

STATUS ASSESSMENT OF THE
PEÑASCO LEAST CHIPMUNK
(*TAMIAS MINIMUS ATRISTRIATUS*)

Final Report

(Professional Services Contract 07-2231)

Submitted to:

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BACKGROUND

Taxonomic History

The Peñasco least chipmunk was originally described as a distinct species (*Eutamias atristriatus*) on basis of 10 specimens collected in 1902 by Vernon Bailey and Ned Hollister in the ponderosa pine (*Pinus ponderosa*) forest zone of the Rio Peñasco drainage (see Historical Records results for a discussion of the type series) on the east slope of the Sacramento Mountains, Otero Co., New Mexico (Bailey 1913). In describing this chipmunk, Bailey (1913) remarked that, while similar in size and general appearance to *E. operarius* (= *T. m. operarius*, the subspecies of least chipmunk found in the Southern Rocky Mountains), it showed so little similarities in cranial characters that it warranted full species status. However, in a subsequent taxonomic revision of the North American chipmunks, Howell (1929) referred *atristriatus* to a subspecies of least chipmunk (i.e., *Tamias minimus atristriatus*). This was based on comparison of the original type series of *atristriatus* with a large series of *T. m. operarius* and the observation that specimens of *T. m. operarius* from northern New Mexico exhibited some similarities in pelage and cranial features with *atristriatus*.

Walt Conley reported “discovering a new population” of least chipmunk in rocky, alpine habitat on Sierra Blanca Peak in the White Mountains, Lincoln and Otero counties, New Mexico, in 1965 (Conley 1970). However, the population of least chipmunk on Sierra Blanca Peak was actually first discovered by Wharton Huber in 1931, although subsequent biologists studying this species, including Conley, failed to recognize this fact (see Historical Records results for more discussion of these records). The White and Sacramento Mountains are northern and southern geological subdivisions of a contiguous elevated region that together is often referred to as the Sacramento Mountains. In this report, use of the term “White Mountains” will refer to the northern division, while use of the term “Sacramento Mountains” will be restricted to the southern division. The White Mountains are centered on Sierra Blanca Peak, the highest summit (ca 3,693 m, 12,003 ft), which is an intrusion of Tertiary rocks surrounded by volcanic material. In contrast, the Sacramento Mountains are composed of sedimentary rocks and were formed through faulting. This resulted in an abrupt west slope and gentle east slope with maximum elevations along the crest of 2,983 m (9,695 ft). Use of the term “White Mountains” should not be confused with the White Mountains in eastern Arizona, which also has an endemic population of least chipmunks (*T. m. arizonensis*).

Conley (1970) examined characteristics of the pelage, external feature, cranium, and baculum of 8 populations of least chipmunks in Arizona and New Mexico, including both the Sacramento and White mountains populations. Conley (1970) considered the Sacramento Mountains population to be most distinctive based on its more blackish pelage color, larger overall size of the cranium and baculum, and distinctive habitats. In contrast, the population from the White Mountains, although located only a short distance away (ca 30 miles) from the Sacramento Mountains population, was most different from the White Mountains population and found to be similar to populations from northern New Mexico and eastern Arizona in these features. Consequently, Conley (1970) referred only the population from the Sacramento Mountains to *T. m. atristriatus*, while all other populations, including that from the White Mountains, to *T. m. operarius*. He concluded that the distinctiveness of the Sacramento

Mountains population was due to the uniqueness of the habitat it occupied (i.e., ponderosa pine forest), although his analyses of habitat relations were cursory. Hall (1981) and many subsequent authors followed this taxonomic arrangement. Patterson (1983) reported cranial measurements in the White Mountain population, but did not make any taxonomic conclusions.

Robert Sullivan and colleagues (Sullivan et al. undated, Sullivan 1985, Sullivan and Petersen 1988) conducted a comprehensive analysis of variation in habitat, pelage color, cranial morphology, bacular morphology, and allozymes among population of *T. minimus* in Colorado, Arizona, and New Mexico. Sullivan and Petersen (1988) concluded that the White and Sacramento mountains populations together should be recognized as *T. m. atristriatus*. Lines of evidence for this arrangement included: similarity in pelage color, similarity in bacular morphology, lack of distinct groupings within all southwestern populations based on cranial morphology, small sample size analyzed for the Sacramento population, and geographic proximity of the White and Sacramento mountains. Genetic data revealed that these animals were most closely related to chipmunks from the Sandia Mountains (Sullivan and Petersen 1988). Consequently, in this report both the White and Sacramento populations are considered *T. m. atristriatus*. However, it should be recognized that differentiation between these populations has occurred and that each contributes uniquely to diversity. Further, because of the differentiation and unique ecological associations of each population, the two populations will be treated separately in this report. *T. minimus* has been variously assigned to the genera *Eutamias*, *Tamias*, and *Neotamias* (Verts and Carraway 2001). The genus *Tamias* is used in this report in order to be consistent with Wilson and Reeder (2005). However, there is considerable disagreement and the weight of evidence may eventually favor use of *Neotamias*.

Overview of Population Trends and Conservation

When the type series of *T. m. atristriatus* was collected in the Sacramento Mountains in 1902, Bailey (1931:91) described it as: “abundant in the open forest and especially along rail fences, but were rarely seen in dense woods. Dozens were seen on the roadside fences, often three or four at a time running ahead of our horses, and while many were shot for specimens many more escaped into holes in the ground under logs, or among the weeds and brush. ...their chipper of alarm was constantly heard along the roadsides”. In his field journal, Bailey noted that “Hundreds of them were seen on the roadside fences, often 3 or 4 at a time” (Bailey 1902b:4). In contrast, Conley (1970:700) found densities of the Sacramento Mountains population to be “greatly depressed” during his fieldwork in 1965 and 1966. Conley (1970:700) noted “Many hours of trapping and observations, over 2 years, were nonproductive as compared with similar efforts for *E. m. operarius* ... and Sierra Blanca”. During those 2 years, Conley reported collecting 26 specimens from Sierra Blanca Peak in the White Mountains, but only 4 from James Canyon in the Sacramento Mountains (Conley 1970). Subsequent surveys by Conley in the James Canyon region during the 1970’s failed to produce additional records of *T. m. atristriatus* (Sullivan et al. undated).

During 1981-1982 biologists from the University of New Mexico conducted surveys for *T. m. atristriatus* in both the White and Sacramento mountains (Sullivan et al. undated). They collected 2 specimens and observed approximately 15-20 *T. m. atristriatus* on Sierra Blanca Peak using 153 trap-days and 48 person-hours (this fact is often misquoted that the population consisted of only 15-20 animals). In contrast, in the Sacramento Mountains they surveyed using

2,802 trap-days and 609 person-hours, but failed to confirm the persistence of *T. m. atristriatus* (Sullivan et al. undated).

Most recently, the persistence of the White Mountains population of *T. m. atristriatus* was confirmed by the capture of animals in 1998 and 2000 (Ortiz 1999, Ortiz et al. undated; Hope and Frey 2000). These were from a large talus area on Buck Mountain, which represented a new locality of record. However, extensive surveys totaling 4,091 trap-days by Hope and Frey (2000) in the Sacramento Mountains during 2000 failed to document the persistence of the Sacramento Mountains population.

T. m. atristriatus was first listed as endangered in New Mexico on 22 July 1983 (NMDGF 1988). There has been no subsequent recommendation to change this status (NMDGF 2006). Currently, it also is listed as Critically Imperiled by Nature Serve, Critically Endangered by the IUCN, and sensitive by the US Forest Service (Sullivan and Nagorsen 1998). NMDGF (2006) recommended studies to better define its distribution, population size, and habitats. Thus, the purpose of this study was to review and assess the status of *T. m. atristriatus*, and, based on this information, assess threats and make recommendation for its conservation and management.

METHODS

Literature Review

Library searches were conducted for literature regarding the distribution, habitat, ecology, and behavior of *T. minimus* from throughout its range. In addition, literature regarding changes to the ecology of the White and Sacramento mountains were sought. These papers were reviewed in order to synthesize information that might contribute to an understanding of the distribution, habitat, and causes for decline in *T. m. atristriatus*.

Historical Records

A total of 34 museum collections were queried for records of chipmunks from Lincoln and Otero counties (Appendix 1). Records were obtained for both *T. minimus* and the gray-footed chipmunk (*T. canipes*), which is sympatric with *T. minimus* in the White and Sacramento mountains. Records for both species were sought in order to assess the distributional patterns of both species in relation to one another, because there is a potential for competitive interactions between the species. Information on specimens in the Academy of Natural Sciences of Philadelphia (ANSP) was discovered late during the study period (i.e., June 2007) and hence these data only included records from Otero County. Further, identifications of specimens in the ANSP have not been independently verified through examination of specimens. Literature records for *T. minimus* from Lincoln and Otero counties were sought. Literature records were referred to specific museum records where possible, although perfect correspondence was sometimes impossible due to differences in how data were reported on specimen tags and in reports and published papers. In order to more precisely determine locations of captures, habitats of collection locations, and relative abundance of *T. canipes* and *T. minimus*, copies of original field notes associated with important collections were requested and examined where available.

Spatial Analyses

There are two methods to create spatial habitat models using geographic information systems. These follow deductive and inductive processes. Deductive modeling uses known information about a species to identify habitat associations and occurrence on the ground. Inductive models use species occurrence locations to identify these habitat associations and create a habitat model. We used both processes to create spatial habitat models for *T. m. atristriatus* and *T. canipes*. Both species were modeled in order to evaluate the degree of habitat separation between the species (as might occur through differences in habitat selection or competition). Further, because available evidence suggested that *T. m. atristriatus* utilized different distinct habitat associations in the White and Sacramento mountains, models for both populations of *T. m. atristriatus* were created.

Deductive Modeling.—The creation of deductive spatial habitat models requires accurate information about an organism's habitat associations. Consequently, Frey reviewed available information on habitat associations of *T. m. atristriatus* and *T. canipes*. Sources of data

included published literature, unpublished reports, and field notes. Through this process, it became apparent that secondary sources of information frequently misinterpreted or misstated information from previous sources. Consequently, only sources that provided original observations of habitat were used for assessing habitat associations of each population. Based on this synthesis, Frey then classified the known habitat associations into land cover types based on the Southwest Regional Gap Analysis Project (SWReGAP) land cover dataset. Only land cover types mapped within the study area were considered for the classification. The study area included Lincoln, Otero, Chaves, and Eddy counties. Further, habitat associations for each population were classified as primary or secondary. Primary habitats were those that the species routinely uses and lives in. Secondary habitats were those that the species may use, either by occasionally living in or traveling through.

Boykin created deductive models for *T. canipes* and *T. minimus* by using the habitat associations derived above and the modeling database created by the SWReGAP project (Boykin et al. 2006). The SWReGAP models were modified based on the habitat associations identified from the habitat review process. Models consisted of land cover identified as either primary or secondary within the study area. Multiple iterations were created based on review of model output and expert knowledge of the species by Frey.

Inductive Modeling.—The creation of inductive spatial habitat models requires coordinates for known species occurrences. These data were generated by georeferencing descriptive locality data from voucher specimens of *T. minimus* and *T. canipes* from the White and Sacramento mountains. Records of *T. canipes* from other mountain ranges and locations were not included in these analyses in order to constrain the analyses to the immediate area of sympatry. Reported locations lacking voucher specimens were not included because identifications cannot be verified. Descriptive localities were mapped using a digital map program (DeLorme Topo USA 5.0) in order to generate latitude and longitude coordinates. Initially, a non-expert did the georeferencing based on verbatim mapping of descriptive localities (e.g., “7 mi. E Cloudcroft” was mapped precisely 7.0 miles at 90° from Cloudcroft). However, Frey reviewed this mapping and found many of the mapped locations to be unlikely locations for the actual collection sites (e.g., “7 mi. E Cloudcroft” was actually taken via road). Consequently, using expert opinion, Frey adjusted verbatim localities based on additional locality information found in publications, unpublished field notes and journals, knowledge about ways locality data are reported (i.e., often mileage is taken via roads rather than straight line), and other sources of evidence and judgment. Coordinates for geographic names were based on those in the DeLorme program. Localities with field-collected Global Positioning System (GPS) coordinates were mapped at those coordinates, providing the remainder of the descriptive locality indicated the same general region.

Inductive models were created using the program Maximum Entropy 2.3 (Phillips et al. 2006). Maximum Entropy is a niche modeling software that identifies the probability distribution closest to uniform subject to constraints (Phillips et al. 2006). Receiver operating characteristic (ROC) plots were used to compare the performance of inductive models and to establish thresholds to identify habitat suitability or unsuitability (Guisan and Zimmerman 2000, Phillips et al. 2006). The ROC plots sensitivity (true positive fraction) on the y-axis and 1-specificity (false positive fraction) on the x-axis. Sensitivity is the absence of omission errors and is a measurement of correctly predicting presence. Specificity represents commission error and is a measure of correctly predicting absence (Fielding and Bell 1997). The area under the

curve (AUC) metric was used to select the “best” inductive model for each species (Fielding and Bell 1997, Phillips et al. 2006). AUC is an index that provides a measure of overall model accuracy with values ranging between 0.5 and 1.0 with a value of 0.5 indicating the model is no better than random. Inductive models were converted from probabilities to binary (suitable/unsuitable) for direct comparison with the deductive models using the equal sensitivity and specificity threshold.

Inductive models were based on the georectified occurrence data and landscape variables derived from the Nation Elevation Dataset (elevation, aspect) and SWReGAP (land cover, Lowery et al. 2006). Testing of variables (land cover, slope, elevation, landform and aspect) identified elevation, land cover, and aspect as contributing the gainful information for each model. During modeling, 21 training sites were used for *T. m. atristriatus* with 5 sites withheld for model validation; 77 training sites were used for *T. canipes* with 19 records withheld for validation.

Field Surveys

Due to time constraints of the contract funding period (performance period was late October 2006 to 30 June 2007), field surveys were only possible during a limited time in Spring 2007. Late summer and early fall are the optimal seasons for presence/absence surveys because population densities are higher, animals are less secretive, and juveniles are dispersing. Further, chipmunks are hibernators. Specimen records of *T. m. atristriatus* are available only from 8 June to 10 September.

Currently, *T. minimus atristriatus* is known from only two areas: 1) rocky areas in the White Mountains above treeline (i.e., Sierra Blanca Peak and Buck Mountain), and 2) transition zone (i.e., ponderosa pine forest) in the Sacramento Mountains. In order to make best use of the limited time for field surveys, the goal was to document persistence of the species in these 2 regions. In each of the two regions, survey work was concentrated at historical locations and potentially suitable habitat. In the White Mountains, this was the large talus slope on the south face of Buck Mountain, where the species was previously captured in 1998 and 2000. In the Sacramento Mountains, this included James Canyon Campground, which was the last location where the Sacramento Mountains population was verified in 1966. It also included an area on James Ridge where there were unverified reports of the species in the 1990s (see Historical Records section for more details).

Standard-sized Sherman live-traps baited with horse sweet feed were used to capture chipmunks. Traps were checked for captures as frequently as logistically feasible in order to reduce stress on captured animals and to reduce trap mortalities. In addition, chipmunks were collected with firearms as logistics permitted. All chipmunks were identified by Frey. For each chipmunk, data on capture location, age, reproductive status, and external measurements were taken. Representative voucher specimens were retained from each location. All other individuals were released at the capture location. Capture and collection of wildlife was conducted under a scientific collecting permit (#2868) issued to Frey.

General habitat features were determined at each location a chipmunk was collected. This included elevation, drainage, vegetation zone, dominant tree species, slope, and presence/nature of other relevant features. In addition, at any *T. m. atristriatus* capture sites, more detailed habitat data would be collected including aspect, slope, soil moisture, canopy cover (using densiometer), identity and size of trees and shrubs, ground cover composition

(using Daubenmire frame) of graminoid, forbs, litter, rocks, bare, ground cover density (using Robel pole), and stubble height. Photographs were used to visually illustrate habitat features.

RESULTS

Least Chipmunk Biology

The least chipmunk (*Tamias minimus*) has the largest geographic range of any North American chipmunk (Hall 1981). It has a boreo-cordilleran distribution, occurring throughout the boreal coniferous forest zone across Canada and eastern Alaska and then southward throughout the Rocky Mountain region (Verts and Carraway 2001). It reaches the southern extent of its distribution in the American Southwest as disjunct montane isolates in the Chuska and White mountains in Arizona and the Sandia and Sacramento (including White) mountains in New Mexico (Findley et al. 1975, Hoffmeister 1986). Throughout this broad distribution, it utilizes a wide array of habitats. For example, it occurs in hot, arid sagebrush Great Basin desertscrub, it uses a broad array of woodland and forest types, and it is one of the only species of chipmunks that routinely occurs in alpine (above tree line) habitats (see review of habitats in Verts and Carraway 2001). Consequently, *T. minimus* is often considered a generalist species. However, populations may evolve morphological, physiological, and behavioral adaptations to local environments and hence they may be considered locally specialized (e.g., Heller and Gates 1971; Heller and Poulson 1972; Willems and Armitage 1975a,b,c; Blake 1977).

Competitive exclusion by other species of chipmunks and ground squirrels is thought to exert an important influence on the distribution and habitat use of *T. minimus* in local regions (Heller 1971, Carey 1978, Chappell 1978). Major factors that seem to influence these relationships are the small body size of *T. minimus*, which is one of the smallest chipmunks, and its tendency to be more terrestrial in comparison with other species of chipmunk that are often more arboreal in behavior (Hall 1981, Verts and Carraway 2001). In most cases, *T. minimus* is excluded by larger species from woodland and forest habitats characterized by trees with branches close to the ground that permit more arboreality (e.g., piñon pine [*Pinus* spp], fir [*Abies* spp], spruce [*Picea* spp.]. In contrast, *T. minimus* often occupies non-forested habitats such as those dominated by shrubs, rocks, or dense herbaceous vegetation, or forests dominated by trees that lack low limbs (e.g., quaking aspen, ponderosa pine; Heller 1971, Heller and Poulson 1972, States 1976, Feldhamer 1979, Bergstrom and Hoffmann 1991). Experimental studies demonstrated that *T. minimus* has an innate preference for talus habitats rather than trees (Meredith 1976). Sheppard (1971) thought that *T. minimus* was better adapted to areas with limited resources because of its small body size. Contrary to these patterns, however, in some situations, such as Engelmann spruce-subalpine fir forests, *T. minimus* is known to co-occur with congeners, although typically at lower abundance (Bergstrom and Hoffmann 1991). They prefer habitats where ground cover is structured such that the lower 15 cm above ground level is sparse, which allows for concealment from aerial predators and a clear travel path for escape (Feldhamer 1979). They have been reported to use recently logged and burned areas (Timm 1975, cited in Verts and Carraway 2001). Ski run development can result in an increase in density of *T. minimus* (Hadley and Wilson 2004).

For nesting, *T. minimus* digs burrows, often under large rocks, but may use other structures such as tree cavities (reviewed in Verts and Carraway 2001). Unlike most other chipmunks, *T. minimus* does not develop fat deposits in fall before hibernation (Verts and Carraway 2001). Rather, *T. minimus* relies on cached food during winter, which it makes use of

during brief non-torpid periods. Overwinter survival rates are less than one third (Bergstrom and Hoffmann 1991). *T. minimus* becomes reproductively active shortly after emerging from hibernation upon snowmelt (Vaughn 1969). Females that fail to obtain a critical mass during the previous fall may not breed immediately after hibernation. The proportion of yearlings that breed varies by year; some adult females may fail to breed (reviewed in Verts and Carraway 2001). Only one litter, typically of 4 or 5 pups, is produced each year (Skryja 1974, reviewed in Verts and Carraway 2001). Mean life span is 0.7 year (Erlie and Tester 1984; cited in Verts and Carraway 2001). Seeds of shrubs and forbs are the most important dietary items, although arthropods, leaves, fruits, flowers, and fungi are also important (Vaughn 1974; reviewed in Verts and Carraway 2001). They forage for foods that they can access on the ground or by climbing into shrubs (Hoffmeister 1986).

Historical Records

A total of 130 museum specimens of *T. m. atristriatus* were found in 6 museum collections (Appendix 2). Previously, only 44 of these records had been published or otherwise reported. Thus, the new records increase the number of known specimens of *T. m. atristriatus* by 66%. Further, these records increase the number of known localities for *T. m. atristriatus* from 9 to 26.

Sacramento Mountains

Bailey 1902 type series.—On 6-7 September 1902 Vernon Bailey and Ned Hollister collected the original series of 10 specimens of least chipmunk from the drainage of the Rio Peñasco that Bailey would later describe as *T. m. atristriatus* (Bailey 1913; Appendix 2). Bailey (1913:129-130) reported that they “collected them along Penasco Creek at various points from 6 to 12 miles east of Cloudcroft and from 7000 to 8000 feet altitude, in the yellow pine zone”. Data from specimen tags indicate that the series was collected from at least 3 locations, including “Penasco, Upper Penasco”, “Cloudcroft, 12 mi E” and “Cloudcroft, 6 mi E”. To determine the route traveled by Bailey and Hollister and the collection locations, Frey examined Bailey’s field journal for an itinerary (see Table 1) and mapped his potential routes using a 1914 (reprinted in 1948) edition of a 1:250,000 map of Lincoln National Forest (mileages were mapped as traveled via road rather than as straight-line distances). The party first encountered the Rio Peñasco at Upper Peñasco where they collected the first 2 of the series (Table 1, Appendix 2). Upper Peñasco was the original name for Mayhill (Julyan 1998), which is located on the Rio Peñasco at the junction with James Canyon. Bailey’s field journal described this point as 20 miles below Cloudcroft. From here it is unclear what route they took to Cloudcroft and hence where the remaining 8 specimens were collected. The 1914 map shows the most direct route to Cloudcroft from Mayhill to be via either James Canyon (ca 18.5 miles) or Cox Canyon (ca 23 miles). A route along the upper Rio Peñasco was possible although it was considerably longer (ca 29.5 miles) and required traveling a substantial distance over mountain ridges.

Bailey’s field journal explicitly stated that they followed James Canyon to Cloudcroft. Other evidence supports this as the route taken. For example, on 6 September they camped 12 miles east of Cloudcroft at an elevation of 7,500 ft, which is consistent with either the James or Cox canyon routes. However, on 7 September they reached 8,000 ft elevation about 5 miles east of Cloudcroft. The 8,000 ft contour is located ca 5.75 miles east of Cloudcroft in James Canyon but ca 8.0 miles east of Cloudcroft in Cox Canyon. Bailey’s field journal indicated that the collection location 6 miles east of Cloudcroft was lower than the 8,000 ft contour. This location is at ca 7,970 ft in James Canyon but at 8,385 ft in Cox Canyon. Finally, on 7 September they camped 1.5 miles east of Cloudcroft, which was shown on a hand-drawn map to be located approximately in Apache Canyon, which is most easily accessed via James Canyon. Consequently, it is concluded that the 8 specimens from 6 and 12 miles east of Cloudcroft were collected in James Canyon rather than along the Rio Peñasco. This conclusion is supported by the fact that, while Bailey (1913) reported the type location “Sacramento Mountains, New Mexico, on Penasco Creek 12 miles east of Cloudcroft, alt. 7400 feet”, the original specimen tag does not include any reference to the Rio Peñasco (Appendix 5). This reallocation of these collection locations to James Canyon also has bearing on the historical distribution of the endangered *Zapus hudsonius luteus*. This species was also collected by Bailey 12 miles east of

Cloudcroft on 7 September 1902, and was previously presumed to have been collected from the vicinity of the junction of Cox Canyon with the Rio Peñasco (Frey 2005).

In addition to *T. m. atristriatus*, Bailey and Hollister also collected 6 *T. canipes* from James Canyon between Mayhill and Cloudcroft. Further, just 2 years earlier, Vernon Bailey collected mammals in vicinity of Cloudcroft from 28 May – 2 June 1900. During that survey, which was apparently restricted to mixed coniferous forest, only *T. canipes* was collected. The combined chipmunk collection data from 1900 and 1902 suggest that *T. m. atristriatus* and *T. canipes* may have partitioned habitat by elevation (Figure 1).

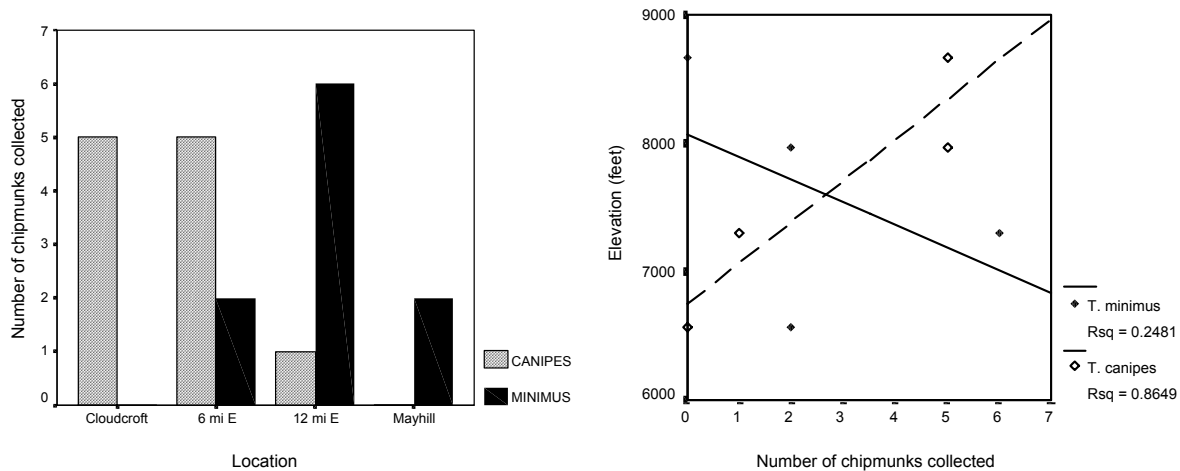


Figure 1. Chipmunks collected by Vernon Bailey and colleagues at 4 locations in vicinity of James Canyon between Cloudcroft and Mayhill during 1900 and 1902.

Brown 1928 collection.—Using the Mammal Networked Information System (i.e., MaNIS ; <http://manisnet.org/>), a series of 12 chipmunks was found in the Harvard University Museum of Comparative Zoology (MCZ) collected by W. W. Brown during fall 1928 from Cloudcroft, Otero County. This series included a previously unreported specimen of *T. m. atristriatus* (MCZ 24613 collected by W.W. Brown 10 September 1928 from Cloudcroft, 9,000 ft). Frey examined the specimen and verified its identification (Appendix 5). However, field notes were not available for this series of specimens so it is unknown if “Cloudcroft” represented a specific capture location or was used generically for collections in vicinity of the town.

Huber 1931-1932 expedition.—During 1931 - 1932 Wharton Huber from the Academy of Natural Sciences in Philadelphia (ANSP) sampled mammals in the Sacramento and White mountains as part of a series of expeditions to the southwestern United States and Mexico during the late 1920s and early 1930s. These trips led to the collection of 85 specimens of *T. m. atristriatus* and 42 specimens of *T. canipes* from Otero County (the late discovery of this collection during June 2007 precluded obtaining records from Lincoln County for this report). In the Sacramento Mountains, these included 56 *T. m. atristriatus* and 21 *T. canipes* from a total of 19 locations on the Mescalero Apache Reservation including Elk Canyon (5 locations from 7,000 – 8,300 ft), Tularosa Canyon (11 locations from 6,600 – 7,500), North Fork Tularosa Canyon (1 location at 7,500 ft), and Fence Canyon (1 location at 8,000 ft). All previous locations had been from the vicinity of James Canyon off the reservation. Of the 19 locations,

only *T. m. atristriatus* was collected at 8 locations, only *T. canipes* was collected at 5 locations, and both species were collected at 6 locations (of these, *T. m. atristriatus* was much more abundant at all but 1).

In considering all chipmunks collected during the Huber expedition, *T. canipes* was captured over a broader range of elevations than *T. m. atristriatus* (Figure 2). However, there was no significant difference (Kolmogorov-Smirnov $Z = 1.099$, $P = 0.179$) in elevation of capture sites between *T. m. atristriatus* ($x = 7,272.0$, $SE = 70.48$) and *T. canipes* ($x = 7273.8$, $SE = 129.13$) or significant relationship between elevation and number of either species collected (Figure 3).

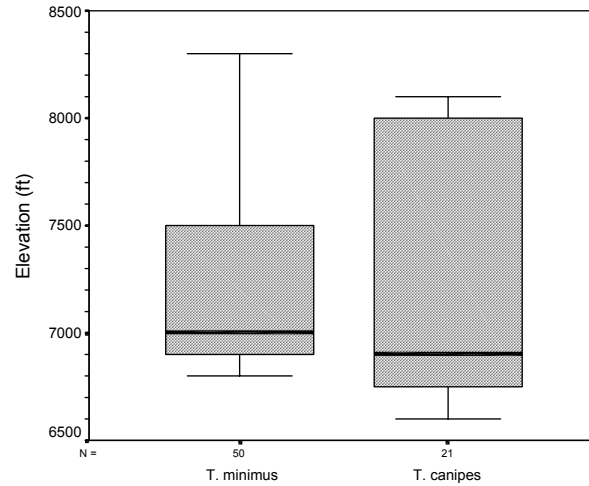


Figure 2. Elevation of chipmunks collected by Wharton Huber and colleagues from the Sacramento Mountains during 1931 and 1932. Black bars represent medians, boxes represent the interquartile range containing 50% of values, whiskers include the highest and lowest values, and asterisks represent outliers.

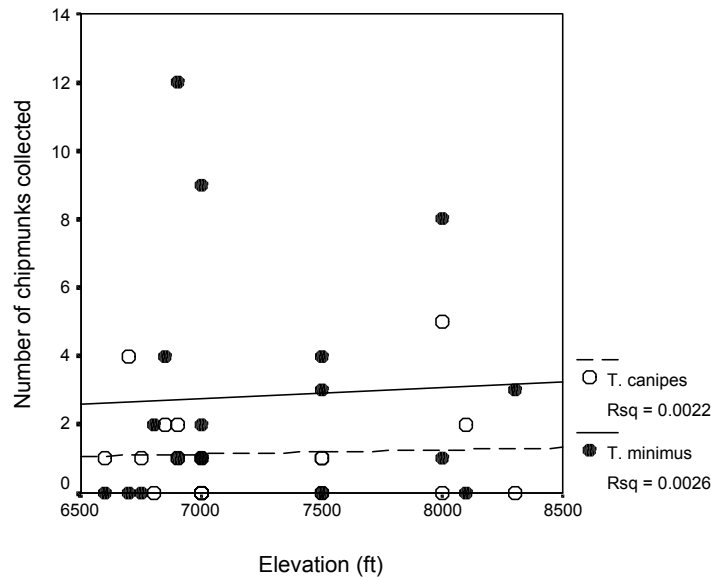


Figure 3. Relationship between elevation and number of chipmunks collected by Wharton Huber and colleagues during 1931 and 1932 from the Sacramento Mountains.

However, a clear pattern of habitat segregation by elevation was apparent when collections from particular canyon were evaluated (Figure 4). In Elk Canyon, where collection locations extended from the middle ponderosa pine forest zone and upward into the mixed coniferous forest zone, 87% of *T. canipes* were collected at or above 8,000 ft, while 82% of *T. m. atristriatus* were collected at or below 8,000 ft (Figure 4a). In Elk Canyon, 8,000 ft marks the approximate boundary between ponderosa pine forest and mixed coniferous forest. In contrast, in Tularosa Canyon collection locations extended from the middle ponderosa pine forest zone and downward into the coniferous woodland zone. In this case, 92% of *T. canipes* were collected from 6,900 ft or below, while 81% of *T. m. atristriatus* were collected from 6,900 ft or above (with none collected below 6,800 ft; Figure 4b). In Tularosa Canyon, 6,900 ft marks the approximate boundary between ponderosa pine forest and piñon-juniper woodland. Thus, these data support the contention that *T. canipes* occupied both the lower coniferous woodland zone and the higher mixed coniferous forest zone, while *T. m. atristriatus* was restricted to the ponderosa pine forest zone. See Appendix 5 for photographs of Elk and Tularosa canyons.

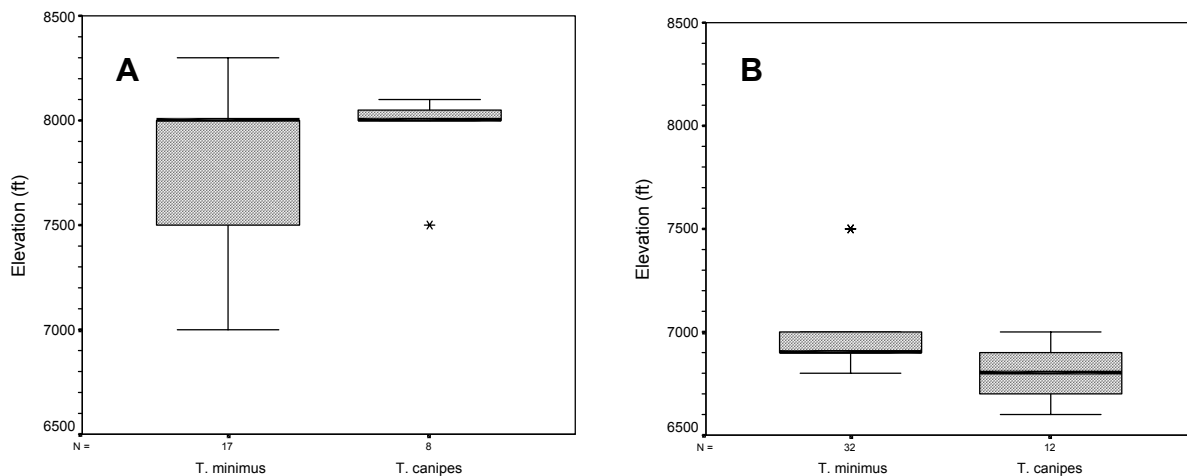


Figure 4. Elevations of chipmunks collected in A) Elk Canyon and B) Tularosa Canyon in the Sacramento Mountains by Wharton Huber and colleagues during 1931 and 1932. Black bars represent medians, boxes represent the interquartile range containing 50% of values, whiskers include the highest and lowest values, and asterisks represent outliers.

Fleharty 1957-1958 study.—Eugene Fleharty completed his Master’s thesis research in 1958 at the University of New Mexico, Museum of Southwestern Biology (MSB) under the direction of James Findley on variation within the *Tamias cinereicollis* group, which then included *T. canipes* (Geluso and Wilson 1997). As part of this research, Fleharty collected chipmunks from the White and Sacramento mountains during 1957 - 1958, which are deposited in the MSB. Chipmunks were collected from 2 locations in the Sacramento Mountains (as well as at 2 locations in the White Mountains where single specimens of *T. canipes* were collected). On 2-4 July 1957 at a location 1 mile south of Cloudcroft (T16S, R12E, Sec 8), which is in vicinity of upper Cox Canyon, he collected a series of 30 *T. canipes*; no *T. m. atristriatus* were collected. In contrast, at a location in James Canyon, 7 miles east of Cloudcroft (T16S, R13E, Sec 4), he collected 2 *T. m. atristriatus* on 12 and 13 July 1958, while no specimens of *T. canipes* were collected (Appendix 5). In 1981 Findley reported that Fleharty had collected those

specimens from the “dry arroyo of James Canyon (Sullivan et al. undated:22). These records confirmed the persistence of *T. m. atristriatus* in upper James Canyon, which was within 1 mile of Bailey’s 1902 historical capture site 6 miles east of Cloudcroft.

Conley 1965-1966 study.—During 1965 - 1966 Walt Conley from New Mexico State University conducted field surveys of *Tamias minimus* in the Sacramento and White mountains as part of a study to assess morphological variation in *T. minimus* throughout the Southwest. During this survey, 4 *T. m. atristriatus* were collected in 1966 from James Canyon Campground, which is located in James Canyon at an elevation of ca 6800 ft. (N 32° 54.262, W 105° 30.261). Conley (1970:699) implied that because rocky outcroppings were generally absent from that area, a large erosional gully running most of the length of James Canyon provided “substitute habitat”. Whether the specimens were collected in the gully is unknown (Appendix 5).

The effort required to collect these 4 specimens was not reported. Two of the specimens were collected on 17 July and one was collected on 4 August; no collection date was recorded on the fourth specimen (Appendix 2). The only other chipmunk specimens collected during 1965-1966 from the Sacramento Mountains and deposited in the NMSU Vertebrate Museum (NMSU) were 2 *T. canipes* from James Canyon Campground collected on 24 and 25 September 1966. Thus, it is unknown if other areas in the Sacramento Mountains were also surveyed for *T. m. atristriatus*. However, Conley (1970:700) stated that “many hours of trapping and observation, over 2 years, were nonproductive”. In 1981 Conley reported that he had attempted to collect *T. m. atristriatus* from the same area but was unsuccessful (Sullivan et al. undated). There are no specimens collected by Conley in the NMSU after fall 1966. The 4 specimens collected in 1966 during Conley’s study represent the last verification of the persistence of the Sacramento Mountains population of *T. m. atristriatus*.

Sullivan 1981-1982 survey.—During 1981 - 1982 Robert Sullivan and colleagues from MSB conducted a survey for *T. m. atristriatus* as part of a study to assess variation in the ecology, morphology, and genetics of montane populations of *T. minimus* in the Southwest (Sullivan et al. undated, Sullivan 1985, Sullivan and Petersen 1988). Sullivan’s fieldwork included 20 locations within Lincoln and Otero counties, including 18 within the Sacramento Mountains (primarily, or exclusively, on lands administered by Lincoln National Forest). Total effort in the Sacramento Mountains included 320 hours (presumably this was with firearms) and 2,569 trap-days. Locality-specific habitat data were not reported. No *T. m. atristriatus* were documented, although 85 *T. canipes* were collected. Of note, James Canyon Campground was intensively surveyed during both 1981 and 1982 (ca 72 hours, 709 trap-days), but only 7 *T. canipes* were collected. Although no *T. m. atristriatus* were verified in the Sacramento Mountains during this survey, Sullivan et al. (undated) reported that on 2 different occasions he and Joe Cook observed chipmunks resembling *T. m. atristriatus* that were feeding on weed and cultivated oats along the side of New Mexico Highway 244, which is in the open ponderosa pine and meadow habitat in lower Silver Springs and upper Elk Canyon on the Mescalero Apache Indian Reservation. Apparently based on these observations, Sullivan et al. (undated) considered *T. m. atristriatus* to persist in that area.

Ward 1991-1996 study.—As part of a dissertation study on the ecology of spotted owls, Pat Ward collected data on small mammals in the Sacramento Mountains from 1991-1996 (Ward 2001). Data collection was focused on 3 habitat types, including montane meadow, “mesic

forest” (i.e., upper montane [=mixed] coniferous forest dominated by Douglas fir and white fir), and “xeric forest” (i.e., lower montane [=ponderosa pine] coniferous forest and conifer [piñon-juniper] woodland). Small mammal sampling grids were established at 6 sites within each habitat type (18 sites total). Based on field identifications, most chipmunks were identified as *T. canipes*, although a smaller number were referred to *T. m. atristriatus*. However, no voucher specimens were collected in order to confirm identifications of the potential *T. m. atristriatus* (P. Ward personal communication). Consequently, morphological data recorded in the field were post-hoc compared with morphological parameters of *T. m. atristriatus* and *T. canipes* summarized by Hope and Frey (2000; P. Ward personal communication). Morphological data collected in the field included mass, tail length, body length, hindfoot length, and ear length (although all measurements were not necessarily available for all captured animals). Based on these comparisons, any records that appeared to be consistent with the morphological parameters of *T. m. atristriatus* were considered possible *T. m. atristriatus* and were reported as *Tamias sp.* (P. Ward personal communication).

However, at least some measurements taken in the field were not taken according to standard mammalogy methods, and hence are not directly comparable to those used in the technical key provided by Hope and Frey (2000). For example, hindfoot length in the Ward study was taken from heel to end of toe excluding nail, as opposed to heel to end of longest claw as is standard in mammalogy. Based on standard measurements, *T. m. atristriatus* has a hindfoot length ≤ 32 , while *T. canipes* has a hindfoot length ≥ 32 (Frey 2007; see Appendix 3). However, because field measurements of the hindfoot were taken without including the claw, some *T. canipes* were likely to fall below the 32 mm cutoff and be misidentified as *T. m. atristriatus*. Similar problems may have occurred with other measurements and some measurements (e.g., ear length) on live animals may be different than taken on dead animals due to constraints associated with handling live animals (P. Ward, personal communication). Mass is a non-overlapping character in adult chipmunks (Appendix 3). However, alone this an unreliable diagnostic character because it is subject to wide variation based on age and reproductive status.

Because no voucher specimens were collected and because of the problems associated with the field-collected measurements, chipmunk identifications should be considered highly questionable. Regardless, repeated patterns of occurrence of possible *T. m. atristriatus* from specific sites may warrant further investigation. Frey examined capture data for 43 possible *T. m. atristriatus* provided by Pat Ward. Based on measurements (e.g., correcting hindfoot length by adding 3 mm for claw length) Frey eliminated 16 of the records as likely *T. canipes*. Another 15 records did not have enough information to evaluate identification. A total of 12 records from 8 sites could not be dismissed as possible *T. m. atristriatus*. The largest concentration of possible *T. m. atristriatus* was 3 individuals captured 8 July 1994 from a xeric forest site located on James Ridge (UTM: 444700, 3647400; NAD 27).

Hope and Frey 2000 survey.—Frey and her graduate student Andrew Hope conducted a survey for *T. m. atristriatus* in the Capitan, White, and Sacramento mountains from 20 May to 3 September 2000 using a total effort of 5,478 trap-days (Table 1; Hope and Frey 2000). During this survey, 22 different habitat associations were sampled in the Sacramento Mountains using 4,091 trap-days (Table 1). No *T. minimus* were captured in the Sacramento Mountains. However, *T. canipes* was captured at 12 of the sampling areas (54%) and relative abundance at these areas ranged from 0.4 to 2.5 chipmunks per 100 trap-days (mean = 1.4/100 trap-days). The

most intensive survey effort was 25-28 July at James Canyon Campground, where 1,280 trap-days were used in 5 different habitat associations; 10 *T. canipes* were captured (Table 1).

Wampler 2007 study.—During 2005 and 2006, Christy Wampler conducted a Master's thesis under the direction of Frey on the effects of thinning mixed coniferous forest on mammals (Wampler 2007). The study area was located 3-15 km southeast of Cloudcroft in upper Pumphouse and Cox canyons. Habitat was mixed coniferous forest. Total sampling effort was 27,440 trap-nights. No *T. m. atristriatus* were captured, although *T. canipes* was the second most abundant species captured (see Habitat Results for more details).

Specimens with identification problems.—A specimen (skeleton without a skin) in the MSB (MSB 35034 collected by Jack (Buck) F. Cully 23 June 1971 from “8 mi. W [sic] Cloudcroft?[sic]”) was cataloged as *T. minimus* but is likely *T. canipes*. A second problem concerns a specimen cataloged as *T. canipes* in the University of Texas El Paso Centennial Museum (UTEP 6017) that was collected by J. N. Fries 11 August 1979 from “McGregor Range, Double Tank (T21S, R11E, NE corner Sec. 34)”. It is a skull without a skin and was examined and measured by Alfredo Montoya who is doing his graduate research under the direction of Frey on geographic variation within *T. canipes*. Montoya classified the specimen as an adult based on tooth wear. Montoya and Frey ran a preliminary multivariate analysis of *T. canipes* specimens from throughout its range and UTEP 6017 fell out as an outlier based on its small size. Thus, it is possible the specimen represents either *T. minimus* or perhaps more likely, a young *T. canipes* with unusually worn teeth. Further investigation of the original data collection sheets revealed that the collection location was incorrectly reported (Brian Locke, personal communication). The actual collection location was in Culp Canyon (ca UTM 3605400E, 431650N, NAD 83; Brian Locke personal communication).

Table 1. Summary of Hope and Frey (2000) survey results for *Tamias minimus* in Lincoln and Otero counties, New Mexico, during 2000.

Location	Range ¹	trap days	Relative abundance ²		elevation	Habitat structure	Habitat type	Stand age	Aspect	Slope	Habitat description ³
			<i>T. minimus</i>	<i>T. canipes</i>							
Capitan Mountains, Peppin Canyon forest	C	380	0	0	2875	forest	df	young		5-25	young DF, some mature QA, forest thick, sparse undergrowth except at edge
Capitan Mountains, Peppin Canyon meadow	C	240	0	0.4	2875	open	meadow	na	S	0-10	fairly open meadow with some mature QA, scattered mature DF; abundant fallen logs in thick grass and forbs
Capitan Mountains, summit talus	C	207	0	0.5	2974	open	talus	na	S	35-40	large area of talus consisting of large stable rocks; surrounded by DF, some QA, Rhus, raspberry
Agua Chiquita Lower Canyon	S	240	0	0.4	2291	open	pp	riparian		0-15	most traps set along creek and some along forest edge; PP; grasses and forbs very abundant and thick
Agua Chiquita Middle Canyon	S	240	0	0.8	2404	open	pp/df	riparian		0-25	traps set in open areas near creek and some under trees; PP and DF; small patch Desert willow; many fallen logs/stumps; no standing water
Agua Chiquita upland	S	140	0	0	2297	forest	pp	mature		5-15	open PP, abundant grasses and forbs
Agua Chiquita Upper Canyon	S	180	0	2.2	2626	forest	df	mature		0-20	traps set along creek; adjacent forest DF, some QA
Bear Canyon north- facing slope	S	90	0	0	2225	forest	pp/df	mature	N	30	mature DF, PP, GO, WP; forest not thick, abundant fallen logs, moderate undergrowth; running stream at base hill
Bear Canyon south- facing slope	S	90	0	0	2225	forest	pp	young	S	20	small PP, GO
Bible Canyon north- facing	S	240	0	1.7	2129	forest	pp	mature	N	10-25	abundant mature PP, some DF, GO, PY; moderate WO understory; numerous fallen logs; sparse undergrowth
Bible Canyon south- facing	S	60	0	0	2129	woodland	pj	na	S	20-35	abundant PY, AJ, moderate WO understory; sparse grass, loose rock/gravel

Carr Gap Burn	S	40	0	0	2161	burn	burn	burn		1-35	no living overstory (formerly mature PP/DF); plentiful logs/stumps; understory LO some WO; moderate dense grass, very abundant forbs; small stone bluff
Elk Canyon	S	70	0	1.4	1928	woodland	pj	na		10-30	AJ, PY, PP, JU; WO present; dry arroyos; limestone cliff; little grass or other groundcover
James Canyon Campground bluff woodland	S	360	0	1.9	2088	forest	pp	mature	N	10-90	rock bluff; PP, large GO; some areas with WO and LO; diverse shrubs
James Canyon Campground dense herbaceous	S	150	0	0	2088	open	meadow	na		0	100% cover tall (1.5 m) forbs; large boulders
James Canyon Campground grassland	S	480	0	0.6	2088	open	various	na		0-25	meadow of blue grama and forbs with dry arroyo and rock walls
James Canyon Campground hilltop shrubland	S	120	0	0	2088	woodland	scrub	na		15	groundcover 90% WO and LO; ground rocky, sparse grass
James Canyon Campground juniper savanna	S	170	0	0	2088	woodland	juniper	na	S	10-40	AJ dominated, some very young PP, WO and skunkbush, rocky, sparse ground cover; traps wet along dry arroyo
McNatt Spring Camp	S	213	0	0.9	2303	forest	pp/df	mature		5-30	mature PP, DF, GO, some AJ; fallen logs and needle litter abundant; near meadow and dry arroyo
Sacramento Lake forest	S	234	0	1.7	2595	forest	df	mature	W	0-45	open DF, sparse GO, few shrubs, abundant forbs and grasses
Sacramento Lake riparian	S	400	0	0	2595	open	riparian	na		0	lake edge; abundant rushes, bulrushes and saltgrass; traps set in dry to very wet locations
Threemile Canyon burn	S	184	0	0.5	2184	burn	burn	burn		1-30	no living overstory; plentiful burnt logs/stumps; dense understory of LO, abundant grasses and forbs; dry arroyos; running spring
Threemile Canyon northeast facing	S	120	0	2.5	2243	forest	pp/df	?	NE	25	abundant PP merging with DF up slope; some fallen logs
Threemile Canyon southwest facing	S	120	0	1.7	2243	forest	pp	mature	SW	20-90	sandstone bluff; overstory PP, GO, WP; sparse undergrowth
Walker Canyon	S	150	0	0	2145	forest	pp/df	mix		0-25	young/mature open stand PP; DF present, some WO in understory; tank with water; dry arroyo; moderately dense grasses and forbs

Buck Mountain montane meadow	W	200	0	0	3226	open	meadow	na	S	1-40	90% groundcover grasses, sparse forbs include alpine lupine, wild onion, mountain iris; soil thin with talus underneath
Buck Mountains forest talus	W	120	0	2.5	3226	open	talus	na		35	small area of talus surrounded by thick DF, ES, SF; thick grass between talus and forest
Buck Mountains open talus	W	80	2.5	0	3226	open	talus	na	SW	40	traps mostly set on bare talus, small sparse DF present
Windy Point Talus	W	160	0	0	3048	open	talus	na		40	large open talus of small, shallow unstable rocks; sparse QA, surrounding forest moderately thick DF, ES; thick grasses, moderately thick forbs/shrubs

¹C=Capitan Mountains, S=Sacramento Mountains, W=White Mountains

²Relative abundance = captures / 100 trap-days

³PP-ponderosa pine, DF-Douglas fir, QA-quacking aspen, GO-Gambel's oak, WO-white oak, LO-New Mexico locust, PY-Colorado pinyon, AJ-alligator juniper, JU-one-seed juniper, WP-southwest white pine, ES-Engelmann spruce, SF-subalpine fir

White Mountains

Sierra Blanca.—During the 1931 - 1932 Wharton Huber expedition from the Academy of Natural Sciences in Philadelphia 29 *T. m. atristriatus* were collected 22-28 July 1931 from vicinity of “Rock Spring” on Sierra Blanca Peak at elevations ranging from 10,200 to 11,950 ft. (Appendix 2). “Rock Spring” could not be found on available maps or in the USGS gazetteer. However, it seems likely that “Rock Spring” referred to an unnamed mapped spring on the south-facing aspect of Sierra Blanca Peak at the head of the South Fork Rio Ruidoso (N 33° 22.055, W 105° 48.881, 10,720 ft elevation). No *T. canipes* were collected from these locations.

Evidently unaware of the large ANSP collection of *T. m. atristriatus*, Walt Conley incorrectly reported discovering a “new” population of least chipmunk from Sierra Blanca Peak in June 1965 (Conley 1970). Subsequent fieldwork by Conley during 1965 - 1966 resulted in the collection of 26 *T. m. atristriatus* from at least 4 locations on the east face of Sierra Blanca Peak and from the ridge extending due north from the peak towards Lookout Mountain (Appendix 2 and 5). Specimen locations ranged in elevation from 11,000 to 11,500 ft, although Conley (1970) reported locations ranging down to 10,500 ft. There was considerable disagreement between localities on specimen tags and those reported in Conley (1970), especially with regards to county and details of descriptive locations. For example, all specimen tags recorded Lincoln County although Conley (1970) reported all from Otero County with the exception of 3 from “T. 10 S, R. 11 E, 0.5 mi. N Sierra Blanca Peak, on north ridge, 11,500”. This location is further complicated because 0.5 mi N of Sierra Blanca Peak is within Otero County and within Township 11 South. Thus, the precise collection locations are uncertain, although undoubtedly within close proximity to Sierra Blanca Peak. All of these specimens are in the Vertebrate Museum at New Mexico State University (NMSU), which does not contain any *T. canipes* from these locations (Appendix 2).

During 1981 and 1982 Robert Sullivan conducted a survey for *T. m. atristriatus* as part of a larger study to assess the subspecies taxonomic validity and ecology (Sullivan undated). Sullivan’s fieldwork included 21 locations within Lincoln and Otero counties, including 2 within the White Mountains. A total of 2 *T. m. atristriatus* were collected 10-12 August 1982 during 48 hours of hunting and using 153 trap-days from “Otero Co., Sierra Blanca Peak, Mescalero Apache Indian Reservation, elev. 11,800 ft.” (Sullivan undated:Table 17). One of these specimens was found uncataloged in a hold-up case at the Museum of Southwestern Biology (MSB; see Appendix 2 for details of date and location); the other specimen is missing. Published accounts of these specimens report the location as “Glacial cirque, NE face Sierra Blanca Peak” (Sullivan 1985, Sullivan and Petersen 1988; see Appendix 5). Also collected during this sampling were 2 *T. canipes*, which are cataloged in the MSB (Sullivan undated; MSB database). A second location sampled in the White Mountains (Lincoln Co., 3 mi W Alto, T10S, R12E, Sec 36) from 5-7 October 1981 resulted in the collection of only 2 *T. canipes*.

Ortiz (1999) reported that a survey for *T. m. atristriatus* was conducted in the White Mountains in late October 1997, during which time a single *T. canipes* was found near the top of the ski lift on Lookout Mountain; no additional details were provided.

Buck Mountain.—In 1998 Lincoln NF Smokey Bear RD conducted a survey for *T. m. atristriatus*. The following information concerning this survey is from SBRD (undated) and Ortiz (1999). The survey was conducted 14 – 24 July 1998 and consisted of 12 survey locations in vicinity of Lookout and Buck mountains using a total effort of 1,260 trap-days (Table 2). A

total of 5 vegetation associations were sampled: ABCOMCQ=*Abies concolor*, *Pseudotsuga menziesii*, *Pinus ponderosa*, *Pinus strobiformis*, *Quercus gambelii*, PSMEPPJ=*Pseudotsuga menziesii*, *Pinus ponderosa*, *Juniperus deppeana*; PIENMC=*Picea engelmanni*, *Abies lasiocarpa*, *Abies concolor*, *Pseudotsuga menziesii*; FETHDAF=*Festuca thurbers*, *Panthonia intermedia*, *Festuca arizonica*; PEINABL=*Picea engelmanni*, *Abies lasiocarpa*. Sampling at each site consisted of 3 parallel transects spaced 20 m apart with each transect composed of 8 or 9 standard and large sized Sherman traps spaced 20m apart (i.e., arrays had 24 or 27 traps total). On the first day of trapping each week, traps were baited but were left closed (i.e., a method called pre-baiting that is sometimes used in ecological studies). On the following 4 days, the traps were opened at dawn and closed in late afternoon; traps were left open for ca 10 hr per day. Bait was a mixture of chicken scratch, peanut butter, and raisins.

No voucher specimens were collected in order to verify identifications. Rather, captured chipmunks were identified in the field based on pelage color patterns and mass. However, data on pelage color patterns were not systematically recorded so pelage characteristics could not be used for post-hoc assessment of field identifications. Alone, mass is an unreliable diagnostic character because it is subject to wide variation based on age and reproductive status. Standard external measurements are useful for identifying *T. m. atristriatus* and *T. canipes* (Frey 2007). However, descriptions of methods for external measurements in SBRD (undated) indicated that they were not taken according to standard mammalogy methods (e.g., hindfoot length was taken from heel to end of toe excluding nail as opposed to heel to end of longest claw as is standard in mammalogy; ear lengths were usually much shorter than range of variation based on standard measurements). Consequently, external measurements taken in the field during this study could not be compared to museum specimens or used in technical keys.

One chipmunk identified as *T. minimus* was captured on 16 July 1998 from site 10 (Trap C6) on Buck Mountain, which was at the top of a large area of talus within the subalpine grassland on the south-facing side of the mountain (Ortiz 1999, SBRD undated). The animal was reported to be a lactating female with external measurements of body=95, tail=87, hindfoot=24, and ear=13. The animal was removed from the field and kept in captivity overnight where it was observed by several biologists. The animal was not taken as a voucher specimen, but was released the following day where captured. In June 2007 Frey examined a series of 51 unlabeled/undated photographs of captured animals, habitat, and researchers taken during the study (photos are in SBRD [undated]). A number of the photographs were of individual chipmunks, including in an aquarium, in plastic bags, being released onto talus, and being held by people. Frey concluded that several of the photographs, presumably of the individual captured on 16 July, were likely *T. m. atristriatus* on basis of blackish rather than brownish dorsal stripes, first pair of lateral dorsal stripes extend to base of tail rather than fading over rump, extensive orange on sides rather than sides orange and gray. No *T. canipes* were captured at this site (Table 2). The reported UTM coordinates of the grid from which the *T. m. atristriatus* are incorrect. Based on descriptions of the location (Larry Cordova personal communication) and photographs contained in SBRD (undated) the capture location was very near the capture locations of 2 *T. m. atristriatus* captured in 2000 by Hope and Frey (2000; see Appendix 5).

Two other captures during the study warrant comment. A datasheet recorded by P. Ward from Site 12 on 24 July 1998 included an unmarked chipmunk of uncertain identification (recorded as "TASP"). Recorded data indicated that it was a reproductively inactive adult female (body=112, tail=94, hindfoot=31, ear=20) that was released unharmed. A note in the

comments field indicated: “coloration like a TAMI; dorsal strips [sic] to base; climbed tree”. On the same day, another datasheet recorded by P. Ward from Site 8 included a recaptured adult male chipmunk identified as *T. canipes* with abdominal testes (body=106, tail=96, hindfoot=29, ear=16) that was released unharmed. A note in the comment field indicated: “tail orange/black/orange – dorsal stripes incomplete to tail”. *T. minimus* has the outer ventral part of the tail hairs orange as opposed to gray in *T. canipes*. Thus, the identity of these records is questionable.

Table 2. Results of *Tamias minimus atristriatus* surveys conducted in the White Mountains by Smokey Bear Ranger District, Lincoln National Forest in 1998 (data compiled by J. Frey from SBRD [undated]).

Site	Location	UTM			Vegetation ¹	Date	Trap-days ²	Relative abundance ³	
		Northing	Easting	Elev.				<i>T. canipes</i>	<i>T. minimus</i>
1	Carlton Canyon	3696520	429600	8740	ABCOMCO	14-17 Jul	108	4.6	0
2	Johnson Canyon	3697600	429860	9170	ABCOMCO	21-24 Jul	96	5.2	0
3	Buck Mtn	3695740	427520	10800	PIENMC	14-17 Jul	108	11.1	0
4	Lookout Mtn	3696500	425280	10300	PIENABL	14-17 Jul	108	4.6	0
5	Lookout Mtn	3695000	425230	10800	PIENABL	21-24 Jul	108	3.7	0
6	Lookout Mtn	3695740	424460	11320	FETHDAF	21-24 Jul	108	20.4	0
7	Buck Mtn	3696080	427340	10250	FETHDAF	14-17 Jul	108	3.7	0
8	Buck Mtn	3696500	427350	10200	FETHDAF	21-24 Jul	96	8.3	0
9	Buck Mtn	3697500	426280	10280	PIENMC	21-24 Jul	96	2.1	0
10 ⁴	Buck Mtn	3696850	427520	10500	FETHDAF	14-17 Jul	108	0	0.9
11	Buck Mtn	3696780	427940	9870	PSMEPPJ	14-17 Jul	108	7.4	0
12	Buck Mtn	3697020	427940	10350	PSMEPPJ	21-24 Jul	108	9.3	0

¹See Historical Locations section for description of habitat types.

²Does not correct for traps found shut but empty.

³Relative abundance = captures per 100 trap-days.

⁴The UTM coordinates for this capture site are an error

Frey and her graduate student Andrew Hope conducted a survey for *T. m. atristriatus* in the White, Sacramento, and Capitan mountains from 20 May to 3 September 2000 based on a total effort of 5,478 trap-days (Table 2; Hope and Frey 2000). During this survey, Hope and Frey resampled the talus area on Buck Mountain from which *T. m. atristriatus* had presumably been captured in 1998. This sampling occurred 11-13 August and 18-20 August and involved 200 trap days in the subalpine grassland, 120 trap-days on talus within the coniferous forest, and 80 trap-days at the presumed historical location on the talus within the subalpine grassland. A total of 2 *T. m. atristriatus* were captured on the talus within the subalpine grassland near the location of the presumed 1998 capture (Appendix 5). One of these was collected as a voucher specimen (see Appendix 2 for details) while the other was released at the capture location (i.e., N 33° 24' 3.5", W 105° 46' 46.6, 3,209 m). No *T. canipes* were captured on the talus within the grassland or in the grassland itself, although 3 were captured in the talus within the coniferous forest. No chipmunks were captured in 160 trap-days from 18 – 20 August 2000 at a second large area of talus near Windy Point (i.e., Sacramento Mountains, Windy Point Talus, State Highway

532, 1 ¼ mi. N, 2 mi. E Sierra Blanca Peak, N 33° 23' 55.6", W 105° 45' 54.3", 3,048 m). Further, only *T. canipes* was captured in 827 trap-days from 1-3 September in the Capitan Mountains (see Table 2), which included 207 trap-days on a large talus area (i.e., Capitan Mountains, Capitan Summit Talus, Forest Road 56, 1 ½ mi. S, 5 ½ mi E Capitan Pass, N 33° 36' 4.8", W 105° 22' 39.3, 2,974 m).

Temporal Patterns

The number of chipmunk specimens collected in the White and Sacramento mountains peaked in the mid part of the 20th century with the highest numbers collected in the 1930's (Figure 5). However, the number of *T. m. atristriatus* specimens has declined, while the number of *T. canipes* specimens increased throughout much of the time period (Figure 6). The mean date of collection of *T. m. atristriatus* was significantly earlier than *T. canipes* ($Z = -8.083$, $P < 0.001$). This pattern was even more dramatic when considering only the Sacramento Mountains. No *T. m. atristriatus* specimens were collected during the last 4 decades despite high numbers of *T. canipes* (Figure 7). Further, the mean date of collection of *T. m. atristriatus* (1928) was significantly earlier than *T. canipes* (1960) in the Sacramento Mountains ($Z = -8.283$, $P < 0.001$). In contrast, the mean date of collection of *T. m. atristriatus* (1946) and *T. canipes* (1951) in the White Mountains were only marginally different ($Z = -2.0320$; $P = 0.042$; Figure 7). In addition to the change in numbers of specimens, since 1950 the number of new locations documented by specimens has decreased for *T. m. atristriatus* and dramatically increased for *T. canipes*, which has also led to a dramatic increase in the proportion of *T. canipes* to *T. m. atristriatus* locations (Figure 8).

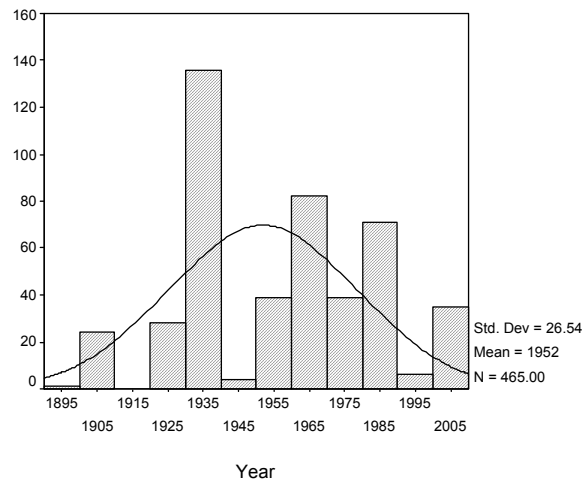


Figure 5. Frequency histogram of chipmunk specimens collected in the White and Sacramento mountains by decade. The line is a normal curve.

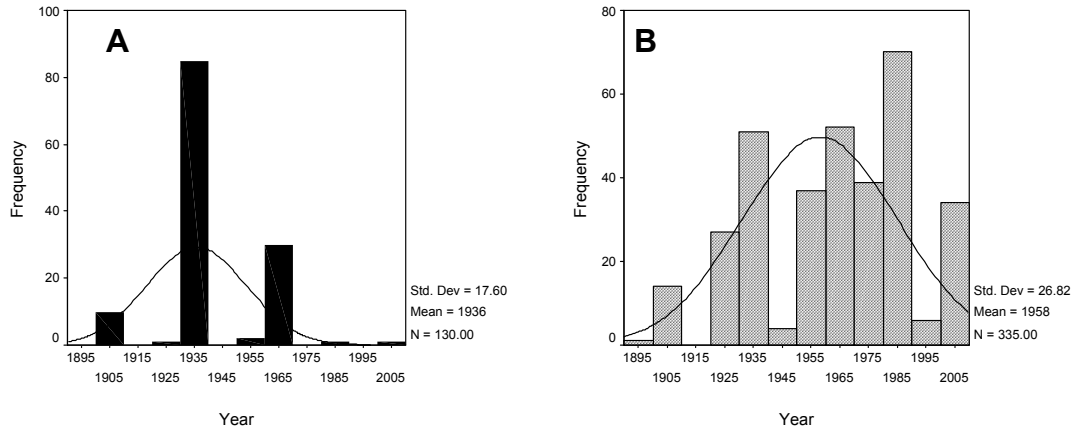


Figure 6. Frequency histogram of A) *T. m. atristriatus* and B) *T. canipes* specimens collected in the White and Sacramento mountains by decade. The lines are normal curves.

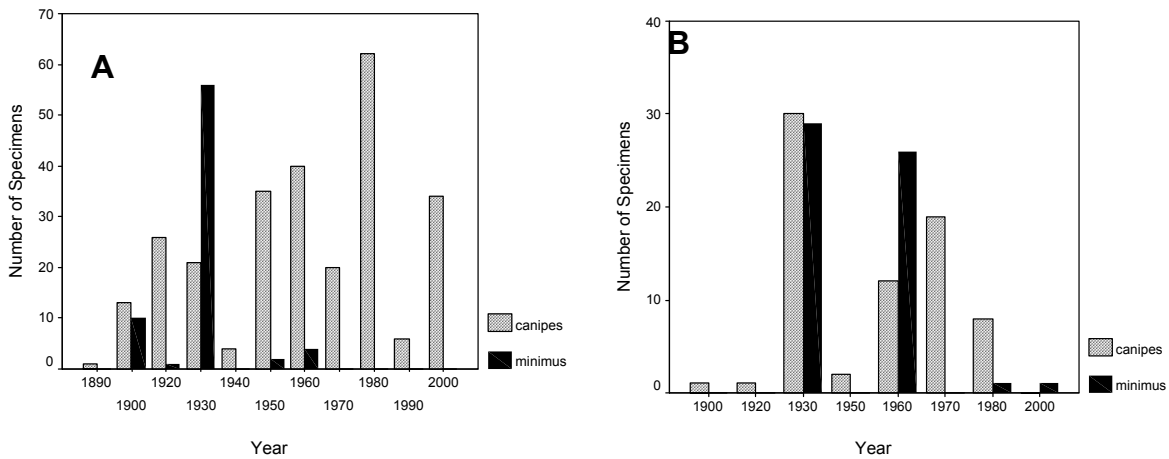


Figure 7. Number of specimens by decade of *T. m. atristriatus* (black bars) and *T. canipes* (cross-hatched bars) in the A) Sacramento Mountains and B) White Mountains.

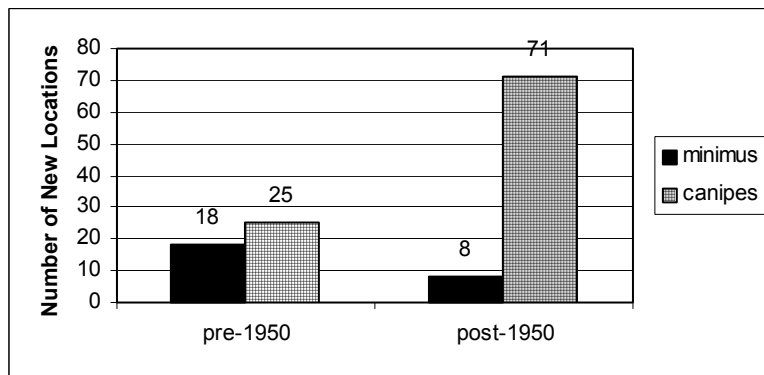


Figure 8. Number of new locations documented by specimens for *T. m. atristriatus* (black bars) and *T. canipes* (cross-hatched bars) before and after 1950.

Habitat

Original information and data about habitat associations for *T. m. atristriatus* (Table 3) and *T. canipes* (Table 4) was sparse. Most information was general descriptions of habitat at the general area where sampling efforts occurred. There was very little detailed information about specific habitat features at specific capture sites.

Peñasco least chipmunk

Sacramento Mountains.—Based on accumulated original habitat data, *T. m. atristriatus* appears to have used different distinctive habitat types in the White and Sacramento Mountains (Table 3). In the Sacramento Mountains, it was almost exclusively associated with the ponderosa pine forest zone (= Transition Zone). Bailey made a point that its distribution did not extend upward into the mixed coniferous forest zone (= Canadian Zone), but ended at the edge of this forest type. In interpreting Bailey's habitat descriptions it is important to note that his use of the term "spruce" referred to Douglas fir [*Pseudotsuga menziesii*], rather than true spruces [*Picea*]. Further, Bailey noted that its distribution only extended downward into the ecotone of ponderosa pine forest with junipers; Bailey never stated that they were observed within fully developed piñon-juniper woodland. Conley (1970:700) stated that they occurred in the "transition and upper pinyon-juniper zones". However, presumably this statement was based on his capture of *T. m. atristriatus* from James Canyon Campground. This area is actually within the ecotone between ponderosa pine forest and piñon-juniper woodland and the valley bottom at this site (where his specimens were presumably captured) is ponderosa pine forest. Thus, evidence indicates that the Sacramento Mountains population of *T. m. atristriatus* was associated with ponderosa pine forest, including its lower ecotone with piñon-juniper woodland. Most subsequent second-hand treatments have misconstrued this habitat association. For example, many sources incorrectly reported it as occurring in piñon-juniper woodland (e.g., Conley 1970:700; Findley et al. 1975:104; Sullivan 1985:436-437) and it has been incorrectly reported as occurring upward into the "spruce-fir zone" (referring either to the Canadian or Hudsonian zone), presumably due to misinterpretation of Bailey's use of the term "spruce" (e.g., Sullivan 1985:436-437). Another inexplicable statement was Sullivan's (no date:3) comment: "While Bailey (1931) reported *E. m. atristriatus* as being abundant in open ponderosa forest, the two most recent collection sites of this subspecies (Fleharty, 1960; Conley, 1970) occurred in rocky areas in or near dry creek beds. This appears to represent either a major shift or reduction in habitat preference." There is no evidence that any of the collection sites in the Sacramento Mountains were associated with rocky areas.

There is only sparse information about the structure of the habitat used by *T. m. atristriatus* in the Sacramento Mountains. Bailey stated that it was abundant in "open forest", but rare in "dense woods" (Table 3). He described the habitat in vicinity of James Canyon as "yellow pine forest [= ponderosa pine forest] with douglas spruce [= Douglas fir] on cold slopes. A few oak trees grow along the edge of the pines and scrub oak covers some of the sidehills. ... At about 5 miles east of Cloudcroft we struck the edge of the Canadian zone on N.E. slopes at 8000 feet, where we left *P. ponderosa* and struck *Abies*, *Picea*, *Populus tremuloides*, *Acer*, and a new set of smaller plants. No more Transition appears except on hot slopes. *Picea* is the most abundant Canadian zone tree. The Canadian forest is dense and beautiful, untouched and

perfect. The yellow pine is being cut below and a spur of the railroad runs out 2 miles east of the pumping station.” (Bailey 1902a:Sept 7). In vicinity of Cloudcroft, Bailey (1900:3) described ponderosa pine as “a large tree 4 to 6 feet in diameter and 100 to 150 [sic] feet high. Much used for lumber”. About the Mescalero Apache Indian Reservation, Bailey (1902c:1-2) wrote: “about two third of the reservation lies in Transition zone between 7000 and 9000 feet altitude and is covered with a beautiful open forest of *Pinus ponderosa*, enclosing numerous grassy parks and long, narrow valleys of rich soil and abundant grass.” “The yellow pine [*Pinus ponderosa*] ... grows mainly in clean, open forest of moderate sized trees, mainly 2 to 4 feet in diameter” (Bailey 1902c:4). “The whole reservation, except where too closely grazed, is covered with a luxuriant growth of grasses, which stand, in the unoccupied valleys, almost knee high, with ripe heads uncropped” (Bailey 1902c:6).

In several places, Bailey remarked that *T. m. atristriatus* was very numerous along rail fences, which presumably enclosed agricultural fields in the valleys of the Rio Peñasco and James Canyon along which the road passed (Table 3). Bailey (1902a:Sept 6) stated: “The valleys have rounded bottoms of rich mellow soil and are extensively cultivated. Good crops of corn, wheat, oats, cane, and vegetables are raised besides fruit. Apples, peaches, and pears are raised in abundance and of excellent quality. Sunflowers and other weeds grow in great luxuriance and often form beautiful field of golden yellow. Flowers are in their full spring prime but mixed with all the fall species, such as goldenrods, asters, sunflowers, roses, are still in flower”. *T. m. atristriatus* was observed feeding on the seeds of these crops and weeds (Table 3). Seeds are the most important food resource for *T. minimus* (Verts and Carraway 2001). Further, chipmunks have been reported to travel long distances (3.2 km) in order to capitalize on large, unnatural concentration of food (Tellen 1978 cited in Bergstrom and Hoffman 1991). These factors may account for the exceptionally high densities of *T. m. atristriatus* observed by Bailey on the rail fences adjacent the agricultural fields.

White Mountains.—All habitat descriptions of *T. m. atristriatus* in the White Mountains have been from rocky areas above tree line (Table 4). On Sierra Blanca Peak these rocky areas include the glacial cirque on the northeastern face of the peak, the rocky ridge extending north from the peak, boulder piles at the base of the cirque, and talus. On Buck Mountain, it has only been found on a large area of talus within the subalpine grassland.

In his evaluation of variation in *T. minimus* throughout the Southwest, Robert Sullivan collected detailed habitat data at all capture sites (Sullivan et al. undated, Sullivan 1985) including slope, substrate, height off ground, distance to nearest tree, tree species, distance to nearest shrub, shrub species, rock abundance, rock type, percent overstory cover, and predominant ground cover. These data were analyzed in a comparative way among various Southwest mountain ranges. Of those populations sampled, capture locations on Sierra Blanca Peak were unique in being the rockiest and having the fewest trees and shrubs (i.e., these capture locations were above tree-line). However, no quantitative descriptions or summaries of the habitat on Sierra Blanca Peak were made (Sullivan et al. undated, Sullivan 1985).

Table 3. Original, first-hand habitat information regarding *Tamias minimus atristriatus* from field notes, reports, and published literature.

Population	Quote	Reference
Sacramento Mountains	"Eutamias _____.—This little yellow bellied chipmunk is found throughout Transition zone along the east slope of the Mts., ranging with <i>canipes</i> up to the edge of the spruces [probably referring to what was then known as "Douglas spruce" <i>Pseudotsuga menziesii</i> rather than Engelmann spruce <i>Picea engelmannii</i> as sometimes referred] and apparently a little below it at the junction of the yellow pine [i.e., <i>Pinus ponderosa</i>] with the junipers. It is abundant in the open forest and especially along rail fences but is rarely seen in dense woods. Hundreds of them were seen on the roadside fences, often 3 or 4 at a time, running ahead of our horses, and while many were shot for specimens many more escaped into holes in the ground or among the weeds and brush or under logs. They were feeding on weed and sunflower seeds along the fences and on the wheat and oats at the edges of fields. The were too busy to [sic] to be noisy, but their chipper of alarm was constantly heard along the roads."	Bailey 1902b:4
Sacramento Mountains	"a small yellow-bellied species [of chipmunk] is abundant along the fences beside the [cultivated] fields"	Bailey 1902a:Sept 6
Sacramento Mountains	"We did not find the little Eutamias above about 8000 feet, not in Canadian zone"	Bailey 1902a:Sept 7
Sacramento Mountains	"...Hollister and I collected them along Penasco Creek at various points from 6 to 12 miles east of Cloudcroft and from 7000 to 8000 feet altitude, in the yellow pine [i.e., <i>Pinus ponderosa</i>] zone"	Bailey 1913:129-130
Sacramento Mountains	"In 1902 Hollister and the writer found these little yellow-bellied chipmunks throughout the Transition Zone along the east slope of the Sacramento Mountains, from 7,000 to 8,000 feet, ranging with <i>canipes</i> up to the edge of the spruce, and apparently a little below it to the junction of the yellow pines with the junipers."	Bailey 1931:91
Sacramento Mountains	"Black-striped chipmunks were abundant in the open forest and especially along rail fences, but were rarely seen in dense woods. Dozens were seen on the roadside fences, often three of four at a time running ahead of our horses, and while many were shot for specimens, many more escaped into holes in the ground under logs, or among the weeds and brush. They were feeding on weed and sunflower seeds along the fences and on the wheat and oats at the edges of the fields. They were too busy to be noisy, but their chipper of alarm was constantly heard along the roadsides."	Bailey 1931:91
Sacramento Mountains	"Specimens are present only from James Canyon on the eastern slope of the Sacramento Mountains. The type specimen (Bailey, 1913) was obtained at 7400 feet, but others I have examined are from below this elevation. Habitat there is dominated by Ponderosa pine (<i>Pinus ponderosa</i>) down to about 7000 feet, where Transition vegetation fades and Pinyon-Juniper (<i>Pinus edulis-Juniperus</i> sp.) begins. I collected four specimens at 6800 feet. Rocky outcroppings are generally absent in this area, but substitute habitat is provided by a large erosion gully running through most of the length of the canyon."	Conley 1970:699

Sacramento Mountains	"Conversely, <i>E. m. atristriatus</i> inhabits a localized area, at elevations some 3000 to 5000 feet lower than the others, and appears restricted to the Transition and upper Pinyon-Juniper zones"	Conley 1970:700
White Mountains; Sierra Blanca	"These chipmunks inhabit areas above 10,000 feet within the confines of a glacial cirque on the northeastern face, and along the rocky ridge pointing north from the top of the peak. Extensive boulder fields characterize the habitat."	Conley 1970:698-699
White Mountains; Sierra Blanca	"The habitat and elevational range where <i>E. minimus</i> is found on Sierra Blanca is quite similar to the areas of northern New Mexico and Arizona where <i>E. m. operarius</i> and <i>E. m. arizonensis</i> occur."	Conley 1970:700
White Mountains; Sierra Blanca	"taken in boulder pile below cirque"	uncataloged MSB specimen bearing collector number JAC 1154
White Mountains; Sierra Blanca	"The rockiest habitat was found on Sierra Blanca Peak, New Mexico, where <i>E. minimus</i> occurs only within the glacial cirque on the northeast face and along the rocky ridge north of the peak. Steep and rocky topography also characterized chipmunk habitats from the Sandia and Chuska Mountains, where individuals were frequently sampled along limestone and sandstone ledges, respectively."	Sullivan et al. no date:15
White Mountains; Sierra Blanca	" <i>E. minimus</i> from Sierra Blanca Peak and Tres Ritos load heavily on this factor because they were sampled primarily on large boulders, the most common landform on the peak"	Sullivan et al. no date 15-16
White Mountains; Sierra Blanca	"...Sierra Blanca Peak population, where <i>E. minimus</i> occurs above treeline. All other localities are characteristically edge of forested habitats."	Sullivan et al. no date:16
White Mountains; Sierra Blanca	"The most saxicolous terrain was found on Sierra Blanca Peak where least chipmunks occur on talus and along the steep rocky ridges north of the peak."	Sullivan 1985:437
White Mountains; Sierra Blanca	"...Sierra Blanca Peak population where chipmunks occur above timberline"	Sullivan 1985:437
White Mountains; Sierra Blanca	"Specimens from Sierra Blanca Peak were sampled on large boulders (> 50 cm in diameter), the most conspicuous landform in the glacial cirque; whereas, individuals from the latter sites were collected more frequently (27.3%, 78.1%, 66.6%, 65.2%, respectively) on fallen snags." (Sullivan 1985:437).	Sullivan 1985:437
White Mountains; Sierra Blanca	"On Sierra Blanca Peak, <i>E. minimus</i> only inhabits the rocky area around the glacial cirque. <i>Eutamias canipes</i> also occurs in this habitat, but ranges from the piñon-juniper zone at 2,130 m to above timberline at 3,900 m."	Sullivan 1985:438
White Mountains; Sierra Blanca	"The single known population of the Penasco subspecies is restricted to a small glacial cirque surrounded by Engelmann spruce (<i>Picea engelmanni</i>), aspen (<i>Populus tremuloides</i>), corkbark fir (<i>Abies lasiocarpa</i> var. <i>arizonica</i>), limber pine (<i>Pinus flexilis</i>), and Douglas-fir (<i>Pseudotsuga menziesii</i>) forest on top of Sierra Blanca Peak (3,900m). In this habitat Penasco chipmunks occur on talus and along the steep rocky ridges north of the peak (Conley 1970, Sullivan 1985, Sullivan and Petersen 1988)"	Sullivan and Nagorsen 1998:54-55
White Mountains; Buck Mountain	"The Penasco least chipmunk was located at an area with potential habitat FETHDAF [=thurber's fescue, <i>Festuca thurbers</i> ; DAIN [unknown plant]; and Arizona fescue, <i>Festuca arizonica</i>) which considered 70% talus habitat (Angular cobble, 25% consisting of grass land and 5% trees. The trees in the area consist of Blue Spruce (<i>Picea pungens</i>) and Corkbark fir. This site has a south facing aspect with a 45% slope which had an elevation of 10,500 feet."	Ortiz 1999:10-11

White Mountains; Buck Mountain	"Both verified specimens recovered in this survey were found above the forest zone on bare talus rock (Appendix 1). Other trapping locations in the vicinity were in close proximity to forest and only gray-footed chipmunks were collected. A likely scenario is competitive exclusion of Peñasco chipmunks from forested habitats by the gray footed chipmunk."	Hope and Frey 2000:9
White Mountains; Buck Mountain	"...a patchy talus slope facing southwest from the tip of Buck Mountain with a slope of 40. Grassy areas were as described above [i.e., 90% groundcover of grasses and also sparse forbs such as alpine lupine, wild onion, and mountain iris. The soil was very thin with talus rock underneath]. However traps were mostly set on bare talus areas and amongst the small, sparse Douglas fir present."	Hope and Frey 2000: 34
Southwest	"In Arizona, Colorado, and New Mexico, populations of <i>E. minimus</i> inhabit environments that include high elevation spruce-fir forests (Sierra Blanca Peak, Sandia Mountains, Sangre de Cristo Range), mixed coniferous forests (Jemez and Chuska Mountains). Ponderosa pine-grasslands bordering mixed conifer forests (White Mountains), piñon-juniper-sagebrush flats (Canjilon), sand dunes, and arid <i>Sarcobatus</i> and <i>Chrysothamnus</i> plains (San Luis Valley). These observations are consistent with those of other population of this polytypic specie that are known to exploit a variety of ecological situations ranging from the arctic tundra to Great Basin sagebrush (Johnson, 1943; Findley et al., 1975; Hall, 1981)."	Sullivan et al. no date: 20-21
Southwest	"Our analysis indicates that the species <i>Eutamias minimus</i> exhibits a high degree of evolutionary plasticity to a wide variety of ecological situations in the southwest, that may predispose it to successful exploitation of marginal environments (i.e., isolated montane mountain ranges). However, each allopatric population is restricted locally to specific and unique ecological situations. This fact may predispose local population to rapid extinction (Patterson, 1982) if reduction of local habitat or other environmental perturbations occur."	Sullivan et al. no date:21

Gray-footed chipmunk

T. canipes occupies a broader range of habitats than *T. m. atristriatus*. It has been described as using all habitats from piñon-juniper woodland and upward through all coniferous forest zones and into the alpine zone at the highest elevations (Table 4). However, it is not uniformly abundant in all habitats. The earliest descriptions describe it as uncommon in open ponderosa pine forest and most common in dense mixed coniferous forest.

Hope and Frey (2000) surveyed chipmunks in 29 different habitat associations in the Capitan, White and Sacramento mountains during 2000 (see Table 1 for summary). *T. canipes* was the most commonly captured species (15 of 29 habitat associations) so the data are most relevant to that species. They made qualitative descriptions of habitat but did not collect quantitative habitat data and capture sites. Although detailed statistical analyses were not possible on most aspects of the habitat information, some patterns were revealed. Higher relative abundance of *T. canipes* was found at sites with mature trees (Kolmogorov-Smirnov $Z = 1.461$, $P = 0.028$). No other significant relationships were found, although there was a tendency for rocky habitats to have higher relative abundance of *T. canipes*. However, *T. canipes* was found to use a variety of habitats including meadows, riparian areas, piñon-juniper woodland, and recently burnt coniferous forest.

During 2005 and 2006, Christy Wampler conducted her Master's thesis research, under the direction of Frey, on the effects of thinning mixed coniferous forest on mammals (Wampler 2007). The study involved 5 treatments (20-30 year post-commercial harvest non-thinned; 60-100 years post-commercial harvest non-thinned; commercially thinned, lop-pile thinned, and lop-scatter thinned). *T. canipes* relative abundance was lowest in the 60-100 years post harvest non-thinned treatment (mean = 0.06/100 trap-nights) and was highest in the 20-30 years post harvest non-thinned treatment (mean = 2.26/100 trap-nights; Wampler et al. submitted). Thinned treatments had mean relative abundance ranging from 1.15 to 1.90 per 100 trap-nights. In addition, *T. canipes* survival was higher in the 20-30 years post harvest non-thinned treatment than in all other treatments (Wampler et al. submitted).

Table 4. Original, first-hand habitat information regarding *Tamias canipes* from field notes, reports, and published literature.

Population	Quote	Reference
Sacramento Mountains	"common in Canadian zone on top of the Mts. They climb trees readily and live in the thickest forest. Are usually seen running over logs and on the ground."	Bailey 1900:1
Sacramento Mountains	"Eutamias canipes is common in the timber"	Bailey 1902a:Sept 6
Sacramento and White mountains	" <i>Eutamias canipes</i> .—Common in Transition and Canadian zones of both Sacramento and White Mts., or approximately in all the country above 7000 feet. Common up to 12000 feet on Sierra Blanca. Usually found in the woods on logs or rocks or on fences along fields. They rarely climb trees and always run to the ground for protection, either disappearing in their burrows or among thick brush and weeds. Along the fields they are feeding to some extent on grain but mainly on wild sunflowers and other weed seeds."	Bailey 1902b:3
Guadalupe Mountains, Texas	"The gray-footed chipmunks are common in Transition zone throughout the Guadalupe Mountains, from 7,000 feet in Dog Canyon and 6,000 feet in Timber Canyon up to at least 8,500 feet and probably to the top of the peaks at 9,500 feet, at which altitude they are common in the Sacramento Mountains a little farther north. While none were found in the lower part of the range, between the Guadalupe and the Sacramentos, they seem to be identical in the tow ranges and many easily have continuous distribution between. In the Sacramento Mountains they occupy the whole width of both the Transition and Canadian zones. In the Guadalupe Mountains they range from the lower edge of the Transition zone upward with the yellow pine and Douglas spruce, but in September they are more closely associated with the shrubby oaks, several species of which are abundant over the upper slopes of the mountains. They were occasionally seen in the densest timber, but more often in the open oak scrub. Gathering the little sweet acorns in the tops of the bushes or sitting on logs or rocks eating them."	Bailey 1905: 81
Sacramento and White mountains	"They range throughout the full width of the Transition and Canadian Zones, and specimens have been taken from 7,500 feet on Penasco Creek to 11,88-0 feet at the summit of Sierra Blanca. In canyons and cold gulches they often range as low as 7,000 feet. They are less common, however, in the lower, more open part of the Transition Zone and seem to be more abundant throughout the spruce and fir forests of the Canadian Zone."	Bailey 1931:87
general	"The gray-footed chipmunks are largely forest animals and are usually found among the trees or in dense thickets, but occasionally running along fences or over logs at the edge of clearings and burns. They are fond of rocky slopes, where brush and timber offer shade and cover and the cliffs afford runways convenient perches, and safe retreats. They are skillful at climbing not only rocks and cliffs, but also trees and bushes. In search of food they run through the tops of the scrub oak chaparral and the various thickets in the gulches and climb such trees as afford provender for chipmunk pantries."	Bailey 1931:87
general	"Along Penasco Creek, Hollister and the writer found them, in company with the smaller black-striped chipmunk (<i>E. minimus atristriatus</i>), busily carrying away grain from the margins of the country, their depredations of this nature are not likely to be serious"	Bailey 1931:88
general	"...the forest has been removed from much of their range..."	Bailey 1931:88

Sierra Blanca Peak	"Similarly, while <i>E. minimus</i> on Sierra Blanca Peak only inhabit the glacial cirque on the northeastern face along the rocky ridge north of the peak, <i>E. canipes</i> also occurs in this area. In fact, <i>E. canipes</i> was sampled in piñon-juniper habitat at 2130 m to above timber-line at 3930 m."	Sullivan et al. no date:17
Sierra Blanca Peak	"On Sierra Blanca Peak, <i>E. minimus</i> only inhabits the rocky area around the glacial cirque. <i>Eutamias canipes</i> also occurs in this habitat, but ranges from the piñon-juniper zone at 2,130 m to above timberline at 3,900 m."	Sullivan 1985:438
Buck Mountain	"Both verified specimens [of <i>T. m. atristratus</i>] recovered in this survey were found above the forest zone on bare talus rock (Appendix 1). Other trapping locations in the vicinity were in close proximity to forest and only gray-footed chipmunks were collected. A likely scenario is competitive exclusion of Peñasco chipmunks from forested habitats by the gray footed chipmunk."	Hope and Frey 2000:9
Buck Mountain	"...a small patch of talus surrounded byu think forest of Douglas fir, Engelman spruce and subalpine fire. ... The slope here was 35°"	Hope and Frey 2000:34

Spatial Habitat Models

Deductive Spatial Habitat Models.—The review and synthesis of first-hand habitat information by Frey (see Habitat section above) resulted in different complements of primary and secondary habitat types for the 2 populations of *T. m. atristriatus* and *T. canipes* (Table 4). The only primary land cover type shared between the 2 species was Southern Rocky Mountain Ponderosa Pine Woodland. With exception of grassland, all land cover types coded for the White Mountain population of *T. m. atristriatus* were unique to that population. All other land cover types coded for *T. m. atristriatus* were also shared by *T. canipes*. *T. canipes* had 9 land cover types, including 5 primary habitats, that were not coded for either *T. m. atristriatus* population.

The deductive spatial models for *T. m. atristriatus* (Figure 9) and *T. canipes* (Figure 10) revealed overt differences in the area and locations of predicted primary habitat between the species. The model for *T. canipes* predicted very large, continuous areas of primary habitat, which was principally located throughout most of the higher elevations of the various mountain ranges within the study area (Figure 10, Table 5). In sharp contrast, the model for *T. m. atristriatus* predicted small, scattered areas of primary habitat, mainly located along the east flank of the Sacramento Mountains (Figure 9). In general, these areas corresponded to the distribution of ponderosa pine forest in the study area. There was no clear predicted area of primary habitat based on habitat associations for the White Mountains population of *T. m. atristriatus*, probably because these habitats occur as small patches in the environment, which may be too small for mapping at this scale. The small patches mapped as primary habitat in southeastern Otero County should not be considered potential habitat for *T. m. atristriatus* because these are exposed rocky areas within Chihuahuan Desert habitats. Overall, *T. canipes* was predicted to have 2.4 times more area of primary habitat within the study area as compared with *T. m. atristriatus* (Table 5). In addition, much of the area of predicted habitat for *T. m. atristriatus* was in areas outside of its known distribution (e.g., Capitan Mountains; Figure 9).

The mapped areas of secondary habitat for *T. m. atristriatus* and *T. canipes* were similar in spatial pattern, primarily due to the inclusion of various coniferous woodland land cover types for both species. A major difference was the addition of the entire Carrizozo lava flow in the model for *T. canipes*, although these chipmunks are only known from the area of dense juniper woodland on the northern, high elevation portion of the flow. The overall area of predicted secondary habitat for *T. m. atristriatus* was actually slightly larger than for *T. canipes* (Table 5). This was probably due to coding Madrean Pine-Oak Forest and Woodland, which is the 5th most widely distributed land cover type in the study area, as secondary habitat for *T. m. atristriatus* and as primary habitat for *T. canipes*.

Table 4. Southwest Regional Gap Analysis Project (SWReGAP) land cover types identified as habitat for 2 populations of *T. m. atristriatus* (Sacramento Mountains, White Mountains) and *T. canipes*.

Use ¹	SWReGAP Code	SWReGAP land cover description
<i>T. m. atristriatus</i> Sacramento Mountains		
-	S035	Madrean Pine-Oak Forest and Woodland
+	S036	Southern Rocky Mountain Ponderosa Pine Woodland
-	S038	Southern Rocky Mountain Pinyon-Juniper Woodland
-	S112	Madrean Pinyon-Juniper Woodland
+	S085	Southern Rocky Mountain Montane-Subalpine Grassland
-	N21	Developed low intensity
-	N80	Agriculture
<i>T. m. atristriatus</i> White Mountains		
+	S006	Rocky Mountain Cliff, Canyon and Massive Bedrock
+	S016	North American Warm Desert Bedrock Cliff and Outcrop
-	S025	Rocky Mountains Subalpine-Montane Limber-Bristlecone Pine Woodland
-	S085	Southern Rocky Mountain Montane-Subalpine Grassland
<i>T. canipes</i>		
-	S019	North American Warm Desert Volcanic Rockland
-	S112	Madrean Pinyon-Juniper Woodland
-	S038	Southern Rocky Mountain Pinyon-Juniper Woodland
+	S035	Madrean Pine-Oak Forest and Woodland
+	S036	Southern Rocky Mountain Ponderosa Pine Woodland
+	S111	Madrean Upper Montane Conifer-Oak Forest and Woodland
+	S032	Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland
+	S034	Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
+	S028	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
+	S030	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
-	S023	Rocky Mountain Aspen Forest and Woodland
-	S025	Rocky Mountains Subalpine-Montane Limber-Bristlecone Pine Woodland
-	S085	Southern Rocky Mountain Montane-Subalpine Grassland
-	S094	North American Warm Desert Lower Montane Riparian Woodland and Shrub
-	N21	Developed low intensity
-	N80	Agriculture
-	D02	Recently Burned

¹(+) = primary habitat; (-) = secondary habitat.

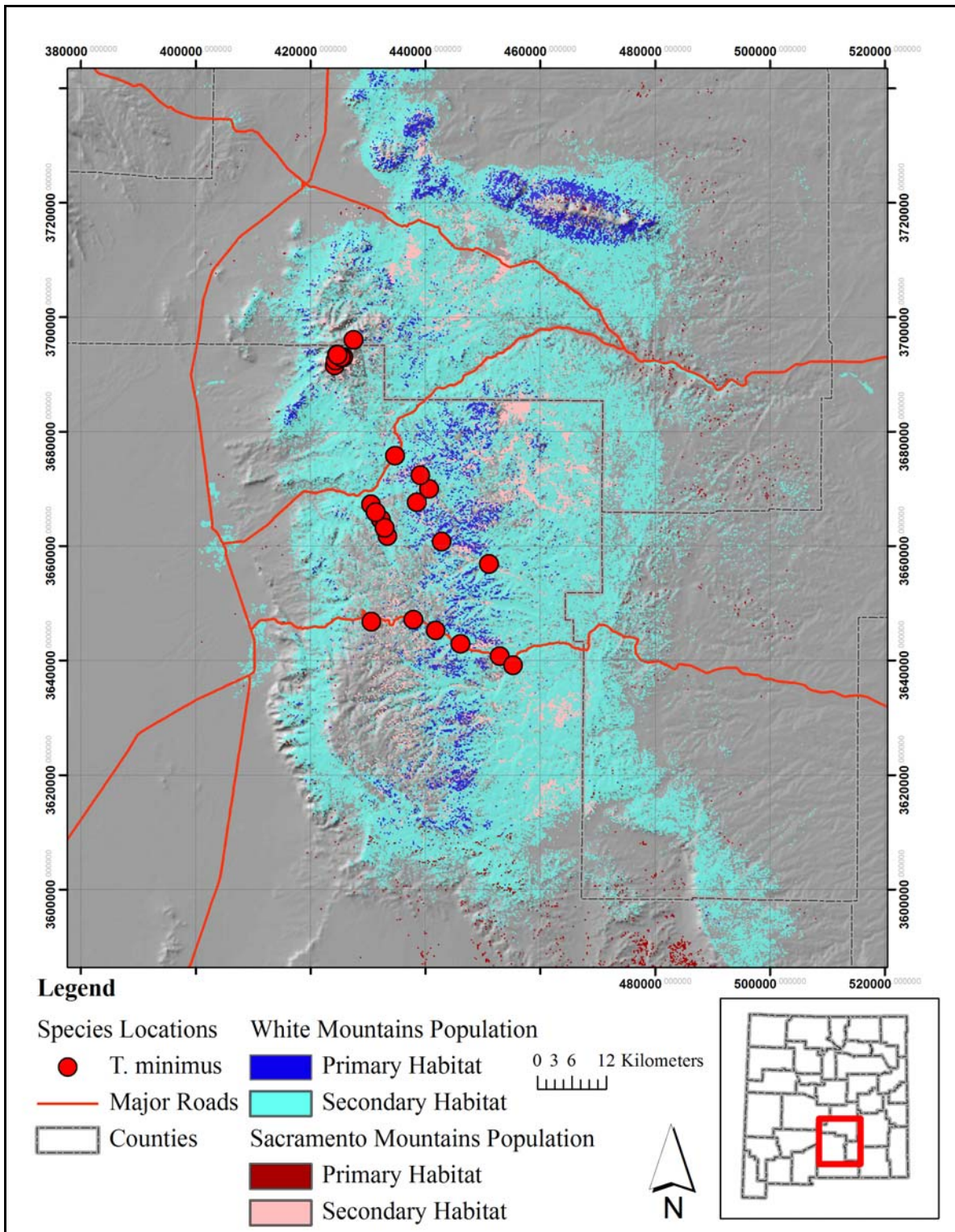


Figure 9. Predicted primary and secondary habitat for *Tamias minimus atristriatus* in the study area based on separate deductive spatial habitat modeling of the Sacramento Mountains population (=Penasco population; blue areas) and the White Mountains population (= Sierra Blanca population; red areas).

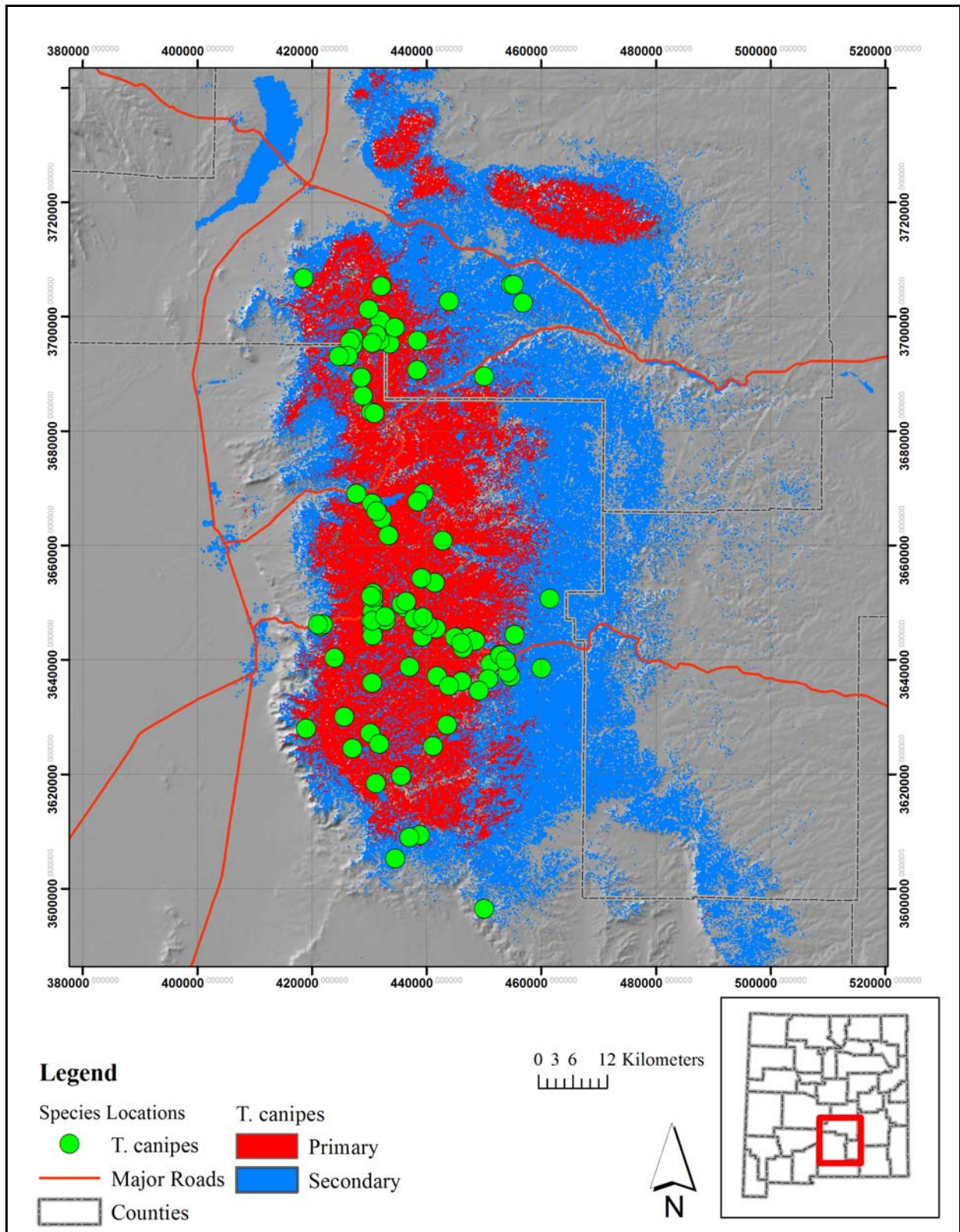


Figure 10. Predicted primary (red) and secondary (blue) habitat for *Tamias canipes* in the study area based on deductive spatial habitat modeling.

Table 5. Area (hectares and percent of study area) for primary, secondary, and unsuitable habitat based on a deductive model for 2 populations of *T. m. atristriatus* and *T. canipes* within the study area.

Population	Primary habitat		Secondary habitat		Unsuitable habitat		Total
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
<i>T. m. atristriatus</i>							
Sacramento Mountains	77,510	1.4	561,792	10.0	4,989,300	88.6	5,628,602
White Mountains	31,106	0.6	44,782	0.8	5,552,700	98.7	5,628,588
<i>T. canipes</i>	262,702	4.7	479,860	8.5	4,886,040	86.8	5,628,602

Inductive Spatial Habitat Models.—The expert georeferencing of voucher specimen descriptive locality data resulted in a total of 26 unique locality coordinates for *T. m. atristriatus* and 96 unique locality coordinates for *T. canipes* that were used for the inductive habitat modeling (Figure 11; Appendix 4). Inductive models performed well based on Receiver Operator Characteristic (ROC) plots and Area Under the Curve (AUC) values (Table 6). Training and testing AUC values were above 0.9 for each chosen model (Table 6).

Table 6. Area Under the Curve (AUC) statistics for the inductive spatial habitat models for *T. m. atristriatus* and *T. canipes*.

Species	Training AUC	Testing AUC	Equal training sensitivity and specificity
<i>T. m. atristriatus</i>	0.995	0.945	69.442
<i>T. canipes</i>	1.000	0.963	24.122

The Maximum Entropy models for *T. m. atristriatus* (Figure 12) and *T. canipes* (Figure 13) appear fairly similar in that both predict the higher elevations to be predicted areas of occurrence. However, differences are evident. For example, the general, the spatial patterns of each probability class were more tightly clustered forming more distinct boundaries in *T. m. atristriatus*. In *T. canipes*, the areas of predicted occurrence were highly scattered forming a diffuse wash of intermixed probabilities of occurrence over most of the elevated portion of the study area. Another striking difference was that in *T. m. atristriatus*, areas of moderate probability of occurrence (40-60 %; yellow) often formed distinct patches along major valleys and drainages. In contrast, no such riparian pattern was observed in *T. canipes*. It is unknown if the reason for this pattern in *T. m. atristriatus* is a function of an actual preference for these areas or if it simply reflects the tendency for early collections (which were dominated by *T. m. atristriatus*) to have been from along major valleys that were used as roads. Finally, areas of high and very high probability of occurrence (>60 %; orange; red) in *T. m. atristriatus* were primarily limited to the higher elevations of the White Mountains. However, there was also a

distinct patch of high probability of occurrence in the relatively high elevations extending northwestward from vicinity of Harley Mountain on the Mescalero Apache Reservation. In contrast, the area of high and very high probability of occurrence in *T. canipes* were more extensive (Table 7), but were scattered across the higher elevations with no particular pattern. In sum, the total area of high and very high probability of occurrence was 2.7 times higher for *T. canipes* (45,032 ha) than in *T. m. atristriatus* (16,887 ha; Table 7).

Equal sensitivity and specificity threshold Maximum Entropy models for *T. m. atristriatus* (Figure 14) and *T. canipes* (Figure 15) were fairly different. For *T. m. atristriatus* there was but a very diffuse wash of points throughout higher elevation areas. The exception was a concentration of predicted suitable habitat located at very high elevations in the White Mountains (Figure 14). In contrast, for *T. canipes* suitable habitat was more continuously distributed with large, scattered patches of suitable habitat (Figure 15). The largest patch of suitable habitat was at very high elevations in the White Mountains, with other patches distributed in various areas of high elevation throughout the Sacramento Mountains (Figure 15). Overall, the threshold models predicted 14.2 times more area of suitable habitat for *T. canipes* than for *T. m. atristriatus* (Table 8).

In comparing the deductive models with the threshold Maximum Entropy models, the deductive models predicted larger areas of potential habitat for both *T. m. atristriatus* and *T. canipes* (Table 5 and Table 8). In *T. canipes*, these differences appeared minor and the spatial pattern of potential habitat was similar, although suitable habitat was more restricted in distribution in the Maximum Entropy model, particularly in the Sacramento Mountains. In contrast, difference between the models was especially acute for *T. m. atristriatus*, where the deductive model predicted 9.6 times more potential habitat than the maximum entropy model. While the deductive model predicted large areas of moderate elevation along the east flank of the Sacramento Mountains (i.e., the ponderosa pine forest zone) to be potential habitat, the Maximum Entropy model did not predict these areas to be suitable habitat. Failure of the Maximum Entropy model to predict these areas as suitable habitat likely reflects changes in land cover between the time when specimen records were obtained and when the SWReGAP land cover maps were created. Additionally, sample size can play a role in inductive modeling and *T. canipes* models had almost four times the sample data as *T. m. atristriatus*. In contrast, both models predicted the higher elevations of the White Mountains to be potential habitat for *T. m. atristriatus*. These findings suggest that alpine habitat in the White Mountains is a core region of suitable habitat for *T. m. atristriatus* and that this habitat has remained relatively unaltered.

Table 7. Area (hectares and percent of study area) for probability classes resulting from Maximum Entropy habitat models of *T. m. atristriatus* and *T. canipes* within the study area.

Probability	<i>T. m. atristriatus</i>		<i>T. canipes</i>	
	(ha)	(%)	(ha)	(%)
0-20	4,906,565	95.8	4,911,126	95.9
21-40	164,349	3.2	125,322	2.4
41-60	31,143	0.6	37,456	0.7
61-80	9,577	0.2	17,528	0.4
81-100	7,310	0.1	27,504	0.5

Table 8. Area (hectares and percent of study area) for probability classes resulting from threshold Maximum Entropy habitat models of *T. m. atristriatus* and *T. canipes* within the study area. Binary values were derived from Equal training sensitivity and specificity metric (Table 6).

Binary	<i>T. m. atristriatus</i>		<i>T. canipes</i>	
	(ha)	(%)	(ha)	(%)
Unsuitable	5,107,705	99.8	4,959,109	96.9
Suitable	11,240	0.2	159,828	3.1

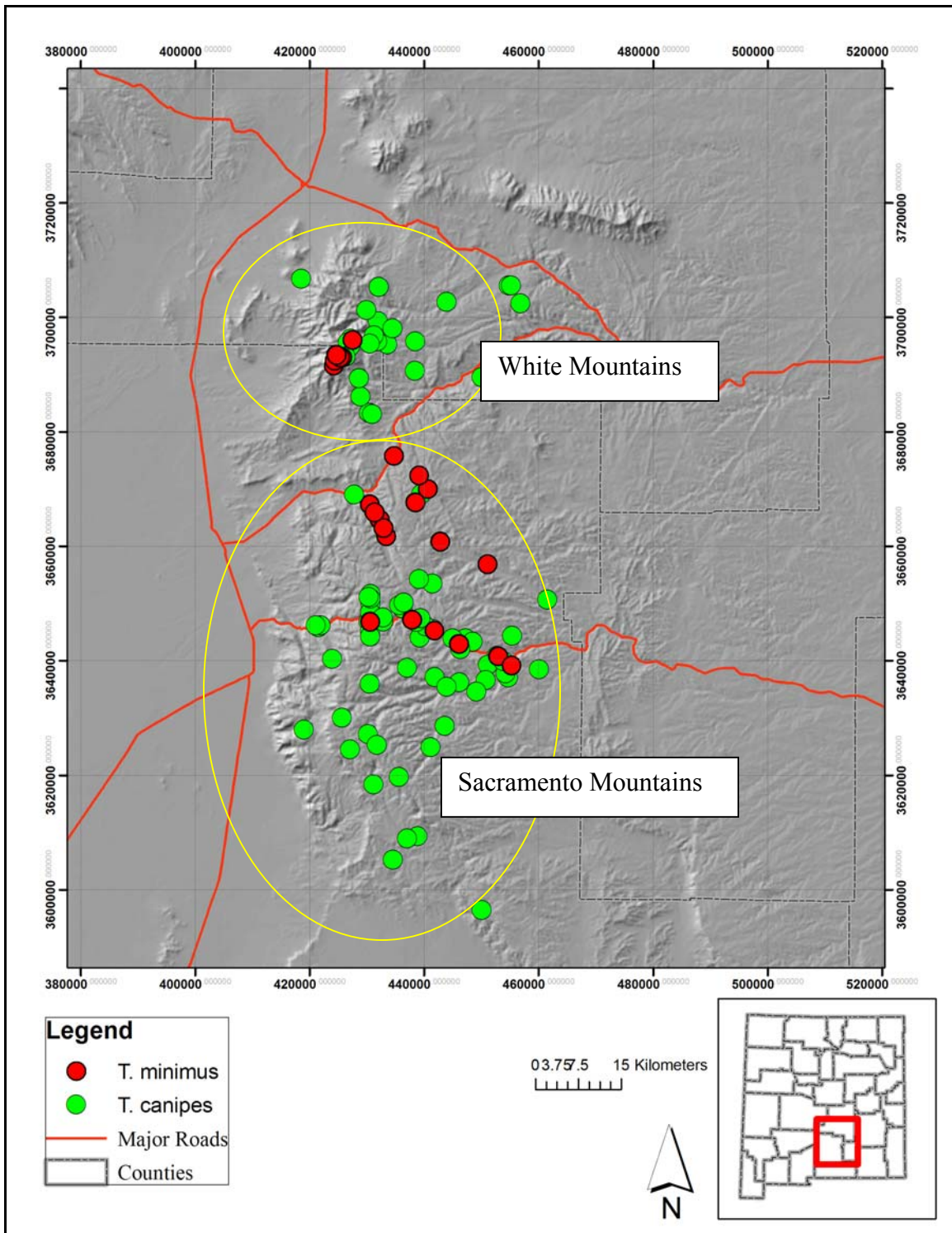


Figure 11. Locations of species occurrence records for *T. m. atristriatus* (red dots) and *T. canipes* (green dots) in the White and Sacramento mountains, New Mexico, that were used for inductive spatial habitat models.

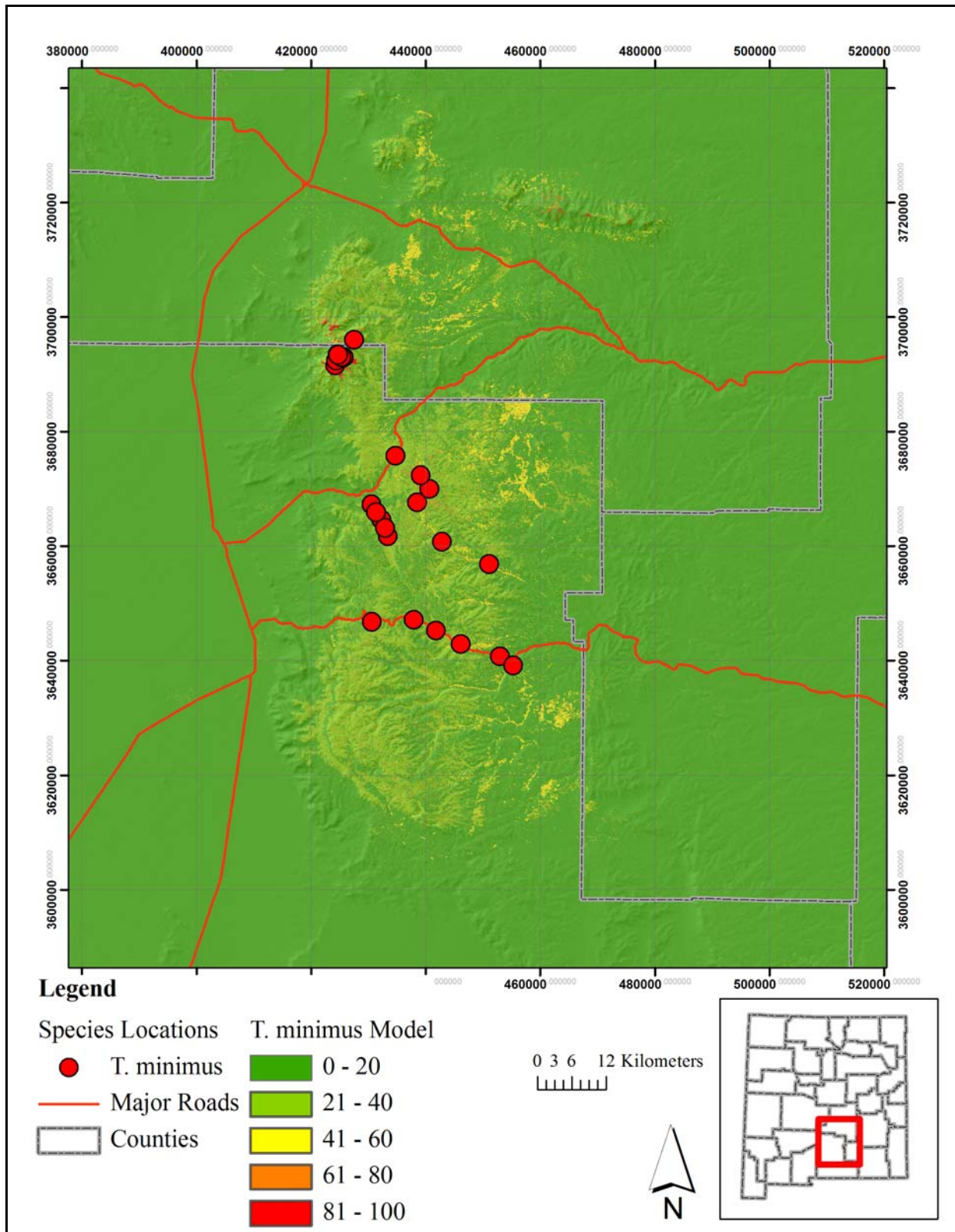


Figure 12. Maximum Entropy model for *T. m. atristriatus* (dots) in the White and Sacramento mountains, New Mexico. Maximum Entropy models are displayed as a probability.

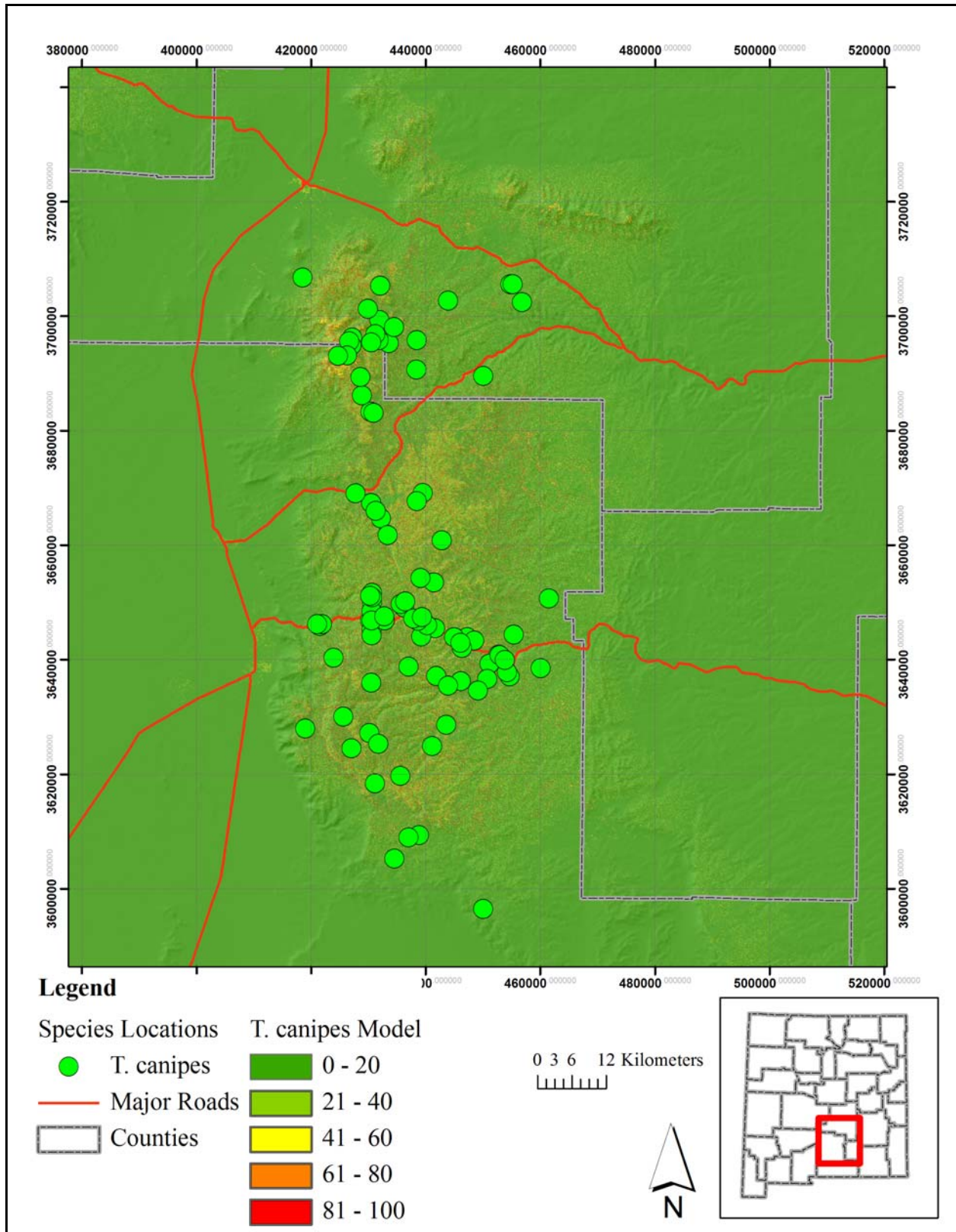


Figure 13. Maximum Entropy model for *T. canipes* in the White and Sacramento Mountains, New Mexico. Maximum Entropy models are displayed as a probability.

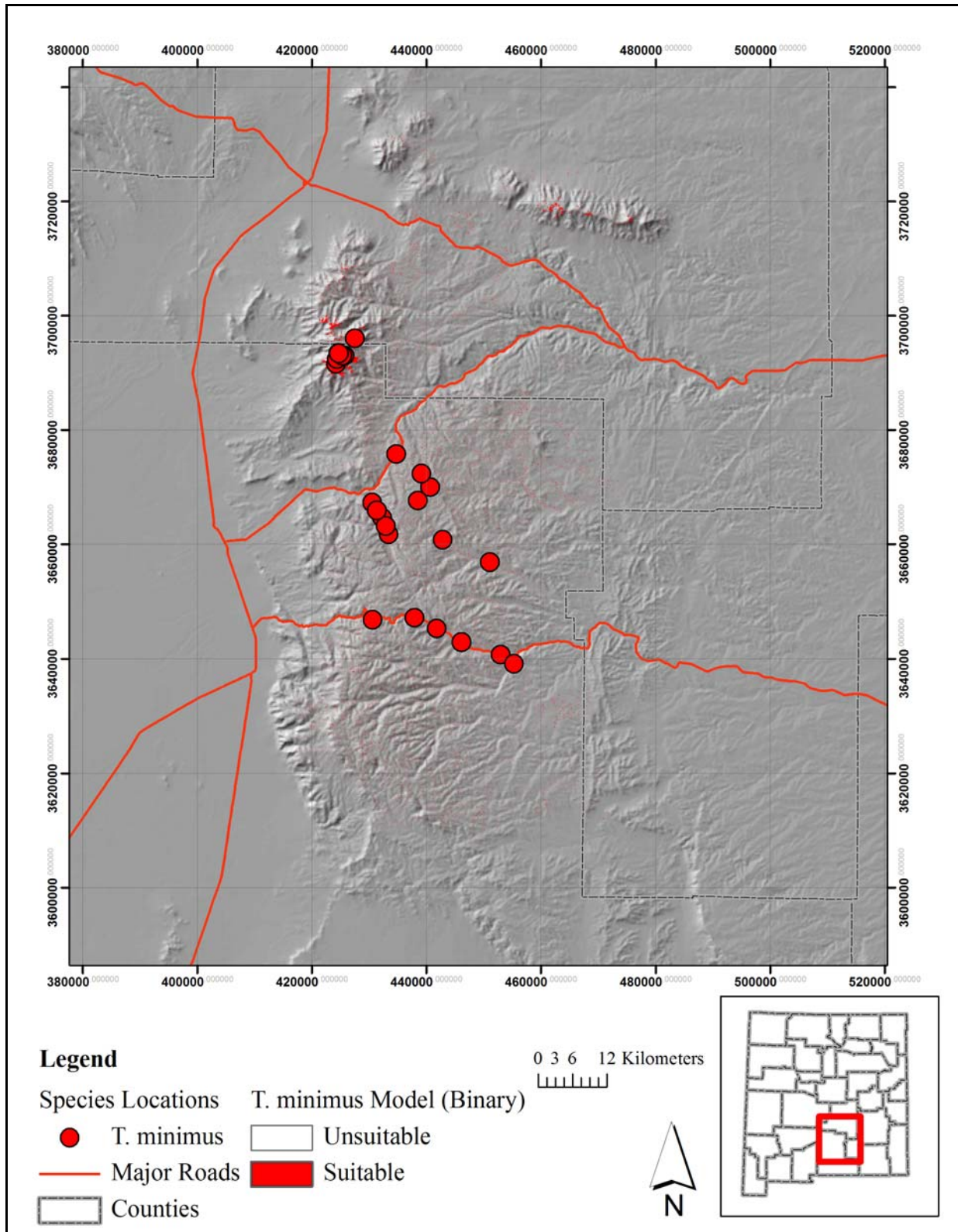


Figure 14. Equal sensitivity and specificity threshold Maximum Entropy model for *T. m. atristriatus* in the White and Sacramento mountains, New Mexico. Red areas are modeled as suitable habitat.

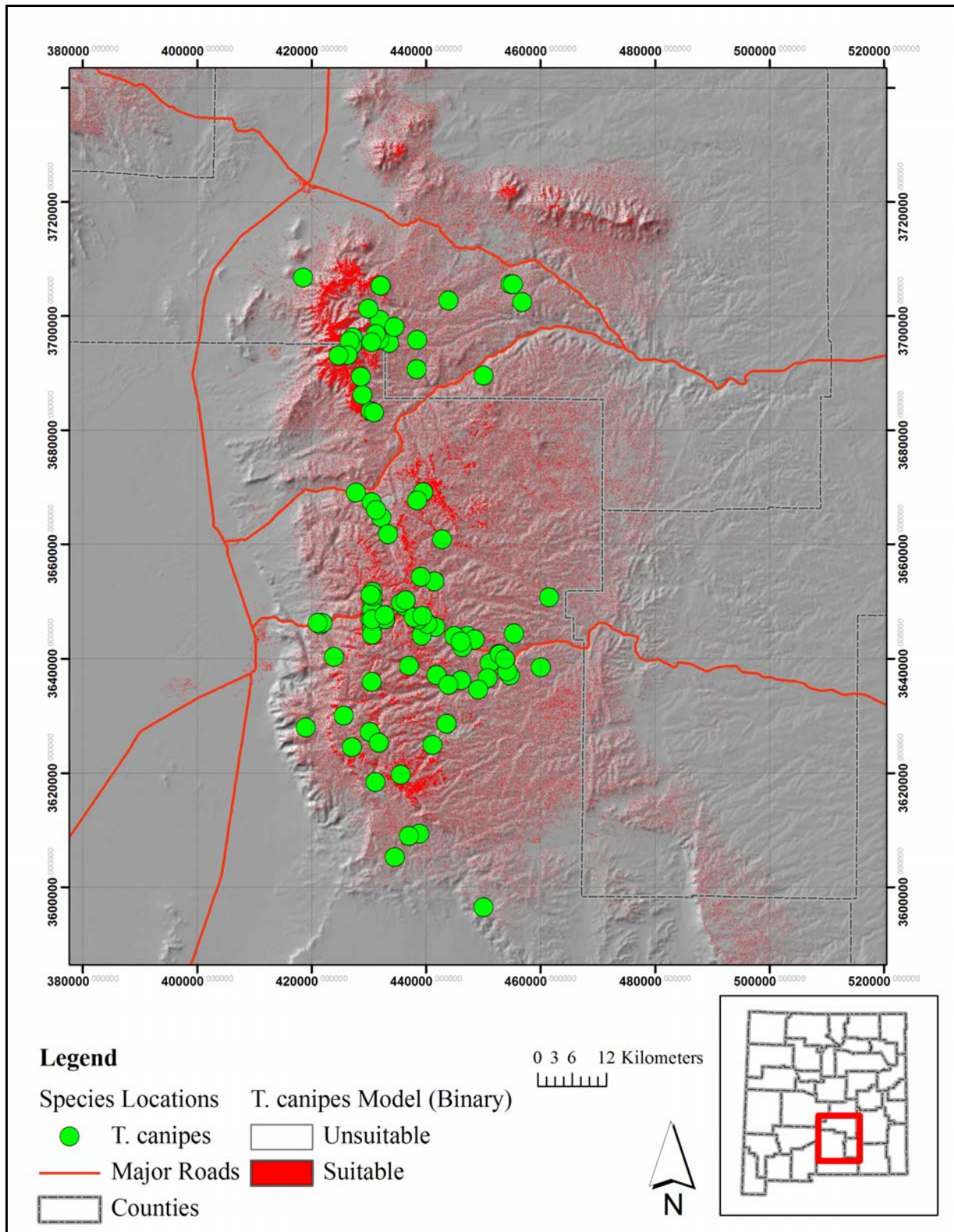


Figure 15. Equal sensitivity and specificity threshold Maximum Entropy model for *T. canipes* in the White and Sacramento mountains, New Mexico. Red areas are modeled as suitable habitat.

Field Surveys

White Mountains

Survey of the White Mountains population occurred 15 – 19 June 2007 on Buck Mountain. This survey primarily focused on the large talus slope located on the south-facing side of the peak (UTM of the talus along the lower part of the Buck Mountain access road (= Forest Road [FR] 5625): N 33° 23.981, W 105° 46.846, 3,150 m). The most recent captures of *T. m. atristriatus* in 1998 and 2000 occurred on this talus area (Appendix 5). The talus had a south-southwest facing aspect and was funnel-shaped (i.e., broad at top and narrowing to an apex at the bottom) that extended ca 366 m (1,200 ft) from an elevation of ca 3,219 m (10,560 ft.) down to ca 3,097 m (10,160 ft.). The talus was imbedded within a subalpine grassland dominated by tall (ca 15 inches), dense thurber fescue, but also including various forbs and scattered dwarf Douglas fir. The primary exception was along the lower east side (i.e., below FR 5625) and bottom of the talus, where the talus abutted dense, mature coniferous forest dominated by Engelmann spruce and Douglas fir. The upper-most portion of the talus area, which included the 3 historical locations, consisted of small patches of talus embedded in the grassland matrix. In this upper region, the slope was ca 30° and the rock size averaged ca 6-8 inches. Below this patchy talus zone, the talus area became largely contiguous with increasingly steeper slopes (to 45° near bottom) and larger average rock size (ca 10-12 inches near bottom).

A total of 400 Sherman traps were set on the talus on the afternoon of 15 June. These included 300 traps set above FR 5625, including vicinity of the 3 historical capture sites, and 100 set below FR 5625. Traps were removed on the evening of 18 June (total effort = 1,600 trap-days). However, poor weather conditions (cool temperatures, cloudy, hail storm) on 16 June reduced the effective trapping effort. In addition to the trapping, an attempt was made to collect all chipmunks observed while traveling along FR 5625 from the campsite (N 33° 24.395, W 105° 47.655, 3,129 m) to both the upper and lower sections of the talus. In addition, between ca 10:00 and 13:00 on 17 June, 3 people observed the talus with binoculars from different positions in an attempt to collect chipmunks with firearms; none were observed.

No *T. m. atristriatus* were captured or observed during this survey. However, a torpid scrotal male *T. canipes* (FT 877) was found in a trap on the morning of 17 June 2007 on the southeast edge of the talus within several meters of the coniferous forest (N 33° 23.949, W 105° 46.887, 3,118). In addition, 3 *T. canipes* were collected with firearms along FR 5625. These included a female (FT 874) shot at 10:00 on 16 June 2007 from a small (ca 5 x 7 m) patch of talus (above road) within mature coniferous forest 1.1 mi (by FR 5625) W NM Hwy 532 (N 33° 24.112, W 105° 47.173, 3,162 m). A female (FT 875) was shot at 10:15 on 16 June 2007 1.2 mi (by FR 5625) W NM Hwy 532 (N 33° 24.150, W 105° 47.255, 3,119 m) from a moderate-sized (15 x 100 m) talus slope (below road) that was bordered on one side by a ca 10-20 m strip of grassland and by coniferous forest on the other and that had a large (1.5 x 15 m) deadfall lying across the center of the talus. Another chipmunk was observed on this talus at the same time. A female (FT 876) was shot at 7:52 (temperature = 51 F°) on 17 June 2007 0.9 mi (by FR 5625) W NM Hwy 532 (N 33 23.971, W 105 46.874, 3,128 m) from the southeast edge (i.e., ca 1 m in the talus) of the main Buck Mountain talus, which was bordered by coniferous forest. A second chipmunk was also observed running down the edge of the talus at the same time. Other species captured on the talus included *Microtus longicaudus*, *Peromyscus maniculatus*, *Neotoma mexicana*, and *Tamiasciurus hudsonicus*.

Sacramento Mountains

Two locations were sampled in the Sacramento Mountains, including James Ridge and James Canyon Campground. An area on James Ridge was sampled was the location of one of Pat Ward's small mammal study grids from which there were several possible *T. m. atristriatus* captures in the early 1990s (see Historical Records results). James Canyon Campground was surveyed because this was the location of the most recent (1966) verified capture of the Sacramento Mountains population (see Historical Records results).

James Ridge.—Pat Ward's small mammal grid on James Ridge was located 0.9 km N and 14 km E Cloudcroft (N 32° 57.916, W 105° 35.504, 2,500 m). The site is on a south-facing aspect and was described by Ward as a xeric coniferous forest assemblage. Habitat was dominated by southwest white pine and Douglas fir, although there were also scattered white fir, ponderosa pine, and alligator juniper (Appendix 5). Shrubs and ground cover were virtually absent (< 5% cover). In the drainage bottom, which was not included in Ward's grid, the habitat was quite different. The canyon bottom was ca 30 m wide near the top of the drainage but narrowed as it descended in elevation. The habitat was dominated by an open canopy of southwest white pine, white fir, Douglas fir. Ground cover was relatively tall and dense (> 75 % cover) consisting of a diverse array of grasses and forbs. There were also many very large, decaying downed logs, slash piles, and rock piles.

This site was surveyed for chipmunks 28 to 30 May 2007. On 28 May, a total of 188 Sherman traps were set along the length of the hillside, including at Ward's former grid location, and 12 traps were set in the canyon bottom. In addition, on 29 May an additional 210 traps were set in the arroyo bottom because it appeared to be excellent chipmunk habitat. All traps were removed on 30 May. Thus, the total effort was 564 trap-days on the hillside and 456 trap-days in the canyon bottom (1,020 trap-days total). No chipmunks of either species were captured. In addition, no chipmunks were observed by any of the 3 field crewmembers during the 3 days. This included habitat surveys along 108 miles of road in the Sacramento Mountains on 29 May. Thus, it was concluded that chipmunks were still in hibernation. Other species captured at the James Ridge site included *Peromyscus maniculatus*, *Neotoma mexicana*, *Microtus mogollonensis*, and *Peromyscus nasutus*.

James Canyon Campground.—James Canyon Campground is located in the valley of James Canyon about 1.5 miles above its confluence with the Rio Peñasco (N 32° 54.260, W 105° 30.261, 2,072 m). Vegetation in the campground consisted of scattered mostly young (8–20 inch DBH) ponderosa pine, a few scattered one-seed juniper, and an understory consisting of moderately tall, fairly dense forbs and grasses (appendix 5). A large erosional gully that runs most of the length of James Canyon crossed the campground from west to east. The gully was ca 3-5 m deep with bare sheer sides along deeper portions. Along the south side of the campground was a rocky cliff-face. Where best developed the cliff was ca 40 ft tall and mostly sheer-sided. Vegetation along the cliff was dominated by Gambel's oak and wavyleaf oak, with scattered New Mexico locust and canyon grape. Vegetation on the uplands above the cliff was dominated by oak scrub. Vegetation on the hillside to the north of the campground consisted of scattered sapling ponderosa pine (< 10 inches DBH), one seed juniper, and scrub oak with a herbaceous understory.

The campground was surveyed 19-20 June 2007. A total of 337 Sherman traps were set on the afternoon of 19 June and removed on the late afternoon of 20 June. These included 80 in the erosional gully through the western portion of the campground, 137 along the cliff, 80 in an arroyo on the hillside north of camp, and 40 around large vehicle barrier boulders. Total effort was 674 trap-days. No *T. m. atristriatus* were captured or observed. A single *T. canipes* was captured from the cliff. Other species captured were *Microtus mogollonensis*, *Reithrodontomys megalotis*, *Neotoma mexicana*, *Peromyscus boylii*, *Peromyscus maniculatus*, and *Peromyscus nasutus*.

DISCUSSION

Current Status

The distribution and abundance of *T. m. atristriatus* has dramatically declined since the early part of the 20th century. This trend has been most striking for the Sacramento Mountains population. There, specimen records and observations revealed that it was abundant and widespread throughout the ponderosa pine forest zone at least until the early 1930's. However, during the middle decades of the century only 6 specimens were collected from 2 locations. The Sacramento Mountains population was last verified in 1966, despite a number of subsequent intensive field surveys. The limited field surveys during this study also failed to document the population's persistence. In contrast, the distribution and abundance of *T. canipes* increased during the same time period and it now occupies some historical locations where *T. m. atristriatus* formerly occurred, such as James Canyon Campground. Whether the Sacramento Mountains population of *T. m. atristriatus* persists remains unknown. There are few areas of mature, open ponderosa pine forest remaining and most of those are of small size. If *T. m. atristriatus* persists in the Sacramento Mountains, it should be sought in large, open stands of mature ponderosa pine where there is large ground structure and abundant cover of grasses, forbs, and fruiting shrubs. Such areas may be found as small isolated stringers along certain drainages within Lincoln National Forest and especially throughout the Elk and Tularosa valleys and other areas on the Mescalero Apache Indian Reservation.

The status of *T. m. atristriatus* in the White Mountains is uncertain, although it seems likely that it persists given that its persistence was verified as recently as 2000. This population is probably structured as a source-sink metapopulation. The core source population is likely associated with the large area of rocky habitat on Sierra Blanca Peak. Other smaller, isolated patches of rock and talus above tree line, such as the talus on Buck Mountain, may represent sink subpopulations that are maintained through dispersal, but that also may experience periodic extinction events. Thus, the significance of our failure to capture *T. m. atristriatus* on the Buck Mountain talus during this study is unknown. Despite the intensive survey effort, it is possible that it was present but was not detected due to natural rarity, poor weather conditions, earliness of the season (and hence low population density), or insufficient sampling. However, the collection and observations of many *T. canipes* on Buck Mountain, including on the talus, argue against this explanation. Alternatively, it is possible that the subpopulation on the Buck Mountain talus has been extirpated. Such an extirpation may be a natural part of source-sink metapopulation dynamics or perhaps a result of other unknown causes. Finally, specimen records of chipmunks collected on Sierra Blanca Peak suggest a possible shift in mammal community. Surveys during the 1930s and 1960s produced large series of *T. m. atristriatus*, but no *T. canipes*. In contrast, during the 1980s both species were collected. There have been no subsequent surveys of chipmunks on Sierra Blanca Peak, which is located on the Mescalero Apache Indian Reservation. Hence the status of *T. m. atristriatus*, and its abundance in relation to *T. canipes* remains unknown.

Threats

Ponderosa pine forest structure.—Previous assessments provided conflicting conclusions about the primary threats to *T. m. atristriatus*, although in general they identified alteration of habitats through increased human development and changes in agricultural and grazing practices (e.g., NMDGF 1988, 2006). In contrast, based on the evidence accumulated and synthesized in this report, the single greatest threat and reason for decline in distribution and abundance of *T. m. atristriatus* is the loss of mature ponderosa pine forest. Originally, ponderosa pine forest occupied large areas at mid elevations in the White and Sacramento mountains. These forests were best developed and most extensive along the relatively gentle east slope of the Sacramento Mountains where elevations are ideal for growth of ponderosa pine (Alexander et al. 1984). In such regions, original uncut ponderosa pine forest typically formed open, park-like stands within a grassland matrix. These stands were a mosaic of large ponderosa pine trees (mean diameter was 2-6 ft) scattered as an open savanna or clumped into small groups, but also including small patches of dense young ponderosa pine (Bailey 1900, 1902c; Dahms and Geils 1997). Mature ponderosa pine trees lack lower limbs and the open structure of the forest, with its dense grassy ground cover, would have been ideal habitat for *T. m. atristriatus*. In contrast, both the lower piñon-juniper woodland and the higher mixed coniferous forest zones are dominated by trees with extensive branching near the ground and these habitats often form dense stands with high canopy cover. Such habitats are apparently ideal for *T. canipes*. Given that ponderosa pine forests include some patches of young ponderosa pine (which retain their lower limbs) and that within ponderosa pine forest dry slopes can include piñon-juniper woodland and mesic slopes can include mixed coniferous forest, it is possible that *T. m. atristriatus* and *T. canipes* may have historically occurred in close proximity at some locations.

These original ponderosa pine forests have been radically altered in structure. With exception of some very small inaccessible areas, all ponderosa pine forest in the White and Sacramento mountains was logged (Moline 1992, Kaufmann et al. 1998). Subsequent recruitment resulted in very dense stands of young ponderosa pine trees (Kaufmann et al. 1998). These dense stands are almost certainly unsuitable for *T. m. atristriatus*, but are suitable for *T. canipes*. To further exacerbate the problem, fire suppression has led to an ingrowth of dense Douglas fir and white fir, which further changes the habitat in favor of *T. canipes* (Covington and Moore 1992, Kaufmann et al. 1998). Finally, as a consequence of the densely stocked forests, insect infestations and especially stand-replacing fires have eliminated most of the former ponderosa pine forest areas on Lincoln National Forest.

The spatial habitat models should be viewed with caution because they are based on general land cover types (e.g., ponderosa pine forest) and do not include data on structural aspects of the forest. Thus, the models are likely to vastly overestimate the amount of predicted habitat *T. m. atristriatus* (i.e., much of the ponderosa pine forest has unsuitable structure). Rather, the areas of predicted habitat may be viewed as including both areas of suitable habitat as well as area that have the potential to be restored to suitable habitat structure.

Livestock grazing.—*T. m. atristriatus* uses herbaceous ground cover for concealment, although it requires that the lowest layers near ground level be open in order to permit escape. This structure is provided by native bunch grasses that naturally dominated both in the subalpine grasslands in the White Mountains and the ponderosa pine forest grassland matrix in the Sacramento Mountains. Further, *T. m. atristriatus* utilizes seeds and other food resources

provided by the herbaceous ground layer and low shrubs. Thus, livestock grazing may presents a threat to *T. m. atristriatus* by reducing or altering suitable cover of herbaceous plants, altering plant species composition, and reducing availability of food (Belsky and Blumenthal 1997). Heavy grazing can cause trees to invade subalpine and montane grasslands, which would promote *T. canipes* to the exclusion of *T. m. minimus* (Dick-Peddie 1993). Further, heavy grazing in subalpine grasslands can cause a conversion from Thurber and Arizona fescue bunch grasses to Kentucky bluegrass (*Poa pratensis*), which may not provide suitable cover and escape structure for *T. m. atristriatus* (Dick-Peddie 1993).

Population size.—A threat to *T. m. atristriatus* is its small population size. Population size in *T. minimus* can dramatically fluctuate and local population extinctions (or near extinctions) have been documented even within large, continuous patches of suitable habitat, although isolated populations would be much more susceptible to such extinction (Bergstrom and Hoffmann 1991). Such factors would likely be relevant either to the metapopulation associated with rocky alpine habitat in the White Mountains or to any relict populations in the Sacramento Mountains. Because *T. m. atristriatus* likely produces only one litter each year, population growth and reestablishment is expected to be slow.

Climate warming.— It is predicted that average temperature in the Southwest will increase 3° to 5° C by 2100 and that both temperature and precipitation will be more variable (EPA 1998, Houghton et al. 2001, IPCC 2001, Reilly et al. 2001, Wigley and Raper, 2001). Consequently, it has been predicted that coniferous forest habitats in the Southwest will be reduced (EPA 1998, IPCC 2001). Reduction in area of ponderosa pine forest is a threat to the Sacramento Mountains population of *T. m. atristriatus*. In the White Mountains, any climate change that would promote more tree growth to the exclusion of subalpine grassland would present a threat to *T. m. atristriatus*.

Conservation and Management Recommendations

1) Surveys.—Intensive field surveys for *T. m. atristriatus* are needed in both the White and Sacramento mountains in order to locate any remaining populations of *T. m. atristriatus*. Such surveys can also provide opportunity to collect additional data on habitat requirements and ecological relations with *T. canipes*. Priority areas for field surveys include: 1) large open stands of mature ponderosa pine on the Mescalero Apache Indian Reservation (MAIR), 2) rocky areas above tree line in the White Mountains, including both on MAIR and Lincoln National Forest (LNF), 3) remnant mature ponderosa pine forest patches in the Sacramento Mountains, especially on LNF, 4) ski-runs on MAIR and LNF. Special efforts should be made to seek means for accomplishing this goal, especially through coordination with the Mescalero Apache Indian Reservation.

2) Voucher specimens.—Some previous conservation recommendations for *T. m. atristriatus* have advocated strict control over collecting, including for scientific purposes (NMDGF 1988, Sullivan and Nagorsen 1998). However, current conservation and management of *T. m. atristriatus* is seriously hampered by a lack of knowledge about its current distribution. Some previous research concerning small mammal monitoring in the White and Sacramento mountains and inventories specifically for *T. m. atristriatus* did not adequately document

supposed records of *T. m. atristriatus*. Thus, it is strongly recommended that any New Mexico scientific collecting permits issued to cover the handling, capture, or collection of *T. m. atristriatus* should require that the researcher make arrangements to collect one voucher specimen of any suspected *T. m. atristriatus* per location and that the specimen be deposited at the an accredited (by the American Society of Mammalogists) museum in New Mexico. This requirement should also be made for any researcher conducting small mammal studies in the White or Sacramento mountains who may inadvertently capture *T. m. atristriatus*.

Specimen collection should follow recommendations of the American Society of Mammalogists. The specimen should be immediately frozen and labeled with the collection location, date, and collector(s) name and contact information. The New Mexico Department of Game and Fish, Conservation Services Division (CSD), should be notified of such a collection within 48 hours with transfer of the specimen to CSD or a final approved repository within 30 days.

- 3) **Monitoring.**—Once remaining populations of *T. m. atristriatus* have been identified, long-term monitoring aimed specifically at these populations should be instituted. Because populations may be small, localized, and densities may fluctuate, monitoring should occur on a relatively frequent basis, at least once every 3 years.
- 4) **Ground structure.**—Downed coarse woody debris, in the form of large diameter logs, fallen trees, and large slash piles, may be an important habitat component for *T. m. atristriatus* in mature ponderosa pine forests. Thus, the creation and maintenance of these structures should be a priority in ponderosa pine forest management, as well as perhaps other types of xeric forests, such as those dominated by southwest white pine.
- 5) **Ponderosa pine forest restoration.**—Ponderosa pine forests should be restored to pre Euro-American settlement conditions to provided required habitat for *T. m. atristriatus*. Structurally, these forests should consist of open stands of large trees within a native grassland matrix. The primary techniques used to achieve these goals include mechanical thinning and prescribed burning, but may also require erosion control, reseeding native grasses and forbs, and other such efforts. Specific recommendations for ponderosa pine forest restoration can be found in Covington and Moore (19994), Covington et al. (1997), Fule et al. (1997), Mast et al. (1999), Moore et al. (1999), Allen et al. (2002), and Noss et al. (2006).
- 6) **Grazing.**—Livestock grazing should be carefully managed to maintain important habitat components for *T. m. atristriatus*. First, tall ground cover of native bunch grasses and forbs should be maintained to provide cover for foraging, escape, and dispersal. Secondly, forbs and shrubs should be allowed to produce seeds and fruit as an abundant food source.
- 7) **Multi-agency approach.**—As originally recommended by Sullivan and Nagorsen (1998), a coordinated multi-agency management plan should be developed for *T. m. atristriatus* and involve MAIR, LNF, New Mexico Department of Game and Fish, US Fish and Wildlife Service.

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APPENDICES

Appendix I

Appendix 1. Museums queried for specimens of *Tamias minimus* and *Tamias canipes* from Lincoln and Otero counties New Mexico.

State	Museum	Specimens	
		<i>canipes</i>	<i>minimus</i>
Alaska	University of Alaska Museum Mammal Collection	0	0
California	California Academy of Sciences (CAS)	0	0
California	Los Angeles County Museum of Natural History (LACM)	0	0
California	University of California, Museum of Vertebrate Zoology (MVZ)	15	0
California	San Diego Natural History Museum (SNHM)	2	0
California	Santa Barbara Museum of Natural History	0	0
Colorado	University of Colorado Museum (UCM)	0	0
D.C.	United States National Museum (USNM)	70	10
Florida	Florida Mus Nat Hist (UF)	0	0
Hawaii	Bernice P. Bishop Museum (BPBM)	0	0
Illinois	Field Museum (FMNH)	3	0
Kansas	Fort Hays State University, Sternberg Museum of Natural History (FHS)	19	0
Kansas	Univ. of Kansas Biodiversity Research Center (KU)	12	0
Louisiana	Louisiana State University Museum of Natural Science (LSUMZ)	0	0
Massachusetts	Harvard University Museum of Comparative Zoology (MCZ)	13	1
Michigan	Michigan State University Museum (MSUM)	0	0
Michigan	University of Michigan Museum of Zoology (UMMZ)	22	0
Minnesota	University of Minnesota James F. Bell Museum of Natural History	0	0
Nebraska	University of Nebraska State Museum (UNSM)	0	0
New Mexico	University of New Mexico Division of Genomic Resources	0	0
New Mexico	Eastern New Mexico University Natural History Museum (ENMU)	56	1
New Mexico	Museum of Southwestern Biology-uncataloged (MSB)	9	1
New Mexico	Museum of Southwestern Biology (MSB)	133	3
New Mexico	New Mexico Museum of Natural History and Science (NMMNH)	4	0
New Mexico	New Mexico State University, The Vertebrate Museum (NMSU)	34	30
New York	Cornell University Museum of Vertebrates (CUMV)	0	0
Oklahoma	Sam Noble Oklahoma Museum of Natural History	0	0
Ontario	Royal Ontario Museum	0	0
Pennsylvania	Academy of Natural Sciences of Philadelphia (ANSP)	42	85
Texas	Museum of Texas Tech University (TTU)	23	0
Texas	University of Texas at El Paso (UTEP)	8	0
Utah	Utah Museum of Natural History (UMNH)	0	0
Washington	James R. Slater Museum (PSM)	0	0
Washington	University of Washington Burke Museum (UWBM)	1	0
TOTAL		466	131

Appendix II

Appendix 2. Specimen records of *Tamias minimus atristriatus*.

Mus. ¹	Cat. #	Pop. ²	County	Descriptive locality	Date	Initial report
USNM	118821	S	Otero	Penasco, Upper Penasco	6-Sep-1902	Bailey 1913; Conley 1970
USNM	118822	S	Otero	Penasco, Upper Penasco	6-Sep-1902	Bailey 1913; Conley 1970
USNM	118823	S	Otero	Cloudcroft, 12 Mi E	6-Sep-1902	Bailey 1913; Conley 1970
USNM	118824	S	Otero	Cloudcroft, 12 Mi E	6-Sep-1902	Bailey 1913; Conley 1970
USNM	118825	S	Otero	Cloudcroft, 12 Mi E	6-Sep-1902	Bailey 1913; Conley 1970
USNM	118826	S	Otero	Cloudcroft, 12 Mi E	6-Sep-1902	Bailey 1913; Conley 1970
USNM	119028	S	Otero	Penasco Creek, 12 Mi. E. Cloudcroft, Sacramento Mtns., 7400 ft	6-Sep-1902	Bailey 1913; type specimen
USNM	119029	S	Otero	Cloudcroft, 12 mi E, 7400 ft	6-Sep-1902	Bailey 1913; Conley 1970
USNM	118832	S	Otero	Cloudcroft, 6 mi E	7-Sep-1902	Bailey 1913; Conley 1970
USNM	118833	S	Otero	Cloudcroft, 6 mi E	7-Sep-1902	Bailey 1913; Conley 1970
MCZ	24613	S	Otero	Cloudcroft, 9000 Alt.	10-Sep-1928	unreported
ANSP	14646	S	Otero	Tularosa Canyon, 4 miles above of Mescalero, 6850 ft.	10-Jun-1931	unreported
ANSP	14634	S	Otero	Tularosa Canyon, 4 miles above of Mescalero, 6850 ft.	20-Jun-1931	unreported
ANSP	14647	S	Otero	Tularosa Canyon, 4 miles above of Mescalero, 7000 ft.	22-Jun-1931	unreported
ANSP	14635	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	23-Jun-1931	unreported
ANSP	14636	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	23-Jun-1931	unreported
ANSP	14637	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	23-Jun-1931	unreported
ANSP	14638	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	27-Jun-1931	unreported
ANSP	14639	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	27-Jun-1931	unreported
ANSP	14640	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	1-Jul-1931	unreported
ANSP	14641	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	1-Jul-1931	unreported
ANSP	14642	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	8-Jul-1931	unreported
ANSP	14648	S	Otero	Tularosa Canyon, 6 miles above of Mescalero, 7000 ft.	8-Jul-1931	unreported
ANSP	14650	S	Otero	Tularosa Canyon, 2 miles above of Mescalero, 6800 ft.	10-Jul-1931	unreported
ANSP	14651	S	Otero	Tularosa Canyon, 2 miles above of Mescalero, 6800 ft.	10-Jul-1931	unreported
ANSP	14649	S	Otero	Tularosa Canyon, 3 miles above of Mescalero, 6900 ft.	10-Jul-1931	unreported
ANSP	14644	S	Otero	Tularosa Canyon, 4 miles above of Mescalero, 6850 ft.	10-Jul-1931	unreported
ANSP	14645	S	Otero	Tularosa Canyon, 4 miles above of Mescalero, 6850 ft.	10-Jul-1931	unreported

Mus. ¹	Cat. #	Pop. ²	County	Descriptive locality	Date	Initial report
ANSP	14643	S	Otero	Tularosa Canyon, 5 miles above of Mescalero, 7000 ft.	10-Jul-1931	unreported
ANSP	14654	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14655	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14656	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14657	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14658	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14659	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14661	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14662	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14663	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14670	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14671	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14672	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14673	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14674	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14675	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14676	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14677	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14678	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14679	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	22-Jul-1931	unreported
ANSP	14653	W	Otero	Sierra Blanca Peak, Rock Spring, 10200 feet	27-Jul-1931	unreported
ANSP	14665	W	Otero	Sierra Blanca Peak, Rock Spring, 11000 feet	27-Jul-1931	unreported
ANSP	14666	W	Otero	Sierra Blanca Peak, Rock Spring, 11000 feet	27-Jul-1931	unreported
ANSP	14667	W	Otero	Sierra Blanca Peak, Rock Spring, 11000 feet	27-Jul-1931	unreported
ANSP	14668	W	Otero	Sierra Blanca Peak, Rock Spring, 11000 feet	27-Jul-1931	unreported
ANSP	14681	W	Otero	Sierra Blanca Peak, Rock Spring, 11000 feet	27-Jul-1931	unreported
ANSP	14664	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	27-Jul-1931	unreported
ANSP	14680	W	Otero	Sierra Blanca Peak, Rock Spring, 11900 feet	27-Jul-1931	unreported
ANSP	14669	W	Otero	Sierra Blanca Peak, Rock Spring, 11000 feet	28-Jul-1931	unreported
ANSP	14682	W	Otero	Sierra Blanca Peak, Rock Spring, 11000 feet	28-Jul-1931	unreported
ANSP	14633	S	Otero	Elk Canyon, 8300 feet	12-Aug-1931	unreported
ANSP	14652	S	Otero	Elk Canyon, Sacramento Mountains, 8300 feet	16-Aug-1931	unreported

Mus. ¹	Cat. #	Pop. ²	County	Descriptive locality	Date	Initial report
ANSP	14652	S	Otero	Sacramento Mountains, Elk Canyon, 8300 ft.	16-Aug-1931	unreported
ANSP	15564	S	Otero	Eastern Slope Sacramento Mountains, Fence Canyon, 8000 feet	10-Jun-1932	unreported
ANSP	15565	S	Otero	Seven Springs, Tularosa Canyon	16-Jun-1932	unreported
ANSP	15566	S	Otero	Seven Springs, Tularosa Canyon	16-Jun-1932	unreported
ANSP	15567	S	Otero	Seven Springs, Tularosa Canyon	16-Jun-1932	unreported
ANSP	15568	S	Otero	Seven Springs, Tularosa Canyon	16-Jun-1932	unreported
ANSP	15569	S	Otero	Seven Springs, Tularosa Canyon	16-Jun-1932	unreported
ANSP	15570	S	Otero	6 miles North East of Mescalero Agency, 7500 feet	28-Jun-1932	unreported
ANSP	15571	S	Otero	Sacramento Mountains, 6 miles North East of Mescalero Agency, 7500 feet	28-Jun-1932	unreported
ANSP	15572	S	Otero	Sacramento Mountains, 6 miles North East of Mescalero Agency, 7500 feet	28-Jun-1932	unreported
ANSP	15598	S	Otero	Elk Canyon, 7000 feet	31-Jul-1932	unreported
ANSP	15597	S	Otero	Elk Canyon, 7000 feet	31-Jul-1932	unreported
ANSP	15573	S	Otero	Sacramento Mountains, Elk Canyon, 7500 feet	9-Aug-1932	unreported
ANSP	15574	S	Otero	Sacramento Mountains, Elk Canyon, 7500 feet	9-Aug-1932	unreported
ANSP	15575	S	Otero	Sacramento Mountains, Elk Canyon, 7500 feet	9-Aug-1932	unreported
ANSP	15576	S	Otero	Sacramento Mountains, Elk Canyon, 7500 feet	9-Aug-1932	unreported
ANSP	15577	S	Otero	Sacramento Mountains, Elk Canyon, 8000 feet	10-Aug-1932	unreported
ANSP	15578	S	Otero	Sacramento Mountains, Elk Canyon, 8000 feet	10-Aug-1932	unreported
ANSP	15579	S	Otero	Sacramento Mountains, Elk Canyon, 8000 feet	10-Aug-1932	unreported
ANSP	15580	S	Otero	Sacramento Mountains, Elk Canyon, 8000 feet	10-Aug-1932	unreported
ANSP	15581	S	Otero	Sacramento Mountains, Elk Canyon, 8000 feet	10-Aug-1932	unreported
ANSP	15582	S	Otero	Sacramento Mountains, Elk Canyon, 8000 feet	10-Aug-1932	unreported
ANSP	15583	S	Otero	Sacramento Mountains, Elk Canyon, 8000 feet	10-Aug-1932	unreported
ANSP	15584	S	Otero	Sacramento Mountains, Elk Canyon, 8000 feet	10-Aug-1932	unreported
ANSP	15585	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15586	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15587	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15588	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15589	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15590	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported

Mus. ¹	Cat. #	Pop. ²	County	Descriptive locality	Date	Initial report
ANSP	15591	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15592	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15593	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15594	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15595	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
ANSP	15596	S	Otero	Tularosa Canyon, 3 miles above Mescalero Agency	24-Aug-1932	unreported
MSB	4900	S	Otero	7 mi. E Cloudcroft; T16S, R13E, Sec 4	13-Jul-1958	Conley 1970
MSB	4901	S	Otero	7 mi. E Cloudcroft; T16S, R13E, Sec 4	12-Jul-1958	Conley 1970
NMSU	2798	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	8-Jun-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2799	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	8-Jun-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2800	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	8-Jun-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2801	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	27-Jun-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2802	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	29-Aug-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2803	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	29-Aug-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2804	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	29-Aug-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2805	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	29-Aug-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"

Mus. ¹	Cat. #	Pop. ²	County	Descriptive locality	Date	Initial report
NMSU	2806	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	4-Sep-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2807	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	4-Sep-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2808	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	4-Sep-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2809	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	4-Sep-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2810	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	5-Sep-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2811	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	5-Sep-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2812	W	Lincoln	Sierra Blanca Peak, E Face, 11500'	5-Sep-1965	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2813	W	Lincoln	0.25 mi. N top Sierra Blanca Peak, 11500'	21-Jun-1966	Conley 1970; published location also includes "T. 11 S, R. 11 E" and "on north ridge"
NMSU	2814	W	Lincoln	0.25 mi. N top Sierra Blanca Peak, 11500'	21-Jun-1966	Conley 1970; published location also includes "T. 11 S, R. 11 E" and "on north ridge"
NMSU	2815	W	Lincoln	0.25 mi. N top Sierra Blanca Peak, 11500'	21-Jun-1966	Conley 1970; published location also includes "T. 11 S, R. 11 E" and "on north ridge"
NMSU	2793	W	Lincoln	Sierra Blanca Peak, N Rise, 11500'	9-Jul-1966	probably = Conley 1970: "T10S, R11E, 0.5 mi N Sierra Blanca Peak, on north ridge 11,500 ft"

Mus. ¹	Cat. #	Pop. ²	County	Descriptive locality	Date	Initial report
NMSU	2794	W	Lincoln	Sierra Blanca Peak, N Rise, 11500'	10-Jul-1966	probably = Conley 1970: "T10S, R11E, 0.5 mi N Sierra Blanca Peak, on north ridge 11,500 ft"
NMSU	2795	W	Lincoln	Sierra Blanca Peak, N Rise, 11500'	10-Jul-1966	probably = Conley 1970: "T10S, R11E, 0.5 mi N Sierra Blanca Peak, on north ridge 11,500 ft"
NMSU	2790	S	Otero	James Canyon Camp, 14 mi. E, 4 mi. N Cloudcroft, 6800'	17-Jul-1966	Conley 1970; published location also includes "T. 16 S, R. 4 E"
NMSU	2791	S	Otero	James Canyon Camp, 14 mi. E, 4 mi. N Cloudcroft, 6800'	17-Jul-1966	Conley 1970; published location also includes "T. 16 S, R. 4 E"
NMSU	2792	S	Otero	James Canyon Camp, 14 mi. E, 4 mi. N Cloudcroft, 6800'	4-Aug-1966	Conley 1970; published location also includes "T. 16 S, R. 4 E"
NMSU	2833	S	Otero	James Canyon, Sacramento Mts.	no data	baculum only; probably one of 4 specimens reported by Conley 1970 from: "T. 16 S, R. 4 E, James Canyon Camp, 14 mi. E, 4 mi. N Cloudcroft, 6800 ft"
NMSU	2796	W	Lincoln	Sierra Blanca Peak, E Face, 11000'	5-Aug-1966	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2797	W	Lincoln	Sierra Blanca Peak, E Face, 11000'	5-Aug-1966	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2816	W	Lincoln	no data	no data	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2817	W	Lincoln	no data	no data	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"
NMSU	2818	W	Lincoln	no data	no data	Conley 1970; probably = 1 of 20 from "T. 11 S, R. 4 E, E face Sierra Blanca Peak, 10,500-11,500 ft"

Mus. ¹	Cat. #	Pop. ²	County	Descriptive locality	Date	Initial report
						field # JAC 1154; 1 of 2 specimens reported by Sullivan et al. (no date) from: "Sierra Blanca peak, Mescalero Apache Indian Reservation, elev. 11,800" and Sullivan (1985) and Sullivan and Petersen (1988) from: "glacial cirque, NE face Sierra Blanca Peak"; second specimen missing.
MSB	uncataloged	W	Otero	Sierra Blanca Peak, taken in boulder pile below cirque	11-Aug-1982	
ENMU	10638	W	Lincoln	Sacramento Mtns; Buck Mtn; Forest Road 5625, 2 mi. N, 1 1/2 mi. E Sierra Blanca Peak, N 33° 24' 3.7", W 105° 46' 47.1", 3,209 m	12-Aug-2000	Hope and Frey 2000

¹Museum acronym definitions are in Appendix 1.

²Populations: W = White Mountains; S = Sacramento Mountains.

Appendix III

Appendix 3. Comparison of external features of adult *Tamias minimus atristriatus* and *Tamias canipes* (from Frey 2007). The measurements were taken according to standard mammalogy methods as recorded on museum specimen tags. See Figure 2 for photographs of specimens depicting pelage differences.

	<i>T. minimus atristriatus</i> (n = 27)	<i>T. canipes</i> (n = 39)
Total length		
mean	200.0	230.5
range	177-223	216-245
Tail length		
mean	89.0	98.0
range	72-106	87-109
Hindfoot length		
mean	29.5	34.5
range	27-32	32-37
Ear length		
mean	16.5	20.5
range	15-18	19-22
Mass		
mean	42.5	67.8
range	30-55	55.5-80
Color of mid-dorsal stripe	black	black
Color of lateral dark stripes	black	brown
Distribution of the lateral dark stripe nearest midline	extends as distinct black stripe over rump to near based of tail	brown stripe thins and fades over rump
Color of ventral side of tail (from middle to outer edge)	orange-black-orange	orange-black-gray or tan
Distribution of orange on body	shoulders, sides, haunches, tops of feet, belly	primarily on sides

Appendix IV

Appendix 4. Georeferenced latitude and longitude coordinates for unique voucher specimen collection locations.

Species	Representative Catalog #	Latitude	Longitude	Date
canipes	TTU 16666	32.503738	-105.531337	15-Oct-1972
canipes	UTEP6018	32.582059	-105.696983	11-Sep-1988
canipes	TTU 54538	32.61549	-105.671344	6-Oct-1973
canipes	MSB 72640	32.61932	-105.651829	1-Jul-1994
canipes	MSB 75477	32.700462	-105.734412	29-Jun-1994
canipes	ENMU 10646	32.712768	-105.687026	25-Jul-2000
canipes	ENMU 10610	32.755255	-105.778323	12-Jul-2000
canipes	ENMU 10645	32.760082	-105.628235	25-Jul-2000
canipes	TTU7452	32.763151	-105.72888	14-Sep-1968
canipes	MSB 18056	32.78007	-105.745285	26-Jul-1963
canipes	UTEP 8227	32.78595	-105.864746	21-Sep-1980
canipes	ENMU 10644	32.793449	-105.601917	25-Jul-2000
canipes	MSB uncat JAC 1184	32.805347	-105.794128	2-Sep-1982
canipes	NMSU 6874	32.847919	-105.543483	23-Jul-1977
canipes	MSB uncat JAC 1178	32.855301	-105.598864	31-Aug-1982
canipes	TTU 77482	32.858906	-105.742284	27-May-1998
canipes	MSB 61486	32.862167	-105.575765	27-Sep-1981
canipes	MSB 61467	32.866158	-105.526248	27-Sep-1982
canipes	MSB 82445	32.870407	-105.621796	3-Sep-1982
canipes	ENMU 10651	32.870547	-105.484056	12-Jul-2000
canipes	MSB 54858	32.876544	-105.48945	13-Aug-1982
canipes	MVZ 19000	32.883797	-105.426776	29-Sep-1931
canipes	MSB uncat JAC 1179	32.884655	-105.673375	1-Sep-1982
canipes	MSB 57939	32.889934	-105.521793	6-Aug-1982
canipes	TTU 7126	32.896414	-105.493641	4-Aug-1966
canipes	TTU 7098	32.898216	-105.813166	14-May-1965
canipes	NMSU 2418	32.903709	-105.503709	25-Sep-1966
canipes	ENMU 10600	32.904493	-105.505358	26-Jul-2000
canipes	MSB uncat JAC 1166	32.914867	-105.573928	20-Aug-1982
canipes	USNM 119030	32.922592	-105.576269	6-Sep-1902
canipes	ENMU 10649	32.926733	-105.55075	12-Jul-2000
canipes	MSB 61476	32.931433	-105.588585	27-Sep-1981
canipes	ENMU 10594	32.931808	-105.564179	15-Jul-2000
canipes	MSB 61530	32.932227	-105.649686	23-Aug-1982
canipes	MSB 2971	32.933578	-105.742385	3-Jul-1957
canipes	MSB 57937	32.936153	-105.477375	25-Sep-1981
canipes	MHP 5518	32.942805	-105.742487	4-Aug-1965
canipes	KU 149904	32.945423	-105.623824	6-Jul-1963

canipes	MSB 35034	32.947998 -105.839501	23-Jun-1971
canipes	MSB uncat JAC 1173	32.949972 -105.63899	22-Aug-1982
canipes	UMMZ 58659	32.950916 -105.84415	29-Jul-1927
canipes	UMMZ 58657	32.950916 -105.835533	24-Jul-1927
canipes	MSB 54860	32.955122 -105.644441	24-Aug-1982
canipes	TTU 35975	32.957225 -105.656255	2-Aug-1973
canipes	USNM 100432	32.9573 -105.742488	19-May-1900
canipes	TTU 7103	32.957311 -105.717987	28-Jun-1966
canipes	ENMU 553	32.957354 -105.745587	22-Oct-1966
canipes	USNM 118827	32.960701 -105.664512	7-Sep-1902
canipes	UTEP 5579	32.963276 -105.648363	29-Sep-1979
canipes	UTEP 5578	32.96392 -105.719214	29-Sep-1979
canipes	UMMZ 58644	32.971805 -105.742526	19-Jul-1927
canipes	MSB 61504	32.978296 -105.68228	26-Sep-1981
canipes	TTU 7099	32.983489 -105.688309	25-Jun-1965
canipes	NMSU 1580	32.986279 -105.742488	1-Oct-1961
canipes	UMMZ 58665	32.987738 -105.680424	1-Aug-1927
canipes	ENMU 10609	32.993274 -105.411763	23-Jul-2000
canipes	UMMZ 58660	32.993488 -105.742487	31-Jul-1927
canipes	UTEP 6846	32.995806 -105.745794	11-Aug-1979
canipes	NMSU 1975	33.000698 -105.742488	24-May-1964
canipes	USNM 118834	33.017778 -105.627069	10-Sep-1902
canipes	UWBM 60161	33.024473 -105.652021	24-Apr-1976
canipes	ANSP 15556	33.084426 -105.612592	9-Aug-32
canipes	ANSP 14612	33.091915 -105.713815	22-Jun-31
canipes	ANSP 14505	33.118501 -105.726881	20-Jun-31
canipes	ANSP 15562	33.130217 -105.736643	24-Aug-32
canipes	ANSP 15554	33.14219 -105.744586	28-Jun-32
canipes	ANSP 15557	33.145409 -105.65995	10-Aug-32
canipes	NMSU 15	33.157586 -105.774156	7/18/1898
canipes	ANSP 14632	33.158798 -105.648716	14-Aug-31
canipes	ANSP 14629	33.284369 -105.741833	8-Jun-31
canipes	ANSP 14626	33.286257 -105.747274	11-Jun-31
canipes	ANSP 15550	33.31192 -105.763706	11-Jun-32
canipes	ANSP14615	33.34033 -105.766899	19-Jul-31
canipes	NMSU 3874	33.34342 -105.536821	1-May-1971
canipes	MVZ 50332	33.35313 -105.661811	28-Apr-1943
canipes	UMMZ 79004	33.373847 -105.808963	6-Aug-1937
canipes	TTU 7100	33.374448 -105.792156	27-Jun-1965
canipes	MSB 35994	33.390627 -105.784245	30-Jun-1977
canipes	MSB 4763	33.394575 -105.714029	6-Jul-1958
canipes	TTU 7101	33.39509 -105.746764	10-Jul-1966
canipes	ENMU 10639	33.395573 -105.782041	19-Aug-2000
canipes	NMSU 5606	33.396978 -105.788129	1-May-1976

canipes	MSB 61536	33.398781 -105.732945	7-Oct-1981
canipes	NMSU 3553	33.399467 -105.661823	3-May-1969
canipes	ENMU 10640	33.402772 -105.782922	20-Aug-2000
canipes	KU 95259	33.407192 -105.739216	12-Aug-1954
canipes	NMSU 7129	33.408566 -105.739589	23-Oct-1977
canipes	NMSU 14493	33.419466 -105.70458	30-May-1983
canipes	MSB 4762	33.430924 -105.731644	4-Jul-1958
canipes	TTU 54537	33.448305 -105.754087	11-May-1974
canipes	NMSU 12149	33.460107 -105.464446	18-Jul-1978
canipes	UMMZ 60323	33.462124 -105.602981	19-Jul-1929
canipes	TTU 4103	33.484697 -105.731272	9-Jul-1967
canipes	NMSU 12147	33.488517 -105.486194	14-Jul-1978
canipes	NMSU 12148	33.48856 -105.482077	14-Jul-1978
canipes	MVZ 190003	33.496971 -105.877231	13-Apr-1943
minimus	USNM 118821	32.889537 -105.478036	6-Sep-1902
minimus	NMSU 2790	32.903709 -105.503709	17-Jul-1966
minimus	USNM 119028	32.922592 -105.576269	6-Sep-1902
minimus	MSB 4901	32.943492 -105.622908	12-Jul-1958
minimus	MCZ 24613	32.9573 -105.742488	10-Sep-1928
minimus	USNM 118832	32.960701 -105.664512	7-Sep-1902
minimus	ANSP15597	33.049107 -105.524591	10-Jul-1932
minimus	ANSP15573	33.084426 -105.612592	9-Aug-1932
minimus	ANSP14635	33.091915 -105.713815	23-Jun-1931
minimus	ANSP14643	33.105476 -105.719682	10-Jul-1931
minimus	ANSP14634	33.118501 -105.726881	20-Jun-1931
minimus	ANSP15585	33.130217 -105.736643	24-Aug-1932
minimus	ANSP14650	33.14219 -105.744586	10-Jul-1931
minimus	ANSP 15577	33.145409 -105.65995	10-Aug-1932
minimus	ANSP14633	33.167038 -105.637128	1-Jul-1932
minimus	ANSP15564	33.188453 -105.653396	10-Jun-1932
minimus	ANSP15570	33.218966 -105.700844	28-Jun-1932
minimus	ANSP 14653	33.360436 -105.814906	27-Jul-1931
minimus	ANSP 14665	33.368697 -105.813467	27-Jul-1931
minimus	ANSP 14654	33.373847 -105.808963	22-Jul-1931
minimus	NMSU 2796	33.37389 -105.799709	5-Aug-1966
minimus	NMSU 2798	33.374019 -105.803577	8-Jun-1965
minimus	MSB uncat JAC 1154	33.375649 -105.806877	11-Aug-1982
minimus	NMSU 2813	33.377452 -105.80959	21-Jun-1966
minimus	NMSU 2793	33.378117 -105.810335	9-Jul-1966
minimus	ENMU 10638	33.401023 -105.779763	12-Aug-2000
unknown	UTEP6017	32.583953 -105.728268	5-Aug-1981

Appendix V: Photographs

Photographs are on an associated CD.