seem to have extended from montane sources into lower intermontane basins and onto the plains of the eastern part of the state.

QUATERNARY FOSSILS FROM THE EASTERN PLAINS

The major sources of information concerning Pleistocene faunas of the plains of eastern New Mexico are from the malacological work of A. B. Leonard incorporated in three publications dealing with northeastern, east-central, and southeastern New Mexico, respectively: Frye, Leonard, and Glass (1978), Leonard and Frye (1975), and Leonard, Frye, and Glass (1975). In northeastern New Mexico, Frye, Leonard, and Glass (1978) found no fossil faunas that they judged to be pre-Wisconsin in age, but reported (p. 5; Fig. 14) 48 collections from 43 localities considered as being of Wisconsin or Holocene age. In east-central New Mexico, Leonard and Frye (1975) listed 31 Pleistocene localities from the High Plains and 14 from the Pecos River Valley to the west. Similarly, in southeastern New Mexico, Leonard, Frye, and Glass (1975) treated assemblages from 11 localities from both the eastern plains and the Pecos Valley. Species reported in the three publications are summarized in Table 1. Precise dating is lacking for most of the New Mexico localities treated by the above authors, although they considered most to be of Wisconsin age. Dates that are available range from ca. 13,000 to 27,500 B.P.

From Harding Co. in northeastern New Mexico, McMullen and Zakrzewski (1972) reported a molluscan fauna in association with late Pleistocene mammalian fossils. Their listing is given in Table 1. In the east-central part of the state, Hester (1972:25) reported a fauna from the Blackwater Draw localities, dated at 10,490±900 B.P. Species listed from this locality include *Gastrocopta armifera*, *G. procera*, *Strobilops texasiana*, *Hawaiia minuscula*, *Vallonia gracilicosta*, *Pupoides marginatus* (probably *P. albilabris*), and *Retinella electrina* [=*Nesovitrea hammonis electrina*]. Drake (1975) reported on 13 assemblages of fossil terrestrial and freshwater snails from localities in northern Roosevelt Co. Most of these were from diatomites at the well-known Blackwater Draw paleontological and archeological locality and at Anderson Basin, a few miles to the east. Ages ranged from ca. 8,500-15,750 B.P., hence, latest Pleistocene and early Holocene. Several tens of thousands of shells were recovered, the majority of which were aquatic. From the 13 assemblages in Roosevelt Co. more than 19,000 specimens were of the aquatic genus *Gyraulus*, while less than 3,000 were of terrestrial species. Total numbers of shells reported for each species from the 13 assemblages, excluding those listed as "fragments," are indicated in Table 1.

To the south, at Nash Draw in Eddy Co., Ashbaugh and Metcalf (1986) reported a fauna associated with a former spring complex in this now arid area (Table 1). Association with fossils of *Camelops* indicates a Pleistocene age. A fauna of latest Wisconsin age (ca. 11,000 BP) reported by Pierce (1987:Table 6-1) from the Lubbock Lake study area (substratum 1 B-C), Lubbock Co., Texas, is summarized in Table 1. This locality is included because of the detailed chronostratigraphy of the site and to provide comparison with a plains fauna some 105 km east of New Mexico. It is likely that most of the above faunas are of Wisconsin age. It is assumed that species represented at numerous localities were important components of the eastern-plains fauna in Wisconsin time. In Table 1, species that are found at 5 or more localities, excluding Roosevelt Co. and the Lubbock Lake site, include the following species, arranged by number of localities from which each species is reported (in parentheses):

Succineids, sp. indet (76)
Hawaiia minuscula (43)
Vallonia gracilicosta (38)
Pupoides albilabris (28)
Pupilla muscorum (23)
Gastrocopta cristata (22)
Pupilla blandi (21)
Gastrocopta armifera (19)
Vallonia cyclophorella (16)
Helicodiscus eigenmanni (13)
Vallonia parvula (11)
Gastrocopta procera (8)
Helicodiscus parallelus (8)
Gastrocopta pellucida (7)
Pupoides inornatus (6)
Vertigo ovata (6)
Vertigo milium (5)
Nesovitrea hammonis electrina (5)

Before returning to specific points suggested by Table 1, some general remarks concerning recent assessments of the late Pleistocene environment of the High Plains seem in order. Wells and Stewart (1987), on the basis of plant (tree), land-snail, and mammalian fossils, proposed that the High Plains of Kansas and Nebraska supported a taiga-like vegetation during the time of the late Wisconsin (Woodfordian) Glaciation. In contrast, Holliday (1987:238) suggested, in regard to the southern High Plains in the general region of Lubbock and Plainview, Texas, and Clovis, New Mexico, that "Available data suggest that the region was primarily an open grassland or grassland with some nonconiferous trees through most of the Quaternary." In northeastern New Mexico, it is probable that some elements of forests such as those presently existing on mesas and scattered mountains of the area extended to lower elevations, onto the plains. However, in reports of Pleistocene land snails from eastern New Mexico, cited above, half the species that Wells and Stewart (1987:Table 1) considered as indicative of forests with some cordilleran affinities are rare or lacking: *Cionella lubrica*, *Vertigo binneyana*, *V. gouldii*, *Columella alticola*, *Discus shimekii*, and *Punctum minutissimum* lacking and *Vertigo modesta* rare. That reliable

Table 1. Species of land snails reported from some localities on the High Plains of eastern New Mexico and Texas.

	(*n*) localities in New Mexico:			[4]Occurrence in Harding Co., New Mexico	(*n*) specimens:		[7]Percentage for Substratum 1,B-C Lubbock Lake, Texas
	[1]Northeast	[2]East-central	[3]Southeast		[5]Roosevelt Co., New Mexico	[6]Nash Draw, New Mexico	
Carychium exiguum					217		7.0
Pupilla blandi	2	13	4	X		526	1.0
Pupilla muscorum	13	8	1	X	8		
Pupilla syngenes (?)		2					
Pupoides albilabris	16	8	2		1	5	2.0
Pupoides inornatus	3	3					
Gastrocopta armifera	15	3					0.2
Gastrocopta ruidosensis							0.4
Gastrocopta contracta			1				
Gastrocopta holzingeri					602		
Gastrocopta pentodon		1	2		538	20	12.0
Gastrocopta procera	7				1		2.0
Gastrocopta cristata	9	8	3	X	9	205	6.0
Gastrocopta pellucida	6					100	
Vertigo ovata		4		X	106	20	37.0
Vertigo elatior		1		X			
Vertigo milium	1	3			15	8	2.0
Vertigo modesta	1						
Vallonia cyclophorella	4	8	2	X	131	90	
Vallonia gracilicosta	18	13	4	X		25	0.1
Vallonia parvula	10					21	2.0
Rabdotus dealbatus	1						
Punctum minutissimum							0.4
Helicodiscus eigenmanni	12						
Helicodiscus parallelus	8	1					0.8
Helicodiscus singleyanus	1						
Discus whitneyi	1	2			2		3.0
Oxyloma retusum	1						6.0
Succineidae	39	27	11	X	270	40	4.0
Euconulus fulvus	1			X	61		2.0
Nesovitrea hammonis	1	2		X	1		0.1
Hawaiia minuscula	24	16	1			28	12.0
Zonitoides arboreus	4				216		0.1
Deroceras laeve		1			8		

[1]Frye, Leonard, and Glass (1978)
[2]Leonard and Frye (1975)
[3]Leonard, Frye, and Glass (1975)
[4] McMullen and Zakrzewski (1972)
[5]Drake (1975); shell fragments recorded by Drake not included
[6]Ashbaugh and Metcalf (1986)
[7]Pierce (1987); substratum 1,B-C, dated ca. 11,000 BP

indicator of woodlands, *Zonitoides arboreus*, was found at only 4 of 44 localities in northeastern New Mexico (Frye, Leonard, and Glass, 1978), and was absent to the south (Leonard and Frye, 1975; Leonard, Frye, and Glass, 1975). Such considerations do not suggest a "taiga" landscape as in the model of Wells and Stewart (1987) for the High Plains in Kansas. Rather, the grassland model proposed by Holliday (1987) seems more likely to apply to most of eastern New Mexico during Wisconsin time.

Of the species listed in Table 1, only a few stand out as being enduring plains-adapted taxa. These include one or more species of succineids and several minute pupillids: *Pupoides albilabris*, *P. inornatus*, *Gastrocopta cristata*, *G. procera* and, to the south, *G. pellucida*. Some of these species also were recorded from the Pliocene strata at the Clayton South locality (noted above) by Leonard and Frye (1978).

The use of the term "eastern plains" may be misleading in regard to both present and Pleistocene habitats of eastern New

Mexico, insofar as it implies a popular image of vast, featureless, grassy plains. Although such expanses dominated by grasslands do exist, they probably were never as hospitable to molluscan life as were scattered aquatic-related situations and areas of more broken terrain within the general Plains region.

There is abundant evidence indicating existence of aquatic habitats on the High Plains during the Pleistocene. This is to be expected, given the lack of external drainage where the Plains are undissected, and assuming an enhancement of effective precipitation during Pleistocene times equivalent to glaciations. Certain terrestrial species must have flourished in habitats marginal to marshes, pools, ponds, and small lakes. Vegetation around such bodies of water probably included rushes, sedges, cattails, and some poolside stands of deciduous trees. In fact, the majority of the localities summarized in Table 1 seem to have been associated with aquatic habitats. This is shown clearly by the presence of aquatic snails in association with terrestrial snails. Of the 43 localities indicated from northeastern New Mexico in Table 1, 36 contain aquatic species. The aquatic, planorbid snail *Gyraulus parvus* occurs at 16 localities, suggesting that pools with aquatic vegetation, favored by this species, were present. Of the 31 localities from east-central New Mexico (Table 1), 16 contain aquatic species, and of the 11 localities from the southeastern part of the state, 5 have aquatic species.

Terrestrial species that were associated most likely with such aquatic habitats include *Vertigo ovata*, *V. milium*, *Gastrocopta pentodon* form *tappaniana*, *Hawaiia minuscula*, *Oxyloma* sp., and *Deroceras laeve*.

Referring to the terrestrial species obtained from the Blackwater Draw and Anderson Basin localities in Roosevelt Co. (Table 1), Drake (1975:203) noted that "damp environments are indicated by practically all the forms of terrestrial snails determined. . . ." Preference for damp habitats is indeed typical of some of the commonest species in Drake's assemblages, such as *Carychium exiguum*, *Gastrocopta pentodon*, form *tappaniana*, and *Vertigo ovata*, as well as *Vertigo milium* and *Deroceras laeve*, which were less abundant. More than 200 specimens of the *tappaniana* form of *Gastrocopta pentodon* were taken in each of two assemblages. (See discussion of *Gastrocopta pentodon* in Metcalf and Smartt, this volume.) In another assemblage, 598 specimens of *Gastrocopta holzingeri* were recorded, suggesting a microhabitat at this stratigraphic level, which was especially congenial for this species.

At the stratigraphic level of the Lubbock Lake site indicated in Table 1 (Pierce, 1987), which quite clearly was marginal to an aquatic habitat, the most common species were *Vertigo ovata*, *Gastrocopta pentodon* form *tappaniana*, and *Hawaiia minuscula*, with the first species comprising 37% of the specimens recovered and the other two, 12% each. These three species were also moderately common in the spring-related deposits studied by Ashbaugh and Metcalf (Table 1). No doubt, aquatic habitats were numerous, although of scattered occurrence during Wisconsin times on the High Plains, but most have disappeared during the Holocene. Snails associated with such habitats may have had an advantage in dispersal provided by the transportation services of aquatic birds visiting the scattered prairie ponds and marshes, which are inferred as having existed.

Topographically, breaks in the High Plains surface have been produced in various ways. Although the High Plains surface itself, formed on the Miocene-Pliocene Ogallala Formation, is internally drained, there are a number of stream systems that traverse the eastern plains, incising valleys flanked by bluffs with rock outcrops, and supporting woody vegetation (often the shrub *Rhus trilobata*). In northeastern New Mexico, there are extensive areas in which basaltic lava deposits surmount the High Plains surface and support different plant associations and assemblages of land snails than do the plains elsewhere. Also, not far distant in much of northeastern New Mexico, higher mountains and mesas often arise from surrounding plains, with the Mesa de Maya and Sierra Grande in Union Co. being prime examples. In general, there is an altitudinal decrease in number of species, which can be observed today, grading from montane to lower bluffs and valley habitats. Fossil evidence indicates fluctuation of these habitat zones up and down in response to Quaternary climatic changes. Such a pattern of life-zone depressions and elevations can be visualized best in this part of the state. Apropos of these altitudinal fluctuations, involving eastern outliers of the Cordillera, the following observations seem germane.

For purposes here, the High Plains (Fenneman, 1931:11) from Nebraska to Texas and New Mexico might be considered as fitting within an elongate arch, with its apex towards the north and its two legs towards the south. During times of glaciation-related cooling, floral and faunal elements seemingly dispersed inward from various parts of the periphery of the arch. Such a model was devised by Wells and Stewart (1987) for the High Plains of Kansas and Nebraska. They referred to taxa dispersing from the western leg of the arch as "cordilleran," those from the eastern leg as "eastern deciduous forest," and those from the northern apex as "boreal." Utilizing these distinctions, they pointed out arboreal, land-snail, and mammalian taxa that likely dispersed inward onto the High Plains, from one or more of these sources. Some taxa were ascribed to only one source, some to two, and a few construed as converging from all three sides and termed "Cordilleran-boreal-eastern deciduous forest" species.

Pierce (1987:43) categorized fossil land snails occurring at the Lubbock Lake site on the Texas High Plains (=Llano Estacado) in a similar manner, referring to some species as "northern or montane" and to others as "eastern or northeastern."

In terms of such an arch model, it seems likely that most of the species that dispersed onto the eastern plains of New Mexico during times of Pleistocene glaciations were derived from the Cordilleran part of the arch. This seems especially likely in northeastern New Mexico where mesas and isolated mountains surely must have acted as routes and stepping-stones during times of dispersal (glaciations) and as refugia for relicts during times of retrenchment (interglaciations). Probably this was also the case farther south in New Mexico. Overall, there was a marked diminution in numbers of species southward. Thus, in the three studies of A. B. Leonard cited above, I interpret the following numbers of species as being indicated: 24 from the northeastern, 19 (or 18) from the east-central, and 10 from the southeastern plains of New Mexico. Species of succineids are combined as one taxon, and *Pupoides hordaceus* is combined with *Pupoides inornatus*. The records of *Pupilla syngenes* may well pertain to *Pupilla blandi* or *P. muscorum*. This pattern suggests that dispersal onto the eastern plains was less marked towards the south. However, even in the south a Cordilleran source for such dispersal was likely dominant, although the eastern outlying mountains and highlands typical of northeastern New Mexico were lacking, except for the relatively low Mescalero Escarpment.

Although distances from mountains to plains were not great in New Mexico, nevertheless, it is clear that some movement that could be termed as "dispersal" did take place, however modest it may have been. One might visualize certain species as extending their range from montane relictua onto the plains in response to climatic and vegetational changes that produced conditions more favorable to them at lower elevations, only to go extinct there as these conditions reversed. Such species might conveniently be termed "dispersalist" and could include *Pupilla blandi, P. muscorum, Vallonia cyclophorella, Discus whitneyi, Euconulus fulvus, Nesovitrea hammonis electrina*, and possibly *Gastrocopta armifera* and *Helicodiscus eigenmanni*. Some or most of these species may have been adapted especially to the scattered aquatic-marginal habitats, discussed above, and aquatic birds might have been involved in dispersal.

Since almost all species that occurred on the eastern plains of New Mexico in the Pleistocene also occurred in the relatively nearby Cordillera to the west, it is difficult to make a case for much dispersal from the eastern leg of the arch described above. However, *Strobilops texasianus*, reported by Hester (1972:Table 7) from the Blackwater Draw Locality, Roosevelt Co., is a southeastern species, which extended onto the High Plains as far west as western Kansas, Oklahoma, and the Texas Panhandle during the Pleistocene (Hubricht, 1985:Fig. 104). The distributional pattern of *Vallonia parvula* suggests that it dispersed onto the High Plains from the east. It has managed to persist to the present as a component of the High Plains fauna of northeastern New Mexico and sparsely in the Sacramento Mountains. If *Helicoduscus parallelus* is, in fact, a species distinct from *H. eigenmanni*, its occurrence in Wisconsin age deposits in northeastern New Mexico (Table 1) might represent another species of eastern origin.

In a broader, longer-term sense, other species may trace back to more eastern origins. Henderson (1931) and Bequaert and Miller (1973) placed the eastern plains of New Mexico at the western margin of their Eastern Division of zoogeographic regions pertaining to North American land snails. In terms of ultimate origins as far back as Late Cretaceous time, this may be a reasonable assignment, because some of the present or Pleistocene species of the plains probably had ancestral roots on the eastern side of the Cretaceous epeiric sea. However, during the long intervening period of Tertiary time, there surely has been a history of distributional complexity that is probably impossible to unravel. Some eastern species may have dispersed westward directly across the High Plains to New Mexico, perhaps using riparian corridors, and established themselves in the Cordillera. Some may have entered the Rocky Mountains at more northerly latitudes (as members of the "boreal" element discussed above) and disseminated southward to New Mexico, comprising part of a "Rocky Mountain" fauna. In both cases, such taxa now would be considered Cordilleran in terms of the arch model proposed above. In some cases such Cordilleran species might be considered as consubspecific with eastern relatives, or they might have speciated into different subspecies or sibling species. Repeated invasions, or possible introgression between still closely related species, could have given rise to taxonomic complexities, perhaps reflected in the difficulty experienced in making specific allocation for some snails treated herein. Examples that might apply here include: 1) *Gastrocopta pilsbryana* and *G. pentodon* (not including "form" *tappaniana*); 2) the *Gastrocopta armifera, G. ruidosensis*, and *G. abbreviata* complex; 3) some populations of larger vallonias, variously assigned to *Vallonia gracilicosta, V. cyclophorella, V. albula*, and *V. sonorana*; 4) *Punctum minutissimum* and *P. californicum*; and 5) *Helicodiscus parallelus* and *H. eigenmanni*.

During times of Pleistocene glaciations when the High Plains environment seems to have been generally more hospitable to land snails, dispersal from various parts of the proposed arch onto the plains must have produced something of a genetic mixing bowl, as populations with varying degrees of interrelationship probably came into contact with each other. In a historical zoogeographic context, the situation seems to be highly complex rather than showing a simplistic east-to-west dispersal pattern.

QUATERNARY FOSSILS FROM BASINS AND MAJOR RIVER VALLEYS

The intermontane basins and major river valleys of New Mexico share with the eastern plains (just discussed) relatively low elevation, low gradients, and similarity in regard to fossil faunas. Similarity is especially close between the eastern plains and the contiguous Pecos River Valley of southern New Mexico.

Pecos River Valley

Although the Pecos Valley is well demarcated from the eastern plains in Chaves Co. by the Mescalero Escarpment, the distinction becomes less obvious to the south as the escarpment diminishes and disappears in southern Eddy Co. Leonard and Frye (1975) and Leonard, Frye, and Glass (1975) included a number of localities from the Pecos Valley in their studies, respectively, of east-central (14 localities) and southeastern (10 localities) New Mexico. In these studies, most species of fossil land snails reported were shared by both the eastern plains and the Pecos Valley. Localities on the adjacent, eastern plains, treated in these papers, are indicated in Table 1. Derived from the two studies, Table 2 indicates numbers of localities in the Pecos Valley from which species were taken, as well as species and numbers of specimens reported by Henderson (1917) from a fossiliferous deposit along Spring River near Roswell.

The heads of western tributary valleys leading into the southern Pecos Valley are in the foothills and higher reaches of the Guadalupe, Sacramento, and other mountains to the west. This western, montane influence seems reflected in some Pleistocene fossil assemblages collected along such tributaries. Species and numbers of specimens taken at several localities

Table 2. Species of Quaternary fossil land snails from the Pecos River Valley. [1]Leonard and Frye (1975); [2]Leonard, Frye, and Glass (1975); [3]Henderson (1917).

	Number of Localities		Number of Specimens					
	[1]East-Central New Mexico	[2]Southeastern New Mexico	Arroyo del Macho	Rio Felix	Rocky Arroyo	Mosley Arroyo	Black River	[3]Spring River
Carychium exiguum								2
Cionella lubrica					3			5
Pupilla blandi	3			2	3	24	2	
Pupilla muscorum	4	1			1			9
Pupoides albilabris	8	3	2	13	1	28	11	23
Pupoides hordaceus	2						13	
Pupoides inornatus					1	10		
Gastrocopta armifera	2	2			4	2	34	20
Gastrocopta contracta		3			1			5
Gastrocopta pentodon	3			1			1	
Gastrocopta procera				1		5	4	136
Gastrocopta cristata	9	1	17	29		18	5	
Gastrocopta pellucida		1	1	8				5
Vertigo ovata	2			2			4	
Vertigo milium	2						1	
Vertigo sp.								5
Vallonia perspectiva			3				1	
Vallonia cyclophorella	2	1			3			
Vallonia gracilicosta	3		58	10		22		373
Vallonia parvula				34				
Rabdotus dealbatus					2	1	32	
Helicodiscus eigenmanni	1			1	7			13
Helicodiscus singleyanus	2	1	23	30	3	14	4	
Discus whitneyi	2				20			
Succineidae	10	8	25	10		15	9	2
Euconulus fulvus	2							
Glyphyalinia indentata								2
Nesovitrea hammonis	2							
Hawaiia minuscula	9	7	6	28				400
Zonitoidesarboreus					2			
Deroceras laeve	2			2				
Linisa texasiana		1		15				
Ashmunella rhyssa					21			

along these western tributary valleys are shown in Table 2. These localities include:

Arroyo del Macho: Chaves Co.; banks of Arroyo del Macho, immediately W of U.S. Hwy. 285; SE¼, NE¼, sec. 1, T 8 S, R 23 E; 1,126 m (3,695-ft) elev.

Rio Felix: Chaves Co.; banks of Rio Felix, ca. 0.8 km (0.5 mi) W of its confluence with the Pecos River; 7.4 km (4.6 mi) SE of Dexter; immediately E of west section line of sec. 35, T 13 S, R 26 E; 1,033-m (3,390-ft) elev.

Rocky Arroyo: Eddy Co.; banks of Rocky Arroyo between Rocky Arroyo Cemetery and Indian Big Spring along NM Road 137; NE¼, NE¼, sec. 26 and NE¼, NW¼ sec. 27, T 21 S, R 24 E; 1,082-1,097 m (3,550-3,600-ft) elev.

Mosley Arroyo: Eddy Co., bank exposures on west side of Mosley Arroyo; NW¼, SE¼, sec. 26, T 23 S, R 25 E; 1,067 m (3,500-ft) elev.

Black River: Eddy Co.; terrace with buff-colored sediments, immediately S of Black River, in road cut along road leading to U.S. Hwy. 62/180, 3.2 km (2 mi) to the east; near center sec. 24, T 25 S, R 24 E; ca. 1,097-m (3,600-ft) elev.

Several larger species of land snails taken in the greater Pecos Valley were not part of the fauna of the eastern plains. Two polygyrid snails occur in Quaternary sediments along the valley. *Linisa texasiana* is fairly common as a fossil from Roswell southward in the valley, indicating that it was formerly more widespread there than at present, when it seems restricted to the Bitter Lake area east of Roswell. Fossil shells of *Ashmunella rhyssa* have been taken in bank sediments of Rocky Arroyo (NE¼, NW¼, sec. 27, T 21 S, R 24 E) at a locality indicated in Table 2, above, and of Black River 12 km (7.5 mi) west of Malaga. It seems that this presently montane species lived at lower elevations along Rocky Arroyo and Black River in the Pleistocene, as it did at Keen Spring in the Tularosa Basin, discussed below.

Along the western margins of the Pecos Valley, a fauna transitional to that of the foothills (exemplified by Dry Cave, discussed hereafter) seems to have occurred. Such an assemblage is represented by materials from a terrace along upper Black River, listed in Table 2. The species *Rabdotus dealbatus neomexicanus*, now typically a montane snail in the area, is common in deposits at this site, as are several other species now found at higher elevations in the Guadalupe and Sacramento Mountains: *Pupilla blandi*, *Gastrocopta a. armifera*, *Gastrocopta procera*, and *Vallonia perspectiva*. The occurrence together at this site of *Rabdotus d. neomexicanus* with *Vertigo ovata* is of interest. Both species still persist in Eddy Co.: the *Rabdotus* only in mountainous areas, and the *Vertigo* only a thousand meters lower in damp habitats alongside the springbrook issuing from Blue Spring. However, along the upper Peñasco River in the Sacramento Mountains, above Mayhill at elevations of from 2,042-2,195 m (6,700-7,200 ft), *R. d. neomexicanus* lives on hillslopes alongside the floodplain of the stream, which is marshy in places and offers habitats suitable for Vertigos. These, and several other species that occur in Pleistocene faunas along the Pecos Valley, exhibit life-zone depressions when compared with faunas presently found at higher elevations in mountains to the west.

Rio Grande Rift Valley

Topographic basins and valleys are, of course, found throughout the Basin and Range Physiographic Province, which incorporates some one-third of the area of New Mexico. The most extensive of these in the state is the Rio Grande Rift Valley, which, by its north-south axis, bisects the state. This valley has been the most intensively investigated of the various basins in regard to Quaternary fossil mollusks. Metcalf (1967, 1969) reported faunas from the valley in southern New Mexico, and David P. Dethier has made available for study assemblages he collected in the Española area, in the northern part of the valley.

In southern New Mexico, collections of Pleistocene age were made at localities in two widespread alluvial units: the Tortugas and Picacho alluviums (Metcalf, 1967). A composite listing of species taken in these units is given in Table 3. In the assessment of Gile et al. (1981:48-49:Fig. 8), some sediments of the Picacho and Tortugas alluviums were considered likely to pertain, respectively, to the first and second interglaciations preceding the Wisconsin Glaciation (oxygen isotope stages 5 and 7). It is likely that these units also contained sediments pertaining to times of the waning glaciations preceding these interglaciations (oxygen isotope stages 6 and 8, in part). The faunas themselves are more indicative of glacial-equivalent than of interglacial-equivalent conditions, as they suggest a lowering of life zones. The listing in Metcalf (1967:Table 1) shows that one-half of the terrestrial species in the Picacho and two-thirds of those in the Tortugas alluvium are species presently living in montane habitats, implying a life-zone depression of from 610-910 m (2,000-3,000 ft). Almost all species involved in this apparent colonization of lower-elevation areas were smaller species. The larger montane species seemingly retained a long-continued preference for highlands. Larger species were found only in the case of the Tortugas alluvium, which yielded *Ashmunella hawleyi* at two localities and a fragment of a *Rabdotus* at one locality.

Ashbaugh and Metcalf (1986:13) discussed a fossiliferous alluvium exposed in banks of Placitas Arroyo, ca. 3 km southwest of Hatch, Doña Ana Co. Species obtained are indicated in Table 3 (under "Placitas Alluvium"). No age determinations were available for this deposit. However, from its stratigraphic position below Holocene alluvium, degree of induration, and nature of the fauna, it seems likely to be of latest Pleistocene or earliest Holocene age, quite possibly of an age near that of the B-2 alluvium, discussed below. The assemblage reflects a habitat very different from the present arid conditions at the site. Ashbaugh and Metcalf (1986:14-16) interpreted faunas from two lower units at the locality to suggest presence of a springbrook with an associated riparian stand of trees, while the fauna of an upper unit was inferred to show evidence of pools and marshes related to spring outflow.

A deposit termed "B-2 alluvium" of early Holocene age with a radiocarbon date of 9,360±150 B.P. was reported by Metcalf (1969:160) from banks of the Rio Grande ca. 2.5 km WSW of Garfield, Doña Ana Co. Species found in this alluvium are indicated in Table 3. The fauna includes *Cionella lubrica*, *Gastrocopta a. armifera*, *Vallonia perspectiva*, *V. gracilicosta*, *Helicodiscus eigenmanni*, *Glyphyalinia indentata*, and

Table 3. Summary of fossil land snails collected from Quaternary sediments along the Rio Grande Valley, New Mexico. Northern = vicinity of Española (collections of David P. Dethier), arranged chronologically by amino-acid age determinations obtained and supplied by Dethier; Southern = alluvial records from Metcalf (1967, 1969) and Ashbaugh and Metcalf (1986).

	NORTHERN (thousands of years before present)					SOUTHERN				
	650-620	500	299-200	199-100	80-40	Tortugas alluvium	Picacho alluvium	Placitas alluvium	B-2 alluvium	Rio Grande floodplain
Cionella lubrica	X					X				X
Pupilla blandi	X	X	X	X	X	X	X	X		
Pupilla muscorum	X	X	X	X	X			X		
Pupilla sonorana										X
Pupoides albilabris	X			X		X	X	X	X	X
Pupoides hordaceus	X			X	X	X	X	X		
Gastrocopta armifera	X			X	X	X		X	X	
Gastrocopta holzingeri				X		X				
Gastrocopta pentodon								X		
Gastrocopta pilsbryana						X	X			
Gastrocopta procera				X					X	X
Gastrocopta cristata				X	X	X	X	X	X	X
Gastrocopta pellucida						X	X	X	X	
Vertigo ovata						X	X	X		X
Vertigo modesta			X	X						
Vertigo berryi							X			
Vallonia perspectiva	X					X		X	X	
Vallonia cyclophorella	X	X	X	X		X	X	X		
Vallonia gracilicosta	X			X	X	X	X	X	X	
Rabdotus dealbatus						X				
Helicodiscus eigenmanni							X		X	
Helicodiscus singleyanus						X	X	X	X	X
Discus whitneyi	X	X	X			X	X	X		
Oreohelix strigosa	X									
Oxyloma sp.								X		X
Succineidae	X	X	X	X	X	X	X	X	X	X
Euconulus fulvus	X									
Glyphyalinia indentata									X	
Hawaiia minuscula						X	X	X	X	X
Zonitoides arboreus		X		X	X	X	X	X	X	
Deroceras laeve								X		
Ashmunella hawleyi						X				

Zonitoides arboreus. These species do not inhabit the Rio Grande floodplain here today, but, except for *G. armifera*, are associated with foothill or montane habitats over 1,675 m (5,500 ft) in elevation. Hackberry seeds (*Celtis*) are associated with the snails, and several kinds of trees may have contributed to a riparian woodland that produced leaf litter inhabited by snails.

Snails from deposits containing partially decomposed plant material, exposed in banks of the Rio Grande at the foot of the Robledo Mountains south of Fort Selden, Doña Ana Co., provide further information concerning Holocene aspects of the Rio Grande floodplain fauna. These outcrops comprise Localities R-34 to R-37 reported by Metcalf (1967:60). A charcoal sample from Locality R-34 yielded a radiocarbon determination of "less than 195 years" (Metcalf, 1967:34). It seems very likely that all localities are comparably young, and indicative of conditions prevailing along the floodplain just before Europeans began modifications of the valley. Species of land snails obtained at these localities are listed in Table 3 (under "Rio Grande F."). The fauna consists mainly of aquatic species and of terrestrial species that typically inhabit the vegetated margins of marshes and pools. The associated fossil plant material also indicates a marshy habitat. Historical accounts suggest that marshes were common along the Rio Grande floodplain in this area until European settlement (Metcalf, 1967:32). The floodplain would have provided a narrow strip with aquatic and moist habitats, quite different from the xeric environment of the valley areas flanking the floodplain. This seems to be reflected in the contrast between the diverse fauna of aquatic and marsh indicators from late Holocene sediments of the Rio Grande floodplain and the sparse fauna of xeric indicators found in alluvium deposited along tributaries entering the valley from the east and west.

Dethier et al. (1988) discussed the geologic dating of erosion surfaces in the Española area, using several dating methods, including amino-acid ratios that were determined for fossil land-snails occurring below three such surfaces. Dates indicated (pp. 934-935) for times of deposition of the snails were "between 700 and 500 ka," "younger than 250 ka," and "younger than 130 ka" (ka = thousands of years). Dethier and McCoy (1993) further discussed utilization of aminostratigraphic relations of Quaternary deposits in the Española area. They noted that amino-acid ratios were determined for gastropods (succineid and *Vallonia* shells) from 44 sites in deposits that they calculated to range in age from 620 ka to modern. Some broad chronological groupings have been provided by Dethier for gastropods submitted to me for identification. These groupings, together with taxonomic determinations, are indicated in Table 3. Age groupings range from 620-650 ka to 40-80 ka.

Faunas of various ages and from various geographical localities in the Rio Grande Rift Valley show considerable similarity. In Table 3, comparing faunas from the Dethier localities (northern) with those of Doña Ana and Sierra Counties (southern), 15 species are recorded as both northern and southern. The dominant species in assemblages from both areas are similar, including *Gastrocopta cristata*, *Pupilla blandi*, *Vallonia gracilicosta*, and succineids. In collections, *Pupilla muscorum* and *Vallonia cyclophorella* were relatively more common to the north and *Pupoides albilabris*, *Gastrocopta pellucida*, *Vertigo ovata*, *Helicodiscus singleyanus*, *Hawaiia minuscula*, and *Zonitoides arboreus* to the south. Three species are recorded only in the north: *Vertigo modesta*, *Euconulus fulvus*, and *Oreohelix strigosa*. However, the first two species do occur in mountains in the southern part of the state. Fourteen species are recorded in the south, but not in the north, although most of these probably occurred in northern New Mexico. Their absence, here, is probably merely attributable to the smaller number of localities sampled in the north and to the lack of latest Pleistocene or earliest Holocene assemblages associated with marshes, such as seem to have occurred at the Placitas Arroyo and B-2 alluvium sites (Table 3).

In general, it seems that a Pleistocene land-snail fauna with much similarity in regard to component species extended along the length of the Rio Grande Valley across New Mexico. Fossil asssemblages comprising this fauna differ in their composition from those presently occurring in the valley. This is surely attributable, in part, to the changes wrought by Europeans in their profound modification of an area so inviting for agriculture and as human habitation. The young fauna noted from Rio Grande floodplain sediments (Table 3) indicates much change in the last century. Apart from this, it has been contended, above, that life-zone depression was involved in the case of the Tortugas and Picacho alluviums and of the faunas from the Española area. It seems that the Placitas Arroyo spring and marsh-related habitat had disappeared by some time in the Holocene, as, above the older beds, there are younger Holocene deposits that contain only scant numbers of shells, all non-hygrophilous.

Gila River Valley

Along the Gila River Valley in extreme western New Mexico (Hidalgo Co.), there are valley-flanking terraces with associated alluvial deposits, which generally resemble some of the alluvial terraces along the Rio Grande Valley. Morrison (1965) designated the lowest of these as "Stream-terrace-gravels" Qt-1 and Qt-2, and tentatively correlated (*in litt.*, 28 July 1967) Qt-2 with the Picacho alluvium of the Rio Grande Valley in the Las Cruces area. In sediments under Morrison's Qt-2 terrace, immediately north of Virden, Hidalgo Co., fossil mollusks were found, including the following terrestrial species: *Pupoides albilabris*, *Gastrocopta a. armifera*, *G. cristata*, *Vallonia cyclophorella*, *Helicodiscus singleyanus*, succineids, and *Hawaiia minuscula*.

Although additional Pleistocene fossil localities have not been found along the Gila Valley in New Mexico, some may be revealed by further search. Not far down-valley in Greenlee Co., Arizona, several fossiliferous exposures have been found in road cuts along Arizona Highway 75, between Sheldon and the junction of Highway 75 with U.S. Highway 666. It is likely that these species also were inhabiting the valley immediately upstream in New Mexico at that time in the Pleistocene. The list from three Arizona localities includes the following land snails (arranged by declining total number of specimens, shown in parentheses):

Gastrocopta cristata (136)
Succineidae (111)

Pupoides albilabris (75)
Vallonia cyclophorella (56)
Helicodiscus singleyanus (25)
Vertigo milium (21)
Hawaiia minuscula (10)
Zonitoides arboreus (10)
Vallonia gracilicosta (9)
Discus whitneyi (9)
Ashmunella sp. (6)
Pupoides hordaceus (5)
Helicodiscus eigenmanni (5)
Vertigo ovata (3)
Nesovitrea hammonis (3)
Pupilla blandi (1)
Vallonia perspectiva (1)

Two species (*Gastrocopta armifera* and *Vallonia gracilicosta*) in the above listings combined (Hidalgo and Greenlee Counties) do not occur that far west at the present time. Bequaert and Miller (1973:145) reported *Nesovitrea hammonis electrina* as being rare in Arizona. These authors listed all three of the above species from Pleistocene sites in Arizona including localities associated with fossil mammoths in the San Pedro River Valley, and dated at some 10,000 to 11,000 B.P. The occurrence of *Neosovitrea hammonis electrina* at this elevation (ca. 1,100 m or 3,600 ft) represents a depression in elevation of some 1,220 m or 4,000 ft from elevations where it occurs in the Mogollon Mountains in New Mexico. The specimens of *Ashmunella* indicated were fragmentary and did not include apertural areas that might have allowed identification to species.

Intermontane Basins

There have been few reports of Pleistocene land-snail faunas from intermontane basins. Perhaps they have not been sought for sufficiently, or perhaps this relates to less dissection by arroyos in these internally drained basins, where arroyo walls might reveal fossils. However, Ashbaugh and Metcalf (1986) reported a diverse fauna including both aquatic and terrestrial snails from the Tularosa Basin in the area of Keen Spring, ca. 3.3 km west of Oscura, Lincoln Co. (Table 4). Today, Keen Spring produces only a trickle of water at the bottom of an entrenched arroyo, but ancient springmounds and nature of the sediments and fauna indicate that it comprised a complex of much larger springs in the Pleistocene. Fossil snails are associated with a Pleistocene mammalian fauna.

The Keen Spring locality comprised five collection sites near and downstream from the present small spring. Twenty-five species of land snails were reported for the locality and are listed in Table 4. This is a surprisingly large number for either fossil or modern land-snail localities in New Mexico. The occurrence also of 4 species of sphaeriid clams and 9 species of aquatic snails indicates presence of permanent water presumably supplied by the former springs noted. The occurrence at one locality of 5 species of *Vertigo* is unusual in New Mexico, and indicates existence of moist conditions probably associated with spring-fed marshes or damp areas alongside springbrooks. Also indicative of a moist environment are *Carychium exiguum*, *Gastrocopta pentodon* form *tappaniana*, *Nesovitrea hammonis electrina*, and the slug *Deroceras laeve* (slugs represented by internal shells).

Sixteen species of the Keen Spring assemblage no longer occur in the Tularosa Basin, but do occur at higher elevations in mountains flanking the basin. The presence of *Ashmunella rhyssa* at this elevation in the basin is noteworthy. It presently occurs only in the mountains east of the basin. However, in the past it likely colonized Salinas Peak on the west side of the basin, where it probably was ancestral to the closely related (or conspecific) *A. salinasensis*.

Occurrence of fossils of *Ashmunella rhyssa* at Keen Spring supports a model of dispersal across the basin simply by locomotion of the snails themselves. Probably some other species in the Keen Spring assemblage also dispersed into the basin from nearby mountains during times of Pleistocene life-zone depression. However, some of the small aquatic and hygrophilous species may have been dispersed by aquatic birds, among what were presumably marshy areas around widely scattered springs in the Tularosa Basin or larger region in the Pleistocene.

QUATERNARY FOSSILS
FROM CORDILLERAN NEW MEXICO

Having surveyed some Quaternary fossil faunas from lowland areas of the eastern plains, major river valleys, and intermontane basins, we now examine some records from Cordilleran areas, again chiefly from southern New Mexico. It has been stressed above that the Cordilleran fauna seems to be a venerable one, and the Pleistocene record seems to conform to such a model. Some sites are, of course, located transitionally between lowlands and mountains, in areas of foothills, as in the case of Dry Cave and of U-Bar Cave, discussed below. In this section, sites and areas in southern New Mexico from east to west are discussed first, followed by remarks on a few sites in the northern part of the state.

Dry Cave

The Dry Cave locality is in Eddy Co., ca. 24 km (15 mi) west of Carlsbad, in arid foothills transitional from the Pecos Valley to the Guadalupe Mountains to the west. Arthur H. Harris and students have excavated and analyzed fossil vertebrates from Dry Cave (Harris, 1970), and Harris' locality numbers are used below and in Table 4. Associated with vertebrate materials are some fossils of land snails (Metcalf, 1970; 1977).

Dry Cave is an extensive cave complex in Permian bedrock at an elevation of 1,280 m (4,200 ft). Localities yielding fossil mollusks are in two areas, which received fill from different sources: Entrance Fissure and Bison Sink. The Entrance Fissure source area was at the present mouth of the cave, and, when filling began, seems to have been a collapse sink some 18.3 m (60 ft) deep, probably with steep rocky walls. The locality designated Animal Fair (Loc. 22) lies near the bottom of this fill, and has an associated date of 15,030±210 B.P. The locality Stalag 17 (Loc. 23) lies higher and has an associated date of 11,880±250 B.P.

Table 4. Abundance of fossil land snails from Quaternary deposits in Dry Cave, Eddy Co., New Mexico. Original locality numbers and radiocarbon determinations for the assemblages (from A. H. Harris) are as follows: Animal Fair (Loc. 22; 15,030 ± 210 BP), Bison Chamber (Loc 4; probably between 10,730 and 14,470 BP), Stalag 17 (Loc. 23; 11,880 ± 250 BP), and Test Trench II (Loc. 54; 10,730 ± 150 BP). Species that presently are living at elevations of 6,600-7,500 ft along Peñasco Canyon, Sacramento Mountains, Otero Co., are indicated at far right. Of these, only *Hawaiia minuscula* and a succineid presently live in the area near Dry Cave.

	Entrance Fissure source area		Bison Sink source area		
Species	Animal Fair	Stalag 17	Bison Chamber	Test Trench II	Peñasco Canyon (living)
Cionella lubrica	3				X
Pupilla blandi	3		62		X
Pupoides albilabris				7	
Pupoides hordaceus			3	8	
Gastrocopta armifera	1	1	2	12	X
Gastrocopta contracta		2			X
Gastrocopta procera	5		153	54	X
Gastrocopta pellucida		4	32	15	
Vallonia perspectiva	65	1	10	4	X
Vallonia cyclophorella			13	9	X
Vallonia gracilicosta	8		94	91	X
Rabdotus dealbatus	5	1	1	2	X
Helicodiscus singleyanus			1	3	
Succineidae	82	1	68	1054	X
Glyphyalinia indentata	53	5	9	21	X
Hawaiia minuscula	24	4	30	150	X
Thysanophora hornii			1	3	

Bison Sink is located 61 m (200 ft) south-southeast of the present mouth of the cave. From it have been derived sediments deposited in Bison Chamber (Loc. 4). Higher on a debris slope, and younger than Bison Chamber, is a locality designated Test Trench II (Loc. 54), with an associated date of 10,730±150 B.P.; hence, of latest Wisconsin age. The Bison Chamber (Loc. 4) sediments are probably older than Test Trench II and younger than sediments at another site (Loc. 6) with an associated date of 14,470±250 B.P.

Localities mentioned above and species and quantities of fossil snails recovered are indicated in Table 4, derived from Metcalf (1977:Table 2). All Pleistocene assemblages differ greatly from the present fauna of the area, which comprises few species: *Gastrocopta pellucida*, *Pupoides albilabris*, *Hawaiia minuscula*, a succineid, and *Thysanophora hornii*.

Table 4 indicates species taken in Dry Cave, which also are found living at 2,013-2,287-m (6,600-7,500-ft) elevations along Peñasco Canyon in the Sacramento Mountains, Otero Co., 120 km (75 mi) northwest of Dry Cave. Samples were collected at 91-m (300-ft) intervals along Peñasco Canyon. The greatest number of shared species was at an elevation of 2,195 m (7,200 ft). Metcalf (1977:63) suggested that conditions of effective moisture similar to those at the elevations noted in Peñasco Canyon might be hypothesized as occurring at Dry Cave during late Wisconsin times, during which the assemblages at Localities 4, 22, and 23 existed. In regard to annual precipitation, this would suggest an increase of some 25.4 cm (10 in.) over the 30.5 cm (12 in.) received in the Dry Cave area today. In terms of life-zone depression, a figure of 915 m (3,000 ft) is indicated if the 1,280-m (4,200-ft) elevation of Dry Cave is compared with the 2,195-m (7,200-ft) elevation in Peñasco Canyon, noted above. However, it is clear that, topographically, the foothills area around Dry Cave is quite different from mountain-flanked Peñasco Canyon, and Metcalf (1970:45) suggested that the Dry Cave area in late Wisconsin time might have resembled the present foothill grasslands (*vegas*) in the vicinity of Las Vegas, San Miguel Co., New Mexico.

The assemblage from Test Trench II seems to be near the Pleistocene/Holocene boundary, judging by the associated radiocarbon date. By Test Trench II time, *Pupilla blandi* no longer occurred in the assemblage, and proportions of *Gastrocopta procera* and *Vallonia gracilicosta* had been reduced from those of the Bison Chamber assemblage. This suggests onset of a climatic trend toward less effective precipitation.

In regard to vertebrate species found in mid-Wisconsin strata in Dry Cave, Harris (1987:148) observed that most presently extralimital species of the fauna were "drawn predominantly from nearby highlands." This may well apply to the land-snail fauna as well.

Higher Mountains

Fossil mollusks have been found in montane Quaternary deposits only in mountains with calcareous bedrock, not in those with igneous bedrock. This can be observed, for example, in crossing from the calcareous Sacramento Mountains to the adjacent igneous Sierra Blanca Mountains. Fossiliferous deposits occur both as alluvium and colluvium. Alluvial deposits containing Quaternary fossils may occur as floodplains of mountain streams, as marsh or other ponded sediments, or as silt or travertine deposits associated with springs and springbrooks. Fossils may be exposed when such sediments are subsequently incised by erosion or downcutting by streams. Fossiliferous colluvial deposits formed on hillslopes, and exhibit varying degrees of calcareous cementation, this generally increasing with age. In many cases, colluvial slope deposits seem to have been related to periglacial phenomena such as solifluction and frost-related processes. Deposits often have an appearance of initially having been a silty slurry that contained varying amounts of angular stones, interpreted as being frost rubble. Such rubble deposits are massive in some places, and seem to have originated as talus or rock glaciers. As they commonly do now in southern New Mexico, snails seem to have occupied interstices of this ancient talus, presumably at times when they were dormant. Subsequently, calcareous silty deposits accumulated and filled these interstices, entombing the snails or their shells. Sometimes small groups of fossil snails appear in these interstitial catacombs, where they may have died together. Colluvial slope mantles are not forming at the present time and seem to provide, in themselves, an indication of a markedly different hillslope regimen during glacial-equivalent times.

Most of the mountains with calcareous bedrock that provided favorable conditions for preservation of Quaternary molluscan fossils are in southern New Mexico. However, such conditions also exist to the north, in the Nacimiento Mountains and in some southern canyons of the Sangre de Cristo range (as in Pecos and Gallinas Canyons).

Sacramento Mountains

Preeminent among the southern mountains in richness of Quaternary molluscan fossil assemblages are the Sacramento Mountains and their southeastern extension, the Guadalupe Mountains of New Mexico and Texas, a Basin and Range-type mountain complex, formed on uplifted Paleozoic strata. Along canyons, fill may consist of alluvial and/or colluvial deposits with the two sometimes interdigitating. Such canyon fill is extensive in these mountains, often forming thick deposits. Older deposits occur higher up on walls of canyons, in which there may have been multiple episodes of cutting and filling. The latest time of downcutting occurred some time before deposition of the present floodplains along canyon floors. Radiocarbon dates from these alluvial floodplain deposits are as old as mid-Holocene, and are superposed on still older deposits. It seems, then, that the latest episode of downcutting must have been no younger than early Holocene. As noted above, it seems likely that fossiliferous hillslope colluvium was deposited during times of Pleistocene cooling. There may be several such colluvial units in a single canyon. Fossiliferous exposures in these mountains are numerous, occurring along almost every canyon that has been investigated. Eventually, it should be possible to correlate such units from one canyon to another. However, such geological study of these sediments has not been undertaken yet, so that chronology and correlation of the fossil faunas are not understood. A composite listing from colluvial and alluvial deposits of the Sacramento Mountains is provided in Table 4.

A suggestion of multiple ages for various colluvial and alluvial units is provided by fossils of the genera *Ashmunella* and *Oreohelix*. Metcalf (1973) described four new species of *Ashmunella* with distinctive denticulation from fill in four different canyons. In addition, fossils of Ashmunellas with very poorly developed teeth, or no teeth, are common in fill deposits in various canyons. All of these may be variants of *Ashmunella rhyssa*, presently the only species of the genus in the Sacramento Mountains. However, fossils from different localities vary considerably in shell morphology, ranging from small to large, depressed to elevated, and from more conical to more angular. Some of these variants may represent still other extinct species. A similarly diverse group of fossil *Oreohelix* occurs in the mountains, some of them in association with various of the above kinds of *Ashmunella*. In treating this complex, Metcalf (1982) described a new species, *Oreohelix oterana*, comprising three subspecies. *Oreohelix penascana*, described by Metcalf and Crews (1982), is a very different *Oreohelix*, morphologically, found at one locality in Rio Peñasco Canyon. *Oreohelix neomexicana*, a more widespread species, occurs in Pleistocene and some early Holocene deposits in the Sacramento Mountains, but is extinct there now, so far as is known (Crews, 1981). *Oreohelix nogalensis* occurs as a fossil in a northern extension of the Sacramento Mountains, east of the Sierra Blanca Mountains, although living populations are restricted to the Sierra Blanca range.

In the Guadalupe Mountains, extending southeastward from the Sacramento Mountains, *Oreohelix neomexicana* and two species of *Ashmunella* (*A. rhyssa* and *A. nana*) occur as fossils in Pleistocene colluvial deposits (Metcalf and Fullington, 1976). In addition, there are two species of *Ashmunella* still living in the Guadalupes: *A. amblya amblya* and *A. carlsbadensis*. *Ashmunella carlsbadensis* also has been found as a fossil in colluvial deposits in the eastern foothills of the Guadalupe Mountains and in several caves, its type being a fossil specimen from a cave near the mouth of Dark Canyon, Eddy Co., at 1,067-m (3,500-ft) elevation.

In addition to the fossil fauna of larger land snails in the Sacramento-Guadalupe mountain chain, there is a good representation of smaller species. Few of these smaller species have gone extinct in the Sacramento Mountains, although this seems to be the case with *Pupoides hordaceus*, *P. inornatus*, and *Nesovitrea hammonis electrina* (the latter has been taken, living, at one locality in the nearby Sierra Blanca Mountains).

Table 5. Quaternary land-snail fossils from mountain ranges flanking the Tularosa/Hueco and Jornada Basins, and from the Tularosa Basin. Indicated by occurrence only (X) are species taken in the Caballo, San Andres, and Sacramento Mountains, New Mexico, and the Franklin Mountains in adjacent El Paso Co., Texas. Number of specimens collected are indicated for the Keen Spring fossil site, 2 miles west of Oscura in the Tularosa Basin (4,850-ft elevation), and for Holocene alluvium below a terrace along Tularosa Creek, north of falls, bridge, and gaging station, SE¼, NE¼, NW¼, Sec.32, T13S, R11E (5,450-ft elevation).

Species	Caballo Mountains	San Andres Mountains	Sacramento Mountains	Franklin Mountains	Keen Spring	Tularosa Creek Alluvium
Carychium exiguum			X		2	29
Cionella lubrica	X		X	X		
Pupilla blandi		X	X	X	62	
Pupilla muscorum			X		82	
Pupilla sonorana	X		X	X	1	
Pupoides albilabris			X		8	2
Pupoides hordaceus	X	X	X	X	5	
Pupoides inornatus			X			
Gastrocopta armifera			X			
Gatrocopta contracta						1
Gastrocopta pentodon					84	201
Gastrocopta pilsbryana	X		X	X	1	
Gastrocopta quadridens	X					
Gastrocopta procera	X		X	X	3	
Gastrocopta cristata			X		62	18
Gastrocopta pellucida			X	X	2	10
Vertigo milium					20	
Vertigo ovata					48	132
Vertigo berryi					26	2
Vertigo elatior			X		2	
Vertigo modesta	X					
Vertigo ventricosa					1	
Vertigo gouldii	X			X		
Vallonia perspectiva	X		X	X	13	
Vallonia cyclophorella	X	X	X	X	107	
Vallonia gracilicosta	X	X	X	X	25	3
Metastoma roemeri		X		X		
Rabdotus dealbatus			X			
Paralaoma caputspinulae			X			
Helicodiscus eigenmanni		X	X			4
Helicodiscus singleyanus	X		X	X	2	5
Discus whitneyi	X	X	X			
Oreohelix caballoensis	X					
Oreohelix neomexicana		X	X	X		
Oreohelix oterana sspp.			X			
Oreohelix penascana			X			
Oreohelix nogalensis			X			
Radiocentrum ferrissi				X		
Sonorella metcalfi				X		
Succineidae			X	X	503	30
Oxyloma retusum						77
Euconulus fulvus	X			X		14
Glyphyalinia indentata	X	X		X		
Nesovitrea hammonis			X		1	2
Hawaiia minuscula	X		X	X	41	20

Table 5 (continued)

Zonitoides arboreus	X		X	X		85
Vitrina pellucida			X	X		
Deroceras laeve					129	5
Ashmunella jamesensis			X			
Ashmunella kochii sspp.	X	X				
Ashmunella pasonis sspp.		X		X		
Ashmunella rhyssa sspp.			X			
Ashmunella ruidosana			X			
Ashmunella tegillum			X			
Ashmunella tularosana			X			
Thysanophora hornii		X		X		

Vertigo elatior seems to be very rare at present. However, it appears that, in general, smaller species are less inclined to go extinct than larger species in these and other mountains of the state. This may be related to the abilities of small species, noted above, to have behaved as dispersalists in the Pleistocene. By contrast, larger species seemingly were loathe to leave their montane habitats, which is not surprising if their lineages indeed have been adapted to mountain environments during periods of time extending back to the earlier Tertiary or even to the Mesozoic.

Ranges of South Central New Mexico

Westward across the Tularosa Basin from the Sacramento Mountains are the predominantly calcareous San Andres Mountains. In this range, colluvial hillslope deposits at a few localities have yielded Quaternary fossils; again, these include *Oreohelix neomexicana*. A composite listing of fossil species from the San Andres Mountains is given in Table 5.

The Franklin Mountains lie south of the San Andres-Organ Mountain chain. Species of Quaternary fossils known from these mountains are listed in Table 5. Although mainly in Texas, the Franklins seem to deserve mention because colluvial deposits, especially those on the north-facing wall of Vinton Canyon in the northern part of the range, have provided a diverse Pleistocene fauna, reported by Metcalf and Johnson (1971), and greatly augmented recently by collections of Richard D. Worthington. *Oreohelix neomexicana* and *Radiocentrum ferrissi* occur in the same colluvial unit along Vinton Canyon. Sympatry of these genera is rare.

Westward across the Jornada del Muerto Basin from the San Andres Mountains are the Caballo Mountains, another block-faulted range with massive limestone outcrops. Quaternary fossil snails have been found in colluvial slope deposits in canyons on the west side of Brushy Peak and in low, outlying foothills in the southwestern part of the range (Metcalf, 1977:55-56). Species taken are listed in Table 5. An endemic subspecies of the Caballo Mountains, *Ashmunella kochii caballoensis*, occurs both living and as a fossil. Known only as a fossil, *Oreohelix caballoensis* seems close, conchologically, to species of *Oreohelix* occurring to the west (Black Range and other mountains).

The Caballo and Franklin Mountains, similar in size and elevation and both arid ranges today, were compared by Metcalf (1977:55-57). The limestone and rhyolitic outcrops of the Franklins are better producers of talus than outcrops of the Caballo Mountains. For land snails inhabiting such arid mountains, accumulations of talus seem to have been a last refuge into which they could withdraw as aridity increased in Holocene time. Probably because they provide fewer such refuges, the Caballo Mountains have fewer species, both living and fossil, than the Franklins. Eighteen fossil and seven living species have been obtained in the Caballos. From the Franklins, including recent collections made by R. D. Worthington, noted above, the numbers are 24 fossil and 16 living. Most of the species now extinct in the Caballo and Franklin Mountains still occur along wooded canyons of the more massive and higher Sacramento, Organ, and Black ranges of south-central New Mexico, where moisture conditions are sufficient to support forest. Thus, these fossil faunas are indicative of a Pleistocene depression of life zones in the region. The occurrence of *Vitrina pellucida alaskana* as a fossil in the Franklin Mountains is especially indicative of a very different climate. Today, it occurs only in forested habitats above ca. 2,195 m (7,200 ft) in moist habitats, as along floodplains of mountain streams. The fossil fauna from the Caballo Mountains contains numerous shells of *Gastrocopta quadridens*, a species of scattered occurrence in New Mexico, which lives along the crest of the Sandia Mountains at ca. 3,230-m (10,600-ft) elevation. Perhaps the present environment of Sandia Crest resembles that which prevailed along the crest of the Caballo Mountains when *G. quadridens* flourished in that range. In both ranges, outcrops of massive limestone occur in areas where *G. quadridens* is found, living or fossil.

Still farther westward, across the Rio Grande Rift Valley, is another complex of ranges, some of which have yielded fossil land snails. North to south, these comprise the Cuchillo Mountains, Black Range, Cooke Peak, the Florida Mountains, and the Tres Hermanas Mountains. In each of these ranges, one or more species of fossil *Oreohelix* has been found, as well as in the Sierra Rica Mountains to the west of the Tres Hermanas range. With the exception of *Oreohelix subrudis* in the Black

Range, all these seem to be part of an interrelated group, which also may include *Oreohelix caballoensis*, mentioned above.

In the Cuchillo Mountains, only a few fossil shells, mainly of *Oreohelix metcalfei cuchillensis*, have been collected. The richest fossiliferous deposits in the Black Range area have been found in the calcareous eastern foothills of the range. Deposits containing large numbers of *Ashmunella mendax* and *Oreohelix subrudis* occur on a south-facing hillslope about 3.7 km (2.3 mi) north-northeast of Kingston and the latter species also occurs in hillslope colluvium in road cuts on the northwestern side of Apache Hill along New Mexico Highway 27, ca. 1.6 km (1.0 mi) north of the ghost town of Lake Valley. The present habitat at this locality is desert grassland, but it seems that there must have been a woodland with some nonconifers (oaks?) on the north slope of Apache Hill at the time when *Oreohelix subrudis* was abundant there.

A fauna comprising only a few species has been found in colluvium in an area of calcareous bedrock in the northwestern foothills of Cooke Peak (the main peak is of igneous rocks), at the ghost town of Cooke's (or Cook's). These include *Helicodiscus eigenmanni*, *Glyphyalinia indentata*, *Ashmunella macromphala*, and *Oreohelix florida*.

Calcareous rocks occur in the Florida Mountains, from Baldy Peak in the central part of the range, southward. In this area, a few fossils of *Oreohelix florida* have been found in slope colluvium. More productive of fossils have been sediments in a cave located on the northwestern side of Baldy Peak, which has been excavated by A. H. Harris, R. A. Smartt, and R. D. Worthington. The fossils they took from the cave deposits are listed on the left, below. For comparison, living species from the Florida Mountains, reported by Pilsbry (1915) and collected by me in the 1970s, are indicated to the right:

Cave Deposits	**Living**
Vallonia gracilicosta	*Gastrocopta ashmuni*
Vallonia perspectiva	*Gastrocopta pilsbryana*
Helicodiscus eigenmanni	*Gastrocopta pellucida*
Discus whitneyi	*Vallonia perspectiva*
Hawaiia minuscula	*Hawaiia minuscula*
Oreohelix florida	*Glyphyalinia indentata*
Sonorella hachitana flora	*Ashmunella walkeri*
	Thysanophora hornii
	Sonorella hachitana flora

Vallonia gracilicosta and *Discus whitneyi* seem to be extinct in the Florida Mountains and other southwesternmost mountains of New Mexico, although *Vallonia sonorana* of Big Hatchet Peak actually may be conspecific with *V. gracilicosta* or be descended from it. To my knowledge, no one has taken living shells of *Oreohelix florida* from the range, and it may well be extinct there.

Fossils of *Oreohelix florida* and of *Sonorella hachitana* ssp have been found south of the Florida Mountains, near Columbus in the Tres Hermanas Mountains. Living specimens of the latter species recently (1992) have been discovered in the range by Richard D. Worthington.

No living species of land snails were found west of the Tres Hermanas Mountains in the Sierra Rica (a low, arid range along the U.S.-Mexican boundary). However, fossils of *Oreohelix florida* occur in hillslope colluvial deposits, apparently living there at a time when even these arid hills were wooded to some extent.

Still farther southwest, distinctive fossil and living faunas have been found in the Big Hatchet Mountains and in calcareous outlying mountains to their northwest and south. The Big Hatchet Mountains are dominated by Big Hatchet Peak (=Hacheta Grande), which reaches 2,550 m (8,366 ft) in elevation. They retain a fauna of a somewhat relict nature, which includes a number of species that have become extinct in nearby, lower mountains. Table 6 indicates 16 living species recorded for the Big Hatchet Mountains, several of which also have been taken as fossils in slope colluvium in the range. Howells Ridge, a northern calcareous outlier of the Little Hatchet Mountains, lies some 27 km (17 mi) to the north of the Big Hatchet Mountains. Metcalf and Smartt (1974) reported eight fossil species from cave deposits and hillslope colluvium there (Table 6). Four of these, plus one additional species, (Table 6) still inhabit Howells Ridge. This led the above authors to suggest that the present fauna was "in the process of extinction." Most of the extinct species of Howells Ridge still occur on the higher peaks of the Big Hatchet Mountains to the southeast.

Southward from Big Hatchet Peak, H. A. Pilsbry and L. E. Daniels (Pilsbry, 1915) collected on Teocalli Butte and other low, arid mountains, and I collected living specimens (Table 6) still farther south on a mountain called, herein, "U-Bar Cave Mountain." The mountain is located west of the northern end of the (igneous) Alamo Hueco Mountains in secs. 25, 26, 35, and 36, T 32 S, R 16 W. This name is applied informally here in reference to U-Bar Cave, located in the southwestern part of the mountain. U-Bar Cave lies at an elevation of 1,570 m (5,150 ft) in an area of massive Cretaceous limestone. Over a period of several years, Arthur H. Harris and associates have excavated vertebrate and molluscan fossils from guano-rich deposits in U-Bar Cave. The cave and its vertebrate fauna have been discussed by Harris (1985, 1987).

Table 6 shows that the fossil land-snail fauna of late Pleistocene age from U-Bar Cave is considerably richer (12 species) than the living fauna taken on U-Bar Cave Mountain (five species). The fossil fauna resembles the living fauna of the Big Hatchet Mountains to the north, with nine species in common. Thus, the U-Bar Cave fossil fauna shows evidence of life-zone depression when compared to the Big Hatchet Peak fauna of today. In general, the area and fauna treated here seem to provide a simplified example of the effect of Pleistocene life-zone depressions on montane land snails. Presumably, Big Hatchet Peak acts and acted as a refugium during interglaciations, and provided propagules for dispersal to nearby, lower mountains during glacial-equivalent times.

Radiocentrum ferrissi seems to be an especially good example of a Big Hatchet Mountains relict, as it formerly occurred not only on Howells Ridge and on U-Bar Cave Mountain, but also in the Franklin Mountains of El Paso Co., Texas.

The U-Bar Cave fossil fauna is noteworthy for the large numbers of specimens of *Thysanophora hornii* recovered (Table 6). This is a species of the Lower and Upper Sonoran Life Zones.

Table 6. Records of Quaternary fossil and living land snails from the Hatchet Mountains area, southwestern New Mexico. Under the heading "U-Bar Cave Mt." are shown total numbers of fossils recovered from sediments in U-Bar Cave by A. H. Harris and living species taken in talus at a locality ca. 2 miles north of U-Bar Cave on the north side of the same mountain. Under the heading "Big Hatchet Mts." are listed species taken as fossils in colluvium on the east side of Big Hatchet Mountain, and living species reported by Pilsbry (1915) and collected by Smartt and Metcalf in the 1980s. Under the heading "Howells Ridge" (located in the Little Hatchet Mountains), are listed species of fossils taken from slope colluvium and from Howells Ridge Cave and living species collected on Howells Ridge.

	U-Bar Cave Mt.		Big Hatchet Mts.		Howells Ridge	
Species	Fossil	Living	Fossil	Living	Fossil	Living
Cionella lubrica				X		
Pupilla sonorana				X		
Gastrocopta pilsbryana				X		
Gastrocopta ashmuni	10	X		X		
Gastrocopta pellucida	27	X		X		X
Vallonia perspectiva	2			X		
Vallonia sonorana				X		
Holospira crossei	40	X	X	X		
Holospira metcalfi					X	X
Rabdotus durangoanus	1				X	X
Helicodiscus singleyanus	321					X
Radiocentrum ferrissi	67		X	X	X	
Radiocentrum hachetanum			X	X		
Succineidae	47				X	
Glyphyalinia indentata	1		X	X	X	
Hawaiia minuscula	1		X	X		
Ashmunella mearnsii	60	X	X	X	X	
Ashmunella hebardi				X		
Thysanophora hornii	1450	X		X	X	X
Sonorella hachitana				X	X	

Northern New Mexico

As demonstrated above, montane sites yielding Quaternary fossil land snails are relatively widespread in southern New Mexico. However, some montane and some cave deposits in the northern part of the state also have yielded such fossils. In the earliest 1900s, T.D.A. and Wilmate Porter Cockerell collected fossil shells along Pecos Canyon north of the village of Pecos on the Valley Ranch (=Alexander Vallé Grant). From these beds, Cockerell (1903) described *Ashmunella thomsoniana pecosensis* and (1905) *Oreohelix yavapai compactula* and reported (1903) *Oreohelix strigosa* and *Vallonia cyclophorella*. I have collected the following species in cuts along New Mexico Highway 63, opposite the entrance to the Benedictine Monastery, ca. 0.8 km (0.5 mi) north of the Pecos River Bridge on the Vallé Grant: *Pupilla* sp., *Vallonia cyclophorella*, *Discus whitneyi*, *Euconulus fulvus*, *Glyphyalinia indentata*, *Zonitoides arboreus*, *Ashmunella thomsoniana* and *Oreohelix strigosa depressa*. In Gallinas Canyon, San Miguel Co., Pleistocene sediments exposed in road cuts along New Mexico Highway 65 between Montezuma and El Porvenir have yielded the following species (number of localities indicated in parentheses): *Pupilla blandi* (1), *Pupilla muscorum* (1), *Vallonia cyclophorella* (3), *Vallonia gracilicosta* (1), *Discus shimekii* (3), succineids (1), *Hawaiia minuscula* (1), *Ashmunella thomsoniana* (3), and *Oreohelix neomexicana* (3).

The Nacimiento Mountains in Sandoval Co. have areas of calcareous bedrock. Colluvial and alluvial deposits in this range have provided specimens of several species. Alluvial deposits along the Rio Guadalupe Canyon 1 km (0.62 mi) north of Gilman, Sandoval Co., yielded the following species (number of specimens indicated in parentheses):

Cionella lubrica	(5)	*Vallonia gracilicosta*	(2)
Pupoides albilabris	(20)	*Vallonia cyclophorella*	(3)
Gastrocopta armifera	(8)	*Oreohelix strigosa depressa*	(2)
Gastrocopta cristata	(9)	Succineids	(8)
Gastrocopta pellucida	(1)	*Euconulus fulvus*	(2)
Vallonia parvula	(10)	*Nesovitrea hammonis*	(1)
Zonitoides arboreus	(3)		

The "Gilman" fauna comprises a mixture of species not usually found together in modern faunas. Living *Gastrocopta armifera* and *Vallonia parvula* occur as far west as the eastern foothills of the Sangre de Cristo Mountains, and *G. armifera* in the upper Pecos Valley. The Gilman fauna indicates that they formerly occurred farther to the west. At present, *Pupoides albilabris*, *Gastrocopta cristata*, and *Gastrocopta pellucida* would be expected at lower elevations, where they may occur in riparian floodplain habitats. They would not be expected to occur with such presently montane species as *Vallonia cyclophorella*, *Euconulus fulvus*, and *Nesovitrea hammonis electrina*. The Gilman Pleistocene site probably comprised a well-watered floodplain, perhaps with both wooded and grassy habitats, and attractive to species now found at both higher and lower elevations.

Exposures located ca. 4 km (2.5 mi) NNW up the Rio Guadalupe Canyon from Gilman, northwest and southeast of the mouth of Deer Creek Canyon, seem to consist of mixed alluvial and colluvial sediments. From these were collected *Vallonia cyclophorella*, succineids, *Nesovitrea hammonis electrina*, and *Oreohelix strigosa depressa*.

Recently, a fossil fauna, dated at being close to the Pleistocene-Holocene boundary has been found in sediments along the Arroyo del Coyote at the base of the Manzanito Mountains, Bernalillo Co. (courtesy of Thomas E. Williamson and Richard A. Smartt). The fauna includes shells of *Pisidium* (fingernail clams) and aquatic snails of several species. With these occur the following land snails: *Carychium exiguum*, *Pupoides hordaceus*, *Gastrocopta armifera*, *Gastrocopta pentodon* form *tappaniana*, *Vallonia cyclophorella*, *Helicodiscus eigenmanni*, *Discus shimekii*, *Euconulus fulvus*, *Oxyloma* cf. *retusum*, succineids, *Nesovitrea hammonis electrina*, *Hawaiia minuscula*, and *Zonitoides arboreus*. As with the Gilman fauna, the presence here of *Gastrocopta armifera* indicates a past extension of range west of its present-known confines in northern New Mexico. Overall, the fauna suggests presence of some kind of aquatic habitat such as marshes or beaver ponds.

Smartt and Hafner (1989) reported a microfauna of fossil terrestrial snails and associated microtine rodents from sediments in Whut Cave on the Mesa del Oro, Cibola Co., southwest of Albuquerque. Snails were much more common in sediments at lower levels, which was interpreted as indicative of a cool, mesic environment. Snails became rarer, upward, during what was considered to involve a shift to drier (although still cool) conditions. Species taken included *Gastrocopta pilsbryana* (only at one level), *Pupilla blandi* and *Vallonia gracilicosta* (concentrated at the lower levels), and the following, which occurred at numerous levels: *Pupilla muscorum*, *Pupoides hordaceus*, *Succinea* sp., *Vallonia cyclophorella*, and *Zonitoides arboreus*. With the possible exception of the succineid, none of the species is known from the immediate area of Whut Cave today.

DISCUSSION

Much of New Mexico and the lands to its west have been a part of the Cordilleran region of North America since far back into the Mesozoic. As such, geologic history of the region has been shaped largely by the activities and migrations of the successive magmatic arcs associated with the Cordillera. These conditions are reflected in physiography and climate and, ultimately, in biotas.

The presence of: (1) Cordilleran highlands related to magmatic-arc tectonics and (2) the proximity of warm seas surely played major roles in development of biotas of the mid-to-late Mesozoic. Mountain building, related to the Jurassic magmatic arc, was occurring at least as close to New Mexico as southwestern Arizona and, from there, southeastward into México. Caldera and lava deposits show that volcanic mountains of considerable heights existed in several areas in southeastern Arizona during the mid-to-late Jurassic. In the Cretaceous, other highlands, such as a rift shoulder and the Mogollon Highlands, have been described as existing in southwestern New Mexico and southeastern Arizona. In regard to seas, it is probably biogeographically significant that, during the later Mesozoic, the area of México was greatly reduced, eastward and southward, with its southern shores bathed by the circumglobal Tethyan-Panamanian Sea. México comprised, in the paleogeographic models of Enos (1983:Figs. 5 and 6), a northern peninsula of varying size, temporally, and a southern archipelago with large islands. Thus, in the late Mesozoic, northern México and the border region of Arizona and southwestern New Mexico seem to have formed a southward extension of the western North American continent. This mountainous extension was surrounded by seas to the east, south, and west.

In this southern extension of the continent, mountains and adjacent warm seas presumably produced tropical lowlands and lushly vegetated highlands, perhaps analogous to present Central America. As the southernmost and most tropical part of western North America of the time, and with a varied topography that would have encouraged endemism and speciation, this extension probably supported a rich and varied land-snail fauna and may have been a center in which some taxa evolved and from which some may have dispersed northward towards the continental interior of western North America.

The sea became especially significant in the Cretaceous. First, an arm extended northward along the Chihuahua Trough into southwestern New Mexico and southeastern Arizona, where it seems to have been flanked by block-faulted highlands of a rift shoulder to the north. (Such a mountainous shoreline could have produced early resort-property possibilities in the Deming Plains area!) Later, this restricted southern sea merged into the Cretaceous epeiric sea, which covered New Mexico. Its transgressions and regressions, interacting with mountains along its western shores, must have produced a dynamic, changing physiography with islands and peninsulas appearing and disappearing. Such conditions probably enhanced development of faunas adapted to environments ranging from coastal lowlands to adjacent highlands with tropical vegetation. Present eastern México, from the Gulf of Mexico to the Sierra Madre Oriental, provides a likely modern analog. As in that part of México, today, an annual dry season may have prevailed, causing land snails to undergo dry-season dormancy.

With the oscillating final recession of the epeiric sea, the western part of New Mexico was uncovered first, so it seems reasonable to suppose that the first and major colonists to move into the *tabula rasa* that was produced came from the west. Although relatively narrow, Cordilleran North America west of the epeiric sea was a region of varied physiography, which related to continued magmatic-arc activities. This was presumably also evidenced in varied climatic conditions and in the environments of biotas. In the coastal states and provinces and in the fold-thrust belt west of the epeiric sea, mountains seem likely to have provided long narrow pathways offering travel opportunities northward and southward from the southernmost extension, noted above, to Alaska and, presumably at times, beyond to northeastern Asia. All of this suggests a fertile mix of land-snail groups comprising an ancient Cordilleran fauna, during the latest Cretaceous and earliest Tertiary, from which were drawn western propagules spreading into New Mexico.

After recession of the epeiric sea and imposition of any vicissitudes caused by a terminal Cretaceous event or events, there may have survived a relatively uniform "ancient Cordilleran fauna" in western North America. As discussed above, fossil records of the Paleocene and Eocene show families such as the Helicinidae, Urocoptidae, Bulimulidae, Camaenidae, and Humboldtianidae and the genera *Ashmunella* and *Radiocentrum* existing much farther north than they do at present (Wyoming and beyond) in the Rocky Mountains region. It seems likely that a fauna ranging from tropical to subtropical affinity existed in the Cordilleran region of the United States (especially at lower elevations) during the Paleocene and most of the Eocene. Probably, diversity would have been greater towards the more tropical south if present patterns prevailed in which there is greater biodiversity towards the tropics.

During the remainder of the Tertiary, these halcyon conditions more or less steadily deteriorated, north to south, so that groups requiring warmer conditions were progressively eliminated in a north-to-south pattern. Climatic change in the region may have been caused by various factors, but it seems that increased regional elevation, evidenced already in the late Eocene, as at Florissant, Colorado, probably played a major role.

As summarized by Lucas (1983:187), "The Eocene-Oligocene transition in New Mexico was a time of significant change in magmatism and sedimentation throughout the state." Between late Eocene and late Miocene time, the mountainous aspect of New Mexico was accentuated as a result of widespread volcanism, regional uplift, and earlier phases of Basin and Range-like extensional activity. Paleobotanical evidence indicates a related climatic cooling with a long-term pattern of decrease in tropical and subtropical floral elements, and an increase in plants adapted to cooler and more xeric conditions. There is evidence also of the existence of high-elevation montane forests of modern aspect in New Mexico. It is likely that a similar situation prevailed in regard to land snails with, as suggested above, the more tropical species that were still present in the Eocene becoming increasingly extirpated as a wave or waves of extinction involving ancient Cordilleran taxa progressed in the region, north to south. Urocoptids, bulimulids, and *Radiocentrum*, which formerly had ranged much farther north, must have succumbed gradually, north to south. Evanoff et al. (1992) recorded *Ashmunella* and the humboldtianid genus *Skinnerelix* (of Evanoff and Roth, 1992) as occurring as far north as Wyoming in the late Eocene (Chadronian), indicating that *Ashmunella* and the Humboldtianidae, also, have undergone a pattern of progressive extirpation, north to south. In the Miocene Jacona fauna of northern New Mexico, none of the more tropical indicators is present.

In New Mexico, at present, several genera of larger snails deemed "ancient Cordilleran" reach their northernmost limits. These limits might be considered lines of retrenchment southward. Such groups include *Humboldtiana* and *Radiocentrum*, relegated only to the extreme southern part of the state; urocoptids and bulimulids, which are holding out in the southern one-third of the state; and *Ashmunella*, which still occurs in the southern three-fourths. These groups have been considered mainly as defining a Southwestern Molluscan Province, which is reasonable and practical. However, as employed here, another way of characterizing these taxa might be in emphasizing that they are ancient Cordilleran groups, still lingering in what may be the southern part (and quite possibly the original part) of their former domain--hence, "southwestern" by virtue of shrinkage of their range. Hochberg et al. (1987) traced a distributional restriction southward of *Radiocentrum* since the Paleocene, and suggested a similar pattern for the Urocoptidae. Probably, extirpation of an "ancient Cordilleran fauna" southward was more marked in inland areas (Montana, Wyoming, etc.) than in the coastal regions, where descendants of an ancient Cordilleran fauna might still be considered predominant.

There seems to have been a trickle of dispersalists, almost all of smaller land-snail species, which entered the northern Cordillera from Eurasia, perhaps even as representatives of the Cordilleran fauna were being decimated in the north, and perhaps in response to the same conditions. That is to say that cooling to the north could have produced conditions inimical to Cordilleran species, but inviting to some Palearctic immigrants. Such invasions probably occurred at various times during the Cenozoic, just as they did in the better-documented cases of woody plants and vertebrates. Some taxa probably entered the northern Cordillera from Eurasia during times when Asiamerican Miocene mesophytic forests existed in the far north. Others, which still are conspecific with Palearctic taxa, probably arrived during times of Pleistocene accessibility, as in the case of some species of fish and mammals. Pilsbry (1948:XLII) and Bequaert and Miller (1973:64-74) have listed a number of species with Holarctic distributions, most of which seem to be of Palearctic origin.

With desiccation of the Cretaceous epeiric sea, access to the area that it had covered was opened to the fauna of adjacent eastern North America. However, the Great Plains, occupying much of the same region as had the epeiric sea, no doubt continued to act as a barrier of sorts between eastern and western faunas. This was suggested also by Henderson (1931:186), who supposed that "the present unfavorable conditions in a broad area east of the Rocky Mountains, which now prevent the mingling of the faunas, have existed with but little change since Eocene time." There is little evidence that elements of an ancient Cordilleran fauna were inclined to venture eastward onto the plains, except for an invasion of

Oreohelix eastward into Iowa during the Pleistocene (Henderson, 1931:184; Pilsbry, 1948:XLV).

There were apparently some groups formerly of broader east-west distribution, which did not survive in the Cordilleran region. Roth and Emberton (1994) discussed the occurrence of the genera *Hendersonia* and *Euchemotrema*, in Arikareean beds (Oligocene-Miocene) in Montana. These genera presently occur in the eastern United States, and were interpreted by these authors (p. 93) as having been "displaced eastward off the North American cordillera." As in the case of Palearctic immigrants, the eastern North American land snails that do seem to have dispersed into the post-Cretaceous Cordillera were mainly small species, especially towards the south (apparently less so in the northern plains). This suggests that snails that are relatively small throughout life are more easily dispersed than those that reach relatively larger sizes. This phenomenon also was pointed out by Henderson (1931:180), who noted that smaller snails are "easily transported in various ways" and tend to be of "wide geographical distribution." Bequaert and Miller (1973:47-48) also discussed the more widespread distribution and less tendency towards endemism in smaller species as contrasted to larger species in the Southwest. They suggested that strong winds of the southwestern region might be involved in aerial transport of small snails. They also suggested that dispersal might take place by floods or by avian transport. In aquatic and paludal species, it seems likely that transport by aquatic birds does, indeed, play a role in dispersal.

In the region comprised by the present Rocky Mountains, most elements of an earlier Cordilleran fauna no longer occur. Cordilleran elements may include the genera *Microphysula* and some species of *Discus*, but are represented mainly by the "mountain snails" of the genus *Oreohelix*. It seems likely that this live-bearing genus evolved in the northern Cordillera, perhaps from an earlier, oviparous oreohelicid stock like *Radiocentrum*. Perhaps its ovoviviparity parallels that of other high-latitude poikilotherms, as in some species of *Natrix*, *Thamnophis*, and *Lacerta*.

During at least the last glaciation-equivalent time of the Pleistocene, it seems that there was an incursion southward into southern New Mexico of a "Rocky Mountain fauna," including some Cordilleran elements, but much enriched by Palearctic and eastern North American derivatives. *Oreohelix* seems to have thrived in mountains across Cordilleran New Mexico during the time of the Wisconsin glaciation (and probably other glaciations), occurring to the southernmost mountains such as the Guadalupe, Franklin, and Sierra Rica ranges. In the Black Range and Sacramento Mountains, *Oreohelix* underwent radiations, still exemplified by living species in the former and by fossil taxa of the *O. oterana* complex in the latter. The extension of *Oreohelix* southward, apparently during times of glaciation-related cooling, seems to have its reciprocal in the pattern of extinction of the genus in southern New Mexico during the warmer time of the Holocene. Similarly, Pleistocene and Holocene evidence amply demonstrates that a number of other, presently montane species extended their ranges farther south and to lower elevations during times of Pleistocene glaciation, and subsequently suffered extinction there. These were mostly smaller species, many of which were probably ultimately Palearctic or eastern North American elements of the Rocky Mountain fauna. Save for a few exceptions, such as the occurrence of an *Ashmunella* and *Rabdotus* in sediments of the Tortugas alluvium of the Rio Grande Rift Valley, the ancient Cordilleran elements seem to have retained their proclivity to be just that: Cordilleran.

The Quaternary fauna of the eastern High Plains of New Mexico, traditionally assigned to the Eastern Molluscan Division, is considered here to be of mixed origin. During times of Pleistocene glaciations, it seems to have been inhabited mainly by derivatives from the more modern (*not* ancient) Rocky Mountain fauna, which was, itself, of mixed origin, as suggested above. At the present time, only the hardiest, remnant species of the Pleistocene fauna persevere on the eastern plains of New Mexico. Some of these probably can be considered *bona-fide* eastern derivatives that did pioneer westward onto the plains. However, at present the fauna, overall, is so depauperate as to impart few intimations of zoogeographic significance.

Molluscan Provinces Redux

> In the absence of insuperable faunal barriers, any attempt to establish zoological provinces very rigidly must fail.--Junius Henderson (1928:88).

In light of the preceding discussion, it may be appropriate to reexamine the allocation of New Mexico to various molluscan zoogeographic provinces. Of course, in terms of the long-term historical point of view emphasized herein, this is only an ephemeral situation. From a short-term historical point of view, the very exercise of proposing zoogeographic provinces is mainly associated with traditional zoogeography of the past and seems to be of scant consequence at the present time. Despite such reservations, a short analysis may be justifiable.

As noted earlier, Bequaert and Miller (1973) had placed much of New Mexico in a Southwestern Molluscan Province (see Fig. 1C), except for a small north-central to northeastern area that was allocated to a Rocky Mountain Molluscan Province, and approximately the eastern one-third of the state, which was placed in an "Eastern Division."

The Southwestern Molluscan Province was viewed by Henderson (1928, 1931) and Bequaert and Miller (1973) as being defined primarily by presence of the genera *Holospira* s.l., *Ashmunella*, *Oreohelix* (then including *Radiocentrum*), and *Sonorella*. Bequaert and Miller also included, as distinguishing genera, *Chaenaxis* and *Eremarionta* in the western and *Humboldtiana* in the eastern part of the Province.

Holospira s.l., *Ashmunella*, *Radiocentrum*, and *Humboldtiana* have been characterized, herein, as components of an ancient Cordilleran fauna, formerly more widespread towards the north, and now restricted to the southern part of their former range. This southern part includes much of the area mapped by Bequaert and Miller (1973:Fig. 1--see Fig. 1C, herein) as pertaining to the Southwestern Molluscan Province. These genera are lacking, however, in almost all of the Colorado Plateau, including that portion of it in northwestern New Mexico and in Arizona northeast of the Little Colorado River. With strict adherence to the presence of the above distinguishing genera as defining the Southwestern Province, these areas would not be

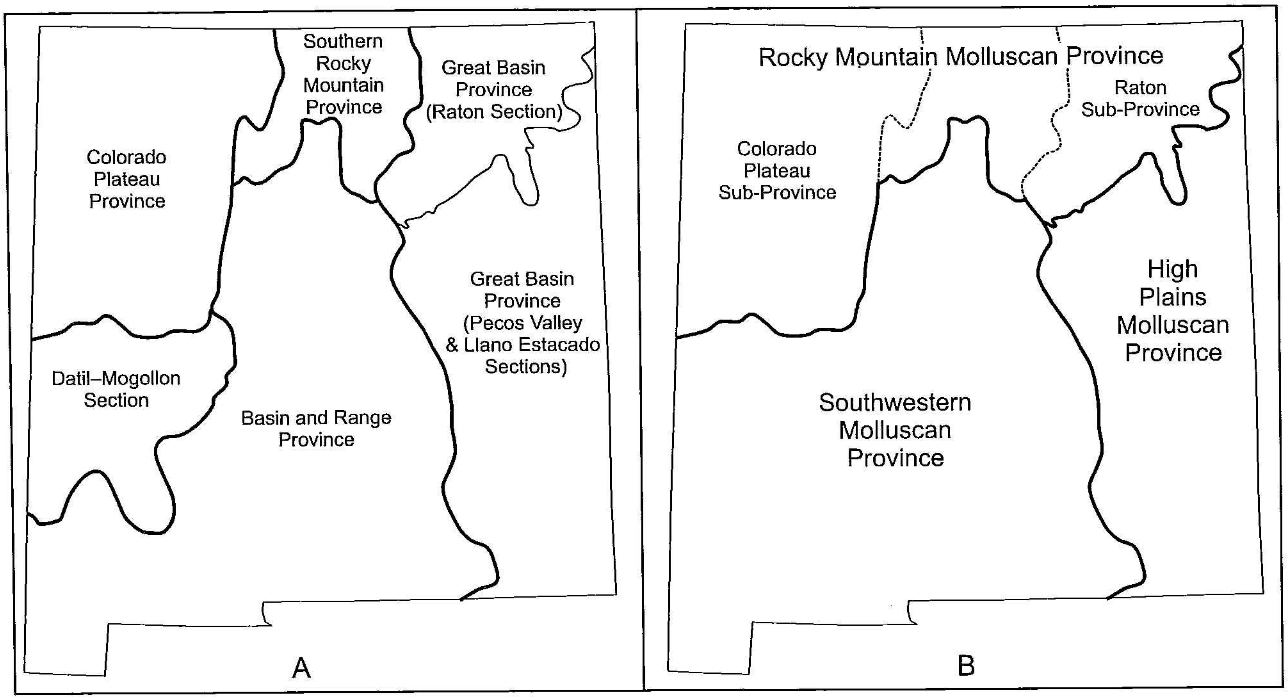

Figure 2.A, Physiographic provinces, sections, and subsections in New Mexico proposed by John W. Hawley (1986: p. 24; by permission of the University of New Mexico Press). B, Molluscan provinces and subprovinces in New Mexico proposed herein. Boundaries of some of Hawley's provinces, etc., (left) are employed, and scale is the same.

included in the Province. They would, however, conform well with the Rocky Mountain Molluscan Province, as they encompass populations of *Oreohelix* (not including *Radiocentrum*), the definitive large land-snail genus of the Rocky Mountain Province. The Rocky Mountain Province is vast, as mapped by Henderson (1931:Fig. 1--see Fig. 1A, herein) and defined by Bequaert and Miller (1973:7). It could well be divided into subprovinces, in which case a Colorado Plateau subprovince might comprise a natural division. The New Mexico part of the Colorado Plateau is so mapped here in Fig. 2B. The fauna of this subprovince in New Mexico is depauperate in comparison with that of the Southwestern Molluscan Province, as mapped to the east and south. These and other molluscan provinces in New Mexico show a close correspondence to some of the physiographic provinces and sections mapped for New Mexico by Hawley (1986:24), indicated in Fig. 2A. In Fig. 2B, a Colorado Plateau Subprovince has been drawn using boundaries of Hawley's Colorado Plateau Physiographic Province, and the Southwestern Molluscan Province has been drawn after his combined Basin and Range Province and Datil-Mogollon Section. The Rocky Mountain Molluscan Province, proper, uses the boundaries of Hawley's Southern Rocky Mountain Physiographic Province in New Mexico.

The problem of how to treat the faunally depauperate northwestern part of New Mexico is echoed in turning to the eastern one-third of the state, which also has a depauperate land-snail fauna. In addition, it has a complex interrelationship with the Rocky Mountain Molluscan Province. This area in eastern New Mexico was allocated simply to an "Eastern Division" by Henderson (1931:Fig. 1), a division comprising a vast region extending from the Atlantic Coast to the Rocky Mountains. This allocation might be justifiable if the western part of the region were thought of as being simply a zone in which the Eastern Division fauna becomes progressively depauperate westward. However, as discussed above, the Pleistocene history of the fauna of the High Plains indicates more complexity than a simple east-west gradient. Derivation of the Pleistocene High Plains molluscan fauna from western, northern, and eastern sources was suggested by Wells and Stewart (1987), and influences from these directions were discussed, above, in terms of an arch configuration, with the top of the arch pointed north.

Bequaert and Miller (1973:9) briefly discussed a High Plains molluscan fauna, noting that a region occupied by such a fauna would approximate that comprised in the Kansan Biotic Province of Dice (1943:26). In New Mexico, the area in question approximates a part of the area mapped by Hawley (1986:24) as pertaining to the Great Plains Physiographic Province. Herein, a High Plains Molluscan Province is indicated in Fig. 2B, using the boundaries employed by Hawley (1986:24) for the Pecos Valley and Llano Estacado Sections of his Great Plains Physiographic Province.

In terms of both physiography and molluscan faunas, the northern part of the High Plains region in New Mexico is problematic, because of the presence of isolated volcanic mountains and the extension of basalt-capped mesas along the New Mexico-Colorado border from the southern Rocky Mountains eastward to the northwest corner of the Oklahoma Panhandle. Physiographically, this has been dealt with by Hawley (1986:24) by assigning this area to a Raton Section of the Great Plains Province. The question arises as to whether, in terms of molluscan provinces, the area of the Raton Physiographic Section would be assigned better to the Rocky Mountain or to the High Plains Molluscan Province. A number of montane snails, typical of the southern Rocky Mountains, occur at higher elevations in the area. However, broad areas of plains, with a depauperate fauna, also occur in the section. Clearly, the area is perplexingly transitional. In an attempt to be consistent, I use an approach similar to that employed, above, for northwestern New Mexico. Accordingly, this area is indicated in Fig. 2B as being within a Raton Subprovince of the Rocky Mountain Molluscan Province. At this point, the epigraph at the beginning of this section may bear rereading.

SUMMARY

Presumably, as indicated by its very name, the Cordilleran region of western North America, to some extent has been mountainous from its beginnings. Successive magmatic arcs and plate interactions have produced various types of mountains during the later Mesozoic and Cenozoic. It seems likely that the Cordillera, with its generally mountainous environment and with its north-south oriented mountain ranges, would have encouraged development of a biota with much in common along its length. Such commonality likely was not shared with the less mountainous lands to the east. Differences between the two regions were, no doubt, accentuated by vicariating interposition of the Late Cretaceous epeiric sea, and of the Great Plains, which later came to occupy the eastern part of the area covered by the sea. Thus, paleogeography and environment probably contributed to development of a distinctive Cordilleran land-snail fauna, termed here the "ancient Cordilleran fauna." No doubt, earlier continental connections, and perhaps accreting terranes, may have had some bearing on this fauna. However, given some initial stocks to work with, a sizable continent with its southern regions in a tropical zone should be quite capable of developing a respectable land-snail fauna on its own.

Therefore, it is suggested that in the later Mesozoic the southernmost extension of western North America was a tropical, mountainous land bounded by warm seas, harboring a probably rich and diverse land-snail fauna. Unfortunately, fossils that would bear out this hypothesis are lacking for that region and time. Instead, in the Cordillera, the earliest fossils are far to the north--in the northern United States and southern Canada. Given the general tropical aspect of late Mesozoic and early Tertiary biotas even that far north, it seems likely that these more northern snails were outlying members of families that also occurred to the south, as in New Mexico and México. Fossils from New Mexico of Paleocene and Eocene age show similarity to these northern faunas. A widespread tropical-to-subtropical biota is still evidenced in the Eocene as far north as Wyoming. Subsequently, climatic cooling and increased aridity, beginning at around a "terminal Eocene Event," gradually decimated elements of the ancient Cordilleran fauna, north to south, in the continental interior, so that most of these elements are now restricted to New Mexico, Arizona, and regions to the south. On the other hand, a moderating maritime climate of the Pacific coastal region has allowed a fauna with more of an ancient Cordilleran aspect to persist there, from California to Canada.

As the ancient Cordilleran fauna of the interior region shrank southward, it seems to have been replaced by snails, mostly small and mostly of Palearctic or eastern North American origin, whose descendants came to make up a large proportion of the fauna of the Rocky Mountain Molluscan Province. These more northern species were well adapted to disperse to lower latitudes and lower elevations in the southwestern states during times equivalent to Pleistocene glaciations, as is amply demonstrated in the late Pleistocene record in New Mexico.

The present fauna of New Mexico seems categorizable into two principal assemblages. The ancient Cordilleran fauna still survives in mountainous areas mainly in the southern part of the state, and its species have been used traditionally to define a Southwestern Molluscan Province. Replacing this venerable Cordilleran fauna from the north are species typical of the Rocky Mountain Molluscan Province. Elements pertaining to these two categories often occur together, especially in higher mountains of the southern part of the state, in such a way as to make the defining of molluscan province boundaries a difficult and perhaps unprofitable exercise, although attempted.

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ALTITUDINAL DISTRIBUTION OF LAND SNAILS IN SOME MONTANE CANYONS IN NEW MEXICO

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ABSTRACT: Land snails were collected along transects in six canyons in New Mexico mountains. Four west-descending canyons of Whitewater Baldy, Sierra Blanca, Lake Peak, and Mount Taylor were in areas of igneous bedrock. Two transects along Tularosa and Peñasco Canyons in the Sacramento Mountains were in areas of sedimentary bedrock. Altitudinal zones were categorized in terms of the traditional Merriam-Bailey Life Zone schema for the Southwest. All transects extended from Canadian, through Transition, to the Upper Sonoran Zones, and three ascended into the Hudsonian Zone. In all transects, the greatest numbers of species and specimens were found from about mid-Transition to mid-to-upper Canadian Zones, from ca. 2,286 m (7,500 ft) to 3,048 m (10,000 ft). Both diversity and density decreased, progressively, at elevations lower and higher than the above. Species tolerant of harsh conditions of higher elevations extended into the Hudsonian Zone, but there were no species that were restricted to highest elevations. Along canyons species descended to lower elevations than they did in inter-canyon areas--the degree depended on variables such as configuration of canyons and the extent to which tongues of mesic, riparian vegetation extended to lower elevations. A "riparian depression" was especially evident along Whitewater Canyon, below Whitewater Baldy. Although shorter, altitudinally, the two transects (together) of the Sacramento Mountains yielded more species (35) than the longer transect along Three Rivers Canyon (26) in the adjacent Sierra Blanca Mountains. It is likely that the widespread occurrence of calcareous bedrock in the Sacramento Mountains contributes to this difference.

INTRODUCTION

Elevation is clearly a factor of environmental importance to the biotas of mountains. Elevation impinges upon a large number of intricately interrelated ecological factors, physical and biotic. In New Mexico's mountains, elevation is related to physical factors such as temperature, precipitation, evaporation, insolation, wind, and air pressure. The physical factors, in turn, relate to geologic aspects such as physiography, slope inclination and aspect, weathering of bedrock, soil erosion, and soil chemistry. All of these are variously interrelated with the biotic factors of the niches of the land snails that are considered here. The biotic factors include vegetation (both living and occurring as leaf litter); microbes and fungi of soil and leaf litter; and animals acting as parasites, predators, or competitors, and in conspecific roles.

Analyzed more closely, "elevation," in its own right, is less an ecological factor than a rough, but useful, index of a complex of factors that can be expected to operate predictably. The greater this predictability, the greater the usefulness of the term "elevation." Its usefulness is similar to that provided by geographic locations, i.e., relation to longitude and latitude. However, the effects of elevation on biotas may be evidenced over much shorter distances than those of longitude and latitude, and this is especially the case in mountains. In a mountainous region such as New Mexico, it seems useful, then, to examine how land snails are related to elevation.

In some studies, an attempt has been made to identify and analyze ecological factors related to elevation, such as those noted above, and which pertain to altitudinal distribution of land snails. Grime and Blythe (1969) suggested that microclimatic differences were responsible for distributions of two species of snails living on opposing slopes of the same "pass" in Great Britain. In Sweden, Waldén (1981) found that increasing soil pH correlated closely with snail diversity, while slope aspect had a modest influence. In an intensive study in Tennessee, Coney et al. (1982) found that microhabitat differences were more important, ecologically, for more species studied, than were rock type, elevation, slope, or soil pH. Dillon (1980), working in one canyon in Arizona, used multivariate and principal component analyses in interpreting distributions of two species of land snails--this based upon the environmental variables of elevation, slope angle, slope aspect, percent of vegetational cover, and substrate type. Dillon found correlation among variables to be high, with vegetational cover accounting for most of the variability. In a study by Cameron (1986), characteristics of litter, soil, and associated vegetation explained most of the diversity observed in snail faunas of Vancouver Island, British Columbia. No doubt, such multivariate approaches will become increasingly sophisticated and useful and will receive wider application in future studies. Still, elevation per se may retain considerable utility as a general, broad index.

For the most part, it is recognized that land snails inhabiting the southern Rocky Mountains and the Basin and Range

Province in New Mexico exhibit distributional trends related to elevation. Despite this, there are few published data detailing such patterns in specific mountain ranges. Karlin (1961) made some general observations concerning altitudinal distribution in the Rocky Mountain region. Hoff (1962) collected land snails incidentally to a study of pseudoscorpions in northern and central New Mexico, noting elevations and major vegetation types of localities. Metcalf (1984) reported on the altitudinal distribution of land snails in the San Andres and Organ Mountains of south-central New Mexico.

Two groups of montane transects are summarized herein. The more extensive survey, by Dillon, was carried out along montane canyons in areas of igneous bedrock in four different areas of New Mexico. Two transects were surveyed by Metcalf along valleys with Paleozoic sedimentary bedrock in the Sacramento Mountains of south-central New Mexico.

TRANSECTS IN CANYONS WITH IGNEOUS BEDROCK

The collections analyzed in this study were made in the summer of 1986. Transects were selected with regard to their elevation (peaks higher than 10,000 ft/3,050 m), geography (spaced nearly equidistant on two north-south axes), geology (igneous bedrock), and accessibility (mostly public lands with foot trails). The localities surveyed were along generally east-west oriented canyons, which drained westward off north-south oriented mountain ranges. Localities were situated at 400-ft (122 m) increments along canyons. Because the designations in feet are in 100's, and the available topographic maps were calibrated in feet, these U.S. designations, rather than metric ones, will be used hereafter.

Sample sites were confined to areas of relatively uniform vegetation and physical features within a square 30x30 meters. Within this area, larger snails were hand-collected for 30 minutes, paying particular attention to logs, talus, and other microhabitats. Litter was collected in small amounts from areas judged to be typical of the site, to total at least 3 liters volume. This was bagged, returned to the laboratory, and allowed to air-dry. Litter was then passed through coarse and fine mesh sieves and was exhaustively hand-picked for shells, dead and living (usually dormant), under bright lights and with magnification. This method is time-consuming, but effective in revealing small specimens, and was considered to be the least biased of several methods evaluated by Waldén (1981).

For quantitative analysis, numbers of snails were standardized volumetrically in the manner of Wäreborn (1969) and Waldén (1981). Volumes of leaf litter, after drying, ranged from 1.00 to 4.00 liters with an average of 2.35 liters. As Wäreborn (1969) did, the number of snails obtained was then evaluated to correspond to 3.00 liters. Though nonrandom sampling and standardization of numbers of snails in the manner noted above must be considered as less than ideal, Waldén (1981:353) observed that "the quantitative results probably do not deviate very much from those which would have been achieved by a strictly randomized sampling . . . ."

The four transects surveyed--with the mountain ranges, highest peaks, highest elevations at which collections were made (in parentheses), and canyons involved were as follows. In the southwest: the Mogollon Mountains, Whitewater Baldy (10,800 ft), Whitewater Creek Canyon; in the southeast: the Sierra Blanca Mountains, Sierra Blanca Peak (11,880 ft), South Fork and Three Rivers Canyons; in the northeast transect: Sangre de Cristo Mountains, Lake Peak (12,000 ft), Rio en Medio Canyon;

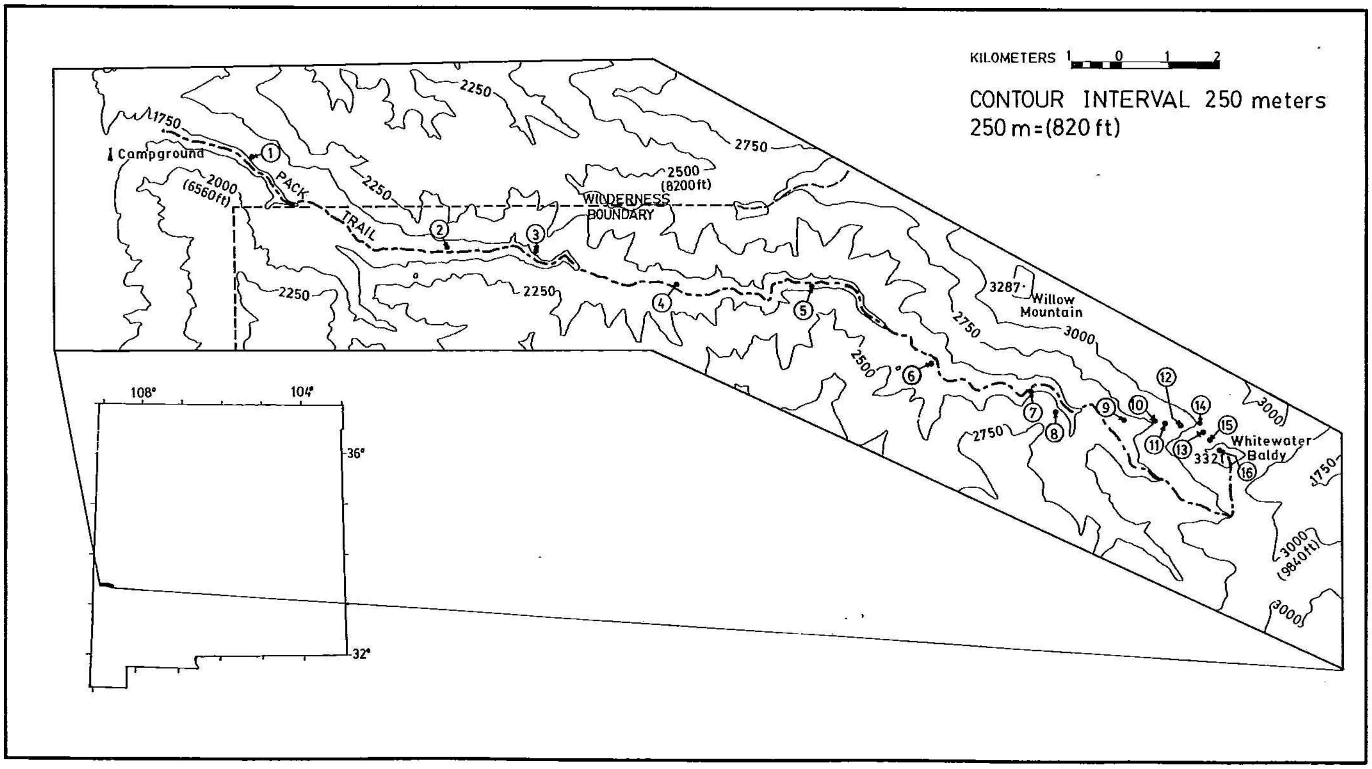

Figure 1. Topography of the Whitewater Baldy transect and locations of collecting stations WB1 to WB16.

and in the northwest: the San Mateo Mountains, Mt. Taylor (11,200 ft), Lobo Canyon. Collection localities are as indicated in Fig. 1-4, Table 1, and in more detail, in Dillon (1992). Localities are given in continuous numerical sequence for the peaks, as follows, and with letter prefixes, as indicated: WB-Whitewater Baldy Peak, SB - Sierra Blanca Peak, LP-Lake Peak, MT-Mount Taylor. Numbers are arranged lowest to highest, altitudinally, within canyons.

Whitewater Baldy Transect--The Mogollon Mountains form a northwest-southeast-trending mountain mass approximately 65 km long and 15 km wide (Ratté et al., 1979). Physiographically, these mountains are situated within the Datil-Mogollon Section, a transitional physiographic subdivision between the Basin and Range and the Colorado Plateau Provinces (Hawley, 1986). The steep southwestern face of the Mogollon Mountains is cut by deep gorges with walls 2,500-3,000-ft (ca. 700-915-m) high in places, the canyons of Whitewater Creek and Big Dry Creek being especially precipitous.

The Whitewater Baldy transect (WB), Catron Co., was accessed by Hummingbird Saddle Trail, beginning at a head on New Mexico State Road 78, about 13 km east of the town of Mogollon. Hummingbird Saddle Trail connects to the south at Whitewater Baldy Peak, elevation 10,892 ft (3,320 m), with Whitewater Creek Trail, which descends to the Catwalk Campground 10 km northeast of Glenwood, comprising, in all, a backpack trip of >26 km. The transect descends along the canyon of Whitewater Creek, which flows westerly to the San Francisco River. Fig. 1 shows the topography of the WB transect and indicates Locs. WB-1 to 16.

The rocks exposed in the WB transect are nearly all volcanics of Oligocene and Miocene age, associated with the Bursum Cauldron (Ratté et al., 1979). They are ash-flow tuffs and lava flows composed of various igneous rock types such as latites, andesites, and rhyolites.

According to Bailey (1913), the central peaks of the Mogollon Mountains, at 11,000 ft (3,353 m), are not high enough to reach true timberline or provide habitat for many Hudsonian Life Zone species. The Canadian Zone covers most of the higher ridges and peaks, forming thick forests of spruce, firs, aspen, and dense understory shrubs, which are "purely Rocky Mountain species" (Bailey, 1913:63). The Transition Zone occurs over large areas from about 6,500 ft to 8,500 ft on colder slopes and from 8,000 to 9,500 ft on warmer slopes. Upper Sonoran Life Zone tree species such as sycamore, box elder, and lance-leaf cottonwood are found along the canyon at the lower stations. Pinyon and juniper are less common along the canyon floor than along the more xeric, adjoining walls.

Sierra Blanca Peak Transect--Physiographically, the Sierra Blanca Mountains lie within the Sacramento Section of the Basin and Range Province (Hawley, 1986). Sierra Blanca Peak, 12,003 ft (3,658 m), is the highest and most salient peak in the range. The SB transect lies mostly within the boundaries of the White Mountain Wilderness, Lincoln National Forest, and mainly in Lincoln Co., but with lowermost and uppermost stations in Otero Co. Access to the lower stations is from Three Rivers Campground at the wilderness boundary and pack trailhead. Forest Trail 44 ascends to the crest trail with access to the mid and upper stations. Access to upper stations also can be reached via the Ski Apache area. The SB transect comprises approximately 20 km. Fig. 2 shows the topography of the transect and Locs. SB-17 to 37.

The rugged western escarpment of the Sierra Blanca Mountains, above the Tularosa Basin, creates about 8,400 ft (2,560 m) of relief, the greatest in New Mexico (Kelley and Thompson, 1964). Drainage for most of the transect is provided by the westerly flowing, springfed, perennial creeks of Three Rivers and South Fork Canyons, terminating in the internally drained Tularosa Basin.

The Sierra Blanca Mountains consist of a thick pile of nearly horizontal volcanic rocks of Tertiary age, which are intruded by three stocks. Localities SB-17 and 18 are situated on alluvium and fanglomerate. Localities SB-19 to 21 are on the Sierra Blanca volcanics described by Thompson (1964) as the Walker Andesite Breccia Member. Localities SM-22 through 36 are located on syenite porphyry and equigranular syenite units of the Three Rivers Stock. Finally, Loc. SB-37, on the northeast side of Sierra Blanca Peak, is on glacial deposits, chiefly till (Segerstrom et al., 1979). Freeman and Dick-Peddie (1970) reported that soils of the Sierra Blanca Mountains are low in organic material, with a low clay content, and a slightly acidic pH.

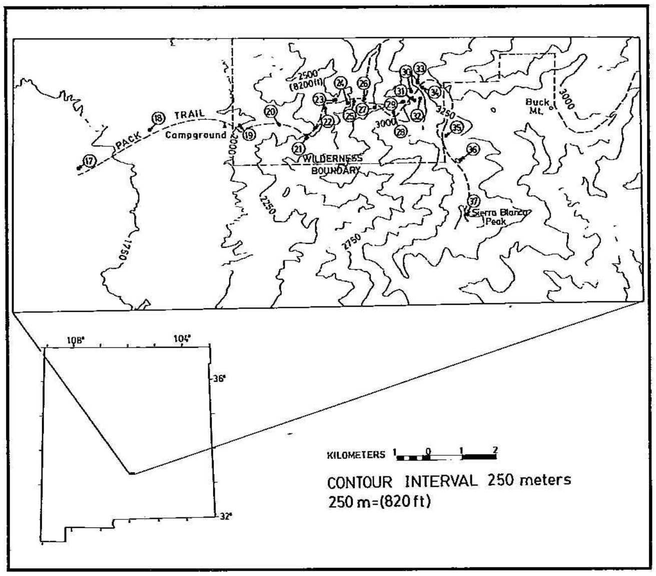

Figure 2. Topography of the Sierra Blanca transect and locations of collecting stations SB17 to SB37.

Bailey (1913) described the summit and northeast slope of Sierra Blanca Peak as being in the Hudsonian Zone, with the Canadian Zone covering most of the higher peaks. Findley et al. (1975:4) described the vegetation of uppermost Sierra Blanca Peak as "relict, depauperate Alpine meadows." Martin (1964) described four montane vegetational zones, which he termed "associations." These comprised: 1) an Alpine Association covering a small area on the summit of Sierra Blanca Peak, 2) a Spruce-Fir Association, which combined Bailey's Hudsonian and Canadian Life Zones, 3) a Transition Association characterized by ponderosa pine, and 4) a Pinyon-Juniper Association.

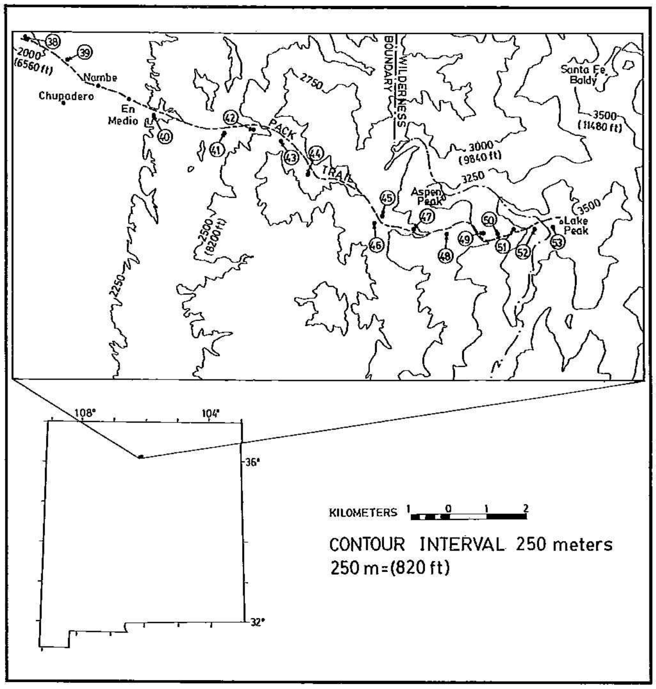

Figure 3. Topography of the Lake Peak transect and locations of collecting stations LP38 to LP53.

Lake Peak Transect--The Sangre de Cristo Mountains encompass the largest and highest montane area in New Mexico. They comprise a north-to-south oriented range, 160 km long in New Mexico, from the Colorado border to near Santa Fe. These mountains include Wheeler Peak, 13,161 ft (4,011 m), the highest point in the state, and more than a dozen peaks higher than 12,000 ft (3,658 m) (Ungnade, 1972). Several ranges comprise the Sangre de Cristo Mountains--the southernmost being the Santa Fe Range. Lake Peak, Santa Fe Baldy, and Capulin Peak, within this range, exceed 12,000 ft in elevation. This transect culminated on Lake Peak, in Santa Fe Co., which reaches an elevation of 12,409 ft (3,782 m). The Sangre de Cristo Mountains are, physiographically, within the Southern Rocky Mountain Province (Hawley, 1986).

The four lowest localities along the transect (LP-38 to 41) are reached by foot trails from the village of En Medio. Localities LP-42 to 53 are within the Santa Fe National Forest, with access via Forest Road 102 west from NM State 475 or from the Santa Fe Ski Basin by hiking trails. The distance covered by this transect exceeds 20 km. Topography of the LP transect and Locations LP-38 to 53 are shown in Fig. 3.

Igneous and metamorphic rocks of Proterozoic age form the bedrock of the Lake Peak study area. The surficial deposits at Locations LP-38 and 39 consist of gravelly alluvium (Hunt, 1977). Localities LP-40 and 41 and 47 to 50 lie on interlayered rock units comprised of amphibolite and various classes of gneisses. A quartz diorite unit underlies Locs. LP-43 and 44. Mapped units for the upper sites, LP-51 to 53, show interlayered gneiss of two species (Moench and Lane, 1988).

Bailey described five life zones in the Sangre de Cristo Mountains: Arctic-Alpine, Hudsonian, Canadian, Transition, and Upper Sonoran. Knight (1990) recognized four elevational floristic zones in the range: 1) alpine tundra, 12,000-13,000 ft; 2) spruce-fir woodland, 9,000-12,000 ft; 3) mixed conifer woodland, 7,500-9,000 ft; and 4) pinyon-juniper woodland, 6,000-7,500 ft.

Mount Taylor Transect--The San Mateo Mountains, which include Mount Taylor, comprise a 71-km-long northeast-southwest trending volcanic plateau northeast of Grants, Cibola Co. (Ungnade, 1972). Mount Taylor formed as a composite stratovolcano during the Pliocene. Its summit rises to the highest point, 11,301 ft (3,445 m), in the New Mexico part of the Colorado Plateau Physiographic Province. Mount Taylor lies within the Acoma-Zuñi Section of the province. This section is characterized by extensive Cenozoic volcanics that cover erosional and constructional landforms (Hawley, 1986).

New Mexico State Road 547, heading northeast out of Grants, provides the main access to the Cibola National Forest and all localities along the transect. The peak of Mount Taylor and upper collecting localities are accessed only by pack trail. The transect covers almost 15 km. Fig. 4 shows topography of this transect and Locs. MT-54 to 67. Maximum relief in this range is the least of the four transects surveyed, spanning only 4,575 ft (1,394 m).

Geologically, units of primarily volcanic rocks surround most transect localities. Locations MT-65 to -67 are on porphyritic flows, which form the main Mount Taylor cone (Lipman et al., 1979). The surface deposits of Locs. MT-55 to -64 consist of alluvium and colluvium, including landslide deposits (Hunt, 1937; Lipman et al., 1979). Some Cretaceous sedimentary rocks are exposed in lower Lobo Canyon, where an erosional surface just to the south of Loc. MT-54 truncates folded beds of sandstone and shale (Hunt, 1938). This small area is the only one in the four transects surveyed, herein, in which some sedimentary bedrock occurs.

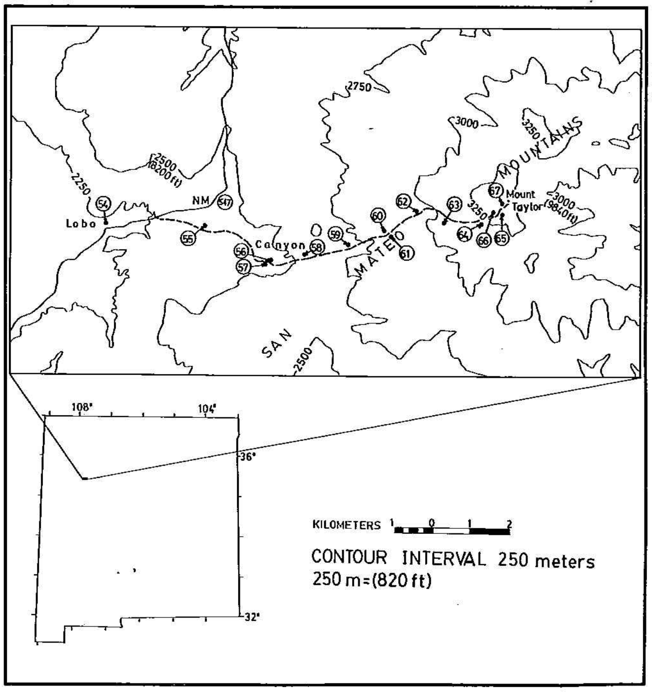

Figure 4. Topography of the Mount Taylor transect and locations of collecting stations MT54 to MT67.

Bailey (1913) discerned only three life zones for the Mount Taylor "Range": Upper Sonoran, Transition, and Canadian. Along the transect, from Locs. MT-54 to -56, occur junipers, pinyon pines, and live oaks typical of the Upper Sonoran Life Zone. The Transition Zone includes scattered ponderosa pine - Douglas fir forest and patches of Gambel Oak, covering much of Locs. MT-57 to 63. Bailey (1913:59) observed that "The Canadian Zone area is so restricted and isolated that it seems to lack many of the mammals and birds of the more extensive areas to the north and south, . . . " In this zone, spruce and fir characteristically vegetate the uppermost stations (Locs. MT-64 to 67), although open grasslands cover much of the upper southern slopes of Mount Taylor proper.

ALTITUDINAL DISTRIBUTION ALONG IGNEOUS ROCK TRANSECTS

In discussing altitudinal relationships, it seems justifiable to make use of the longstanding life-zone scheme, employed above, that was defined and discussed for New Mexico by Bailey (1913) and which, during the past 80 years, seems not to have been much improved upon. These zones have been discussed by Metcalf and Smartt (this volume).

Since life zones tend to descend to lower elevations along mesic canyons than elsewhere, the lower elevations provided by Bailey for "cold" slopes are employed here. These include the: 1) Hudsonian Zone, 11,000-12,000 ft; 2) Canadian Zone, 8,500-11,000 ft; 3) Transition Zone, 7,000-8,500 ft; and 4) Upper Sonoran Zone, 4,500-7,000 ft. The lowest three zones are roughly equivalent (Canadian to Upper Sonoran) to the Spruce-Fir, Ponderosa Pine, and Pinyon-Juniper Zones of some authors. Species taken at all elevations sampled along the four transects are indicated in Table 1, except for the slug *Deroceras laeve*. Balds occur at highest elevations on the four peaks surveyed. They are in the uppermost Canadian, Hudsonian, or Arctic-Alpine Zone of Bailey. In this study, highest collections were not obtained above 12,000 ft, thus were in the uppermost Hudsonian Zone. Bailey (1913) was not inclined to recognize a Hudsonian Zone on the summits of the Mogollon Mountains and Mount Taylor. However, in various tables we have included the highest locality on Mount Taylor (11,200 ft) in the Hudsonian Zone, in accordance with our arrangement noted above. The Hudsonian Zone is narrow and is essentially a zone at and slightly above timberline, where the number of species of trees becomes greatly reduced, and where trees are usually dwarfed and gnarled. The main conifers are bristlecone pine, alpine fir, and Engelmann spruce. Dwarf willows, gooseberries, and other shrubs are common here. Bailey (1913:50) noted that this zone (like others) may send "narrow tongues down steep gulches 1,000 feet below normal." However, canyons are generally not well developed in the Hudsonian Zone, since, in progressing upward, canyons flatten out and ultimately merge with upper slopes on the balds. This produces more uniform habitats and biotas at the highest elevations than those at more biotically diverse, lower zones.

In the Hudsonian Zone, collections were made as high on transects as 12,000 ft on LP, 11,800 ft on SB, and 11,200 ft on MT. Only *Vitrina pellucida* was taken at the highest station (12,000 ft on Lake Peak). However, Hoff (1962) reported a *Pupilla* (probably *blandi*) and a *Vertigo* (probably *modesta*) from 12,300 ft on Lake Peak. At 11,880 ft on SB, five species were taken: *Vitrina pellucida*, *Columella columella*, *Discus whitneyi*, *Euconulus fulvus*, and *Vertigo modesta*. At 11,600 ft, the following species were added to the high elevation list: *Discus shimekii* (LP), *Microphysula ingersolli* (LP), and *Pupilla blandi* (SB), while *Striatura meridionalis* (MT) and *Vallonia cyclophorella* (LP) were added at 11,200 ft. None of the above 10 species is restricted to the high elevations of the Arctic-Alpine and Hudsonian Zones. In fact, there seems to be no gastropod association restricted to highest peaks in New Mexico, like those observed in some other groups of organisms, particularly in the herbaceous plants. Rather, the gastropod inhabitants of these highest zones can be regarded as tolerant species extending to high elevations, but better represented in the Canadian and Transition Zones, below.

Proceeding downward, the boundary between the Hudsonian and Canadian Zones seems to be clearly identifiable in comparing their respective gastropod faunas. As indicated in Table 2, no more than seven species were found at any elevation (combined for all transects) above 11,000 ft, whereas, 16 or more species were recorded from all elevations (combined transects) from 10,800 down to 6,400 ft. Numbers of specimens taken per sample show a comparable marked decrease from Canadian to Hudsonian Zone localities as well (Table 2). It appears that this decrease in diversity and density is related to a timberline effect, as was discussed by Hoff (1962:62). Hoff noted that low winter temperatures and short growing seasons become increasingly inimical to the growth of trees at higher elevations. He stressed that the upward decline in leaf-litter-producing deciduous trees such as aspen, Gambel oak, and maples, was of critical importance to land snails in providing food (indirectly) and shelter. Both Hoff (1962) and Karlin (1961) pointed out the special importance of stands of aspen to land snails and the concomitant decline observed in both aspens and snails at elevations near timberline.

In our transects, overall, as noted above, a considerable increase in number of species is observed in descending from 11,200- to 10,800-ft elevations, which are considered here to span the Canadian/Hudsonian boundary. However, almost all of this increase is contributed by the SB transect. Taxa additional to the 10 listed above for the Hudsonian Zone, which were recorded at 10,800 ft, include: *Oreohelix nogalensis* (SB), *Pupilla muscorum* (SB), *Radiodiscus millecostatus* (SB), *Ashmunella rhyssa* (SB), *Gastrocopta quadridens* (SB), *Glyphyalinia indentata* (MT), and *Zonitoides arboreus* (LP, MT). A preference for arboreal habitats often has been noted for *Z. arboreus*. Some of the other species that appear here, below timberline, may also require or prefer the presence of trees.

In contrast to the rather clear-cut distinction observed between the Hudsonian and Canadian Zones, a similar distinction is not evidenced between the Canadian and Transition Zones. In general, a situation occurs in which diversity in land-snail species is less in the upper Canadian and lower Transition Zones, and becomes progressively richer towards elevations nearer the Canadian/Transition Zone boundary. The best-developed stands of deciduous trees occur at or near these elevations, and they are associated with and

Table 1. Numbers of specimens of land snails for species (listed alphabetically) collected along 4 transects in New Mexico. Numbers of specimens for each lot are listed by elevations where collected (elevations indicated, in feet, at left), and are standardized to a 3-liter sample (see text). Horizontal lines indicate boundaries between life zones, as interpreted herein, upper to lower: Hudsonian, Canadian, Transition, and Upper Sonoran. Transects are indicated by abbreviations: WB = Whitewater Baldy, SB = Sierra Blanca, LP = Lake Peak, and MT = Mount Taylor. Abbreviations used in regard to names are as follows: (under *Ashmunella*) *mo* = *mogollonensis*, *rh* = *rhyssa*, *th*=*thomsoniana*; (under *Oreohelix*) *ba* = *barbata*, *s u* = *subrudis*, *no* = *nogalensis*, *st* = *strigosa*; (under *Pupilla*) *mu* = *muscorum*, *so* = *sonorana*; (under *Vallonia*) *cyclo* = *cyclophorella*, *gr* = *gracilicosta*, *persp* = *perspectiva*.

Elevation	*Ashmunella* *mo*	*rh*	*th*	*Cionella lubrica*				*Columella columella*			*Discus whitneyi*				*Discus shimekii*		*Euconulus fulvus*				*Gastrocopta pilsbryana*				*Gastrocopta pellucida*	
(feet)	WB	SB	LP	WB	SB	LP	MT	WB	SB	LP	WB	SB	LP	MT	LP	MT	WB	SB	LP	MT	WB	SB	LP	MT	SB	LP
12,000																										
11,880									6			14						3								
11,600															14			4								
11,200															15	16				3						
10,800		41							1			2						5								
10,400		74									4	4			41	12										
10,000	24	75									23				5	132			2		2			11		
9,600	8	12	10								30			65	13						75			7		
9,200	29	24	28	2			3				39			10	163		8		35	45	50			95		
8,800	8	29		12						9	15	15		17	104		26		18	92	3	2		93		
8,400	9	125			4					4	30	28	1	15	76		6	13	17	5		14	9	53		
8,000	60	24	18			2				6	64	47	22	28			4	62	41	3	4	49	19	2		
7,600	110	170	5		1	31					123	79					8	26	32	45	3	3	1	9		
7,200	56	95		20	5	3					20	56					3	43			23	41		14		
6,800	71	45		11	41	3		15			64	10	20				30	19			118	53				1
6,400	125			5	2						125						30				138	35				19
6,000	2			9	6						83						6				68	1			39	
5,600	8			4							24										68				190	
Total	510	714	61	63	59	39	3	15	7	19	644	255	43	135	431	160	121	175	145	193	552	198	29	254	229	20

Table I (continued)

Elevation	*Gastrocopta quadridens*			*Glyphyalinia indentata*				*Hawaiia minuscula*				*Helicodiscus eigenmanni*			*Microphysula ingersolli*				*Nesovitrea hammonis*			*Oreohelix*			
																						ba	*su*	*no*	*st*
(feet)	WB	SB	MT	WB	SB	LP	MT	WB	SB	LP	MT	WB	SB	LP	WB	SB	LP	MT	WB	LP	MT	WB	WB	SB	LP
12,000																									
11,880																									
11,600																	8								
11,200																4	14	8							
10,800		1					6									14	20	60						5	
10,400				5									8		5	52	42	2					1		
10,000	32	25	10	9			3								53	32	27	64		2		13	8		2
9,600	38	5													43	13	126	43				30	8	1	13
9,200	50	4				3					5				23	44	63			18		11	5		5
8,800				5					2				1		9	26	28	1		7			2		2
8,400		1		3	1				18				13		36	58	99			9	24		6	15	
8,000						10			56	13			4		21	11	4			13	22	6	4		1
7,600				10		15			55		8				38				9	10	2		20		
7,200				6					26		11		11		18							12			
6,800				11	4				17			4	1	2	39	4				4					
6,400				20	2			51				15	4		83							14			
6,000				8											15							11			
5,600												8			2										
Total	120	36	10	77	7	28	9	51	174	13	24	27	42	2	385	258	431	178	9	63	48	97	54	21	23

Table 1 (continued)

Elevation	*Paralaoma caputspinulae*		*Punctum minutissimum*				*Pupilla blandi*				*Pupilla*		*Radiodiscus millecostatus*		*Striatura meridionalis*				*Vallonia*				
											mu	*so*							*cyclo*		*gr*	*persp*	
(feet)	SB	LP	WB	SB	LP	MT	WB	SB	LP	MT	SB	SB	WB	SB	WB	SB	LP	MT	SB	LP	MT	WB	SB
12,000																							
11,880																							
11,600								9															
11,200																		1		3			
10,800								6		24	3			23				126	21				
10,400	266			209				11		1				164	1	12			128				
10,000					2		2	5		4				25	26			3	73				
9,600							45	5	1	65	2		15	13	15				47	3			
9,200	1		29	4	3			4					218	17	11	4		24	45	33			
8,800	105			7				14	7	131				5	9	5			71	2	9		
8,400	21	2		7	32			18	2		30		39	55	6	23		3	303	133			
8,000	66		2	49	12			36	12		6	88		2	9	139	22	15	422	247			
7,600	4		5	11	2	1		86		9		2	3		20	9	12		145		58		
7,200	2			11								17	2			38			78	2	99		
6,800	18			8				9				3		17	41	6			8			2	49
6,400							56								12					1		87	
6,000																						15	
5,600																						17	363
Total	483	2	36	306	51	1	103	203	22	234	41	110	277	321	150	236	34	172	1341	424	166	121	412

Table 1 (continued)

Elevation	*Vertigo gouldii*				*Vertigo modesta*				*Vitrina pellucida*				*Zonitoides arboreus*			
(feet)	WB	SB	LP	MT	WB	SB	LP	MT	WB	SB	LP	MT	WB	SB	LP	MT
12,000											40					
11,880						8				8						
11,600							27			6	18					
11,200						21		30		28	12					
10,800					10	110	45			7	43				1	3
10,400		2			59	189	23	86		89	42		1			4
10,000					208	205	272	539		5	11					
9,600				158	165	103	74			4	80			1	1	18
9,200	21	116		27	120		20		11	8	58				13	45
8,800		12		167		170	215	479	6	18	16	16	8			12
8,400		36	6		84	69	493			49	13	3	12	7	8	7
8,000		126	25		45	34	14			62	7			23	29	26
7,600	23	38			475	3				30	4		20	17	5	25
7,200	59	32			2	5				10			11	16	3	22
6,800	4	19				28				14			41	19	5	
6,400	123				101								14	6	2	
6,000	53												24			
5,600													4			
Total	283	381	31	352	1269	945	1183	1134	17	338	344	19	135	89	67	162

Table 2. Numbers of species and number of specimens (standardized mathematically to a 3-liter standard; see text) taken along each of four transects in New Mexico. The slug, *Deroceras laeve*, observed at some localities, is omitted. Transects are abbreviated as in text and Table 1. Horizontal lines indicate boundaries between life zones as in Table 1.

Elevation	Number of Species					Number of Specimens				
(feet)	WB	SB	LP	MT	Total	WB	SB	LP	MT	Total
12,000			1		1			40		40
11,880		5			5		39			39
11,600		3	4		6		19	67		86
11,200		3	4	5	7		53	44	58	155
10,800	1	13	4	5	16	10	239	109	219	577
10,400	7	13	4	5	17	76	1208	148	105	1537
10,000	11	8	8	8	20	400	445	323	766	1934
9,600	11	11	9	6	21	474	204	321	356	1355
9,200	15	11	12	8	26	627	271	442	254	1594
8,800	11	15	10	10	26	103	482	408	1017	2010
8,400	10	22	14	7	27	231	912	898	80	2121
8,000	10	19	19	6	28	219	1306	517	96	2138
7,600	14	16	10	8	24	867	679	117	157	1820
7,200	12	16	3	4	22	232	486	8	146	872
6,800	13	21	6		25	451	392	35		878
6,400	16	5	3		18	999	49	22		1070
6,000	11	3			12	294	46			340
5,600	8	2			9	135	553			688

seem to provide favorable habitats for land snails. In Table 2, considering stations from 7,200 to 10,800 ft to be comprised in the Canadian-Transition Zones, greatest species diversity is found in the medial part of this series of localities, from 8,000 to 9,200 ft (26 to 28 species, all transects included). Greatest densities of specimens (calculated to three liters), considering all four transects, were found (1,355 to 2,138 per sample) from 7,600 to 10,400 ft, which encompasses most of the two zones combined. Thus, in these transects, and probably in canyons of New Mexico mountains, in general, land snails flourish best at elevations comprising the middle Transition to middle Canadian zones, or from approximately 7,500 to 10,000 ft. Several species were found to be restricted mainly to the Canadian and Transition Zones. With all transects considered, these include the following: *Ashmunella thomsoniana*, *Gastrocopta quadridens*, *Nesovitrea hammonis electrina*, all species of *Oreohelix* except *O. barbata*, *Punctum minutissimum*, *Pupilla muscorum*, and *Radiodiscus millecostatus*. In addition, several species are mainly restricted to the Transition and Canadian Zones, except for extending to lower elevations along the WB transect, where special, locally mesic habitats prevail (discussed below). These include *Euconulus fulvus*, *Hawaiia minuscula*, *Microphysula ingersolli*, and *Vertigo gouldii*.

In New Mexico, the Upper Sonoran Zone is often referred to as a Pinyon-Juniper Zone. Especially along canyons, trees such as various live oaks, Arizona walnut, lance-leaf cottonwood, box elder, hackberry, mulberry, and species of ash and willow occur together with conifers. Shrubs such as mountain mahogany, silktassel, and species of *Rhus* may be common. There are present, then, a number of deciduous species that can provide some leaf litter.

Although not as well-defined as the boundary between the Hudsonian and Canadian land-snail associations, there is a discernible and progressive decrease in land snail taxa in proceeding from the Transition Zone down through the Upper Sonoran Zone. As indicated in Table 2, at the four Upper Sonoran stations from 6,800 to 5,600 ft, there is a progressive decrease in numbers of species (transects combined) through 25, 18, 12, and 9.

Precipitation decreases at lower elevations, just as temperature increases, and, in turn, increases evaporation. A decrease in montane land snails dependent on moist conditions might be expected, and is seemingly being observed here in the upper Sonoran Zone. A comparable increase in arid-adapted species is not encountered, so that species diversity, overall, shows a progressively marked decline, with decrease in elevation. Hoff (1962:61-62) noted that "Land molluscs are scarce in the pinyon-juniper community . . . ," which he identified as occupying elevations from 6,500 to 7,500 ft. He related this to a decrease in availability of moisture, although noting that the more immediate effect on snails likely would be the decrease in "broad-leaved trees and other suitable mesic plants" at lower elevations.

As with the other life zones, there are no species that could be considered as specific indicators of the Upper Sonoran Zone alone. In the transects discussed here, *Vallonia perspectiva* was found only in the Upper Sonoran Zone. However, in other mountains it commonly occurs also at higher elevations, as in the Organ and San Andres Mountains, where Metcalf (1984:42) considered it a species typical of the Transition Zone. Most Upper Sonoran Zone species are shared with the Transition Zone, above, and a few with the Lower Sonoran Zone, below. Several species, which seemed to find their optimal habitat in the middle Transition to middle Canadian Zones, descend into the upper part of the Upper Sonoran Zone, but it seems likely that they gradually are approaching their limits of tolerance at lower elevations. As shown in Table 1, a majority of species extend at least a short distance down into the Upper Sonoran Zone, but most only to 6,800 or 6,400 ft, except along the WB transect, a special case discussed below. The only species of low elevations, typical of the combined Lower and Upper Sonoran Zones, which occurred in these transects, was *Gastrocopta pellucida*.

There is considerable variation in regard to the physiography of the lower parts of canyons, and this is reflected in the nature of canyon biotas. In some cases, canyons gradually widen as they descend, and biotas show a corresponding gradual change. This is the pattern seen in the SB, LP, and MT transects. Whitewater Canyon (WB), on the other hand, exemplifies a type of canyon that becomes entrenched in high-walled "narrows" as it nears the mountain front. This is well shown along the "Catwalk," where the lowermost canyon is constricted greatly. Just below the Catwalk segment, the narrow canyon abruptly gives way to a broad valley, so that there is a striking change both in physiography and in the biota over a short distance. Along the narrow, deeply shaded, lower part of Whitewater Canyon, many elements of a montane biota extend as a narrow tongue down to the Catwalk area. This includes montane trees and other plants and the land snails commonly associated with them. Table 1 shows that several species descend to lower elevations along the WB than they do along other transects studied. *Euconulus fulvus*, *Helicodiscus eigenmanni*, *Vertigo gouldii*, and *Zonitoides arboreus* were collected 800 ft lower and *Discus whitneyi* and *Microphysula ingersolli* were found 1,200 ft lower than along other transects. *Ashmunella mogollonensis* was taken 1,200 ft lower than its relative, *A. rhyssa*, in the SB transect. A similar situation was noted in a distributional study of land snails of the Grand Canyon area, Arizona, by Spamer and Bogan (1993). They observed (p. 21) that "specialized riparian communities" at lower elevations were inhabited by species "normally found in higher Life Zones."

The species *Discus whitneyi*, *Vitrina pellucida*, *Microphysula ingersolli*, and *Zonitoides arboreus* seem especially tolerant of a broad altitudinal range, occurring vertically through at least 4,400 ft in 2 different transects, each, and the first 2 species through at least 5,080 ft in the SB transect. With all transects considered, *Discus whitneyi* occurs through a vertical range of 6,280 ft, *Microphysula ingersolli* through 6,000 ft, *Euconulus fulvus* through 5,880 ft, *Vertigo modesta* through 5,480 ft, and *Pupilla blandi*, *Vitrina pellucida*, and *Zonitoides arboreus*, through 5,200 ft. The altitudinally tolerant *Discus whitneyi* occurs at still lower elevations both in New Mexico and in Arizona (Bequaert and Miller, 1973; Dillon, 1980).

SUMMARY OF ZONATION IN NUMBERS OF SPECIES AND SPECIMENS

For the transects discussed above, numbers of species that were taken and numbers of specimens that were calculated for the standardized sample (three liters) are summarized in Table 2 for each elevation collected. Both of these show patterns of altitudinal zonation. Again, the WB transect displays higher values at lower elevations, which are not shared by the other three transects. Along WB, the largest numbers of species were at 6,400 ft (16) and 9,200 ft (15). More than 10 species were found at all stations from 6,000 to 10,000 ft; 11 species at 6,000, 8,800, 9,600, and 10,000 ft.

Along WB, the largest number of specimens calculated per sample also was from a low-altitude station: 999 at 6,400 ft, with second and third largest numbers being 867 at 7,600 ft and 627 at 9,200 ft. In summary, there is a relatively uniformly rich fauna over some 4,000 ft, from 6,000 to 10,000 ft along transect WB.

For the other three transects, highest numbers of species and specimens calculated per sample all occur in the 8,000-8,800 ft range--for species: 22 at 8,400 ft (SB), 19 at 8,000 ft (LP), and 10 at 8,800 ft (MT), and for calculated number of specimens: 1,306 at 8,000 ft (SB), 898 at 8,400 ft (LP), and 1,017 at 8,800 ft (MT). On SB, after a decrease in number of species (only 8 to 11) from 9,200- to 10,000-ft levels, a resurgence is exhibited higher up, with 13 species at 10,400 and 10,800 ft. The second largest number of specimens, per sample, for the SB transect was taken at 10,400 ft. It seems that at these 10,400- and 10,800-ft localities there is a local habitat effect that produced assemblages that are exceptionally rich for these elevations. This effect is similar to, but in the reverse direction from that noted for the lower WB transect. Disregarding these two higher stations of the SB transect and the lower stations of the WB transect, there is a fairly consistent pattern, wherein largest numbers of species (20-28 with all transects considered) and greatest densities per sample (1,355-2,138, totals for all transects) occur between 7,600- and 10,000-ft elevation.

In summary, in terms of life zones, the richest faunas occur from the middle Transition to the middle Canadian Zones. Above 10,800 ft, a Hudsonian Zone fauna becomes progressively impoverished in terms of both number of species and specimens, with relatively few species appearing to be tolerant of these highest elevations. A similar decrease occurs downward through the Upper and Lower Sonoran Zones.

GEOGRAPHIC PATTERNS

One objective involved in choosing transects that roughly define the four corners of a square within New Mexico was to ascertain if there might be discerned any noteworthy patterns of geographic distribution. As indicated in Table 2, there is a general trend of reduction in number of species and abundance of snails calculated per sample (where containing 300 or more specimens) from southeast to northwest, as shown below:

		Number of localities having specimens per sample indicated:			
Transect	Number of Species	>1000	700-999	500-699	300-499
SB	26	2	1	1	4
WB	24	-	2	1	3
LP	22	-	1	1	4
MT	18	1	1	1	1

The greater faunal diversity of the two southern versus the two northern transects might relate to greater proximity to the summer Mexican monsoonal belt. Of the four, the SB transect is closest to the Gulf of Mexico, a source of monsoonal moisture. However, in comparison to WB, SB ascends 1,000 ft higher, which also may be related to its greater faunal diversity and richness. Nevertheless, in regard to diversity, the two transects are similar (26 and 24 species, respectively).

Mount Taylor, on the other hand, may be located too far east to benefit significantly from western sources of winter Pacific precipitation, and too far northwest for Gulf of Mexico summer sources. Mueller (1989) noted that this part of New Mexico has less access to moist and unstable air from the Gulf of Mexico during the summer thunderstorm season. Lake Peak, the eastern counterpart of Mount Taylor, is in a better position in regard to Gulf moisture sources, and is also part of the high chain of the Sangre de Cristo Mountains, which may sap summer moisture supplies from mountains to their west, such as Mount Taylor. The comparative aridity of the Mount Taylor transect probably relates to the depauperate land-snail fauna found in the area below ca. 7,000 ft.

Excluding the records of *Vallonia gracilicosta* from the MT transect and of *Pupilla muscorum* from the SB transect, both of which are widespread elsewhere in the state, the remaining taxa that were recorded from only one transect are: MT - none; LP-*Ashmunella thomsoniana* and *Oreohelix strigosa depressa*; WB-*Ashmunella mogollonensis*, *Oreohelix barbata*, and *O. subrudis*; SB-*Ashmunella rhyssa*, *Oreohelix nogalensis*, *Paralaoma caputspinulae*, and *Pupilla sonorana*. *Radiodiscus millecostatus* and *Vallonia perspectiva* are recorded for only the two southern transects, and *Discus shimekii* for only the 2 northern. This modest elevation in number of taxa towards the south may conform to a model by Metcalf (this volume) which relates greater diversity in southern New Mexico to paleoclimatic factors causing extinctions that have encroached from north to south in the Cordilleran region.

There seem to be no significant differences between eastern and western transects. No species are shared by the western transects, WB and MT, to exclusion of the eastern ones. The records of *Gastrocopta pellucida* and *Vallonia cyclophorella* from only the eastern transects are of no zoogeographic significance, as both are widespread species that extend into Arizona.

Fifteen species are found in all four transects. Because the faunal list from the MT transect comprises only 18 species, it is clear that most of these are widespread species in New Mexico and probably ecologically tolerant as well.

TRANSECTS ON SEDIMENTARY BEDROCK

The Sierra Blanca Mountains, discussed above, abut the Sacramento Mountains to the south. Physiographically, the two ranges are conjoined and are scarcely discernible from each other in places. Petrologically, however, the ranges are distinctive, the Sierra Blanca Mountains being of Tertiary igneous and the Sacramento Mountains of Paleozoic sedimentary bedrock. Rocks of the Sacramento Mountains are of Pennsylvanian and Permian age, comprising mainly limestone and calcareous shale units. Structurally, the mountains are block-faulted and tilted.

Because of the geographic proximity of the Sierra Blanca and Sacramento Mountains, but of their geologic dissimilarity, it is of interest to compare transects in the two ranges. Collections were made along transects in two canyons in the Sacramento Mountains in the late 1960s and early 1970s. The Peñasco Canyon (PC) transect heads in the central part of the mountains and descends eastward. The Rio Peñasco ultimately flows into the Pecos River. The Tularosa Canyon (TC) transect heads in the northwestern part of the Sacramento Mountains and descends north to Mescalero and then west to Tularosa, beyond which the Tularosa River debouches into the Tularosa Basin.

The Sacramento Mountains do not reach the heights of the Sierra Blanca Mountains. The Peñasco Canyon transect culminates at the crest of the range at some 9,600 ft; the Tularosa Canyon transect culminates at 8,400 ft at the head of the canyon, which forms a "pass" to Turkey Pen Canyon, tributary to Silver Springs Canyon. Collections were made at 300-ft intervals, rather than at the 400-ft intervals used in the transects discussed in the preceding sections. An exception was the lowermost station on the PC transect, at 5,280-ft rather than the expected 5,400-ft elevation. Along the TC transect, collections extended from 5,400 to 8,400 ft.

At elevations of 7,200-9,000 ft along PC, collections were made both on the alluvial floodplain of Peñasco Canyon and along adjoining valley walls, where collections consisted of ca. two liters of leaf litter, a sample size smaller than that used in the transects above. On the floodplain, it was often not practical to obtain leaf-litter samples, and these collections relied heavily on hand-picking snails from under dead wood and stones. In Table 3, collections from the two habitats are shown separately for elevations 7,200-9,000 ft and indicated as PCF (Peñasco Canyon Floodplain) and PCV (Peñasco Canyon Valley walls).

Along the TC transect, leaf-litter samples were from 1.5 to 2.0 liters in quantity and were augmented by hand-picking. In middle elevations of the canyon, valley wall and floodplain samples were combined. At higher elevations, the floodplain was poorly developed or absent. At lowest elevations, the floodplain was broad, and collections were not made from valley walls, which were widely separated and far back from the Tularosa River.

Table 3. Numbers of specimens of land snails for species (listed alphabetically) collected along two transects in the Sacramento Mountains, south-central New Mexico (X = only voucher specimens collected). Transects were along Tularosa Canyon (TC) and Peñasco Canyon (PC), the latter indicated as floodplain (PCF) or as valley wall (PCV) habitats. Numbers of specimens for each lot are listed by elevation. Horizontal lines indicate boundaries between Canadian, Transition, and Upper Sonoran life zones (upper to lower). The slug, *Deroceras laeve,* occurred at several localities, but is not included.

Elevation	*Ashmunella rhyssa*			*Carychium exiguum*			*Cionella lubrica*			*Discus whitneyi*			*Euconulus fulvus*			*Gastrocopta armifera*			*Gastrocopta ashmuni*		
(feet)	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC
9,600		3												5							
9,300		23												34							
9,000	30	X											1	6							
8,700			20							21				9							
8,400	42	X	X								8			12	6						
8,100	8	X	X											3	13	7					
7,800	40	X	X									7	4		13						
7,500	37	X	X					5					7	24	10						
7,200	33	X	X					4					12	13		21	15	28			
6,900	27	X	X					6	5						13						
6,600		29	X			7		20	1			42		4							
6,300		18	X					15	1												
6,000		13	X					63	1			1		12							1
5,700			X									3									
5,400																					
5,280																					
Total	217	106				7		113	8	21	8	53	24	122	55	28	15	28			1

Table 3 (continued)

Elevation	*Gastrocopta contracta*			*Gastrocopta pellucida*			*Gastrocopta pilsbryana*			*Gastrocopta procera*			*Gastrocopta quadridens*			*Glyphyalinia indentata*			*Hawaiia minuscula*		
(feet)	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC
9,600																					
9,300								5												13	
9,000								1												5	
8,700								41						6			4		1	20	
8,400								6	7		1			1						13	8
8,100								8	1			1					1	4		12	6
7,800							1	7													6
7,500		4						26	6								3		6	35	6
7,200	1	3						8	1			1					2		1	16	2
6,900			4					4	4		6						3				
6,600		1						35	4		4						1	1		4	
6,300		12						11			2						3				1
6,000		35				33		24			7						15			1	1
5,700																					1
5,400																					
5,280					3												1			1	
Total	1	55	4		3	33	1	176	24		20	2		7			33	5	8	120	31

Table 3 (continued)

Elevation	*Helicodiscus eigenmanni*			*Microphysula ingersolli*			*Oxyloma retusum*			*Paralaoma caputspinulae*			*Punctum minutissimum*			*Pupilla blandi*			*Pupilla sonorana*		
(feet)	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC
9,600					11												32			3	
9,300																	15			15	
9,000				1													24		6	22	
8,700					13									1		1	5		1	14	
8,400		1			3	4					3			1			5	48		7	6
8,100					1	2											1	30	1	14	50
7,800																	4	64	2	11	20
7,500	1				8									4	2	5	44		3	13	18
7,200																				10	1
6,900																				5	6
6,600		1							X												1
6,300																				8	
6,000																				6	11
5,700																					
5,400																					
5,280																					
Total	1	2		1	36	6	1	176	24		3			6	2	6	130	142	13	128	113

Table 3 (continued)

Elevation	*Pupoides albilabris*			*Rabdotus dealbatus*			*Radiodiscus millecostatus*			*Striatura meridionalis*			Succineidae sp. indet.			*Vallonia cyclophorella*			*Vallonia gracilicosta*		
(feet)	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC
9,600								10			3						76				
9,300														3			178				
9,000								1					2	10			42		13	15	
8,700								2					6	2		2	200		11		
8,400												2	2		2		52	15	24	30	
8,100												4	8	8	2		38	11	95	4	9
7,800													1	1	2			1	1		13
7,500								22			5		4	6	1	1	80	11	87	8	1
7,200					6						1	1	10	3			13		88	1	5
6,900														1							
6,600					3	X															6
6,300					27									2	2						
6,000					1															1	6
5,700															X						1
5,400																					X
5,280		1												1						62	
Total		1			37			35			9	7	33	37	9	3	679	38	319	121	41

Table 3 (continued)

Elevation	*Vallonia parvula*			*Vallonia perspectiva*			*Vertigo elatior*			*Vertigo gouldii*			*Vertigo modesta*			*Vitrinia pellucida*			*Zonitoides arboreus*			
(feet)	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	PCF	PCV	TC	[1]*n*
9,600											3			62			14				13	235
9,300					6						3			16			3				14	328
9,000					2						1			13		5	6		2			208
8,700					17						7			37			16		3			460
8,400					1						8	2		4	28		12	3		1	16	384
8,100					17		1				1	7		8	22		1	4	1	3	10	417
7,800				1		3					6	6		3		2			2	23	1	245
7,500					36	18					8	7		14		2	9	8	12	9	7	623
7,200					12						4			2		1	4		13	5		341
6,900					14							6						2		3		109
6,600					43															9	1	218
6,300					1																	99
6,000					86	3														2	3	330
5,700																					2	7
5,400																						0
5,280		51																				120
Total		51		1	235	24	1				41	28		159	50	10	65	17	33	82	40	4124

[1] total number of specimens in both transects

Species taken at each elevation are indicated in Table 3, except for the slug *Deroceras laeve*, which was observed at several stations, but was not collected. Number of specimens, per species, collected at each locality is indicated, except where voucher specimens, only, were collected in cases indicated by "X." For the two transects, combined, 36 species were taken. Thirty-three species were taken along the PC transect, with 19 in the PCF and 32 in the PCV habitats. Twenty-nine species were taken along the TC transect (these totals include *Deroceras laeve*). Six species were collected along PC only: *Gastrocopta quadridens*, *Helicodiscus eigenmanni*, *Paralaoma caputspinulae*, *Pupoides albilabris*, *Radiodiscus millecostatus*, and *Vertigo elatior*. Three species were taken along TC only: *Carychium exiguum*, *Gastrocopta ashmuni*, and *Oxyloma retusum*.

Along the Sacramento Mountains transects, 12 species were taken, which were not recorded for the Sierra Blanca transect: *Carychium exiguum*, *Gastrocopta armifera*, *G. ashmuni*, *G. contracta*, *G. procera*, *Oxyloma retusum*, *Pupoides albilabris*, *Rabdotus dealbatus neomexicanus*, *Succinea* sp., *Vallonia gracilicosta*, *V. parvula*, and *Vertigo elatior*. Only 3 species were found in the SB, but not in the PC or TC transects: *Columella columella*, *Oreohelix nogalensis*, and *Pupilla muscorum*. Although the Sacramento Mountains transects culminated at elevations some 2,280 ft (PC) and 3,480 ft (TC) lower than the SB transect, the number of species found is greater. It seems likely that the widespread presence of calcareous bedrock in the Sacramento Mountains area produces conditions supportive of a more diverse fauna. It is, of course, well documented that some species of land snails are more calciphilic than others. *Rabdotus dealbatus neomexicanus* is such a calciphilic species. Four species of *Gastrocopta*, which were recorded from the Sacramento Mountains, were not found in any of the four transects on igneous bedrock. Perhaps some of these are also calciphiles.

The three species found in the Sierra Blanca Mountains, but not in the Sacramento Mountains, may find the higher elevations available in the SB transect more favorable. Perhaps they are relicts there. This is suggested because *Oreohelix nogalensis* and *Pupilla muscorum* occur as Pleistocene fossils at lower elevations in the Sacramento Mountains than where they presently occur in the Sierra Blanca Mountains (in which there are no known fossiliferous deposits).

Apart from the above differences, altitudinal distributional patterns show similarity in a comparison of the Sierra Blanca Peak and the two Sacramento Mountains transects (abbreviated below to SB and SacM). *Gastrocopta quadridens* and *Punctum minutissimum* were restricted to the Canadian and Transition Zones, *Cionella lubrica* to the Transition and Upper Sonoran Zones, and *Gastrocopta pellucida* to the Upper Sonoran Zone in both the SB and SacM transects.

Six species extended from the Canadian Zone down to at least the uppermost part of the Upper Sonoran Zone in both groups of transects: *Discus whitneyi*, *Euconulus fulvus*, *Hawaiia minuscula*, *Vertigo gouldii*, *Vitrina pellucida*, and *Zonitoides arboreus*. Very similar were altitudinal distributions of six other species, except that, in these, specimens were taken at slightly lower elevations in the SB transect. In all cases, these species were taken as low as 6,800 ft in the SB transect, but only down to 7,200 or 7,500 ft in the SacM transects. This likely relates to Three Rivers Canyon being somewhat narrower and supporting a more mesic arboreal flora to lower elevations than is the case in Peñasco and Tularosa Canyons. These species are *Microphysula ingersolli*, *Pupilla blandi*, *Radiodiscus millecostatus*, *Striatura meridionalis*, *Vallonia cyclophorella*, and *Vertigo modesta*.

In contrast to the above species, *Ashmunella rhyssa* and *Pupilla sonorana* were taken at lower elevations in the SacM transects (5,700 and 6,000 ft, respectively) than in the SB transect (6,800 ft for both). *Pupilla sonorana* also extends to higher elevations in the SacM transects (9,600 ft) than in the SB (8,000 ft) transect, and this suggests that it may prefer habitats available in the Sacramento Mountains. A similar pattern is exhibited by *Vallonia perspectiva*, which extends much higher (9,300 ft) in the SacM than in the SB (6,800 ft) transect.

Paralaoma caputspinulae was a common snail in the SB transect, taken from 6,800 to 10,400 ft, but was found at only one locality in the SacM transects, at 8,400 ft. This suggests that its preferences, regarding the habitats offered by the two mountain ranges involved, contrast with those of the species discussed in the preceding paragraph.

Maximum densities (total specimens) occur within the general range of 7,200-9,300 ft (maximal numbers are at 7,500 and 8,700 ft). This is similar to the altitudinal pattern of specimen densities for SB localities (Table 2) where the three largest numbers of specimens were at 8,000, 8,400, and 10,400 ft. The Sacramento Mountains transects reached only to 9,600 ft, with canyon habitat progressively diminishing, upward, on the widespread, relatively level crest of the range. Thus, habitats along the uppermost Sacramento Mountains transects differ significantly from those at comparable elevations along the SB transect.

In summary, it appears that in mountains both with igneous and with sedimentary bedrock, greatest species diversity and largest land-snail populations are to be found from the middle Transition to middle Canadian Zones. These values decrease concomitantly with decreasing elevations into the lower Transition and the Upper Sonoran Zones. A similar decrease is shown along the igneous transects in progressing upward into the Hudsonian Zone. In this regard, both highest and lowest elevations tend to be inhabited by hardy, ecologically eurytopic species, occurring through several thousands of feet in elevation.

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APPENDICES

In Appendix A are listed, alphabetically, the species discussed in Parts 1 and 3 of this volume (Metcalf and Smartt; Dillon and Metcalf). Taxa are listed only to genera and species, not to subspecies. Counties in New Mexico in which each species is known to occur are indicated. Most of these records are based on specimens collected during studies reported in this volume, and are deposited in collections of the University of Texas at El Paso (UTEP) or the New Mexico Museum of Natural History & Science (NMMNH&S). In addition, a few county records are derived from the literature or from museum specimens, other than the above. These are indicated by author or by museum: Academy of Natural Sciences of Philadelphia (ANSP); Museum of Comparative Zoology, Harvard University (MCZ); University of Michigan Museum of Zoology (UMMZ); National Museum of Natural History (USNM). Most literature citations are from the monographs of H. A. Pilsbry, in which he summarized previous records.

After the county records, lot numbers are listed for specimens in the UTEP or NMMNH&S collections, excluding specimens collected by Dillon, which are discussed in Part 3 of this volume. These lot numbers are also listed, numerically, in Appendix B, which provides, in addition to county of collection, a brief indication of the local physiography or other features and UTM zones and coordinates. For other sorted listings of these locality data, contact the Registrar, NMMNH&S.

APPENDIX A

SPECIES	**COUNTIES AND LOCALITIES**
Arion fasciatus	San Miguel 615, 631
Ashmunella amblya	Otero 119
Ashmunella animasensis	Hidalgo 128
Ashmunella ashmuni	Los Alamos, Rio Arriba, Sandoval 031, 042, 150, 151, 474, 478, 479, 583
Ashmunella auriculata	Doña Ana 013,014,053,138,170,171,209,227,231,269
Ashmunella binneyi	Grant 459
Ashmunella carlsbadensis	Eddy 001, 002, 005, 301
Ashmunella cockerelli	Grant 433, 434, 503, 520, 524
Ashmunella danielsi	Catron 531
Ashmunella harrisi	Doña Ana 154, 155, 206
Ashmunella hebardi	Hidalgo 460, 462
Ashmunella kochii	Doña Ana, Sierra 091, 197, 210, 234, 235, 237, 425

Appendix A (continued)

Ashmunella macromphala	Luna 528
Ashmunella mearnsii	Hidalgo 251, 323, 460, 461, 466, 549
Ashmunella mendax	Grant, Sierra 057, 092, 093, 094, 115, 131, 207, 432, 539, 543, 547, 553, 576, 644
Ashmunella mogollonensis	Catron, Grant 033, 034, 058, 152, 153, 293, 365, 375, 376, 378, 381, 382, 416, 431, 447, 508, 541, 591, 592, 661
Ashmunella organensis	Doña Ana 016, 018, 132, 133, 136, 144, 145, 179, 180, 228
Ashmunella pasonis	Doña Ana 124, 160, 161, 167, 168, 169, 213, 224, 229, 232, 233
Ashmunella pseudodonta	Lincoln 205, 215, 458, 465, 497, 501, 544, 545
Ashmunella rhyssa	Chaves, Lincoln, Otero 021, 022, 023, 025, 026, 029, 030, 067, 068, 069, 096, 097, 098, 102, 183, 184, 185, 186, 187, 189, 190, 191, 192, 193, 194, 195, 198, 199, 200, 201, 202, 203, 249, 250, 253, 259, 349, 408, 448, 551, 552, 640, 641, 647, 650, 653
Ashmunella rileyensis	Doña Ana 061, 062, 063, 659
Ashmunella salinasensis	Sierra 164
Ashmunella tetrodon	Catron, Grant, Sierra, Socorro 130, 178, 302, 336, 340, 345, 346, 347, 431, 439, 447, 498, 532, 643
Ashmunella thomsoniana	San Miguel, Santa Fe 032, 126, 127, 129, 282, 586, 588, 607
Ashmunella todseni	Doña Ana 216, 217, 270
Ashmunella walkeri	Luna 059, 243
Carychium exiguum	Otero 027, 028
Catinella vermeta	Reported by Wu (1993) from Colfax, Doña Ana, Mora, Rio Arriba, San Miguel, and Union counties
Cecilioides acicula	Likely in Doña Ana (see text)

Appendix A (continued)

Cionella lubrica	Bernalillo, Catron, Chaves, Cibola, Colfax, Doña Ana, Eddy, Grant, Hidalgo, Lincoln, Mora, Otero, Rio Arriba, San Juan, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance, Union, Valencia 001, 002, 003, 008, 009, 010, 019, 020, 025, 026, 027, 041, 053, 067, 076, 079, 080, 084, 092, 094, 101, 115, 118, 128, 130, 131, 142, 164, 173, 174, 176, 183, 184, 185, 190, 191, 193, 195, 201, 202, 203, 205, 207, 220, 236, 239, 244, 250, 253, 264, 271, 279, 280, 283, 285, 286, 287, 288, 302, 316, 318, 321, 322, 324, 327, 336, 337, 340, 341, 343, 346, 347, 352, 353, 354, 355, 356, 365, 368, 369, 375, 378, 379, 381, 383, 386, 390, 406, 410, 411, 414, 431, 433, 435, 436, 437, 438, 446, 447, 448, 449, 452, 455, 457, 459, 462, 465, 468, 471, 474, 490, 492, 493, 494, 495, 497, 498, 503, 505, 508, 509, 510, 520, 521, 523, 527, 528, 531, 532, 546, 547, 559, 561, 562, 563, 570, 571, 572, 573, 576, 578, 580, 581, 582, 583, 585, 591, 618, 644, 649, 650
Coelostemma pyrgonasta	Doña Ana 035, 054, 134, 218, 388, 548
Columella columella	Catron, Colfax, Lincoln, Otero, San Miguel, Sandoval, Santa Fe, Sierra, Taos (Pilsbry, 1948) 240, 407, 497, 560, 582
Deroceras heterura	Catron (Pilsbry, 1948), Grant, Sierra (Pilsbry, 1948) 639, 646
Deroceras laeve	Chaves, Eddy, Otero, Rio Arriba, Socorro (Hoff, 1962), Taos (Hoff, 1962) 148, 220, 292, 307, 308, 571
Discus shimekii	Bernalillo, Cibola, Colfax, Rio Arriba, San Miguel, Sandoval (Pilsbry, 1948), Santa Fe, Taos, Torrance 032, 043, 047, 117, 118, 127, 129, 196, 275, 282, 383, 386, 387, 390, 393, 450, 467, 483, 493, 502, 505
Discus whitneyi	Bernalillo, Catron, Cibola, Colfax, Grant, Hidalgo, Lincoln, Los Alamos, Luna, Mora, Otero, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance (Hoff, 1962), Union 007, 008, 009, 010, 023, 026, 027, 028, 029, 037, 039, 041, 042, 047, 052, 057, 065, 066, 073, 076, 080, 094, 102, 115, 128, 148, 153, 173, 175, 176, 188, 189, 190, 191, 193, 194, 195, 239, 245, 257, 259, 263, 265, 273, 277, 285, 302, 309, 311, 314, 318, 324, 327, 333, 334, 336, 338, 339, 354, 355, 356, 363, 364, 365, 368, 369, 371, 375, 376, 377, 379, 382, 408, 409, 411, 414, 416, 419, 431, 432, 436, 437, 439, 442, 443, 444, 445, 446, 447, 455, 456, 457, 459, 472, 485, 491, 493, 495, 498, 503, 519, 531, 532, 536, 547, 552, 572, 576, 582, 584, 591, 592, 608, 618, 619, 624, 637, 640, 646
Euconulus fulvus	Bernalillo, Catron, Chaves, Cibola, Colfax, Doña Ana, Eddy, Grant, Hidalgo, Lincoln, McKinley, Mora, Otero, Quay, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance, Union 001, 003, 007, 009, 010, 013, 014, 016, 017, 019, 020, 021, 022, 023, 024, 025, 030, 032, 038, 039, 041, 043, 044, 048, 066, 080, 084, 085, 093, 094, 109, 118, 128, 131, 142, 148, 152, 163, 164, 173, 176, 183, 184, 185, 186, 187, 188, 189, 191, 192, 193, 194, 195, 196, 198, 199, 200, 202, 205, 207, 220, 222, 225, 227, 230, 236, 239, 244, 249, 250, 253, 256, 259, 261, 266, 268, 270, 271, 273, 278, 279, 280, 282, 286, 288, 302, 309, 313, 314, 315, 316, 318, 324, 327, 328, 329, 330, 332, 333, 334, 336, 337, 338, 339, 340, 341, 343, 346, 347, 349, 352, 353, 354, 356, 359, 363, 364, 365, 366, 367, 369, 370, 371, 374, 375, 377, 381, 382, 383, 385, 386, 387, 389, 390, 393, 407, 408, 410, 411, 413, 414, 417, 418, 419, 429, 431, 433, 436, 437, 438, 439, 443, 444, 445, 446, 447, 448, 450, 455, 456, 457, 459, 465, 467, 468, 471, 472, 474, 475, 477, 478, 489, 491, 493, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 508, 510, 514, 518, 519, 522, 523, 531, 532, 544, 545, 546, 547, 551, 556, 557, 558, 559, 560, 561, 562, 564, 572, 573, 574, 576, 578, 580, 581, 582, 583, 585, 586, 587, 591, 608, 637, 641, 642, 645, 649, 650
Gastrocopta armifera	Eddy, Guadalupe, Lincoln (ANSP 73944--possibly fossil), Mora, Otero, San Miguel, Union 050, 095, 184, 187, 253, 277, 281, 374, 586, 596, 612, 613, 616

Appendix A (continued)

Gastrocopta ashmuni	Catron, Cibola, Doña Ana, Grant, Guadalupe, Harding, Hidalgo, Lincoln, Luna, McKinley, Otero, Sierra, Socorro, Torrance, Union 015, 020, 026, 059, 060, 079, 080, 091, 132, 142, 154, 156, 157, 158, 159, 160, 161, 162, 163, 165, 166, 167, 170, 171, 172, 197, 206, 211, 227, 228, 229, 234, 242, 251, 267, 268, 269, 287, 289, 310, 312, 322, 323, 336, 350, 380, 396, 405, 410, 420, 422, 424, 425, 427, 428, 441, 460, 462, 486, 499, 525, 527, 529, 530, 542, 546, 547, 587, 649
Gastrocopta cochisensis	Hidalgo 128, 173
Gastrocopta contracta	Chaves, Eddy, Otero 001, 025, 038, 183, 184, 185, 202, 203, 250, 253, 352, 353
Gastrocopta cristata	Doña Ana, Eddy, Grant, Lea, Lincoln (USNM 152373), Luna, Otero, Roosevelt, Sierra, Socorro, Union 082, 086, 088, 256, 297, 298, 307, 308, 567, 568, 569, 570, 597, 599, 617, 627, 628, 629, 634, 638, 652
Gastrocopta dalliana	Union 173
Gastrocopta holzingeri	Mora, San Miguel (ANSP 11617 and USNM 152114), Santa Fe (USNM 152112--by E. H. Ashmun), Socorro (ANSP 83042), Union 050, 277, 286, 327, 374
Gastrocopta pellucida	Chaves, Cibola, Colfax, De Baca, Doña Ana, Eddy, Grant, Guadalupe, Harding, Hidalgo, Lea, Lincoln, Luna, Mora, Otero, Quay, Roosevelt, San Miguel, Santa Fe, Sierra 005, 020, 026, 036, 059, 064, 071, 088, 091, 101, 104, 105, 106, 111, 112, 122, 137, 139, 140, 141, 142, 154, 156, 157, 158, 159, 160, 161, 162, 163, 165, 166, 167, 172, 173, 181, 197, 204, 211, 228, 229, 234, 235, 242, 247, 248, 251, 256, 269, 277, 296, 299, 307, 323, 350, 353, 357, 358, 360, 361, 362, 372, 373, 394, 395, 397, 398, 399, 400, 401, 402, 403, 404, 415, 420, 424, 425, 427, 428, 430, 440, 441, 460, 461, 462, 486, 499, 500, 507, 525, 529, 530, 542, 566, 587, 594, 597, 599, 600, 606, 613, 649, 650, 657, 658, 659, 663
Gastrocopta pentodon	Colfax, Eddy, Lincoln, Mora, Union 001, 002, 038, 048, 191, 283, 285, 286, 352, 412, 413
Gastrocopta pilsbryana	Bernalillo, Catron, Chaves, Cibola, Colfax, Doña Ana, Eddy, Grant, Hidalgo, Lincoln, Luna, McKinley, Mora, Otero, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance, Union, Valencia 007, 008, 009, 010, 013, 014, 016, 017, 019, 020, 021, 022, 024, 025, 039, 053, 065, 079, 080, 092, 093, 094, 095, 128, 148, 164, 171, 173, 183, 184, 185, 186, 187, 188, 189, 191, 192, 193, 194, 195, 198, 199, 201, 202, 203, 205, 207, 223, 225, 226, 236, 239, 244, 245, 251, 253, 256, 259, 261, 264, 265, 266, 268, 269, 270, 271, 273, 274, 275, 279, 283, 285, 288, 289, 309, 310, 311, 312, 313, 314, 316, 317, 318, 321, 329, 333, 336, 337, 340, 341, 342, 343, 344, 346, 349, 351, 352, 354, 356, 359, 363, 365, 366, 367, 368, 369, 370, 375, 377, 378, 380, 381, 382, 383, 384, 391, 392, 405, 406, 409, 410, 411, 414, 417, 418, 419, 421, 429, 431, 432, 433, 434, 435, 436, 437, 438, 439, 442, 444, 446, 447, 448, 452, 453, 456, 459, 460, 461, 462, 463, 465, 468, 469, 470, 471, 472, 474, 477, 478, 480, 484, 488, 489, 490, 491, 492, 494, 496, 497, 498, 499, 500, 501, 502, 503, 504, 506, 507, 508, 510, 511, 515, 520, 523, 526, 528, 531, 532, 544, 545, 546, 547, 554, 556, 558, 559, 560, 561, 562, 563, 564, 573, 574, 576, 577, 578, 579, 580, 582, 583, 584, 585, 586, 588, 645, 650, 653
Gastrocopta procera	Chaves, Curry, Eddy, Guadalupe, Lincoln, Otero, Quay, San Miguel, Socorro (UMMZ 67950), Union 030, 051, 095, 101, 107, 108, 110, 113, 120, 183, 188, 201, 202, 203, 253, 284, 296, 298, 326, 358, 360, 395, 398, 586, 650

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Gastrocopta prototypus	Catron, Grant 498, 592
Gastrocopta quadridens	Bernalillo, Catron, Cibola, Grant, Lincoln, Otero, San Miguel, Sandoval, Sierra, Socorro, Taos 188, 192, 239, 240, 257, 265, 309, 382, 439, 472, 476, 482, 501, 502, 505, 560, 653
Glyphyalinia indentata	Catron, Chaves, Cibola, Colfax, Doña Ana, Eddy, Grant, Hidalgo, Lincoln, Luna, Mora, Otero, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance 001, 002, 003, 004, 005, 009, 010, 011, 013, 014, 019, 020, 028, 030, 038, 053, 056, 060, 066, 079, 084, 091, 100, 101, 115, 128, 130, 131, 138, 142, 143, 153, 160, 161, 162, 163, 164, 165, 171, 173, 174, 181, 183, 184, 185, 187, 192, 193, 197, 201, 202, 203, 204, 205, 227, 229, 234, 236, 242, 244, 250, 251, 268, 270, 279, 282, 301, 302, 309, 313, 316, 318, 319, 321, 336, 337, 340, 341, 342, 343, 347, 349, 350, 352, 353, 354, 355, 359, 365, 375, 380, 381, 382, 391, 396, 405, 408, 410, 414, 418, 419, 420, 422, 424, 425, 429, 431, 433, 435, 436, 438, 446, 447, 454, 457, 459, 460, 462, 465, 475, 486, 490, 493, 498, 499, 500, 503, 508, 510, 531, 532, 544, 545, 546, 547, 559, 574, 575, 576, 578, 579, 583, 585, 587, 592, 593, 625, 643, 649, 650, 659
Hawaiia minuscula	Bernalillo, Catron, Chaves, Cibola, Colfax, Doña Ana, Eddy, Grant, Guadalupe, Harding, Hidalgo, Lincoln, Luna, McKinley, Mora, Otero, Quay, Rio Arriba, Roosevelt, San Juan, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Torrance, Union 001, 009, 013, 014, 017, 019, 020, 021, 023, 024, 028, 030, 038, 053, 059, 069, 080, 082, 084, 088, 089, 091, 092, 095, 108, 110, 120, 122, 158, 159, 160, 162, 164, 165, 167, 176, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 198, 199, 202, 204, 205, 222, 225, 230, 234, 244, 250, 251, 253, 256, 262, 264, 266, 268, 269, 270, 274, 286, 288, 289, 299, 307, 311, 315, 318, 322, 324, 327, 329, 336, 349, 352, 353, 361, 364, 367, 372, 391, 394, 395, 397, 398, 404, 412, 415, 419, 424, 430, 431, 433, 436, 437, 439, 447, 448, 451, 458, 459, 460, 461, 462, 464, 465, 468, 471, 472, 478, 492, 497, 498, 499, 500, 501, 503, 504, 505, 506, 507, 508, 517, 520, 525, 531, 532, 544, 545, 546, 547, 554, 558, 563, 573, 575, 576, 579, 584, 589, 595, 596, 597, 599, 600, 603, 606, 612, 617, 622, 640, 641, 645, 650, 652
Helicodiscus eigenmanni	Bernalillo, Catron, Chaves (Pilsbry, 1948), Colfax, Doña Ana, Eddy, Grant, Harding, Lincoln, Luna (Pilsbry, 1948), Mora, Otero, Rio Arriba, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Torrance, Union 010, 014, 019, 020, 036, 038, 079, 080, 106, 112, 113, 120, 130, 131, 142, 149, 171, 176, 179, 183, 185, 188, 189, 193, 194, 228, 236, 244, 252, 256, 270, 275, 277, 279, 288, 298, 299, 301, 302, 309, 313, 318, 343, 346, 373, 374, 378, 380, 414, 416, 431, 433, 436, 446, 447, 458, 471, 472, 478, 495, 497, 498, 499, 500, 501, 503, 504, 505, 508, 510, 523, 531, 532, 544, 546, 547, 570, 573, 583, 588, 641, 644, 649, 650
Helicodiscus singleyanus	Chaves, Colfax, De Baca, Doña Ana, Eddy, Grant, Hidalgo, Mora, Otero, Roosevelt, San Miguel 005, 012, 137, 139, 140, 141, 247, 256, 281, 308, 350, 358, 398, 399, 401, 404, 414, 415, 440, 441, 451, 462, 530, 594
Helix aspersa	Bernalillo, Doña Ana, Eddy, Grant, Lea, Otero, Santa Fe, Socorro 590, 595, 599, 604, 605, 607, 611, 617, 626, 627, 636, 662
Holospira cockerelli	Sierra 236, 509, 649, 655
Holospira crossei	Hidalgo 251, 323, 460, 462
Holospira metcalfi	Hidalgo 137, 139, 140, 660, 663

Appendix A (continued)

Holospira montivaga	Eddy 001, 301
Humboldtiana ultima	Eddy 001, 002, 301, 352, 353
Lehmannia valentiana	Bernalillo 651
Limax flavus	Grant 567, 570
Linisa texasiana	Chaves, Eddy 292, 300, 596, 599, 606, 656
Metastoma roemeri	Doña Ana, Eddy, Otero, Sierra 011, 091, 125, 154, 158, 159, 161, 167, 168, 169, 206, 210, 211, 213, 214, 232, 237, 301
Microphysula ingersolli	Bernalillo, Catron, Cibola, Colfax, Grant, Lincoln, Los Alamos, Otero, Rio Arriba, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance 021, 030, 043, 077, 093, 094, 117, 129, 152, 153, 175, 185, 186, 187, 188, 189, 192, 196, 198, 200, 239, 256, 257, 265, 275, 279, 282, 288, 309, 314, 318, 333, 338, 341, 343, 349, 354, 355, 356, 363, 369, 375, 377, 382, 383, 385, 393, 407, 414, 416, 418, 429, 431, 437, 439, 447, 450, 459, 465, 472, 476, 478, 479, 481, 482, 483, 485, 495, 497, 501, 502, 504, 505, 508, 531, 532, 572, 573, 576, 581, 584, 588, 640, 653
Nesovitrea hammonis	Bernalillo, Catron, Cibola, Colfax, Mora, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Taos, Union. Records for *Retinella electrina* from Grant and Luna counties (Pilsbry, 1946) are probably in error, as they are not listed by Pilsbry (1915) and Pilsbry and Ferriss (1917) from these counties. 032, 037, 041, 047, 052, 114, 117, 118, 148, 149, 263, 278, 280, 282, 283, 286, 324, 327, 328, 329, 332, 381, 383, 385, 386, 390, 411, 412, 414, 419, 455, 456, 465, 472, 479, 493, 495, 506, 572, 582, 586, 588, 619
Oreohelix barbata	Catron, Doña Ana, Grant 431, 447, 498, 531, 661
Oreohelix confragosa	Grant 142
Oreohelix florida (extinct?)	Luna 059
Oreohelix houghi	Catron, McKinley 238, 538
Oreohelix litoralis	Catron 258, 290, 294, 295, 319, 320, 335
Oreohelix magdalenae	Socorro 009, 219, 309, 313, 574
Oreohelix metcalfei	Grant, Sierra 093, 131, 236, 405, 459, 503, 509, 510, 520, 521, 524, 539, 543, 547, 553, 576, 635, 649, 654, 655

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Oreohelix neomexicana	Bernalillo, Lincoln, Otero, Rio Arriba, San Miguel, Sandoval, Santa Fe, Socorro, Torrance. Reported by Pilsbry (1939) from "Grant, Valencia Co." (=Grants, Cibola Co.). 046, 066, 087, 196, 262, 263, 264, 265, 275, 279, 288, 305, 470, 540, 561, 563, 564, 572, 573, 580, 581, 650
Oreohelix nogalensis	Lincoln, Otero 096, 097, 550, 640
Oreohelix pilsbryi	Sierra 436
Oreohelix strigosa	Bernalillo, Colfax, Mora, Rio Arriba, San Juan (see text), San Miguel, Sandoval, Santa Fe, Taos, Union (ANSP 156440). Record from McKinley Co. (Pilsbry, 1939) is very questionable (see text). 032, 041, 043, 072, 117, 129, 149, 151, 196, 280, 282, 303, 306, 383, 384, 385, 393, 407, 411, 414, 450, 455, 474, 493, 495, 502, 504, 505, 550, 579, 588, 631
Oreohelix subrudis	Catron, Grant, Sierra, Socorro 033, 034, 057, 073, 093, 130, 153, 174, 239, 287, 302, 304, 334, 340, 341, 346, 347, 365, 369, 375, 376, 380, 382, 432, 433, 435, 437, 459, 489, 490, 491, 503
Oreohelix swopei	Grant, Sierra (both county records from Pilsbry, 1939)
Oxychilus draparnaudi	Lea, San Miguel, Santa Fe 607, 614, 627
Oxyloma retusum	Grant (Wu, 1993), Otero 027, 533
Paralaoma caputspinulae	Lincoln, Otero, Santa Fe, Socorro 188, 193, 339
Polygyra septemvolva	Eddy; probably in Doña Ana
Punctum minutissimum	Catron, Cibola, Colfax, Lincoln, Otero, Sandoval, Santa Fe, Sierra, Socorro, Union 024, 185, 186, 188, 192, 194, 259, 280, 286, 339, 508, 576, 582, 653
Pupilla blandi	Bernalillo, Catron, Cibola, Colfax, Grant, Lincoln, Luna, Mora, Otero, Rio Arriba, San Juan, Sandoval, Santa Fe (Hoff, 1962), Sierra, Socorro, Taos, Torrance, Union 007, 021, 022, 023, 024, 025, 028, 030, 039, 043, 044, 046, 047, 094, 111, 117, 118, 185, 186, 187, 188, 189, 191, 192, 193, 194, 195, 196, 198, 199, 200, 205, 220, 230, 239, 245, 249, 250, 256, 273, 277, 288, 311, 318, 331, 333, 334, 338, 339, 356, 383, 384, 385, 387, 392, 393, 407, 413, 414, 437, 439, 449, 450, 456, 465, 472, 482, 485, 488, 493, 495, 502, 504, 505, 528, 544, 545, 546, 559, 560, 574, 584, 608, 624, 632
Pupilla hebes	Cibola, Colfax, McKinley. Records from Mora and San Miguel counties (Pilsbry, 1948) and from Mora and Santa Fe counties (Hoff, 1962) seem questionable 272, 330, 331, 514, 518
Pupilla muscorum	Colfax, Lincoln, Otero, Rio Arriba, San Juan, Sierra, Torrance, Union 048, 049, 050, 067, 102, 122, 195, 283, 286, 324, 325, 327, 328, 329, 332, 374, 385, 390, 391, 408, 448, 453, 455, 465, 495, 506, 507, 560, 619, 630, 640

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Pupilla sonorana	Chaves, Doña Ana, Eddy, Hidalgo, Lincoln, Otero, Sierra, Socorro 001, 013, 014, 016, 017, 019, 021, 022, 023, 024, 025, 026, 030, 095, 119, 164, 176, 184, 185, 186, 187, 188, 189, 190, 191, 192, 194, 195, 198, 199, 200, 201, 202, 203, 205, 220, 225, 226, 230, 249, 250, 253, 256, 259, 268, 269, 270, 349, 352, 353, 462, 465, 468, 496, 500, 501, 560, 561, 563, 564, 585, 645, 650
Pupilla syngenes	Cibola 314, 316, 578
Pupoides albilabris	Chaves, De Baca, Doña Ana, Eddy, Grant, Hidalgo, Lea, Mora, Quay, Roosevelt, San Miguel, Sierra, Torrance, Union 051, 064, 070, 078, 081, 086, 105, 107, 108, 110, 112, 113, 120, 122, 204, 246, 247, 248, 284, 296, 298, 299, 307, 325, 357, 358, 362, 373, 395, 398, 400, 404, 451, 566, 568, 594, 597, 598, 599, 606, 616, 665
Pupoides hordaceus	Cibola, Guadalupe, McKinley, Rio Arriba, Torrance. Records from Grant and San Miguel counties (Pilsbry, 1948) seem questionable. 040, 103, 122, 123, 260, 578, 613
Pupoides inornatus	Quay, San Miguel, Union 110, 112, 120, 121, 296
Rabdotus dealbatus	Doña Ana, Eddy, Lincoln, Otero 002, 005, 091, 098, 099, 100, 101, 124, 125, 161, 183, 184, 201, 203, 208, 212, 214, 224, 229, 237, 254, 301, 535, 575
Rabdotus durangoanus	Doña Ana, Grant, Hidalgo, Otero 011, 137, 140, 213, 657, 660, 663
Radiocentrum ferrissi	Hidalgo 251
Radiocentrum hachetanum	Hidalgo 460, 461, 462, 466, 549
Radiodiscus millecostatus	Catron, Lincoln, Otero, Socorro 176, 185, 192, 193, 198, 200, 309, 377, 465, 653
Rumina decollata	Bernalillo, Chaves, Eddy, Grant, Lea, Otero, Roosevelt, Socorro 182, 594, 596, 597, 599, 600, 602, 603, 605, 617, 627, 628, 629, 634, 664
Sonorella animasensis	Hidalgo 128, 173
Sonorella hachitana	Hidalgo, Luna 006, 059, 060, 241, 242, 243, 291, 461, 462, 466, 534, 660
Sonorella metcalfi	Doña Ana 146
Sonorella orientis	Doña Ana, Sierra, Socorro 013, 014, 016, 019, 020, 053, 091, 135, 136, 138, 144, 156, 159, 163, 171, 177, 179, 180, 209, 217, 223, 226, 227, 229, 268, 270, 562, 648

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Sonorella todseni	Doña Ana 147
Striatura meridionalis	Bernalillo, Catron, Cibola, Doña Ana, Eddy, Grant, Hidalgo, Lincoln, Luna, Otero, Sandoval, Santa Fe, Sierra, Socorro, Torrance, Valencia 001, 002, 009, 014, 021, 022, 030, 080, 084, 095, 128, 164, 171, 173, 184, 185, 189, 192, 193, 194, 200, 205, 207, 220, 225, 244, 253, 256, 259, 264, 270, 271, 275, 279, 288, 309, 310, 312, 313, 317, 318, 322, 330, 333, 338, 339, 340, 342, 343, 349, 352, 354, 355, 363, 364, 365, 367, 375, 377, 378, 382, 409, 417, 418, 420, 429, 431, 432, 433, 434, 437, 438, 439, 446, 447, 459, 465, 473, 475, 476, 478, 489, 494, 497, 498, 500, 501, 503, 508, 528, 532, 546, 547, 560, 576, 577, 580, 645, 650, 653
Succinea forsheyi	Reported (as *S. concordialis*) by Wu (1993) from Quay and San Miguel counties.
Succinea grosvenori	Otero (Wu, 1993). Some or all of the records of *S. avara* (Franzen, 1982) may appertain to this species: Doña Ana, Eddy, Otero, Union counties. Many other county records may be represented by the large numbers of shells collected, but not determined to species. 565
Succinea luteola	Doña Ana
Succinea vaginacontorta	Colfax (Wu, 1993), San Miguel (Franzen, 1971), Union (Wu, 1993)
Thysanophora hornii	Doña Ana, Eddy, Grant, Hidalgo, Lincoln, Luna, Sierra 015, 060, 071, 132, 137, 140, 158, 160, 162, 165, 166, 170, 181, 228, 235, 242, 251, 323, 420, 440, 441, 451, 542, 566, 575, 648, 657, 658
Vallonia cyclophorella	Bernalillo, Catron, Cibola, Colfax, Grant, Lincoln, McKinley, Mora (Hoff, 1962), Otero, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance, Union 007, 021, 023, 024, 030, 032, 039, 043, 044, 045, 046, 047, 065 067, 068, 085, 117, 148, 175, 184, 185, 186, 187, 188, 189, 191, 192, 193, 194, 195, 196, 198, 199, 200, 205, 220, 239, 245, 249, 250, 256, 259, 262, 265, 273, 275, 278, 282, 288, 309, 324, 330, 333, 334, 339, 349, 369, 384, 385, 386, 387, 389, 392, 393, 407, 448, 450, 455, 456, 472, 478, 482, 488, 493, 495, 501, 502, 504, 505, 508, 513, 518, 554, 559, 560, 561, 563, 564, 574, 578, 579, 584, 585, 592, 622, 623, 640, 641, 647, 650
Vallonia gracilicosta	Bernalillo, Chaves, Cibola, Colfax, Curry, De Baca, Eddy, Grant, Guadalupe, Harding, Lea, Lincoln, Luna, Mora, Otero, Quay, Rio Arriba, San Juan, San Miguel, Santa Fe, Socorro, Taos, Torrance, Union 023, 024, 025, 026, 027, 028, 029, 030, 040, 046, 047, 048, 049, 050, 051, 059, 095, 101, 105, 106, 107, 108, 110, 111, 112, 113, 114, 118, 120, 121, 122, 123, 184, 185, 186, 187, 188, 192, 193, 194, 198, 202, 204, 205, 221, 230, 253, 256, 276, 277, 280, 281, 283, 284, 285, 286, 296, 297, 298, 299, 324, 325, 326, 327, 328, 348, 360, 361, 372, 373, 374, 390, 391, 395, 399, 402, 411, 412, 413, 414, 415, 419, 449, 453, 465, 502, 504, 506, 507, 529, 545, 558, 563, 564, 571, 578, 585, 586, 587, 590, 593, 594, 601, 603, 604, 605, 607, 609, 610, 612, 613, 614, 616, 617, 618, 619, 622, 623, 624, 626, 628, 632, 636, 642, 650
Vallonia parvula	Chaves, Guadalupe, Harding, Mora, Quay, Union 107, 204, 221, 277, 285, 297, 298, 299, 525, 613

Appendix A (continued)

Vallonia perspectiva	Bernalillo, Catron, Chaves, Cibola, Doña Ana, Eddy, Grant, Harding, Hidalgo, Lincoln, Luna, Otero, San Juan, San Miguel, Sierra, Socorro 001, 004, 009, 013, 014, 016, 017, 019, 020, 021, 023, 024, 026, 038, 052, 053, 059, 060, 079, 080, 092, 095, 101, 106, 131, 142, 157, 163, 164, 171, 183, 184, 185, 186, 187, 188, 189, 191, 192, 194, 195, 197, 198, 199, 201, 202, 203, 205, 220, 223, 225, 226, 227, 230, 236, 251, 253, 256, 262, 266, 268, 269, 270, 273, 302, 311, 318, 340, 341, 352, 353, 378, 380, 381, 396, 410, 421, 431, 433, 434, 435, 436, 438, 446, 447, 448, 457, 459, 460, 461, 462, 465, 468, 491, 492, 498, 499, 503, 510, 520, 523, 527, 528, 531, 532, 544, 546, 547, 560, 561, 562, 563, 564, 570, 571, 574, 576, 585, 645, 649, 650, 664
Vallonia pulchella	Bernalillo, Cibola, Doña Ana, Eddy, Grant, Lea, Luna, Otero, Roosevelt, San Juan, San Miguel, Santa Fe, Socorro, Torrance 029, 569, 570, 571, 578, 586, 589, 590, 595, 597, 604, 606, 607, 615, 617, 618, 619, 620, 621, 622, 623, 626, 627, 629, 632, 636, 638
Vallonia sonorana	Hidalgo 462
Vertigo elatior	Cibola, Colfax, Otero, Sandoval, Socorro (Pilsbry, 1948) 037, 187, 330, 332, 407, 514, 518
Vertigo gouldii	Bernalillo, Catron, Cibola, Colfax, Doña Ana, Eddy, Grant, Lincoln, Otero, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance, Union 001, 007, 013, 016, 021, 023, 024, 025, 030, 093, 118, 164, 176, 184, 185, 186, 187, 188, 192, 194, 198, 199, 200, 205, 225, 245, 253, 256, 259, 270, 275, 278, 280, 282, 288, 309, 311, 314, 318, 324, 327, 329, 333, 349, 354, 356, 363, 365, 369, 381, 382, 383, 384, 387, 389, 411, 414, 418, 431, 432, 437, 439, 456, 459, 465, 495, 497, 500, 501, 502, 503, 504, 506, 508, 531, 547, 551, 552, 560, 582, 584, 588, 645, 650, 653
Vertigo hinkleyi	Hidalgo 128, 173
Vertigo milium	No records of living specimens
Vertigo modesta	Bernalillo, Catron, Cibola, Colfax, Grant, Lincoln, Los Alamos, Otero, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Socorro, Taos 007, 021, 022, 039, 043, 044, 077, 085, 117, 118, 184, 185, 186, 187, 188, 189, 191, 192, 193, 195, 196, 198, 199, 200, 205, 239, 240, 256, 257, 262, 273, 309, 311, 314, 330, 334, 339, 349, 356, 363, 365, 366, 371, 375, 376, 377, 382, 387, 393, 407, 414, 437, 445, 448, 450, 456, 467, 472, 476, 481, 482, 483, 485, 495, 501, 502, 504, 505, 546, 640, 653
Vertigo ovata	Eddy, Socorro 252, 308
Vitrina pellucida	Bernalillo, Catron, Cibola, Colfax, Grant, Lincoln, Los Alamos, McKinley (Pilsbry, 1946), Mora, Otero, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Sierra (Pilsbry, 1946), Socorro, Taos, Torrance, Union 009, 021, 024, 025, 027, 030, 037, 041, 043, 044, 052, 067, 077, 084, 117, 129, 148, 149, 176, 184, 185, 186, 187, 188, 190, 192, 193, 195, 196, 198, 199, 200, 205, 220, 249, 250, 253, 255, 256, 259, 263, 264, 275, 278, 279, 280, 283, 286, 288, 324, 329, 330, 331, 349, 376, 379, 383, 385, 386, 387, 389, 390, 393, 407, 408, 414, 419, 437, 448, 450, 455, 465, 467, 472, 474, 483, 485, 488, 495, 497, 504, 505, 552, 557, 572, 573, 580, 581, 582, 586, 587, 588, 618, 640, 647, 650, 653

Appendix A (continued)

Zonitoides arboreus	Bernalillo, Catron, Cibola, Chaves, Colfax, De Baca, Eddy, Grant, Guadalupe, Harding, Lincoln, Los Alamos, McKinley, Mora, Otero, Rio Arriba, San Juan, San Miguel, Sandoval, Santa Fe, Sierra, Socorro, Taos, Torrance, Union, Valencia 001, 003, 008, 009, 021, 022, 024, 026, 027,, 028, 029, 030, 036, 037, 039, 041, 042, 043, 044, 045, 047, 048, 049, 051, 052, 065, 066, 067, 068, 077, 084, 092, 093, 094, 105, 106, 114, 115, 117, 118, 119, 129, 148, 152, 153, 174, 176, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 198, 199, 200, 201, 202, 207, 222, 230, 244, 249, 253, 255, 259, 261, 263, 265, 272, 273, 274, 275, 278, 279, 281, 282, 285, 286, 288, 289, 302, 309, 310, 311, 313, 314, 317, 318, 324, 327, 328, 329, 330, 331, 332, 333, 334, 337, 338, 339, 343, 344, 345, 346, 349, 351, 352, 354, 356, 359, 364, 365, 367, 369, 370, 371, 374, 375, 376, 377, 379, 381, 382, 383, 384, 385, 386, 387, 389, 390, 391, 392, 393, 406, 408, 409, 411, 412, 413, 414, 416, 417, 418, 419, 423, 426, 429, 431, 433, 434, 436, 437, 438, 439, 442, 443, 444, 445,446, 447, 448, 450, 453, 454, 455, 456, 459, 464, 465, 472, 473, 474, 475, 476, 477, 478, 479, 480, 482, 484, 485, 487, 488, 489, 491, 492, 493, 495, 497, 498, 500, 501, 502, 503, 504, 505, 506, 507, 510, 511, 512, 514, 515, 516, 517, 518, 519, 520, 522, 525, 526, 531, 532, 537, 547, 551, 552, 555, 556, 557, 558, 569, 570, 571, 572, 573, 574, 576, 577, 578, 579, 580, 581, 582, 586, 588, 591, 592, 596, 605, 608, 612, 613, 616, 617, 618, 619, 621, 624, 637, 640, 641, 644, 646, 647, 650, 653

APPENDIX B

County, general location, and UTM zone and coordinates for lot numbers included in Part 1 (Metcalf and Smartt).

			UTM Coordinates		
No.	**County**	**Location**	**Zone**	**Northing**	**Easting**
001	Eddy	Guadalupe Mts.	13	3543900	518200
002	Eddy	Guadalupe Mts.	13	3542800	518200
003	Eddy	Guadalupe Mts.	13	3544200	519000
004	Eddy	Guadalupe Mts.	13	3567000	528200
005	Eddy	Guadalupe Mts.	13	3546600	518900
006	Luna	Florida Mts.	13	3560000	252200
007	Socorro	San Mateo Mts.	13	3752900	267800
008	Sierra	Black Range	13	3704900	234300
009	Socorro	Magdalena Mts.	13	3767000	301900
010	Catron	Mogollon Mts.	13	3687300	753200
011	Otero	Sacramento Mts.	13	3624200	415200
012	Chaves	Pecos Valley	13	3634400	510200
013	Doña Ana	Organ Mts.	13	3580500	351500
014	Doña Ana	Organ Mts.	13	3578400	352900
015	Doña Ana	Organ Mts.	13	3579000	351200
016	Doña Ana	Organ Mts	13	3578500	354000
017	Doña Ana	Organ Mts.	13	3578200	353900
018	Doña Ana	Organ Mts.	13	3576900	352200
019	Doña Ana	Organ Mts.	13	3576900	352200
020	Doña Ana	Organ Mts.	13	3577500	352300
021	Otero	Sacramento Mts.	13	3651400	438000
022	Otero	Sacramento Mts.	13	3655000	435200
023	Otero	Sacramento Mts.	13	3656100	434800
024	Otero	Sacramento Mts.	13	3660100	433300
025	Otero	Sacramento Mts.	13	3665800	431200
026	Otero	Sacramento Mts.	13	3669500	423200
027	Otero	Sacramento Mts.	13	3660100	430100
028	Otero	Sacramento Mts.	13	3668200	428700
029	Otero	Sacramento Mts.	13	3669100	419200
030	Otero	Sacramento Mts.	13	3654400	435800
031	Sandoval	Jemez Mts.	13	3960000	385000
032	San Miguel	Sangre de Cristo Mts.	13	3957500	439500
033	Grant	Mogollon Mts.	12	3676400	753000
034	Catron	Mogollon Mts.	12	3692600	716200
035	Doña Ana	Bishop's Cap Mt.	13	3563400	348200
036	Harding	Canadian Cn.	13	3974700	559000
037	Sandoval	Jemez Mts.	13	3964000	356200
038	Eddy	Guadalupe Mts.	13	3546400	520100
039	Taos	Sangre de Cristo Mts.	13	4002000	448200
040	Rio Arriba	Echo Amphitheater	13	4024600	363200
041	Rio Arriba	San Juan Mts.	13	4028000	389800
042	Los Alamos	Jemez Mts.	13	3984100	382700
043	Taos	Sangre de Cristo Mts.	13	3995300	444600
044	Rio Arriba	San Juan Mts.	13	4051800	377300
045	Rio Arriba	N Rio Grande Valley	13	4000500	410600
046	Rio Arriba	San Juan Mts.	13	4038800	371400
047	Colfax	Sangre de Cristo Mts.	13	4043400	482800
048	Union	Capulin Mt.	13	4071200	592200
049	Union	Capulin Mt.	13	4068400	589800
050	Union	Cimarron Valley	13	4081300	600600
051	Union	Cimarron Valley	13	4087000	624600
052	Catron	Mogollon Mts.	12	3695600	720800
053	Doña Ana	Organ Mts.	13	3578400	353000
054	Doña Ana	Bishop's Cap Mt.	13	3562200	350600
055	Doña Ana	S Rio Grande Valley	13	3559500	334700
056	Hidalgo	Peloncillo Mts.	12	3488000	690800
057	Grant	Black Range	13	3645100	240300
058	Catron	Mogollon Mts.	12	3683400	745400
059	Luna	Florida Mts.	13	3552000	252400
060	Luna	Florida Mts.	13	3552000	251400
061	Doña Ana	Mt. Riley	13	3533400	305800
062	Doña Ana	Mt. Riley	13	3532700	302800
063	Doña Ana	Mt. Riley	13	3533400	303000
064	Doña Ana	La Mesa Plain	13	3543900	306800
065	Lincoln	Gallinas Peak	13	3785200	430800
066	Lincoln	Gallinas Peak	13	3788700	427200
067	Lincoln	Sierra Blanca Mts.	13	3698800	432000
068	Lincoln	Sierra Blanca Mts.	13	3698000	432900
069	Otero	Sacramento Mts.	13	3647100	468200
070	Chaves	Pecos Valley	13	3639700	477700
071	Eddy	Pecos Valley	13	3582100	548800
072	Taos	Sangre de Cristo Mts.	13	3998800	453000
073	Grant	Pinos Altos Mts.	12	3646000	764000
074	Catron	Mogollon Mts.	12	3686200	754900
075	Hidalgo	Peloncillo Mts.	12	3469300	693000
076	Grant	Pinos Altos Mts.	12	3644700	759500
077	Lincoln	Sierra Blanca Mts.	13	3695600	426400
078	Doña Ana	La Mesa Plain	13	3552000	309800
079	Sierra	Black Range	13	3691800	249400
080	Sierra	Black Range	13	3692000	240100
081	Doña Ana	S Rio Grande Valley	13	3597300	316800
082	Sierra	S Rio Grande Valley	13	3640000	285400
083	Doña Ana	La Mesa Plain	13	3532800	314200
084	Torrance	Manzano Mts.	13	3835600	371200
085	Sandoval	Jemez Mts.	13	3982200	380600
086	Sierra	S Rio Grande Valley	13	3629600	284000
087	San Miguel	Sangre de Cristo Mts.	13	3945300	474000
088	Doña Ana	S Rio Grande Valley	13	3584000	324400
089	Hidalgo	SW Lowlands	12	3545300	685700
090	Doña Ana	La Mesa Plain	13	3538400	314200
091	Doña Ana	San Andres Mts.	13	3615800	355100
092	Grant	Black Range	13	3644500	240500
093	Sierra	Black Range	13	3643000	240400
094	Sierra	Black Range	13	3642600	240500
095	Otero	Sacramento Mts.	13	3662900	432900
096	Otero	Sierra Blanca Mts.	13	3695800	419200
097	Lincoln	Sierra Blanca Mts.	13	3706600	425500
098	Lincoln	Sacramento Mts.	13	3692700	451800
099	Lincoln	Sacramento Mts.	13	3685600	440300
100	Lincoln	Sacramento Mts.	13	3688500	451100

Appendix B (continued; lot numbers 101-200)

			UTM Coordinates						UTM Coordinates		
No.	**County**	**Location**	**Zone**	**Northing**	**Easting**	**No.**	**County**	**Location**	**Zone**	**Northing**	**Easting**
101	Lincoln	Sacramento Mts.	13	3688100	453000	151	Rio Arriba	Jemez Mts.	13	398220	379800
102	Otero	Sierra Blanca Mts.	13	3692900	424800	152	Catron	Mogollon Mts.	12	3693900	712600
103	McKinley	NW lowlands	12	3947800	702000	153	Catron	Mogollon Mts.	12	3694700	709800
104	Cibola	Mt. Taylor	13	3885400	246800	154	Doña Ana	San Andres Mts.	13	3602600	363200
105	De Baca	Pecos Valley	13	3828900	556000	155	Doña Ana	San Andres Mts	13	3603100	363200
106	Harding	NE lowlands	13	3961400	606800	156	Sierra	San Andres Mts.	13	3686400	354300
107	Union	NE lowlands	13	4049200	652600	157	Sierra	San Andres Mts.	13	3684500	353100
108	Union	NE lowlands	13	4044200	637600	158	Sierra	San Andres Mts	13	3672400	347700
109	Union	NE lowlands	13	4004200	624400	159	Sierra	San Andres Mts.	13	3660200	351100
110	Union	NE lowlands	13	4063100	651000	160	Doña Ana	San Andres Mts.	13	3637600	352400
111	Union	NE lowlands	13	4082700	637600	161	Doña Ana	San Andres Mts.	13	3634600	352900
112	Union	NE lowlands	13	4070600	633400	162	Sierra	San Andres Mts.	13	3692000	365400
113	Union	NE lowlands	13	4060000	627600	163	Sierra	San Andres Mts.	13	3687500	356200
114	Mora	Sangre de Cristo Mts.	13	3969800	477400	164	Sierra	San Andres Mts.	13	3686500	356400
115	Grant	Black Range	13	3644400	238200	165	Sierra	San Andres Mts.	13	3683800	356600
116	Guadalupe	Central Highlands	13	3835200	489600	166	Doña Ana	San Andres Mts.	13	3599000	361600
117	Taos	Sangre de Cristo Mts.	13	3998600	453000	167	Doña Ana	San Andres Mts.	13	3599600	359600
118	Taos	Sangre de Cristo Mts.	13	3540800	451700	168	Doña Ana	San Andres Mts	13	3600000	359600
119	Otero	Cornudas Mts.	13	3540800	451700	169	Doña Ana	San Andres Mts.	13	3600200	360000
120	San Miguel	Sangre de Cristo Mts.	13	3938800	481300	170	Doña Ana	Organ Mts.	13	3584400	350800
121	San Miguel	NE lowlands	13	3940000	508000	171	Doña Ana	Organ Mts.	13	3578500	352000
122	Torrance	Central highlands	13	3812600	461800	172	Sierra	San Andres Mts.	13	3705200	364400
123	Torrance	Central highlands	13	3795200	449300	173	Hidalgo	Animas Mts.	12	3498300	711100
124	Doña Ana	San Andres Mts.	13	3603800	350000	174	Socorro	San Mateo Mts.	13	3749700	265300
125	Doña Ana	San Andres Mts.	13	3607400	355600	175	Socorro	Magdalena Mts.	13	3768600	295800
126	San Miguel	Sangre de Cristo Mts.	13	3945200	474200	176	Lincoln	Sierra Blanca Mts.	13	3696200	419400
127	Santa Fe	Sangre de Cristo Mts.	13	3956600	425000	177	Doña Ana	Organ Mts.	13	3572200	350100
128	Hidalgo	Animas Mts.	12	3496600	710700	178	Catron	Mogollon Mts.	12	3680400	704700
129	San Miguel	Sangre de Cristo Mts.	13	3964400	440600	179	Doña Ana	Organ Mts.	13	3577300	352900
130	Socorro	San Mateo Mts.	13	3715000	275800	180	Doña Ana	Organ Mts.	13	3577200	352400
131	Sierra	Black Range	13	3652400	244900	181	Sierra	Caballo Mts.	13	3467200	291500
132	Doña Ana	Organ Mts.	13	3567600	352800	182	Otero	Sacramento Mts.	13	3645800	422800
133	Doña Ana	Organ Mts.	13	3567200	352200	183	Otero	Sacramento Mts.	13	3638800	455400
134	Doña Ana	Bishop's Cap Mt.	13	3563200	350300	184	Otero	Sacramento Mts.	13	3635500	444100
135	Doña Ana	Organ Mts.	13	3567600	349200	185	Otero	Sacramento Mts.	13	3634300	438400
136	Doña Ana	Organ Mts.	13	3568400	352600	186	Otero	Sacramento Mts.	13	3633700	433600
137	Grant	Animas Mts.	12	3533500	736400	187	Otero	Sacramento Mts.	13	3632200	431000
138	Doña Ana	Organ Mts.	13	3582200	352000	188	Otero	Sacramento Mts.	13	3632500	427500
139	Grant	Howell's Ridge	12	3529600	742800	189	Lincoln	Sierra Blanca Mts.	13	3696200	418800
140	Grant	Howell's Ridge	12	3530400	742500	190	Lincoln	Sierra Blanca Mts.	13	3696000	417500
141	Grant	Animas Mts.	12	3529000	743400	191	Lincoln	Sierra Blanca Mts.	13	3696000	418200
142	Grant	Pinos Altos Mts.	12	3637500	775500	192	Otero	Sacramento Mts.	13	3633800	426200
143	Hidalgo	Pyramid Peak	12	3568800	714700	193	Lincoln	Sierra Blanca Mts.	13	3696300	418500
144	Doña Ana	Organ Mts.	13	3568700	353000	194	Lincoln	Sierra Blanca Mts.	13	3695900	420000
145	Doña Ana	Organ Mts.	13	3573500	352800	195	Lincoln	Sierra Blanca Mts.	13	3695600	420200
146	Doña Ana	Organ Mts.	13	3567800	353400	196	Bernalillo	Sandia Mts.	13	3895200	369500
147	Doña Ana	Doña Ana Mts	13	3592300	331600	197	Sierra	Caballo Mts.	13	3648600	290200
148	Rio Arriba	San Juan Mts.	13	4037100	400700	198	Otero	Sacramento Mts.	13	3635200	426000
149	Rio Arriba	San Juan Mts.	13	4037800	400200	199	Otero	Sacramento Mts.	13	3637300	426500
150	Sandoval	Jemez Mts.	13	3958000	368000	200	Otero	Sacramento Mts.	13	3637400	436800

Appendix B (continued; lot numbers 201-300)

			UTM Coordinates						UTM Coordinates		
No.	**County**	**Location**	**Zone**	**Northing**	**Easting**	**No.**	**County**	**Location**	**Zone**	**Northing**	**Easting**
201	Otero	Sacramento Mts.	13	3635100	447600	251	Hidalgo	Big Hatchet Mts.	12	3505800	747800
202	Chaves	Sacramento Mts.	13	3641500	467000	252	Socorro	San Mateo Mts.	13	3717200	257400
203	Otero	Sacramento Mts.	13	3642000	458400	253	Otero	Sacramento Mts.	13	3654700	432200
204	Chaves	Sacramento Mts.	13	3638400	491500	254	Otero	Sacramento Mts.	13	3668600	428600
205	Lincoln	Patos Mts.	13	3732400	436100	255	Otero	Sacramento Mts.	13	3646600	417800
206	Doña Ana	San Andres Mts.	13	3603400	363100	256	Otero	Sacramento Mts.	13	3653600	436200
207	Sierra	Black Range	13	3644200	241200	257	Socorro	Magdalena Mts.	13	3762600	298600
208	Eddy	Guadalupe Mts.	13	3570300	528500	258	Catron	San Agustin Plains	13	3748600	224000
209	Doña Ana	Organ Mts.	13	3579800	353500	259	Otero	Sacramento Mts.	13	3617600	431700
210	Doña Ana	San Andres Mts.	13	3608200	356400	260	McKinley	NW lowlands	13	3936200	260600
211	Sierra	San Andres Mts.	13	3678800	335800	261	Lincoln	Gallinas Peak	13	3788800	427000
212	Doña Ana	San Andres Mts.	13	3604100	353700	262	Bernalillo	Sandia Mts.	13	3893200	363300
213	Doña Ana	San Andres Mts.	13	3596800	360800	263	Bernalillo	Sandia Mts.	13	3894900	372200
214	Doña Ana	San Andres Mts.	13	3594800	353000	264	Bernalillo	Sandia Mts.	13	3894100	373500
215	Lincoln	Capitan Mts.	13	3718700	461500	265	Bernalillo	Sandia Mts.	13	3897100	368100
216	Doña Ana	Organ Mts.	13	3579900	357400	266	Doña Ana	Organ Mts.	13	3582400	351800
217	Doña Ana	Organ Mts.	13	3579500	357500	267	Doña Ana	Organ Mts.	13	3587100	352100
218	Doña Ana	Bishop's Cap Mt.	13	3562700	348900	268	Doña Ana	Organ Mts.	13	3579100	356300
219	Socorro	Magdalena Mts.	13	3769600	298600	269	Doña Ana	Organ Mts.	13	3585200	351200
220	Otero	Sacramento Mts.	13	3651300	438400	270	Doña Ana	Organ Mts.	13	3579200	355700
221	Quay	Ogallala Scarp	13	3863500	586200	271	Catron	Gallos Mts.	12	3763400	746000
222	Lincoln	Sierra Blanca Mts.	13	3688400	431400	272	McKinley	Zuñi Mts.	12	3911400	754600
223	Doña Ana	Organ Mts.	13	3579400	355900	273	San Juan	Chuska Mts.	12	3996000	692800
224	Doña Ana	San Andres Mts.	13	3622000	353400	274	McKinley	Zuñi Mts.	12	3921800	723000
225	Doña Ana	Organ Mts.	13	3577000	352700	275	Torrance	Manzano Mts.	13	3832100	369200
226	Doña Ana	Organ Mts.	13	3579700	354500	276	Colfax	NE lowlands	13	4023100	536200
227	Doña Ana	Organ Mts.	13	3582100	350700	277	Mora	NE lowlands	13	3963100	508600
228	Doña Ana	Organ Mts.	13	3573900	352800	278	Colfax	Cimarron Valley	13	4093000	555400
229	Doña Ana	San Andres Mts.	13	3621200	354900	279	Torrance	Manzano Mts.	13	3849600	373400
230	Otero	Sacramento Mts.	13	3667200	430300	280	Colfax	Cimarron Valley	13	4088600	563900
231	Doña Ana	Organ Mts.	13	3584400	351600	281	Mora	NE lowlands	13	3963600	510600
232	Doña Ana	San Andres Mts.	13	3628000	352000	282	San Miguel	Sangre de Cristo Mts.	13	3958600	440100
233	Doña Ana	San Andres Mts.	13	3628100	352600	283	Colfax	Cimarron Valley	13	4083600	584200
234	Doña Ana	San Andres Mts.	13	3604600	360000	284	Union	Cimarron Valley	13	4080200	592400
235	Doña Ana	San Andres Mts.	13	3604500	360300	285	Mora	NE lowlands	13	3985000	529800
236	Sierra	Black Range	13	3672400	248300	286	Union	Cimarron Valley	13	4080600	588900
237	Doña Ana	San Andres Mts.	13	3602800	358500	287	Catron	Tularosa Mts.	12	3752800	730300
238	McKinley	Zuñi Mts.	12	3884000	702100	288	Torrance	Manzano Mts	13	3845600	372900
239	Socorro	San Mateo Mts.	13	3743700	271400	289	McKinley	Zuñi Mts.	12	3918900	724700
240	San Miguel	Sangre de Cristo Mts.	13	3963400	438600	290	Catron	Luera Mts.	12	3745600	775600
241	Luna	Florida Mts.	13	3553700	252200	291	Luna	Florida Mts.	13	3554800	252000
242	Luna	Florida Mts.	13	3551800	251400	292	Chaves	Pecos Valley Chaves	13	3698600	555000
243	Luna	Florida Mts.	13	3551700	251200	293	Grant	Mogollon Mts.	12	3670200	736000
244	Socorro	Ladron Mts	13	3813000	309600	294	Catron	San Agustin Plains	12	3736000	753400
245	Lincoln	Sierra Blanca Mts.	13	3707300	422400	295	Catron	San Agustin Plains	12	3738100	750900
246	Grant	Black Range	13	3613000	230200	296	Quay	NE lowlands	13	3953000	669400
247	Doña Ana	S Rio Grande Valley	13	3600100	313400	297	Union	NE lowlands	13	4029000	663000
248	Hidalgo	SW lowlands	12	3543100	685700	298	Union	NE lowlands	13	3993200	662200
249	Otero	Sacramento Mts	13	3651400	437600	299	Union	NE lowlands	13	4078700	676600
250	Otero	Sacramento Mts.	13	3649400	435600	300	Chaves	Pecos Valley	13	3702800	554600

Appendix B (continued; lot numbers 301-400)

			UTM Coordinates						UTM Coordinates		
No.	County	Location	Zone	Northing	Easting	No.	County	Location	Zone	Northing	Easting
301	Eddy	Guadalupe Mts.	13	3558200	530400	351	Catron	Tularosa Mts.	12	3743200	736400
302	Socorro	San Mateo Mts.	13	3722000	281000	352	Eddy	Guadalupe Mts.	13	3543500	521600
303	Taos	Sangre de Cristo Mts.	13	4044200	442800	353	Eddy	Guadalupe Mts.	13	3550800	522000
304	Socorro	San Mateo Mts.	13	3722800	271400	354	Catron	Tularosa Mts.	12	3729400	724400
305	Torrance	Manzano Mts.	13	3852000	371600	355	Catron	Tularosa Mts	12	3729200	724000
306	Santa Fe	Sangre de Cristo Mts.	13	3961800	427800	356	Catron	Tularosa Mts.	12	3729200	724300
307	Eddy	Pecos Valley	13	3561000	567400	357	Lea	Ogallala Scarp	13	3634600	620500
308	Eddy	Pecos Valley	13	3560600	566100	358	Eddy	Ogallala Scarp	13	3642100	608600
309	Socorro	Magdalena Mts.	13	3762600	298400	359	Catron	Tularosa Mts.	12	3743400	734000
310	Cibola	Mt. Taylor	12	3893500	765400	360	Guadalupe	Central Highlands	13	3856200	467800
311	Cibola	Mt. Taylor	13	3901700	259700	361	Guadalupe	Central Highlands	13	3850000	468400
312	Cibola	Mt. Taylor	13	3907100	263600	362	Lea	Ogallala Scarp	13	3636200	618600
313	Socorro	Magdalena Mts.	13	3763500	301000	363	Catron	Mogollon Mts.	12	3699400	724600
314	Cibola	Mt. Taylor	13	3907000	263700	364	Catron	Tularosa Mts.	12	3734000	725200
315	Cibola	Mt. Taylor	13	3898200	251400	365	Catron	Mogollon Mts.	12	3699500	725900
316	Cibola	Zuñi Cn.	13	3891400	229900	366	Catron	Mogollon Mts.	12	3705200	721200
317	Torrance	Manzano Mts.	13	3851000	372800	367	Catron	San Francisco Mts	12	3742900	683000
318	Socorro	Magdalena Mts.	13	3764000	302200	368	Grant	Mogollon Mts.	12	3674200	760400
319	Catron	San Augustin Plains	12	3740400	758400	369	Grant	Pinos Altos Mts.	12	3646750	762000
320	Catron	San Augustin Plains	12	3740400	758200	370	Catron	San Francisco Mts.	12	3722750	684000
321	Cibola	Mt. Taylor	12	3889000	773400	371	Catron	Mogollon Mts.	12	3701700	715200
322	Cibola	Mt. Taylor	13	3897700	250800	372	Quay	Ogallala Scarp	13	3863200	584800
323	Hidalgo	Alamo Hueco Mts.	12	3486000	745400	373	Union	NE Mesas	13	4085000	609000
324	Union	Sierra Grande	13	4063400	599200	374	Union	NE Mesas	13	4088100	600500
325	Union	N.E. Mesas	13	4083400	600400	375	Catron	Mogollon Mts	12	3693800	716000
326	Union	N.E. Mesas	13	4086300	617100	376	Catron	Mogollon Mts.	12	3697700	723000
327	Union	Sierra Grande	13	4063400	599000	377	Catron	Mogollon Mts.	12	3703500	717000
328	Union	Sierra Grande	13	4063200	599300	378	Catron	Mogollon Mts.	12	3696600	706000
329	Union	N.E. Mesas	13	4071000	589400	379	Catron	San Francisco Mts.	12	3732300	681500
330	Cibola	Zuñi Mts.	12	3894500	763400	380	Catron	San Francisco Mts.	12	3720500	684000
331	Colfax	Sangre de Cristo Mts.	13	4070100	480900	381	Catron	Mogollon Mts.	12	3700000	733200
332	Colfax	Sangre de Cristo Mts.	13	4070000	482700	382	Catron	Mogollon Mts.	12	3692200	716100
333	Socorro	San Mateo Mts.	13	3748400	270900	383	Rio Arriba	San Juan Mts.	13	4085400	359600
334	Socorro	San Mateo Mts.	13	3751200	270200	384	Rio Arriba	San Juan Mts.	13	4090500	395200
335	Catron	San Agustin Plains	12	3738600	750300	385	Rio Arriba	San Juan Mts.	13	4090600	395000
336	Socorro	San Mateo Mts.	13	3728400	281000	386	Rio Arriba	San Juan Mts.	13	4090500	395000
337	Socorro	San Mateo Mts	13	3728600	282200	387	Rio Arriba	San Juan Mts.	13	4089200	390700
338	Socorro	San Mateo Mts.	13	3746000	271600	388	Doña Ana	Bishop's Cap Mt.	13	3562800	348400
339	Socorro	San Mateo Mts	13	3752600	270200	389	Rio Arriba	San Juan Mts.	13	4094800	342000
340	Socorro	San Mateo Mts.	13	3724800	282200	390	Colfax	NE Mesas	13	4087000	584600
341	Socorro	San Mateo Mts.	13	3733300	266700	391	Colfax	SE Colfax Co. Mts.	13	4047900	570200
342	Socorro	San Mateo Mts.	13	3727200	284000	392	Colfax	Sangre de Cristo Mts.	13	4072000	492100
343	Socorro	San Mateo Mts.	13	3742900	270000	393	Colfax	Sangre de Cristo Mts.	13	4070000	481100
344	Socorro	San Mateo Mts.	13	3716900	275700	394	Quay	Ogallala Scarp	13	3864000	642200
345	Socorro	San Mateo Mts.	13	3719000	275800	395	Curry	Ogallala Scarp	13	3850200	676000
346	Socorro	San Mateo Mts.	13	3717900	276400	396	Sierra	Cuchillo Mts.	13	3684000	256900
347	Socorro	San Mateo Mts.	13	3714100	275200	397	Quay	Ogallala Scarp	13	3869200	673000
348	Torrance	Mesa de los Jumanos	13	3805600	415900	398	Chaves	San Juan Mesa	13	3758000	605600
349	Lincoln	Sierra Blanca Mts.	13	3695900	431600	399	Chaves	Ogallala Scarp	13	3662000	611000
350	Otero	Guadalupe Mts.	13	3565700	511400	400	Quay	Ogallala Scarp	13	3836700	587000

Appendix B (continued; lot numbers 401-500)

			UTM Coordinates		
No.	County	Location	Zone	Northing	Easting
401	DeBaca	Pecos Valley Middle	13	3817800	591200
402	Quay	Ogallala Scarp	13	3863700	585200
403	Quay	Ogallala Scarp	13	3827800	588000
404	Roosevelt	Ogallala Scarp	13	3784900	601800
405	Sierra	Cuchillo Mts.	13	3695000	257800
406	Grant	Pinos Altos Mts.	12	3648500	761500
407	Colfax	Sangre de Cristo Mts.	13	4018300	471400
408	Lincoln	Sierra Blanca Mts	13	3706800	427800
409	Grant	Pinos Altos Mts.	12	3651000	759000
410	Grant	Mogollon Mts.	12	3666800	762600
411	Colfax	Sangre de Cristo Mts.	13	4045200	488800
412	Colfax	Sangre de Cristo Mts.	13	4045800	491200
413	Colfax	SE Colfax Co. Mts.	13	4021600	509600
414	Colfax	Sangre de Cristo Mts.	13	4043300	485900
415	Chaves	Ogallala Scarp	13	3653300	606400
416	Catron	Mogollon Mts.	12	3703400	716600
417	Catron	Gallos Mts.	12	3770000	749000
418	Catron	Gallos Mts.	12	3771400	748500
419	Mora	Sangre de Cristo Mts.	13	4003000	479000
420	Hidalgo	Peloncillo Mts.	12	3496600	696400
421	Catron	Pelona Mt.	12	3729800	768600
422	Catron	Pelona Mt.	12	3729600	768300
423	Catron	Datil Mts.	13	3795200	230200
424	Sierra	Caballo Mts.	13	3647400	291600
425	Sierra	Caballo Mts.	13	3645400	290900
426	Catron	Gallos Mts.	12	3786200	735700
427	Guadalupe	Pecos Valley	13	3850000	505400
428	Lincoln	Valley of Fires	13	3727000	414600
429	Catron	Gallos Mts.	12	3770900	748000
430	Quay	Ogallala Scarp	13	3872300	650200
431	Catron	Mogollon Mts.	12	3682400	711700
432	Grant	Black Range	13	3654300	228200
433	Grant	Black Range	13	3642000	238000
434	Grant	Black Range	13	3636200	239400
435	Catron	Mogollon Mts.	12	3700000	768400
436	Sierra	Black Range	13	3694000	247200
437	Grant	Black Range	13	3656400	232800
438	Grant	Tularosa Mts.	13	3656500	229100
439	Grant	Black Range	13	3655400	233400
440	Hidalgo	Alamo Hueco Mts.	12	3484200	743800
441	Hidalgo	Alamo Hueco Mts.	12	3485600	744000
442	Catron	Tularosa Mts.	12	3736700	733500
443	Catron	Tularosa Mts.	12	3731800	733200
444	Catron	Gallos Mts.	12	3755200	716200
445	Catron	Mogollon Mts	12	3700800	722400
446	Catron	Mogollon Mts.	12	3680600	711400
447	Catron	Mogollon Mts.	12	3681400	711600
448	Lincoln	Sierra Blanca Mts.	13	3707400	430100
449	Lincoln	Jicarilla Mts.	13	3744000	440600
450	Rio Arriba	San Juan Mts.	13	4094000	390800
451	Eddy	Pecos Valley	13	4084000	342800
452	Catron	Elk Mt.	13	3585000	547600
453	Colfax	Kiowa Mesa	13	4055600	578800
454	Catron	Tularosa Mts.	12	3736200	729800
455	Rio Arriba	San Juan Mts.	13	4077800	360000
456	Rio Arriba	San Antonio Mt.	13	4082200	409000
457	Sierra	Black Range	13	3644700	245200
458	Lincoln	Capitan Mts.	13	3721000	486600
459	Grant	Black Range	13	3644000	238000
460	Hidalgo	Big Hatchet Mts.	12	3503600	746000
461	Hidalgo	Big Hatchet Mts.	12	3503400	746600
462	Hidalgo	Big Hatchet Mts.	12	3503200	746000
463	Catron	Gallos Mts.	12	3786600	735600
464	Catron	Datil Mts.	13	3790800	231800
465	Lincoln	Carrizo Mts.	13	3729000	446000
466	Hidalgo	Big Hatchet Mts.	12	3503200	745800
467	Cibola	Mt. Taylor	13	3904100	265600
468	Lincoln	Jicarilla Mts.	13	3744400	436800
469	Catron	Datil Mts.	13	3781400	231800
470	Santa Fe	San Pedro Mts.	13	3896500	391100
471	Sandoval	Jemez Mts.	13	3983600	338400
472	Sandoval	Nacimiento Mts.	13	3985000	331900
473	Catron	Gallos Mts.	12	3772200	711600
474	Sandoval	Nacimiento Mts.	13	3965400	338600
475	Catron	Gallos Mts.	12	3771000	713200
476	Cibola	Mt. Taylor	13	3904200	266400
477	Sandoval	Nacimiento Mts.	13	3973900	337600
478	Sandoval	Nacimiento Mts.	13	3969400	344200
479	Sandoval	Jemez Mts.	13	3978600	346200
480	Valencia	Zuñi Mts.	12	3880900	763600
481	Los Alamos	Jemez Mts.	13	3973000	373900
482	Cibola	Mt. Taylor	13	3904400	264400
483	Cibola	Mt. Taylor	13	3904000	263000
484	Catron	Gallos Mts	12	3773000	711800
485	Cibola	Mt. Taylor	13	3907100	263500
486	Sierra	Caballo Mts.	13	3647500	292200
487	Catron	Gallos Mts.	12	3780200	735200
488	Rio Arriba	San Juan Mts.	13	4084000	342800
489	Catron	Gallos Mts.	12	3774900	718800
490	Catron	Gallos Mts.	12	3754700	731000
491	Catron	Gallos Mts.	12	3756000	716500
492	Lincoln	Jicarilla Mts.	13	3754200	441800
493	Taos	Sangre de Cristo Mts.	13	4060000	453000
494	Valencia	Manzano Mts.	13	3836000	368200
495	Rio Arriba	San Juan Mts.	13	4096300	329800
496	Lincoln	Jicarilla Mts.	13	3745000	437200
497	Lincoln	Capitan Mts.	13	3718400	476600
498	Grant	Mogollon Mts.	12	3674200	717300
499	Sierra	Black Range	13	3644800	256000
500	Lincoln	Capitan Mts.	13	3721400	472200

Appendix B (continued; lot numbers 501-600)

			UTM Coordinates						UTM Coordinates		
No.	**County**	**Location**	**Zone**	**Northing**	**Easting**	**No.**	**County**	**Location**	**Zone**	**Northing**	**Easting**
501	Lincoln	Capitan Mts.	13	3719800	455000	551	Lincoln	Nogal Peak	13	3707000	429800
502	Taos	Sangre de Cristo Mts.	13	4080200	465800	552	Lincoln	Nogal Peak	13	3706600	425400
503	Grant	Black Range	13	3641200	237600	553	Grant	Black Range	13	3635800	240200
504	Rio Arriba	San Juan Mts.	13	4090400	354700	554	Cibola	S of La Ventana	13	3859200	233100
505	Bernalillo	Sandia Mts.	13	3895700	369400	555	Cibola	Zuñi Mts.	12	3882100	761000
506	Colfax	Pine Buttes	13	4049200	574600	556	McKinley	Zuñi Mts.	12	3915800	725900
507	Colfax	Mesa Larga	13	4060900	575900	557	Cibola	Zuñi Mts.	12	3895000	764500
508	Catron	Mogollon Mts.	12	3712600	724800	558	Cibola	S of La Ventana	13	3861200	234200
509	Sierra	Black Range	13	3648500	255300	559	Cibola	S of La Ventana	13	3862000	234600
510	Sierra	Black Range	13	3653100	246900	560	Sierra	Salinas Peak	13	3686000	356600
511	Catron	El Caso Spring area	13	3782000	735200	561	Socorro	Oscura Mts.	13	3724000	372500
512	Cibola	Zuñi Mts.	12	3887200	762000	562	Socorro	Oscura Mts.	13	3730400	372600
513	McKinley	Zuñi Mts.	12	3902500	731900	563	Socorro	Oscura Mts.	13	3735600	372800
514	Cibola	Zuñi Mts.	12	3895000	761000	564	Socorro	Oscura Mts.	13	3725600	372600
515	Catron	Datil Mts.	13	3781300	231700	565	Hidalgo	Gila R. Valley	12	3614800	692000
516	McKinley	Zuñi Mts.	12	3913300	729800	566	Grant	Gila R. Valley	12	3622700	716200
517	McKinley	Zuni Mts.	12	3907000	721400	567	Grant	Gila R. Valley	12	3622000	716000
518	Cibola	Zuni Mts.	12	3894100	763000	568	Grant	Gila R. Valley	12	3621300	714600
519	Sierra	Black Range	13	3640300	240200	569	Grant	Mangas Springs	12	3635400	734000
520	Grant	Black Range	13	3635200	240600	570	Grant	Gila R. Valley	12	3649600	725600
521	Sierra	Black Range	13	3647100	245600	571	Grant	Gila R. Valley	12	3645500	725500
522	Sierra	Black Range	13	3640600	230100	572	Sandoval	Sandia Mts.	13	3901700	371600
523	Sierra	Black Range	13	3647100	245600	573	Sandoval	Sandia Mts.	13	3899600	371600
524	Grant	Black Range	13	3635600	240200	574	Socorro	Magdalena Mts.	13	3774100	302200
525	Harding	Burro Canyon	13	3960900	581000	575	Eddy	Walnut Canyon	13	3560300	550300
526	Catron	Datil Mts.	13	3797500	231200	576	Sierra	Black Range	13	3644100	241400
527	Grant	Cooke Range	13	3604200	244800	577	Bernalillo	Sandia Mts.	13	3892500	370300
528	Grant	Cooke Range	13	3603000	244800	578	Cibola	Bluewater Canyon	13	3909800	769000
529	San Miguel	Las Mesas Negras	13	3950300	554400	579	Los Alamos	White Rock Canyon	13	3963300	392400
530	San Miguel	Las Mesas Negras	13	3946800	558800	580	Bernalillo	Sandia Mts.	13	3897500	371800
531	Catron	Mogollon Mts.	12	3688800	704200	581	Sandoval	Sandia Mts.	13	3902300	372400
532	Catron	Mogollon Mts.	12	3682800	706800	582	Sandoval	Jemez Mts.	13	3952200	353000
533	Otero	Mescalero (town)	13	3668700	427000	583	Sandoval	Jemez Mts	13	3955550	340300
534	Luna	Tres Hermanas Mts.	13	3534300	242800	584	Bernalillo	Sandia Mts.	13	3897500	372000
535	Otero	Guadalupe Mts.	13	3584900	495000	585	Socorro	Oscura Mts.	13	3723450	372400
536	Catron	Mogollon Mts.	12	3735300	730000	586	San Miguel	Villaneuva State Park	13	3902600	467600
537	Catron	Mogollon Mts.	12	3736700	733500	587	San Miguel	Villaneuva State Park	13	3902600	467600
538	Catron	along Carrizo Wash	12	3801200	683600	588	San Miguel	Pecos River Canyon	13	3955200	439000
539	Sierra	Black Range	13	3641000	241300	589	Doña Ana	Las Cruces	13	3572900	334900
540	Socorro	North Oscura Peak	13	3730400	372600	590	Bernalillo	Albuquerque	13	3883625	351450
541	Catron	Mogollon Mts.	12	3712500	726000	591	Catron	Gila Hot Springs area	12	3677000	759500
542	Lincoln	V. of Fires Malpais	13	3727700	414800	592	Catron	Gila Cliff Dwellings	12	3679100	757000
543	Grant	Black Range	13	3636200	238200	593	Grant	Silver City	12	3636000	755300
544	Lincoln	Lone Mountain	13	3738000	428000	594	Eddy	Carlsbad	13	3586600	571800
545	Lincoln	Lone Mountain	13	3739100	428600	595	Eddy	Carlsbad	13	3588200	572900
546	Grant	Black Range	13	3636200	238200	596	Eddy	Carlsbad	13	3587900	572250
547	Sierra	Black Range	13	3637000	243200	597	Eddy	Carlsbad	13	3588250	571000
548	Doña Ana	Bishop's Cap Mtn.	13	3564800	348400	598	Eddy	Carlsbad	13	3590400	572150
549	Hidalgo	Big Hatchet Mts.	13	3505500	748100	599	Eddy	Carlsbad	13	3587050	572350
550	Otero	Sierra Blanca Peak	13	3697800	422100	600	Eddy	Carlsbad	13	3589300	567800

Appendix B (continued; lot numbers 601-665)

			UTM Coordinates		
No.	County	Location	Zone	Northing	Easting
601	Eddy	Rattlesnake Spring	13	3552450	549800
602	Chaves	Roswell	13	3696200	546600
603	Chaves	Roswell	13	3696200	545700
604	Grant	Silver City	12	3629600	754700
605	Grant	Silver City	12	3629500	755000
606	Eddy	Artesia	13	3634100	555600
607	Santa Fe	Santa Fe	13	3949200	415500
608	Grant	Pinos Altos Mts.	12	3647100	764550
609	Bernalillo	Cedar Crest	13	3888600	375400
610	Santa Fe	Cerrillos	13	3924100	403100
611	Bernalillo	Albuquerque	13	3885025	348200
612	Guadulupe	Pecos River Valley	13	3861200	531600
613	Guadalupe	Santa Rosa Reservoir	13	3875600	527600
614	San Miguel	Las Vegas	13	3939050	479600
615	San Miguel	Montezuma	13	3945300	473600
616	San Miguel	Tecolotito	13	3899100	485200
617	Socorro	Socorro,	13	3771000	324300
618	San Juan	Animas River	13	4097500	244800
619	San Juan	La Plata River	12	4098000	749800
620	San Juan	Navajo Reservoir	13	4095800	277800
621	San Juan	Bloomfield	13	4066100	237350
622	San Juan	vicinity Aztec Ruins	13	4080600	232700
623	San Juan	Animas River	13	4098300	244750
624	San Juan	Los Pinos River	13	4097650	268350
625	Eddy	Walnut Canyon	13	3551350	535800
626	Otero	High Rolls	13	3646650	422050
627	Lea	Hobbs	13	3620000	675800
628	Lea	Lovington	13	3647000	675800
629	Roosevelt	Portales	13	3782850	652200
630	Union	Clayton	13	4034300	662250
631	San Miguel	Pecos River Valley	13	3838900	438000
632	Torrance	Mountainair	13	3820200	385800
633	San Miguel	Gallinas Creek	13	3953100	454100
634	Otero	Alamogordo	13	3640900	411500
635	Grant	Iron Cr. Campgrnd.	13	3644800	238350
636	Grant	Silver City	12	3629600	754700
637	Grant	Pinos Altos Mtns.	13	3657600	765300
638	Luna	Deming	13	3572500	239200
639	Grant	Mogollon Mtns.	12	3664600	734600
640	Lincoln	Nogal Pk.	13	3705700	424000
641	Lincoln	Sierra Blanca Mtns.	13	3706900	441600
642	Lincoln	Nogal Peak area	13	3708700	436200
643	Sierra	Ladder Ranch	13	3657850	260200
644	Sierra	Black Range	13	3653000	241600
645	Dona Ana	Organ Mtns	13	3580350	352700
646	Grant	Signal Peak	12	3646600	765300
647	Otero	Cloudcroft	13	3646400	430700
648	Dona Ana	Organ Mtns.	13	3568650	349800
649	Sierra	Black Range,	13	3648300	248100
650	Otero	Sacramento Mtns.	13	3640600	421600
651	Bernalillo	Albuquerque	13	3886700	356175
652	Otero	Alamogordo	13	3640000	410600
653	Lincoln	White Mtns.	13	3697100	431400
654	Sierra	Black Range	13	3649000	247000
655	Sierra	Black Range	13	3650700	247200
656	Chaves	vicinity Bitter Lake	13	3702300	555000
657	Hidalgo	Peloncillo Mts.	12	3556000	691900
658	Hidalgo	Peloncillo Mts.	12	3556300	692300
659	Dona Ana	Mt. Riley	13	3534200	304700
660	Hidalgo	Little Hatchet Mts.	12	3525700	741800
661	Catron	Mogollon Mts.	12	3695730	702400
662	Doña Ana	Las Cruces	13	3576200	332900
663	Grant	Little Hatchet Mts.	12	3530800	741500
664	Bernalillo	Albuquerque	13	3888400	350150
665	Mora	Wagon Mound	13	3986500	526800