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MAMMALS AND REPTILES OF THE PEDRO ARMENDARIS LAVA FIELD

A Contribution of the Biodiversity Division, Armendaris Ranch

MAMMALS AND REPTILES

OF THE PEDRO ARMENDARIS LAVA FIELD

A Study in Desert Biodiversity

prepared for

Biodiversity Division
Armendaris Ranch
Truth or Consequences, New Mexico

by

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ABSTRACT

The Pedro Armendaris Lava Field, approximately half of which lies within the Armendaris Ranch, supports a unique and diverse community of desert mammals and reptiles. The presence of the lava rock, formed by volcanic eruption 760,000 years ago, has led to the evolution of melanism (dark coloration) in some rodents, lizards, and snakes. The melanism confers a camouflage advantage to both prey and predatory species living in lava-rock habitats. At least three rodent species, five lizards, and two snakes exhibit various levels of melanism. Although some of these species also have melanistic forms in other lava flows, the Armendaris lava diamondback rattlesnakes probably are truly unique. The presence of melanism reflects not only genetic variation for color, it also signals other kinds of genetic diversity not as easily seen. Geographic isolation of the lava field ecosystem has not only enhanced the diversity within species, the close interspersion of rocky and sandy habitats has elevated the diversity among species. Bison grazing in the lava field is not likely to adversely affect either the genetic or the species diversity of the mammals and reptiles, but could cause minor shifts in the relative abundances of species. The Armendaris Lava Field ecosystem has no counterparts on private lands in New Mexico, thus that portion on the Armendaris Ranch offers an unparalleled opportunity to manage, research, or display a unique desert ecosystem independently of government intervention.

INTRODUCTION

The Pedro Armendaris Lava Field (Fig. 1) covers about 286 square miles (Weber 1963) in the northern Jornada del Muerto plain, a dry intermountain basin extending between Las Cruces and Socorro, New Mexico. Most of the eastern half of the lava field is administered by the U.S. Bureau of Land Management; a small portion at the far southeastern edge extends into the White Sands Missile Range administered by the U.S. Army. The western half lies within the Pedro Armendaris Ranch now owned by Ted Turner.

Formed by volcanic extrusion about 760,000 years ago (Bachman and Mehnert 1978), the lava field currently appears as a vegetated island of brown to black lava rock surrounded by and interlaced with sandy, buff-colored soil. This sandy soil has formed largely by windblown (aeolian) deposition of fine-grained particles from outside. A central volcanic crater within the Pedro Armendaris Ranch rises a few hundred feet higher than the main lava field and the plain surrounding it.

Most of the lava field is rolling to flat on the larger scale, but on the smaller scale the lava is sharply incised by numerous flat-bottomed, soil-filled depressions that are up to several hundred yards across (Weckerly 1983) (Fig. 2). At the margins of these depressions and at the edges of the lava field, the rock formations merge abruptly into the soil, in places forming rubbly or deeply-fissured bluffs several yards high (Fig. 3). Oty (1983) and Weckerly (1983) called the two distinctive landforms "lava" and "aeolian"; we sometimes substitute the terms "rock substrate" and "sand substrate", respectively.

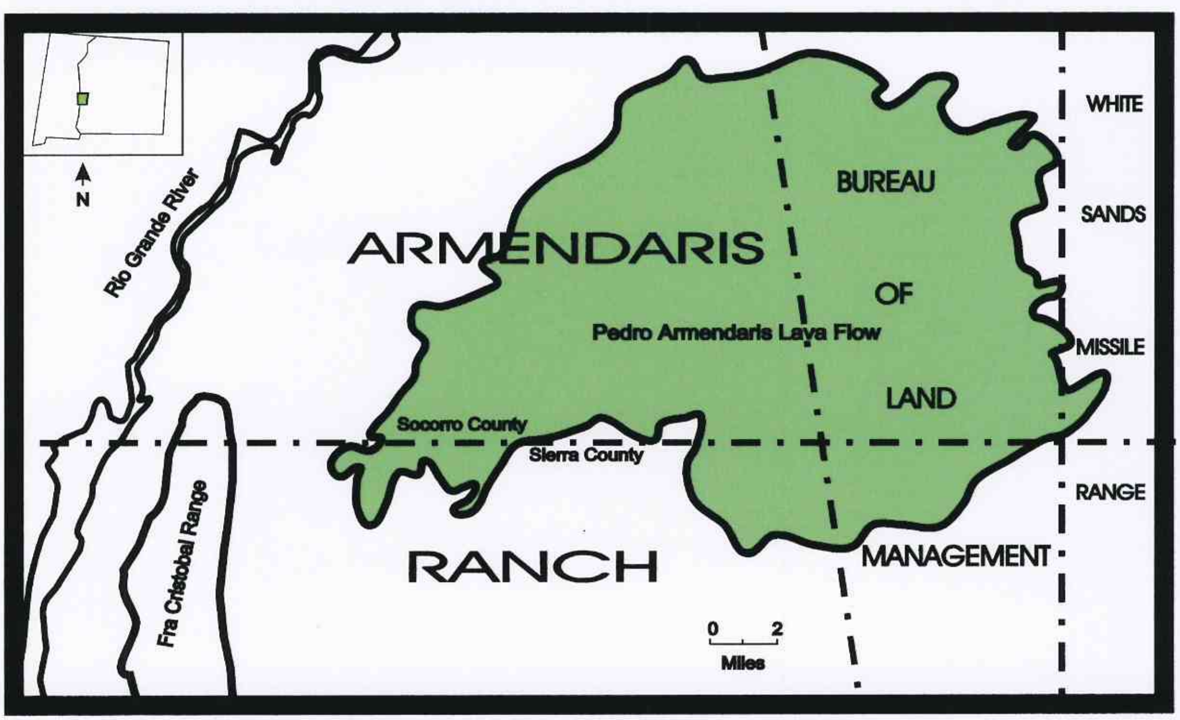


Figure 1. Land ownership and administration on the Pedro Armendaris Lava Field, Socorro and Sierra counties, New Mexico.

Figure 2. Soil-filled depressions in the Armendaris Lava Field contrast with the surrounding lava rock. Tobosa grass often dominates the almost shrubless flats (above), which may have large patches of bare ground (below).

The most distinctive vegetative difference between these two types of terrain, both in terms of visual signature and animal habitat, is the structural component. Structural differences arise mainly from the relative proportions of shrubs and grasses rather than from differences in the species composition of the vegetation. The aeolian habitat is largely shrubless (see Fig. 2) except for occasional individuals of Mormon tea (*Ephedra torreyana*), soap-tree yucca (*Yucca elata*), four-wing saltbush (*Atriplex canescens*), and honey mesquite (*Prosopis glandulosa*); it is dominated by perennial grasses, e.g., tobosagrass (*Pleurapsis mutica*) and burrograss (*Scleropogon brevifolius*), and subshrubs, e.g., snakeweed (*Gutierrezia sarothrae*). Because the lava substrate has locally wetter pockets of soil than occur in the aeolian substrate, it supports a

Figure 3. Rock outcrops typically merge abruptly with the sandy, wind-blown (aeolian) soil deposits in the Armendaris Lava Field. The deeply-fissured lava supports a faunal community distinctly different from that of the sandy soils. Note the dense shrub growth atop the lava.

much denser and more prominent shrub component of mainly four-wing saltbush, creosotebush (*Larrea tridentata*), honey mesquite, and Mormon tea (see Fig. 3). Dominant perennial grasses on the lava include black grama (*Bouteloua eriopoda*) and bush muhly (*Muhlenbergia porteri*); snakeweed is common on the lava as on the aeolian deposits (Oty 1983, Weckerly 1983, Truett pers. observation). Both the lava and aeolian habitats have bare areas without vegetation.

All the resident vertebrate species (Appendices 1 - 4) occur also in areas beyond the lava field, but the bizarre landscape within the lava field has given rise to a unique assemblage. Some species that live among the lava rocks have undergone an evolutionary selection for unusually dark skin or hair color (melanism) to match the habitat background. Biodiversity has been enhanced both by this melanistic variation within species and the variety among species brought about by close interspersion of the lava and aeolian substrate types.

Early twentieth-century ecologists (e.g., Bradt 1932, Benson 1933) perceived the cause of the melanism--natural selection influenced by predation. Genetic mutations for dark color were preserved in lava-dwelling animals because they offered superior camouflage against the dark background. Such mutations were not preserved in species preferring the lighter-colored sand substrates within the lava field, nor were they preserved in animals living in the lighter-colored habitats outside the lava field.

As Charles Darwin observed on the Galapagos Islands during his famous 1830's voyage aboard the H.M.S. *Beagle*, unique forms of life develop and remain distinctive only if they attain substantial isolation from their ancestral gene pools. Otherwise, constant interbreeding with the source population homogenizes the gene pool and prevents aberrations from persisting. The best circumstance for such development is complete isolation for a long period, as on the Galapagos. Less optimal but effective to some degree is partial isolation. This frequently occurs in animals with limited mobility, especially if partial barriers to dispersal exist. Its effects can be observed even in human populations that mix little with surrounding communities.

Small mammals and reptiles that prefer rocky habitats on the lava field demonstrate the effects of partial isolation. These animals not only move short distances during their lifetimes, some face a formidable barrier--a plain without rocks--at the edges of the lava field. In contrast, lava-field animals that prefer sand substrates face no barriers between the lava field and the sandy plain surrounding it, nor do they face different selective pressures in the lava field than outside. The birds and the medium-to-large mammals such as ringtail cats, cottontail rabbits, coyotes, and mule deer range so widely relative to the size of the lava field that genetic mixing with outside populations usually would prevent the development of unique forms, even should the lava habitat impose selective pressures for such forms.

In this study we focus on animals that reside in the lava field year-round. Those capable of flight (birds, bats) are not addressed because most that use the lava field are migratory, though some tend towards year-round residency despite their ability to migrate. Existing information indicates that approximately 56 non-flying species (Appendix 1) live in the lava field; a few others may live there but have not been detected by the survey efforts that have been made. Among this vertebrate fauna, this study addresses mainly lizards, snakes, and rodents, for it is within these groups that melanism has evolved.

OBJECTIVES

The objectives of this study were:

1. To describe and illustrate the uniqueness and diversity of the Armendaris Lava Field fauna,
2. To discuss the ecological mechanisms that have generated this fauna, and
3. To assess how land use may affect the unique forms or the diversity of the fauna.

METHODS

This study required a review of relevant literature, field forays to locate and capture animals, and photography of representative specimens. Trapping and photographic efforts focused on the small mammal and reptile species that would best illustrate melanism and its causes.

Literature Review

Technical literature relevant to this project included journal publications, theses and dissertations, and reports. Two well-known lava flows in addition to the Armendaris Lava Field exist in southern New Mexico, and faunal studies conducted there provided important comparative material for the few studies sited in the Armendaris lava. The general literature on the role of natural selection and isolation helped explain the mechanisms that gave rise to unique populations in lava fields.

Field Collections

Field collections were made during several periods between mid-August and mid-November 1997. Reptiles, especially snakes, usually remain in hiding, and only by searching in different months and under different weather conditions did we find a representative array of species and individuals. Mammals were easier to find than reptiles but often more difficult to photograph, and this necessitated some repeat photography. Thus several field efforts were required to obtain a series of photographs depicting the diversity we wished to illustrate.

Many of the reptiles and all mammals were captured preparatory to photographing them. We located reptiles by driving along roads in the lava field and by hiking in selected locations.

We captured lizards by hand or by noosing them with a monofilament line on the end of a fishing rod, and snakes (most of which were venomous) by lifting them with a shepherds-crook stick and maneuvering them into a cloth bag or plastic bucket. We captured small mammals in Sherman folding-aluminum live traps (9" x 3½" x 3") (Fig. 4) or Tomahawk wire-mesh live traps (19" x 6" x 6"), which we deployed in an array of sites within both lava and sandy terrain that appeared to be good rodent habitat.

Figure 4. Using Sherman live traps to capture rodents in the Armendaris Lava Field allowed investigators to release them unharmed after identifying and photographing them.

Specimens were identified by reference to standard taxonomic guides. The texts for identifying mammals included Findley et al. (1975) and Hoffmeister (1986); Degenhardt et al. (1996) was the main authority for reptiles. Mammal specimens were placed inside clear plastic bags if close examination was necessary for identification. All animals caught were later released in the same areas they were captured.

Photography and Printing

We photographed landscapes and animals by using 35-mm color slide film in single lens reflex cameras, often fitted with telephoto and macro lenses. We photographed some lizards and snakes without restraining them; others we photographed on lava rock or soil backdrops inside containers to prevent their escape. Nearly all small mammals had to be restrained inside enclosures to successfully photograph them.

From selected slides we made internegatives, color prints, and computer scans. Color prints derived from computer scans proved the most attractive method for illustrating the report.

LIZARDS

Melanism has been described in five lizard species in the Armendaris Lava Field (Appendix 2). Some of the same species are known to exhibit melanism in one or both of the two other major lava flows in southern New Mexico, the Tularosa Malpais about 35 miles east of the Armendaris Lava Field and the Afton Lava Flow about 100 miles south of the Armendaris (Fig. 5).

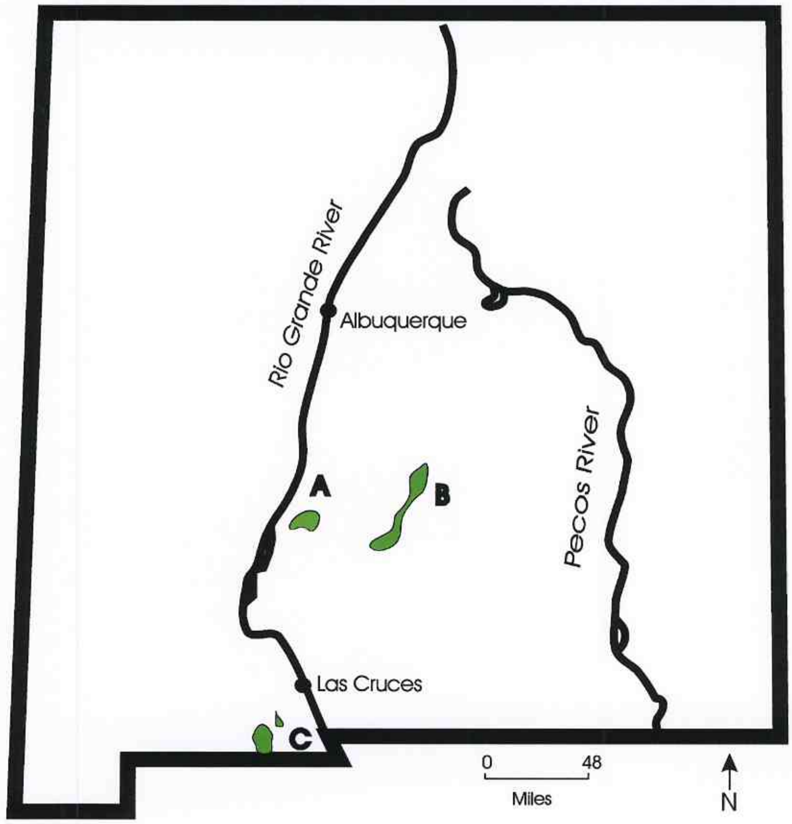


Figure 5. Three major lava flows exist in southern New Mexico, and faunal studies have been conducted in all of them. A = Armendaris, B = Tularosa, C = Afton.

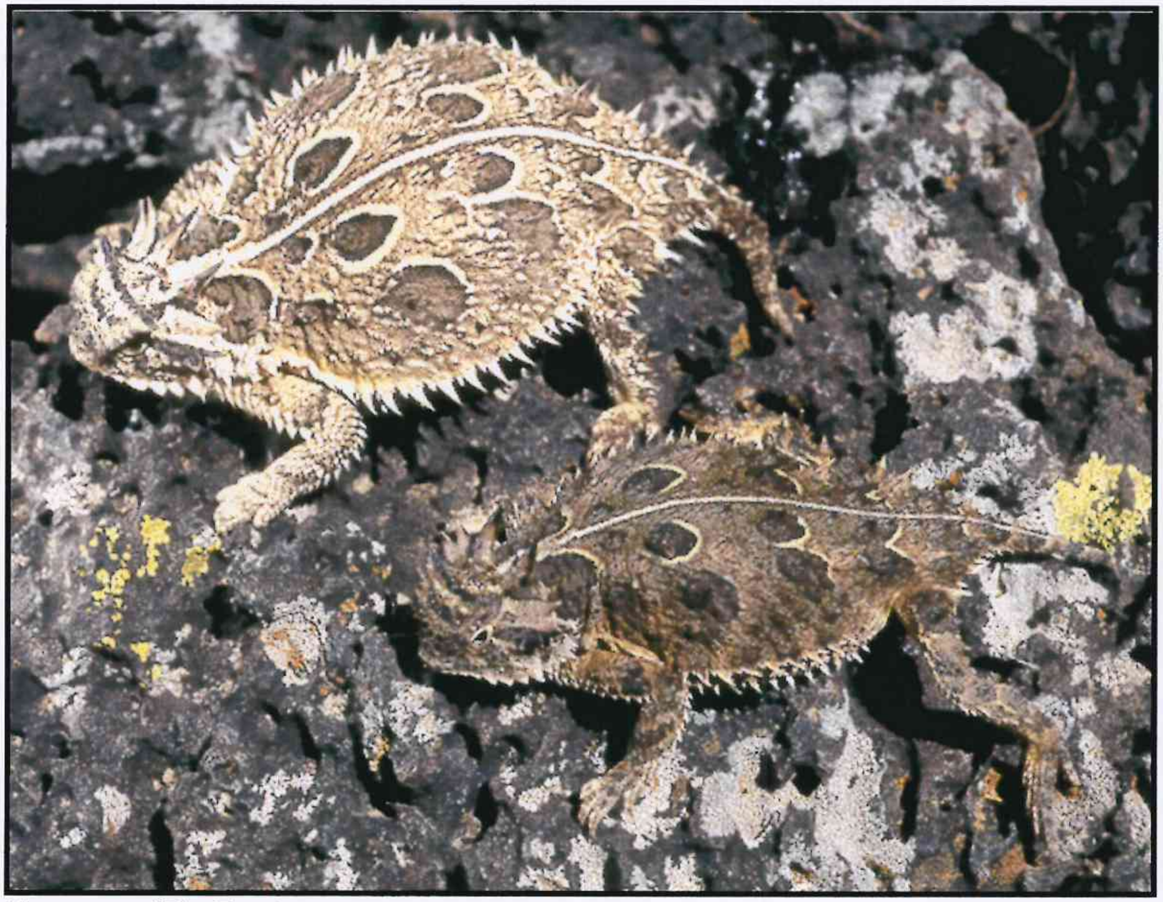
Collared Lizard

Among the more than 100 specimens of this rock-dwelling species that Best et al. (1983) collected in the Armendaris Lava Field, most were darker than specimens from elsewhere. These biologists saw considerable variability in the melanism of those they caught on the lava-flow, with color in individuals ranging from almost black to pale green. The approximately 10 lizards we saw in 1997 also varied in the amount of melanism they exhibited, but invariably their dorsal (upper) color blended with lava rock. All appeared darker than individuals seen outside the lava field (Fig. 6).

The Tularosa and Afton lava flows also have melanistic collared lizards (Appendix 2). The relatively small number of individuals examined from those areas gives little indication of the extent of melanism in the populations. Collared lizards in general show considerable genetic potential to adjust over time to background color--biologists commonly find large color variations among populations from different locations (Degenhardt et al. 1996:132).

(Photo courtesy of Rhett Turner)

Figure 6. Collared lizards in the Armendaris Lava Field (left) were darker and blended with the lava rock they usually inhabited better than did collared lizards from outside the lava field (right).



(Photo courtesy of Rhett Turner)

Figure 7. Texas horned lizards found in the Armendaris Lava Field (bottom) blend better with rock background than those from outside the lava field (top), even though they sometimes can be found in buff-colored sandy areas near lava.

Texas Horned Lizard

This lizard, found in both lava and sand substrates, shows a tendency in the Armendaris Lava Field to be darker than individuals living in uniformly light-colored backgrounds (Best et al. 1983). The darker individuals blend better with lava rock (Fig. 7). No Texas horned lizards have been described from the Tularosa or Afton lava flows (Appendix 2). Southwestern populations of this lizard, like those of collared lizards, show considerable color variation from place to place and among substrate types (Degenhardt et al. 1996:149), suggesting a genetic plasticity for color variation to match backgrounds.

Round-tailed Horned Lizard

This horned lizard, like the Texas horned lizard, can be found in both lava and sand. However, its melanism seems more pronounced than that of the Texas horned lizard--Best et al. (1983) reported all 15 specimens they collected from the Armendaris Lava Field to be melanistic, some colored nearly black. The melanism serves as excellent camouflage against lava (Fig. 8) in comparison with the lack of concealing coloration exhibited by a normal individual on a lava background (Fig. 9). No specimens have been described from the Tularosa or Afton lava flows.

Reasons for the relatively great extent of melanism in this species are unknown but presumably are related to predation. Even more so than the Texas horned lizard, populations of this species are generally known to match the substrate color wherever they live (Bundy and Neess 1958). The smaller size and less spiny body of this lizard may increase the relative vulnerability of poorly camouflaged individuals to a wider array of predators such as snakes and birds. Although it can be found on both sand and rocks in the lava field, its invariable melanistic coloration suggests a preference for lava background.

Prairie Lizard

This reptile seems invariably to be darker when found on lava than when found outside the lava field on lighter-colored substrates. All specimens collected from the Armendaris and Tularosa lava flows were melanistic; none have been documented from the Afton lava flow (Appendix 2). Despite its name, it inhabits rocks or other prominences if they are present in its habitat (Best et al. 1983). Like the collared lizard and the round-tailed horned lizard, its populations in general are known to match in color the local substrate (Gillis 1989). Individuals we found on lava substrate in the Armendaris Lava Field were considerably darker (Fig. 10) than those living on lighter-colored backgrounds outside the lava field (Fig. 11).

Side-blotched Lizard

This common lizard of the Armendaris Lava Field prefers a rocky substrate but seemingly thrives better when sandy soil is nearby (Best et al. 1983). Perhaps this ambivalence accounts for the wide range of skin color reported in this species from the three lava fields in southern New Mexico (Appendix 2). Melanism varied substantially in the more than 100 specimens Best et al. (1983) collected from the Armendaris Lava Field. Side-blotched lizards in general apparently are not subject to as great a range of color variation to match backgrounds (Degenhardt et al. 1996:190) as are the collared lizard, the two horned lizards, or the prairie lizard. Those photographed in the Armendaris Lava Field (Fig. 12) matched the lava color better than those found outside, which we found sometimes perched on man-made substrates offering little camouflage (Fig. 13).

Figure 8. Round-tailed horned lizards living in the lava field blend remarkably well with their rocky habitat. Because they are smaller and less spiny than Texas horned lizards, they are probably vulnerable to a wider range of predators, and thus may need better camouflage.

(Photo courtesy of Rhett Turner)

Figure 9. A round-tailed horned lizard from the Fra Cristobal Mountains within ten miles of the Armendaris Lava Field stands out on lava rock like a rice grain in a coal-bin--an easy meal for a predator.

Figure 10. Prairie lizards in the Armendaris Lava Field live on rock outcrops, where they can be difficult to see because of their melanistic color.

(Photo courtesy of Rhett Turner)

Figure 11. A prairie lizard from Deep Well ten miles south of the lava field lives in light-colored habitat; it is poorly camouflaged on lava rock.

Figure 12. Side-blotched lizards, named for the spot near the armpit, prefer rocky habitats. This individual exemplifies the melanistic shading which, although variable, typifies populations of the species in the Armendaris Lava Field.

Figure 13. This side-blotched lizard is, for the moment, poorly camouflaged on a piece of galvanized roofing at its home at Lava Camp a half-mile west of the Armendaris Lava Field. Its color exemplifies the light brown shading of populations living on stumps, fence posts, and other gray or brown backgrounds outside the lava field.

Sand-dwelling Lizards

The lava-field lizard species having no melanistic coloration invariably prefer the patches of sand substrate interspersed among the lava formations. Several species of whiptail lizard (*Cnemidophorus* spp.) are the only ones of these that are common within the lava field proper. Three are relatively abundant--New Mexico whiptail, little striped whiptail, and checkered whiptail. In addition, lesser earless lizards and leopard lizards are locally common in sandy soils, but only at the outer edges of the lava flow (Best et al. 1983).

The whiptail lizards depend on wariness and speed to avoid predators and often contrast with the background in which they live (Fig. 14). Body color and markings change to some extent with age in some of the species, with location in some, and with background color in some.

(Photo courtesy of Rhett Turner)

Figure 14. This New Mexico whiptail lizard, a young one, shows little concealing coloration against the background of its sandy habitat. Like all whiptails, it depends on wariness and speed rather than camouflage to escape being eaten.

Some whiptail species are unusual among vertebrates in that they are parthenogenetic, i.e., all individuals are females and the young develop from unfertilized eggs. A few fish and amphibian species, but no mammals or birds, are likewise known to be parthenogenetic (Leuck 1980:4). No males exist in parthenogenetic populations, which were derived by past hybridization between bisexual species. Offspring are identical to mothers generation after generation. Two of the common whiptails in the lava field--New Mexico whiptail (Fig. 14) and checkered whiptail--are parthenogenetic.

SNAKES

Populations of two snakes--western diamondback rattlesnake and blacktail rattlesnake--exhibit melanism in the Armendaris Lava Field (Appendix 3). Blacktail rattlesnakes show melanism in the two other lava flows in southern New Mexico, but no melanistic diamondbacks have been found in these other lava flows. Prairie rattlesnakes and non-venomous snakes that have been found in the Armendaris Lava Field were not melanistic, although slight amounts of melanism have been noticed in some of these from other lava flows.

Western Diamondback Rattlesnake

Western diamondbacks vary in color from place to place, usually having evolved to resemble the dominant hue of habitat substrate (Degenhardt et al. 1996:341) (Fig. 15). Diamondbacks we found in the lava field usually were darker than any encountered well outside the lava field.

Best et al. (1983) examined 14 western diamondbacks from the Armendaris Lava Field and all showed some degree of melanism. The dorsal background color ranged from nearly black to moderately dusky; the diamond-shaped markings were visible on all specimens. Often the ventral side (belly) was pinkish rather than the usual cream color exhibited by diamondbacks from light-colored habitats.

We found varying levels of melanism in 6 diamondbacks we found in the lava field. The range in color agreed with that described by Best et al. (1983). Bellies of some were bright pink.

Our observations of habitat preference by diamondbacks also generally agreed with those of Best et al. (1983). These snakes usually were found in lava outcrops and areas next to lava, although sometimes they occurred in adjacent sandy areas at dusk. We disturbed one deep within a lava crevice, and found another coiled beside a bannertail kangaroo rat den in sandy soil next to a lava outcrop.

Among the darker specimens we found (Fig. 16), one was in a scrap heap at Lava Camp, an area with light-colored soils about a half mile outside the western extremity of the lava field. This and the occurrence of some relatively light individuals within the lava field (Fig. 17) suggests the distribution of melanism in the Armendaris lava population of diamondbacks makes a gradual rather than abrupt change at the edge of the lava field.

Melanistic diamondbacks have not been reported to occur elsewhere (Best and James 1984). Lewis (1951) and Prieto and Jacobson (1968) found several diamondbacks in the Afton Lava Flow and none were darker than normal. Although color variation is common in this species, the predominant color is usually a muted gray, tan, reddish, or pink (Degenhardt et al. 1996:341).

Figure 15. Western diamondback rattlesnakes usually have evolved to blend reasonably well with the substrate in the region they inhabit. Thus an individual in its native habitat near the south end of the Fra Cristobal range (above) is much more inconspicuous than one from a light-colored soil on the Ladder Ranch temporarily placed on an Armendaris Lava background (below).

Figure 16. Melanism in some diamondback rattlesnakes associated with the Armendaris Lava Field is so pronounced as to almost obliterate the diamond markings. The effectiveness of such melanism as camouflage against lava is evident in a snake found at Middle Well (above); its disadvantage on light-colored soils is clearly seen on another (below) found at Lava Camp just outside the west end of the Lava Field.

(Photo courtesy of Rhett Turner)

(Photo courtesy of Rhett Turner)

Figure 17. A wide range of melanism can be seen in diamondback rattlesnakes from the Armendaris Lava Field. Some are little darker than those found elsewhere, and thus blend poorly with the lava background (above); others show intermediate levels of melanism and accordingly contrast less with the lava background (below).

Blacktail Rattlesnake

Figure 18. This blacktail rattlesnake found outside the lava field has the yellowish background hue and dark bands typically found on blacktails inhabiting areas with light-colored substrates.

Apparently blacktail rattlesnakes are rare relative to diamondbacks in the Armendaris Lava Flow. Best et al. (1983) made extensive reptile collections there during five periods when rattlesnakes are known to be active and found only one blacktail, and this among rocks near the bat cave. We found none. The species is known to prefer rocky habitats (Degenhardt et al. 1996:347).

The one specimen found on the Armendaris Lava Field by Best et al. (1983) was "darker than those examined from adjacent areas". Four blacktail rattlesnakes found in the Tularosa Malpais were noticeably darker than usual (Lewis 1949), and two from the Afton Lava Flow were so black that the characteristic dark bands (see Fig. 18) were not visible (Prieto and Jacobson 1968). Color variation is common in blacktails (Degenhardt et al. 1996:346).

Prairie Rattlesnake

(Photo courtesy of Rhett Turner)

Figure 19. Prairie rattlesnakes found within the Armendaris Lava Field, like those outside, inhabit sandy, buff-colored substrates rather than the lava rock substrate, and their color demonstrates this affiliation.

Similarly to diamondbacks and blacktails, this rattlesnake is known to demonstrate much geographic color variation, from light to dark and even a jet black in some individuals in one subspecies (Degenhardt et al. 1996:351). Those in the Armendaris Lava Field invariably matched the buff-colored soil substrate rather than the lava (Fig. 19), signifying their close association with the sandy aeolian habitat rather than the rocky substrate. Further demonstrating this substrate preference, prairie rattlers (but not diamondbacks or blacktails) occur abundantly in the sandy Jornada del Muerto plain surrounding the lava field (Little and Keller 1937, Lewis 1950). Prairie rattlesnakes have not been reported from the Tularosa or Afton lava flows.

Other Species

Four additional snakes have been described from the Armendaris Lava Field (Appendix 3) (Best et al. 1983), and all were non-melanistic. Only two of these--coachwhip and gopher snake--are relatively abundant. The gopher snake is known to vary geographically from light to dark in the color of its usually brownish spots on a creamy or yellowish body (Degenhardt et al. 1996:295). The coachwhip varies geographically from gray to reddish to almost black (Degenhardt et al. 1996:289). On the Tularosa Malpais, Lewis (1949) noticed a slight degree of melanism in the only specimen of gopher snake he collected. Both the coachwhip and the gopher snake use a broad range of habitat types (Degenhardt et al. 1996:290,296), and perhaps for this reason no color parallels to any particular substrate have developed in these species in the Armendaris Lava Field.

MAMMALS

Only small mammals (rodents) among the several groups of mammals that live in the Armendaris Lava Field have been reported to exhibit melanism (Appendix 4). A partial explanation for this is that few other mammals restrict themselves as closely to the lava substrate as do some of the rodents. Additionally, most of the other mammals are relatively wide-ranging carnivores, lagomorphs (cottontails and jackrabbits), and hoofed mammals that exchange genes more extensively with surrounding populations than do rodents; this gene exchange probably quickly swamps any mutations for melanism that might arise. (But Tom Waddell, Armendaris Ranch manager, reported seeing an unusually dark bobcat near the central crater.) The abundant rodent species in the lava field are easily separable by color into melanistic rock dwellers (rock pocket mouse, cactus mouse, and white-throated wood rat) and non-melanistic inhabitants of the sand substrate (silky pocket mouse and Ord's, Merriam's, and bannertail kangaroo rats).

Rock Pocket Mouse

This small mouse is so closely tied to rocky substrate that it is rarely found in the Southwest except on rocky hills, mountains, and canyons (Findley et al. 1975:168, Oty 1983, Weckerly 1983:1). These rocky habitats often exist as islands surrounded by a sea of sand and silt. Thus populations of this species offer prime examples of genetic isolation, and this is reflected in the great preponderance of melanistic individuals in the populations that live on New Mexico's lava flows (Appendix 4). Only two percent of 151 rock pocket mice trapped by Weckerly (1983) in the Armendaris Lava Field were the normal tan color and none of approximately two dozen we trapped were normal-colored (Fig. 20).

Different biologists have reported different degrees of variation in melanism in these mice on lava flows. Disagreements are apparent even within the same lava flow (Appendix 4). For example, in the Armendaris Lava Field, Weckerly (1983) described these mice as uniformly melanistic, Oty (1983) said they showed a broad range of melanism, and we found at least two visually-evident color variations, dark brown and black (Fig. 20). Because estimating shades of color without the aid of a spectrophotometer or similar device, as used by Oty (1983), is subjective, some of the reported differences may be more imagined than real.

Figure 20. We found two visually evident levels of melanism in rock pocket mice in the Armendaris Lava Field, a dark brown phase (above) and a black phase (below). A study in the Afton Lava Flow 100 miles south of the Armendaris (Koschmann 1972) found juveniles of this species to be darker than adults.

Among the lava-field rodents, the rock pocket mouse demonstrates most dramatically the tendency for natural selection to weed out those individuals not colored to match the background. Not only are individuals from outside the lava field extremely conspicuous when placed on lava rock, those from inside the lava field contrast markedly with the surrounding sandy desert (Fig. 21).

Figure 21. A normal-colored pocket mouse from limestone rock habitat in the Fra Cristobal Mountains contrasts markedly with Armendaris lava rock (left). Likewise, one from the Armendaris lava habitat stands out against the buff-colored soil that surrounds the lava habitat (right). These color contrasts show, respectively, the selective disadvantage of normal color in lava rock and the avoidance of sandy habitat by lava-field mice.

Cactus Mouse

Though not restricted to rocky habitats in its total range (Findley 1975:201) or in lava flows (Elder 1977), this close relative of the deer mouse prefers rocks over sand. Oty (1983) did not find them away from rocks on the Armendaris Lava Field, but they occurred mainly where the lava merged nearby into sand. Elder (1977) found them to be the only rodents commonly coexisting with rock pocket mice in lava substrates of the Afton Lava Flow. Thus cactus mice would be expected to exhibit melanism in lava fields, though perhaps to a lesser extent than rock pocket mice.

And, in fact, cactus mouse populations in lava fields do show a wider range of melanism than do the rock pocket mice with which they coexist (Appendix 4). In the Armendaris Lava Field, Weckerly (1983) found that cactus mice had highly variable coloration, ranging from tan to dark. Oty (1983) found the average difference in color between Armendaris Lava Field cactus mice and their counterparts off the lava field to be less than the contrast between rock pocket mice on and off the lava field. We likewise found that the lava-field cactus mice varied in degrees of melanism. On average they were lighter-colored than the rock pocket mice living in the same place, but darker than cactus mice living outside the lava field (Fig. 22).

Figure 22. Normal-colored cactus mice living among light-colored rocks in the Fra Cristobal mountains are much more conspicuous on Armendaris lava rock (left) than are cactus mice that evolved in the lava field (right).

(Photo courtesy of Rhett Turner)

(Photo courtesy of Rhett Turner)

Figure 23. White-throated wood rats inhabiting the Armendaris Lava Field (above) were typically much darker than those living in light-colored backgrounds such as the nearby Fra Cristobal Range (lower left) or the Mogollon Mountains 100 miles to the west (lower right). Only the feet and throat patch (not visible) remain normal-colored on the lava-field rats.

White-throated Wood Rat

Although this "pack rat" commonly lives in a great variety of substrate types (Findley 1975:241), including the sandy plains surrounding the southern New Mexico lava flows, it has distinctly melanistic populations in each of the lava flows (Appendix 4). Within lava fields, these rodents strongly prefer lava substrates (Weckerly 1983:7), probably because of the security they find in rock crevices. In rockless habitats they seek out clumps of cactus, large shrubs, trees, and debris to build their nests (Vorhies and Taylor 1940:487-493), but seldom do so in the lava fields (Benson 1933:43). Few good nest-shelter plants and few packrat nests are evident in the plain immediately surrounding the lava field, suggesting a relative scarcity of packrats. Thus the influx into the lava field of genes for normal color may be slow despite the general habitat plasticity of this rat.

Melanism varies widely among individuals of this species in lava fields (Bradt 1932, Benson 1933, Weckerly 1983). Some are almost black; others approach normal color. Such variability in these rock-inhabiting populations suggests some gene influx from normal-colored populations. Among the approximately 20 individuals we captured in the Armendaris Lava Field, most were quite dark in comparison with individuals of the same species captured outside the lava field (Fig. 23).

These rats, and possibly others, exhibit behavior that enhances the camouflage advantages of melanism. Some rats we placed in lava backdrops to photograph crouched motionless among the rocks (Fig. 24) for long periods while we moved about nearby.

Figure 24. A white-throated wood rat as it might appear to a predator in moonlight in the Armendaris Lava Field. This hiding posture enhances the camouflage advantages of the rat's melanism.

Sand-dwelling Rodents

Species largely restricted to sandy substrates within the Armendaris Lava Field show no evidence of melanism. Several species--silky pocket mouse and Ord's, Merriam's, and bannertail kangaroo rats--have been examined in sufficient numbers to leave little doubt this is the case. It is probably true in all the sand-dwellers, but remains to be confirmed in the uncommon ones.

The silky pocket mouse, though meeting at the sand-lava interface with its close relative the melanistic rock pocket mouse, shows no signs of melanism in lava fields. It is known to select loose and sandy soils for habitat (Findley et al. 1975:159). Among 42 silky pocket mice that Oty (1983) trapped from the Armendaris Lava Field and nearby areas, none differed much in color from the average, although nearly 20% of these were taken at the lava-sand interface.

Likewise the three kangaroo rats--Ord's, Merriam's, and bannertail--that are common in and near the lava field (Weckerly 1983, Truett pers. observation) are almost exclusively dwellers in soil with few or no rocks (Findley et al. 1975:174, 181, 183). None are melanistic. Color may vary somewhat geographically with soil color or rainfall regime, especially in the Ord's and Merriam's populations, but color variation is not great compared with that in the rock-dwellers discussed above (Findley et al. 1975:174, 183). In the Armendaris Lava Field, the color of the kangaroo rats blends well with the buff-colored soil in which they live rather than with the lava rock (Fig. 25).

(Photo courtesy of Rhett Turner)

Figure 25. The bannertail kangaroo rat (left) photographed in sand and the Ord's kangaroo rat (right) photographed in lava rock, are common residents in sandy soils of the Armendaris Lava Field and their color shows their habitat affiliation.

DISCUSSION

Melanism: Its Evolution and Significance

Melanism in most lizards, snakes, and small mammals almost certainly has evolved independently in different lava fields. In southern New Mexico, lava flows are separated by substantial barriers of distance, pale rocks, and rockless substrate. That melanism recurs in the same species in different lava flows suggests that color mutations that give rise to melanism are common in most of these species.

Diamondback rattlesnakes in the Armendaris Lava Field seem to be an anomaly with respect to recurrence of melanism--nowhere else have they been reported to be melanistic (Best and James 1984). Thus they apparently constitute a truly unique population.

The relatively old age of the Armendaris Lava Field is one of several possible reasons that melanistic diamondbacks evolved there but not in other lava flows. At 760,000 years old, this lava field has offered fertile ground for the evolution of melanism longer than has the Afton Lava Flow (several eruptions ranging from 11,000-500,000 years ago--Koschmann 1972, Elder 1977) or the Tularosa Malpais (less than 1000 years old--Shields and Crispin 1956). (The Tularosa Malpais is near an older lava flow that could have contributed genetic source material for some of its melanistic populations.)

A detailed study of rock pocket mice in the Armendaris Lava Field (Weckerly 1983) showed that they differed from those outside the lava field not only in their melanistic color but also in other physical characteristics--hind foot length and skull measurements, for example. Thus the lava-flow pocket mice, and by extension probably other melanistic forms in the lava fields, are different in more ways than is disclosed by casual observation. Melanism may signal a wider range of genetic differences that have evolved because of long isolation in an anomalous habitat.

As a final note on color variation, some lava-field animals may show color differences with differences in temperature, sex, or age. Reptiles, especially lizards, often vary in shade of color with large changes in their body temperature; we observed this to be pronounced in the round-tailed horned lizards and collared lizards we photographed. Male lizards often have different color patterns than females (Degenhardt et al. 1996). Juvenile rock pocket mice may have darker coats than adults (Koschmann 1972:28). Color differences caused by melanism generally overshadow these variations.

Biodiversity

Biodiversity, though much discussed of late among ecologists and conservationists, defies easy definition. Wildlife biologists traditionally see it as synonymous with variety among species (Smith and Rhodes 1992). Some conservationists just as readily focus on the genetic variation within species, noting the importance of this level of diversity in conditioning a population's resilience to stress or its utility to humans. Landscape ecologists add the context of space to the biodiversity concept, e.g., a rich biodiversity within an acre becomes poor when spread over a section of land (Westman 1985:333).

For such an arid environment, the Pedro Armendaris Lava Field supports an unusually rich vertebrate diversity at both the gene pool and species levels. Not only has genetic variation within species been enhanced over that in surrounding areas by natural selection operating within this island of anomalous substrate, the close juxtaposition of lava rock and sandy soil within the lava field has generated a greater species richness within small acreages than typically exists either in the adjacent sandy desert or in nearby rocky hills.

Enhancement of biodiversity by close interspersion of habitat types is well known. Leopold (1933:131) introduced the concept of "edge effect", by which two habitats meeting enhance the diversity of animal species by providing a greater array of options than provided by either alone. Modern-day ecologists commonly invoke "habitat heterogeneity" as an amplifier of animal diversity. Whittaker and Levin (1977) and Petraitis et al. (1989) applied the term "mosaic phenomena" to encompass the general enrichment of diversity by close type interspersion.

Similarly to habitat type interspersion, vertical layering of vegetation enhances diversity. Both desert lizards (Pianka 1966) and small mammals (Rosenzweig and Winakur 1969) increase in species diversity as vegetation layers (i.e., herb, shrub, and tree) are added to a landscape. Total removal of either the herbaceous layer, i.e. the grasses and broad-leafed herbs (forbs), or the shrub layer of the vegetation in the Armendaris Lava Field likely would reduce biodiversity by causing local extinctions of some reptiles and small mammals. Changes in the relative abundance of grasses or shrubs would probably cause no extinctions but only changes in relative abundance of the animals.

Temporal Fluctuations in Animal Numbers

Animals commonly fluctuate in abundance from time to time. When we compared the number of lizards we saw during this investigation with what previous investigators of the Armendaris Lava Field (Best et al. 1983, Oty 1983, Weckerly 1983) had found, we deduced that lizards were less common now than in the early 1980's. On the other hand, we had much greater success at trapping rodents than did Oty (1983) or Weckerly (1983). These temporal differences are not surprising--quite large fluctuations (both annual and seasonal) in populations of desert lizards (Pianka 1966) and small mammals (MacMahon 1976) are common. However, seldom do such oscillations result in even local extinctions (MacMahon 1976).

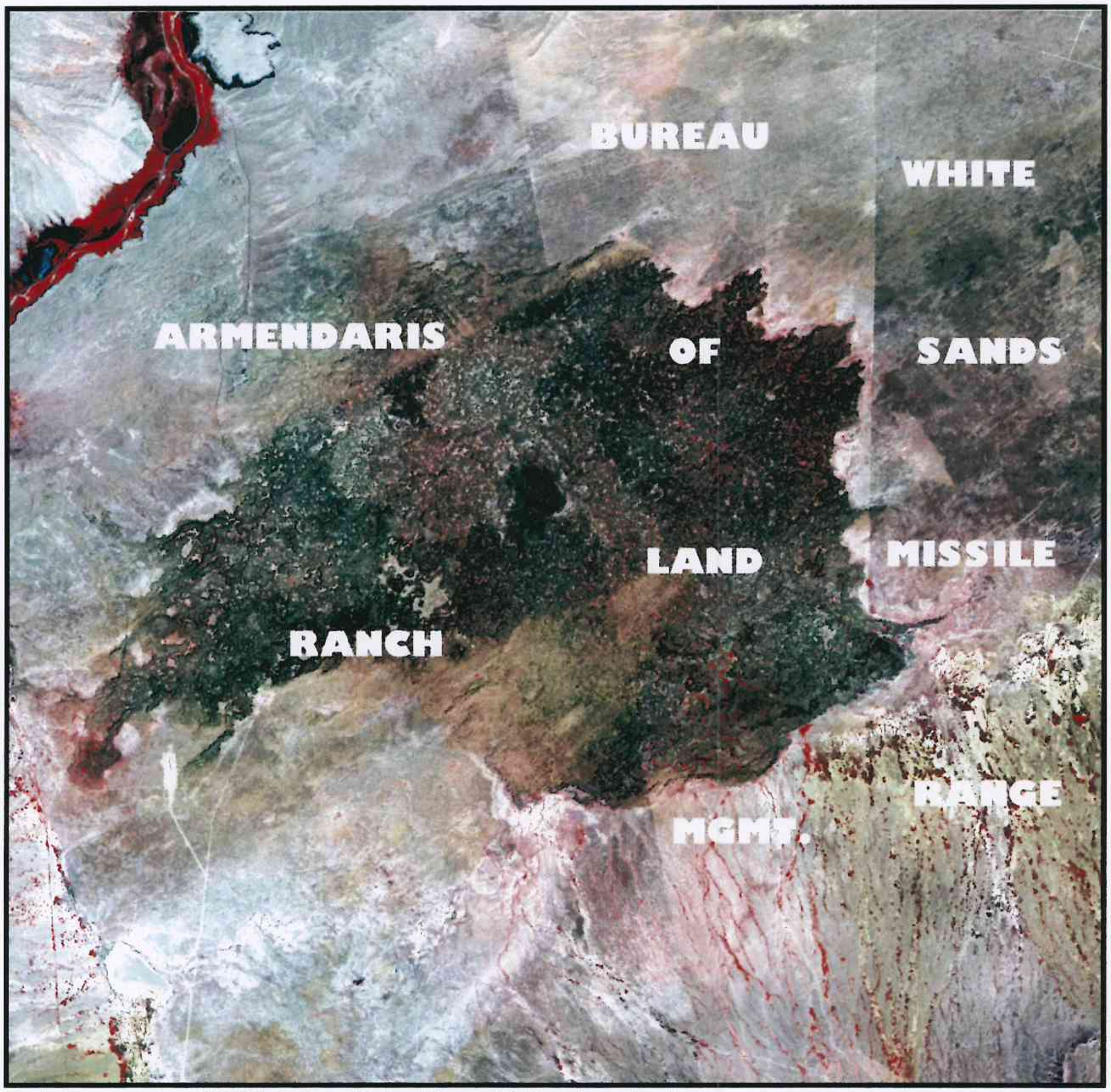
LAND MANAGEMENT AND BIOLOGICAL CONSERVATION

The dominant human-oriented use of land within the Armendaris Lava Field currently is grazing by bison. Grazing by cattle, and probably other livestock, historically was the most widespread use of the lava field. (Exploitation of guano at bat roosts in lava tubes south of the main crater was an intensive, but highly localized, activity in the early 1900's.)

Fenceline contrasts between the Armendaris Ranch and adjacent land managed by the Bureau of Land Management (BLM), and between the BLM land and the White Sands Missile Range, show that grazing can substantially alter the vegetation. In the lava field area, the Armendaris Ranch and the Missile Range have been grazed less intensively in recent decades than BLM land, because of the scarcity of water (and thus livestock) on the Armendaris Ranch and the historical removal of livestock from the Missile Range. The resulting difference stands out even on Landsat imagery (Fig. 26).

Recent development of water in the lava field coincident with the introduction of bison suggests that grazing may be more intensive in the future, and certainly different, than in the recent past. Bison will in the short term crop the grass, and over the longer term may alter to some extent the species composition and cover of the herbaceous layer of vegetation (grasses and forbs). Heavy grazing during the past century in similar landscapes has promoted shrub invasion at the expense of perennial grasses (Archer 1994). If such vegetative changes occur in the Armendaris Lava Field, will they drastically affect the animal community? Several lines of evidence suggest not.

Reptiles and mammals already accommodate great natural variation in the very factors likely to be altered by grazing. Within the lava field, more variation occurs in grass and shrub cover, height, and species composition from year to year and from place to place than is ever likely to be caused over time by grazing. The relative abundances of the animal species often change drastically between wet and dry years and between heavily-vegetated and sparsely-vegetated areas in the lava field, even without grazing. The fact that the resident species have persisted attests to their resilience to modest levels of vegetation change.



(Landsat image courtesy of MRJ Technology Solutions, Tucson, AZ. Do not reproduce.)

Figure 26. Historic differences in livestock grazing pressure in the Armendaris Lava Field area show up on Landsat as fenceline contrasts in vegetation between land managed by different entities. The low-intensity grazing on the Armendaris Ranch and the White Sands Missile Range have had much less of an impact than has the high-intensity grazing on lands administered by the Bureau of Land Management.

As discussed earlier, the substrate rather than the condition of the vegetation controls in large measure which animal species persist and where they live in the lava field. Grazing has a very small effect on the condition of the substrate, and none on its basic composition.

Most of the melanistic species are both common and prolific. Their abundance attests to their ability to thrive under a variety of conditions; their fecundity allows them to recover quickly from catastrophic events, such as heavy grazing in a drought year. Such animals are seldom at risk from land uses that introduce modest changes.

One melanistic species that may be uncommon in the lava field--the black-tailed rattlesnake--is common elsewhere, in a great range of color variants, including melanism. It also is probably resilient to grazing, which benefits its main prey base, the rodents (see below). The one specimen found in the early 1980's in the lava field was coiled in rubble at the bat cave, an area undoubtedly heavily impacted in the past by grazing and human activity.

Grazing by bison is as likely to benefit endemic animals, including the species addressed herein, as it is to adversely affect them. Rodents (and by inference their predators such as snakes and carnivores) in southwestern rangelands often have been found to increase in both diversity and abundance with grazing (Vorhies and Taylor 1940, Reynolds 1958, Wood 1969). The grazing-related invasion of grasslands by shrubs in the Southwest probably has enhanced the habitat for several lizards--prairie, collared, and perhaps side-blotched (Degenhardt et al. 1996: 133, 180, 191)--without eliminating the grassland lizards not particularly benefitted by shrubs. Moderate levels of grazing in the lava field probably will lead simply to modest changes in the abundance of resident species rather than the addition or elimination of species.

In sum, conservation of animal biodiversity in the Pedro Armendaris Lava Field is unlikely to be compromised by current land use. Not only are the fauna resilient to habitat changes that grazing could induce, historic and prehistoric changes of similar kinds almost certainly exceed in magnitude those likely to be caused by the current grazing regime. This suggests that any species or gene pools that might be threatened by grazing already have been weeded out.

However, the lava field and its biota constitute an unusual ecosystem worthy of special management attention. Not only are lava-field ecosystems scarce in North American deserts, some constituents of the Armendaris Lava Field ecosystem, e.g. melanistic diamondback rattlesnakes, are clearly different from those found elsewhere. Others, particularly among the rock-dwelling reptiles and small mammals, also undoubtedly have unique gene pools that casual observation cannot easily disclose. It is unlikely that the U.S. Government, which administers nearly all the lava-flow habitats in New Mexico outside the Armendaris Lava Field (Bureau of

Reclamation 1968, Morain et al. 1977), will focus much attention on lava field biodiversity. Thus the Pedro Armendaris Lava Field on the Armendaris Ranch offers a unique opportunity for a private landowner to preserve, manage, research, or potentially exhibit a Galapagos of the American Southwest.

APPENDIX 1

Non-flying vertebrates in the Pedro Armendaris Lava Field, New Mexico. Scientific names after Degenhardt et al. (1996) (amphibians and reptiles) and Hoffmeister (1986) (mammals). Presence, habitat preference, and abundance based on Best et al. (1983), Weckerly (1983), Findley et al. (1975), and personal observations of animals and sign.

Common Name	Scientific Name	Habitat Affiliation	Abundance on Lava Field
Salamanders			
Tiger Salamander	*Ambystoma tigrinum*	Earthen stock tanks	Common in tanks
Toads and Spadefoots			
Couch's Spadefoot	*Scaphiopus couchii*	Rainpools and tanks	Locally abundant
New Mexico Spadefoot	*Spea multiplicata*	Rainpools and tanks	Locally abundant
Plains Spadefoot	*S. bombifrons*	Rainpools and tanks	Locally abundant
Great Plains Toad	*Bufo cognatus*	Rainpools and tanks	Locally abundant
Green Toad	*B. debilis*	Rainpools and tanks	Locally abundant
Turtles			
Box Turtle	*Terrapene ornata*	Sand preferred	Abundant
Lizards			
Lesser Earless Lizard	*Holbrookia maculata*	Sandy soils	Locally common at edges
Collared Lizard	*Crotaphytus collaris*	Lava substrate	Abundant
Leopard Lizard	*C. wislizenii*	Sandy soils	Uncommon
Prairie Lizard	*Sceloporus undulatus*	Lava substrate	Locally common
Side-blotched Lizard	*Uta stansburiana*	Lava adjacent to sand	Locally abundant
Texas Horned Lizard	*Phrynosoma cornutum*	Lava and sand	Locally common
Round-tailed Horned Lizard	*P. modestum*	Lava/sand mixture	Locally abundant
New Mexico Whiptail	*Cnemidophorus neomexicanus*	Sandy soils	Locally abundant
Little Striped Whiptail	*C. inornatus*	Sandy soils	Common
Marbled Whiptail	*C. tigris*	Sandy soils	Rare
Checkered Whiptail	*C. grahamii*	Sandy soils	Common
Snakes			
Ground Snake	*Sonora semiannulata*	Unknown	Apparently uncommon
Western Hognose Snake	*Heterodon nasicus*	Unknown	Apparently uncommon
Coachwhip	*Masticophis flagellum*	Sandy soils	Common
Gopher Snake	*Pituophis melanoleucus*	Lava and sand	Common
Western Diamondback Rattlesnake	*Crotalus atrox*	Lava preferred	Common
Black-tailed Rattlesnake	*C. molossus*	Lava preferred	Uncommon
Prairie Rattlesnake	*C. viridis*	Sandy soils	Common
Shrews			
Desert Shrew	*Notiosorex crawfordi*	Unknown	Presence probable
Rabbits and Hares			
Desert Cottontail	*Sylvilagus auduboni*	Lava and sand	Common
Black-tailed Jackrabbit	*Lepus californicus*	Sandy soils	Common
Rodents			
Rock Squirrel	*Spermophilus variegatus*	Lava outcrops	Uncommon
Spotted Ground Squirrel	*S. spilosoma*	Sandy soils	Uncommon
Botta's Pocket Gopher	*Thomomys bottae*	Sandy soils	Presence probable
Desert Pocket Gopher	*Geomys arenarius*	Sandy soils	Presence probable
Silky Pocket Mouse	*Perognathus flavus*	Sandy soils	Common
Rock Pocket Mouse	*Chaetognathus intermedius*	Lava substrate	Abundant
Ord's Kangaroo Rat	*Dipodomys ordii*	Sandy soils	Common
Merriam's Kangaroo Rat	*D. merriami*	Sandy soils	Common
Bannertail Kangaroo Rat	*D. spectabilis*	Sandy soils	Common
Western Harvest Mouse	*Reithrodontomys megalotis*	Unknown	Probably uncommon
Cactus Mouse	*Peromyscus eremicus*	Lava substrate	Abundant
Deer Mouse	*P. maniculatus*	Unknown	Uncommon
Grasshopper Mouse	*Onychomys* sp.	Unknown	Uncommon
White-throated Wood Rat	*Neotoma albigula*	Lava substrate	Abundant
Porcupine	*Erethizon dorsatum*	Unknown	Probably uncommon

Appendix 1. (cont'd)

Common Name	Scientific Name	Habitat Affiliation	Abundance on Lava Field
Carnivores			
Coyote	*Canis latrans*	Lava and sand	Common
Kit Fox	*Vulpes macrotis*	Sandy soils	Unknown
Gray Fox	*Urocyon cinereoargenteus*	Lava and sand	Presence probable
Raccoon	*Procyon lotor*	Lava and sand	Presence probable
Ringtail Cat	*Bassariscus astutus*	Lava substrate	Presence probable
Badger	*Taxidea taxus*	Sandy substrate	Presence probable
Striped Skunk	*Mephitis mephitis*	Unknown	Presence probable
Mountain Lion	*Felis concolor*	Lava and sand	Unknown
Bobcat	*F. rufus*	Lava and sand	Unknown
Hoofed Mammals			
Mule Deer	*Odocoileus hemionus*	Lava and sand	Common
Pronghorn (Antelope)	*Antilocapra americana*	Lava and sand	Common
Bison	*Bison bison*	Lava and sand	Common
Oryx	*Oryx gazella*	Lava and sand	Uncommon

APPENDIX 2

Melanism in lizards of the Pedro Armendaris Lava Field in comparison with its occurrence in lizards of two other lava flows in southern New Mexico. Blanks indicate no specimens found.

SPECIES[1]	LAVA FLOW		
	Pedro Armendaris[2]	Tularosa[3]	Afton[4]
Collared Lizard <u>Crotaphytus</u> <u>collaris</u>	Most of 100+ specimens were dark, ranging from almost black to pale green.	Dark coloration contrasted with lighter tones of the species away from the lava.	The one specimen found was "heavily suffused with black" dorsally.
Lesser Earless Lizard <u>Holbrookia</u> <u>maculata</u>	No melanism in 34 specimens found		
Texas Horned Lizard <u>Phrynosoma</u> <u>cornutum</u>	Some of 7 individuals seen were slightly melanistic.		
Round-tailed Horned Lizard <u>P.</u> <u>modestum</u>	All 15 specimens melanistic, pale to nearly black.		
Prairie Lizard <u>Sceloporus</u> <u>undulatus</u>	All 12 specimens dark; dorsalateral stripes visible.	All specimens collected were "much darker" than those in adjacent desert.	
Side-blotched Lizard <u>Uta</u> <u>stansburiana</u>	Melanism variable but present in all of >100 specimens.	The one specimen found was "very much darker" than those in adjacent desert.	The two specimens observed not darker than specimens from areas adjacent to lava.
Whiptails <u>Cnemidophorus</u> <u>neomexicanus</u>, <u>C.</u> <u>inornatus</u>, <u>C.</u> <u>tigris</u>, <u>C.</u> <u>grahamii</u>	No melanism in any of these four species of ~150 specimens total.	<u>C.</u> <u>gularis</u>, the one species found, was not darker in the lava than in adjacent areas.	<u>C.</u> <u>tigris</u>, the one species found, was not darker in the lava than in adjacent areas.

[1]Nomenclature after Degenhardt et al. (1996)
[2]Reported by Best et al. (1983)
[3]Reported by Lewis (1949)
[4]Reported by Lewis (1951)

APPENDIX 3

Melanism in snakes of the Pedro Armendaris Lava Field in comparison with its occurrence in snakes of two other lava flows in southern New Mexico. Blanks indicate no specimens found.

SPECIES[1]	LAVA FLOW		
	Pedro Armendaris[2]	Tularosa[3]	Afton
Ground Snake Sonora semiannulata	No melanism in the 2 specimens found	No color comparisons made	
Western Hognose Snake Heterodon nasicus	No melanism in the 1 specimen found	No color comparisons made	
Coachwhip Masticophis flagellum	No melanism in the 5 specimens found	The one specimen collected had darker blotches on sides and back and a darker belly than specimens from adjacent areas.	
Western Diamondback Rattlesnake Crotalus atrox	All 14 specimens found were melanistic, ranging from dusky to nearly black, but with diamond-back markings always visible.		The one speciman found had approximately normal color.[4] The several specimens found were not darker than normal.[5]
Blacktail Rattlesnake C. molossus	The one specimen found was darker than those in adjacent areas.	The two specimens found were "very noticeably darker" than four from the Organ Mts., N.M.	The two specimens found lacked banding and the ground color was black.[5]
Western Rattlesnake C. viridis	No melanism in 6 specimens found.		

[1]Nomenclature after Degenhardt et al. (1996)
[2]Reported by Best et al. (1983)
[3]Reported by Lewis (1949)
[4]Reported by Lewis (1951)
[5]Reported by Prieto and Jacobson (1968)

APPENDIX 4

Melanism in small mammals of the Pedro Armendaris Lava Field in comparison with its occurrence in mammals of two other lava flows in southern New Mexico. Blanks indicates no information available.

SPECIES[1]	LAVA FLOW		
	Pedro Armendaris	Tularosa	Afton
Rock Pocket Mouse <u>Chaetognathus intermedius</u>	Ninety-seven percent of 151 specimens were uniformly melanistic, 2% were tan[2]. Broad range of melanism, but most clustered near average darkness[3].	Individuals much darker than related forms in surrounding region[4] color blackish, showing little variation in 48 specimens captured[5].	Color dark but less so than in specimens from Tularosa, little variation among 27 specimens[5]. Wide and evenly-distributed range of melanism among 112 individuals[6]. Color dark but variable.[2]
Cactus Mouse <u>Peromyscus eremicus</u>	The 221 specimens captured showed highly variable levels of melanism, from tan to dark[2]. Broad variations in pelage reflectance.[3]	Wide range of melanism among 10 specimens collected.[5]	Wide range of melanism among 15 specimens collected[5]. Melanism highly variable.[7]
White-throated Woodrat <u>Neotoma albigula</u>	The 17 specimens captured showed highly variable levels of melanism, from tan to dark[2].	Individuals much darker than related forms in surrounding region.[4] Wide range in melanism among 9 specimens--2 slightly darker than normal, 7 much darker.[5]	Large differences in melanism in 3 specimens captured.[5] Several sepcimens examined mostly light-colored, few darker than normal.[7]
Merriam's Kangaroo Rat <u>Dipodomys merriami</u>	No melanism in 18 specimens captured.[2]		
Ord's Kangaroo Rat <u>D. ordii</u>	No melanism in 4 specimens captured.[2]		
Banner-tailed Kangaroo Rat <u>D. spectabilis</u>	No melanism in 1 specimen captured.[2]		
Mearn's Grasshopper Mouse <u>Onychomys arenicola</u>	No melanism in 3 specimens captured.[2]		
Silky Pocket Mouse <u>Perognathus flavus</u>	No melanism in 81 specimens captured.[2] Color not different from that of the lava.		
Deer Mouse <u>Peromyscus maniculatus</u>	No melanism in 5 specimens captured.[2]		
Western Harvest Mouse <u>Reithrodontomys megalotis</u>	No melanism in 3 specimens captured.[2]	No melanism in 20 specimens.[2]	No melanism in 1 specimen.[5]

[1]Nomenclature after Hoffmeister (1986)
[2]Reported by Weckerly (1983)
[3]Reported by Oty (1983)
[4]Reported by Bradt (1932)
[5]Reported by Benson (1933)
[6]Reported by Elder (1977)
[7]Reported by Koschmann (1972)

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