SURVEY FOR THE NEW MEXICO MEADOW JUMPING MOUSE (*ZAPUS HUDSONIUS LUTEUS*) ON CARSON NATIONAL FOREST, NEW MEXICO

Western jumping mouse (*Zapus princeps*) captured at Stewart Meadows18 August 2012.

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ABSTRACT

The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is a high priority candidate for listing on the federal Endangered Species Act. It is a riparian-obligate that utilizes tall, dense herbaceous riparian vegetation on saturated soils along perennial streams. The species historically occurred on Carson National Forest, but there have been no recent records. Thus, the purpose of this study was to determine current presence of the species on the forest. A collaborative, systematic method was used to select survey sites based on known natural history data and expert knowledge of the taxon and local habitats. Thus, the entire Forest was effectively considered and the process generated 17 pre-selected survey areas. These areas were evaluated for habitat and site conditions in the field in order to select three sites for trapping that offered the very best potential for *Z. h. luteus*. Trapping locations included the lower Rito de la Olla (Camino Real District), the Rio Grande del Ranch Forest Road 432 Wetland Project area (Camino Real District), and San Antonio Creek at Stewart Meadows (Tres Piedras District). The total trapping effort was 1,320 trap-nights. No *Z. h. luteus* was captured. The relatively abundant and competitively dominant western jumping mouse (*Zapus princeps*) was captured at two of the sites, Stewarts Meadows and Rito de la Olla. *Z. princeps* was especially common at Stewarts Meadow and hence that site was considered unsuitable for *Z. h. luteus*. Although no jumping mice of either species was documented at the Forest Road 432 wetland, it was deemed most suitable for *Z. h. luteus*. Failure to document *Z. h. luteus* does not verify that the species is not present on the Forest or that it could not become established on the Forest in the future. It is possible that some areas of potential habitat were missed by the site selection process and it is known that *Z. h. luteus* can reoccupy sites from adjacent refugia if riparian habitat conditions improve. Most perennial streams on Carson NF are currently unsuited for occupation by *Z. h. luteus* due to high elevation, steep gradients in narrow valleys, or degraded riparian habitat along with loss of beaver. The only extensive area on Carson NF that currently meets all of the needs for *Z. h. luteus* (i.e., suitable elevation, site conditions, and habitat) is the watershed of the Rio Grande del Rancho on the Camino Real District. A major contributing factor to the quality of the riparian habitat in this watershed was that it has not been grazed by livestock for more than 20 years. Management recommendations primarily deal with habitat restoration, livestock grazing, and beaver, but include a variety of other topics including recreation and upland grassland restoration.

BACKGROUND

The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is a morphologically and genetically distinctive taxon that is endemic to the American Southwest (Miller 1911; Hafner et al. 1981; King et al. 2006; Malaney et al. 2012). Originally, it was named as a distinct species (*Z. luteus*), but later it was reassigned as a subspecies of the western jumping mouse (*Z. princeps*), and more recently it was reassigned as a well-diverged subspecies of the meadow jumping mouse (*Z. hudsonius*; Miller 1911; Krutzsch 1954; Hafner et al. 1981; King et al. 2006; Malaney et al. 2012). It has a relict distribution composed of several isolated populations: the White Mountains and Verde River valley in Arizona, the Jemez and Sacramento mountains in New Mexico, the Rio Grande Valley in New Mexico, and the vicinity of the southern San Juan and Sangre de Cristo mountains in southern Colorado and northern New Mexico (Malaney et al. 2012, Frey 2012). *Z. h. luteus* is a habitat specialist that occupies herbaceous riparian habitats (Frey 2006, Frey and Malaney 2009). More specifically, it is associated with saturated soils along perennial flowing water that supports tall, dense herbaceous vegetation, especially sedges (Frey and Malaney 2009). Frey and Malaney (2009) reported extensive recent extirpations of montane populations in New Mexico over the past two decades. The primary threat is livestock grazing, which can dramatically alter the structure and composition of herbaceous riparian vegetation (Morrison 1990, Frey and Malaney 2009). Other identified threats include wildfire, drought and climate change, urbanization, water development, recreation, flooding, loss of beaver, and conversion of riparian habitat to agricultural crops (Morrison 1990, 1992; Hafner and Yensen 1998; NMDGF 1998; Frey 2005, 2006, AGFD in prep.). In December 2007 *Z. h. luteus* was listed as a high priority candidate for protection under the federal Endangered Species Act. In New Mexico, *Z. h. luteus* is listed as Endangered. The US Forest Service Rocky Mountain Region (Region 2) considers it a sensitive species http://www.fs.fed.us/r2/projects/scp/sensitivespecies/index.shtml).

Knowledge about the historical and current distribution of *Z. h. luteus* in northern New Mexico is scant. In northern New Mexico and southern Colorado the situation is complicated by presence of another species of jumping mouse, the western jumping mouse (*Zapus princeps*; Figure 1). Elsewhere (i.e., where *Z. princeps* does not occur), *Z. h. luteus* has been collected from low elevations in desert regions (e.g., 4,500 ft elevation on Rio Grande, New Mexico) up through high elevations on mountaintops (e.g., 9,400 ft in the White Mountains, Arizona). However, Frey (2011a) provided multiple lines of evidence suggesting that presence of *Z. princeps* influences the distribution of *Z. h. luteus* where they are sympatric, potentially through direct competition (i.e., competitive exclusion). *Z. princeps* is a quintessential montane species in southern Colorado and New Mexico. The lowest elevation records for *Z. princeps* in northern New Mexico are ca 7,400 ft on Rito de la Olla, Taos County (Frey 2006), and ca 7,430 ft on Middle Ponil Creek on the Barker Wildlife Management Area, Colfax County (ENMU 11188; Frey unpublished data). Capture rates indicate that *Z. princeps* becomes more common as elevation increases, perhaps being most abundant at 9,500 – 10,000 ft in this region (Frey 2003, 2006, 2011a). Recent captures of both species have shown pronounced separation by elevation with *Z. h. luteus* occurring at lower elevations (Figure 2). Lastly, *Z. princeps* is a habitat generalist that can occupy a wide range of scrub and coniferous forest habitats, although it is most common in riparian zones (Frey 2003). Both *Z. princeps* and *Z. h. luteus* can use habitats that are essentially identical in structure of the plant community, although *Z. princeps* uses a wider range of conditions (Frey 2011a).

In the zone of sympatry(southern Colorado and northern New Mexico), *Z. h. luteus* has only been found at 12 widely separated locations (Figure 3; Table 1). The paucity of records in this region likely is due to a number of factors, including: 1) there has been relatively little work on small mammals in this region; 2) most small mammal studies in this region have been conducted at high elevations; 3) most public land is at high elevation (i.e., and hence is occupied by *Z. princeps*); 4) most riparian habitats have been radically altered due to human land-use, especially at lower elevations; 5) *Z. h. luteus* is naturally rare; and 6) *Z. h. luteus* is difficult to capture. However, the potential natural distribution of *Z. h. luteus* within this region can be extrapolated based on the known locations along with knowledge of its natural history, especially that its distribution and movements are tied to perennial watercourses (e.g., Frey 2011). For instance, low elevations do not appear to limit its modern distribution in this region. Further, phylogeographic analyses and paleodistribution modeling indicate that *Z. h. luteus* originally colonized areas during cool, moist periods associated with the Pleistocene and early Holocene (Malaney et al. 2012). Thus, its potential natural distribution likely would include any perennial stream within the San Juan, Chama, Rio Grande, and Canadian watersheds (Note: Based on modeled Pleistocene distribution and modern records within the Pecos River watershed in southern New Mexico, the distribution of *Z. h. luteus* also likely includes the Pecos River watershed in the zone of sympatry, but there are no specimen records to support that conclusion.). This potential distribution is then modified by natural site condition, interspecific interactions, and habitat changes caused by human land-use issues. Site conditions, such as width, gradient, and substrate of a stream valley, are important because these determine the potential for development of herbaceous riparian vegetation (i.e., which us associated with wide valleys, low gradients, and soil substrate). Interspecific interactions with *Z. princeps* probably limit the upper elevation distributional limits of *Z. h. luteus* in the zone of sympatry as there are no known environmental limits of cool temperature and high precipitation (except *Z. hudsonius* does not occur in tundra).

Of special interest to the distribution of *Z. h. luteus* in northern New Mexico is the report of two potential cases of syntopy (i.e., occur at same site) between *Z. h. luteus* and *Z. princeps* at high elevations in the Sangre de Cristo Mountains, Taos County (Frey 2008). Frey (2008) conducted a comprehensive analysis of morphology and genetics of 755 specimens of *Zapus* in the Southwest. The use of genetics (see Malaney et al. 2012 for full analysis of the genetic data) provided definitive reference samples of both species on which the morphological data were analyzed and used to identify historical specimens that lacked fresh genetic tissue samples. Both putative cases of syntopy involve series of historical specimens that were identified by Frey based on morphological data only. The first instance involved a series of 9 *Zapus* collected in 1966 from "2.5 miles N of Williams Lake", which is likely in Taos Ski Valley (Frey 2006, 2008). One of the series was identified as *Z. h. luteus* by both Frey (2008) and Hafner et al. (1981). No field notes were associated with the specimens, but all 9 specimens had "Grid Station" designations as part of the locality information on the tags, which suggests that all came from the same sample site. The second instance involved a series of 4 *Zapus* collected in 1958 from "2 mi NE Tres Ritos, Rio la Junta", which based on field notes was at the location of Duran Canyon Campground (Frey 2008). One of the specimens was identified as *Z. h. luteus* by Frey (2003, 2008). Field notes indicate that beaver ponds were present and that traps were set in shrubby areas along both streams and in a meadow.

Both putative syntopic *Z. h. luteus* specimens were young males. Three potential scenarios may explain these records. First, it is possible that the specimens represent

misidentified *Z. princeps*. Compared to older animals, young *Z. princeps* may be morphologically more similar to *Z. h. luteus* because they are smaller and they have a higher frequency of isolated paracones on the upper molars (a trait characteristic of *Z. h. luteus*) (Frey 2008). This scenario seems unlikely because the morphological data was thought to provide unambiguous identifications. Only genetic data can resolve this possibility but our attempts to examine DNA from these old specimens failed. Second, it is possible that the specimens came from another location and were mislabeled. For instance, field notes associated with the Tres Ritos series indicate that traps also were set at a location 1 mile west of Penasco (which is classic *Z. h. luteus* habitat). However, the notes also state that all of the jumping mice came from vicinity of the collectors' camp at the mouth of Duran Canyon. Thus, evidence suggests that the specimen was not mislabeled. Finally, it is possible that the specimen records are accurate. However, the presence of a young male does not necessarily mean that a breeding population of *Z. h. luteus* was located at those sites. For a small mammal, jumping mice can move relatively long distances, especially the males, with movements up to 4 km recorded (Wright 2011, Schorr 2012). Given that the core of the distribution of *Z. h. luteus* in the zone of sympatry is low to mid-elevation and that a competitively dominant species occurs at high elevation, it seems likely that *Z. h. luteus* could have established metapopulations along riparian corridors into increasingly more hostile higher elevations (due to increasing abundance of *Z. princeps*). Metapopulations are patches of occurrence (i.e., subpopulations) linked by dispersal. In a metapopulation, many subpopulations will be "sinks" that can persist only through immigration; only patches of habitat with high enough quality can persist without immigrants. Thus, *Z. h. luteus* could have established metapopulations along streams into higher elevations when overall habitat conditions were ideal (e.g., numerous beaver ponds, low grazing impacts, little recreation, etc). The increasing abundance of *Z. princeps* at progressively higher elevations would be one factor influencing metapopualtion structure even with no habitat change. However, such metapopulation structures are fragile because any deterioration in the habitat can cause local extirpation of subpopulations and increase dispersal distances beyond the species' capacity. Together, these factors can cause a metapopulation to collapse. In such a case, it is expected that high elevation occurrences of *Z. h. luteus* would be preferentially extirpated and that any persisting populations would occur at low elevations (note that the opposite may be true in locations where *Z. h. luteus* is the only species of jumping mouse). Habitat conditions at both syntopic sites are no longer suitable for *Z. h. luteus* (Frey 2006).

Carson National Forest consists of 2,174 square miles of mostly mid- and higher elevations in northern New Mexico (Figure 4). It represents the largest track of public land within the zone of sympatry. However, there has been relatively little study of the small mammals on the Forest. Most early Mammalogy work consisted of opportunistic specimen collecting, often focused on favorite field sites of mammalogists (e.g., Canjilon Lakes, La Junta Canyon). More recently, there have been a few studies specifically aimed at documenting riparian small mammals, most with the explicit goal to document *Z. h. luteus* (Table 2). Together, the previous studies surveyed 20 riparian sites on the forest. However, in none of those studies were sites selected based on *a priori* knowledge of the natural history of *Z. h. luteus* in the zone of sympatry, either because it was unknown at the time of the study or because sites were selected based on other criteria. Thus, the goal of this study was to use a systematic, information-based approach to survey Carson National Forest for presence of *Z. h. luteus*.

Figure 1. Western jumping mouse (*Zapus princeps*) caught at Stewart Meadows during this study.

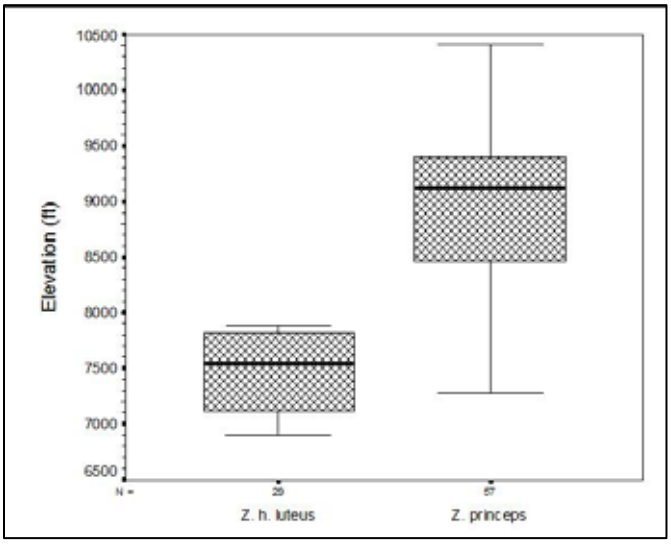

Figure 2. Elevation of recent captures of *Z. h. luteus* and *Z. princeps* in their zone of sympatry in northern New Mexico and southern Colorado. Data do not include historical locations, which would extend the range for *Z. h. luteus* lower and extend the range for *Z. princeps* higher. Figure from Frey (2011a).

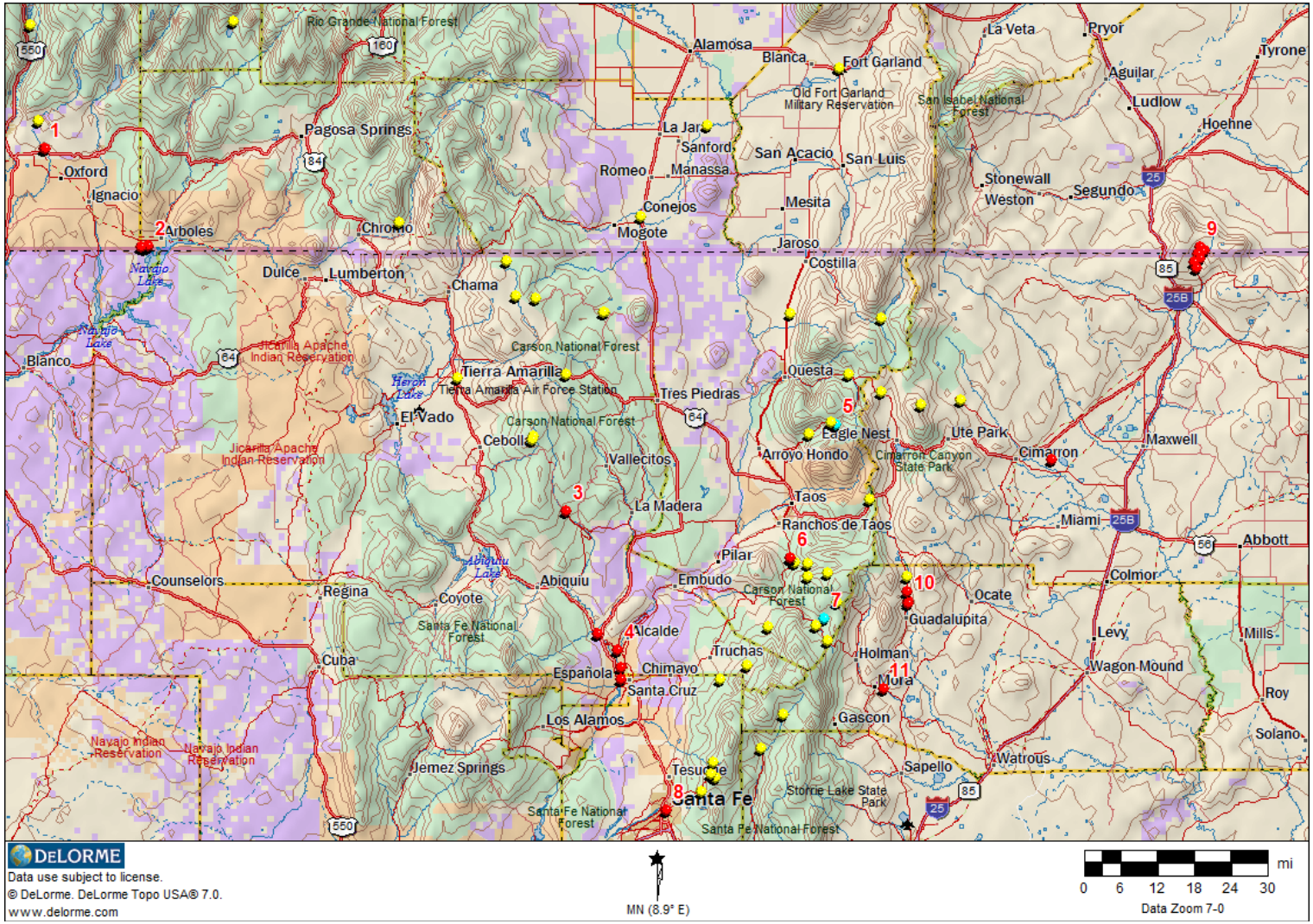

Figure 3. Distribution of jumping mice in the zone of sympatry in southern Colorado and northern New Mexico: Red dots = New Mexico meadow jumping mouse (*Zapus hudsonius luteus*); Yellow dots = western jumping mouse (*Zapus princeps*). Blue dots are potential syntopic locations (i.e., both species). Map does not show locations of *Z. h. luteus* in the Jemez Mountains. Numbers correspond to Table 1.

Table 1. Locations of the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) in the zone of sympatry with the western jumping mouse (*Zapus princeps*) in southern Colorado and northern New Mexico. Numbers correspond to Figure 3.

No.	State	County	Carson NF	Site	elevation (ft)	Year of capture	Reference	Notes
San Juan River watershed								
1	CO	La Plata	No	Florida River	6800	1945, 2007	Frey 2008	
2	CO	Archuleta	No	Sambrito Creek and vicinity	6090	1960, 2012	Durrant and Dean 1961; Harris 1963; Frey 2008; C. Kloster pers. com.	
Rio Grande (and Chama River) watershed								
3	NM	Rio Arriba	Yes	El Rito Creek	7350	1928	Frey 2008	
4	NM	Rio Arriba	No	vicinity Espanola (Rio Chama and Rio Grande)	5600-5710	1904, 1987	Miller 1911; Morrison 1988; Frey 2006a	
5	NM	Taos	possibly	Taos Ski Valley	9630*	1966	Hafner et al 1981; Frey 2008	syntopic?; precise location unknown
6	NM	Taos	possibly	Camp Burgwyn (=Fort Burgwin)	7400	1858	Miller 1911; Frey 2008	precise location unknown
7	NM	Taos	Yes	La Junta Canyon (near Tres Ritos)	8750*	1958	Frey 2003, 2008	syntopic?
8	NM	Taos	No	Santa Fe	7000	1894	Frey 2008	precise location unknown
Canadian River watershed								
9a	CO	Las Animas	No	Sugarite Canyon	7500-7720	1996	Jones 1999, 2002	
9b	NM	Colfax	No	Sugarite Canyon	7140-7880	2006	Frey 2006, 2008; Frey and Schwenke 2012	
10	NM	Colfax	No	Coyote Creek	7675-7780	2006, 2012	Frey 2006b,c, 2008, 2012	
11	NM	Mora	No	Mora	7120	1990	Frey 2008	

Table 2. Studies of riparian small mammals on Carson National Forest.

Study	Goal	Location	Sites	Trap-nights	Number *Z. h. luteus* captured	Number *Z. princeps* captured
Frey 2003	Prey-base communities in major ecosystems	Carson NF	16 total; 6 riparian	4,564 total; 1,268 riparian	0	15
Frey 2006	survey *Z. h. luteus*	Sangre de Cristo Mountains	27 total; 9 on Carson	4,083; 1,714 on Carson	25; 0 on Carson	40; 25 on Carson
Ecosphere 2011	survey *Z. h. luteus*	Carson NF	5	1,045	0	2
Frey current	survey *Z. h. luteus*	Carson NF	21 (3 trapped); all of forest evaluated	1,320	0	8

METHODS

Survey Site Selection

The overarching goal of this study was to document any populations of *Z. h. luteus* that might currently exist on lands administered by Carson National Forest (rather than determining presence/absence at pre-determined site). Consequently, methods used were designed to maximize efficiency of the survey and chance for documenting the species. Given the large size of the forest (i.e., 5,362 km^2 spread over 4 distinct regions) and lack of significant prior small mammal survey work on much of the Forest, key to achieving this goal was identifying locations with the highest potential to harbor the species. This was done as a multi-step process as a collaboration between Carson NF and Frey. To start the process, Carson NF identified a list of sites that best conformed to characteristics recommended by Frey. The site characteristics recommendations were based on specific conditions known to be important to occurrence of *Z. h. luteus* in the New Mexico-Colorado borderland region (Frey 2011). The list of sites was then modified by Frey based on existing information, expert judgment, and consultation with Carson NF.

Recommended site characteristics included:

- **Perennial stream.** Ideally, the stream reach is in a low gradient floodplain. Reaches in narrow canyons with conifer trees in the riparian zone generally are not suitable (willow and alder acceptable). Stream size is not important and can range from small seeps to larger rivers. It also may include irrigation canals (acequias) that contain water throughout the growing season. Standing water areas (e.g., kettle pond, stock pond) with no associated flowing water are not suitable.

- **Tall, dense herbaceous riparian vegetation (especially sedges) on saturated soil.** *Z. h. luteus* is associated with the herbaceous component of riparian zones. Herbaceous vegetation must be well-developed. The herbaceous layer (i.e., sedges, forbs, grasses, rushes) in the riparian zone should be at least knee-deep with no bare ground showing. Scattered riparian shrubs (i.e., willow, alder, cottonwood) are acceptable, but the riparian zone should not contain conifer trees. The well-developed herbaceous vegetation must be on saturated soil (e.g., wet meadow or stream-edge). Rocky stream banks are not suitable.

- **Low elevation.** Ideally, sites are below 7,600 ft (2,300 m), which represents the upper threshold of the 95% confidence intervals for elevation of recent capture locations of *Z. h. luteus* in the New Mexico-Colorado borderland region (Frey 2011). From an ecological community perspective, sites should be selected from within the ponderosa pine forest, piñon-juniper woodland, or lower ecological zones. However, areas up to ca 8,000 ft (2,438 m) elevation may be considered if the ecological situation seems appropriate (i.e., below the mixed coniferous forest zone, large area of potentially suitable habitat, and presence of corridors to other potentially occupied areas at lower elevation). A different species, the western jumping mouse (*Z. princeps*), occurs in mixed coniferous forest and higher ecological zones. As additional support for the 8,000

ft threshold, the highest elevation reported for a well-studied population of *Z. h. preblei* in the Monument Creek watershed was 7,400 ft (2,255 m; Monument Creek is the southernmost population of *Z. h. preblei* on the Front Range of the Rocky Mountains in Colorado). Using a formula for crude temperature equivalents based on elevation and latitude (Frey et al. 2007), that corresponds to 8,150 ft at latitude 36° N in the Sangre de Cristo Mountains, which is the approximate latitude of Fort Burgwin, a historical location for *Z. h. luteus*.

- **No livestock grazing.** In rare instances the presence of extensive beaver wetland can allow for the occurrence of *Z. h. luteus* where livestock grazing occurs. However, in most instances, there should be no livestock grazing.

- **Low recreational use.** Very heavy recreational activity that causes bare spots in the riparian vegetation (e.gt., abundant fishing foot trails, camping/picnicking areas, ATV trails, erosion) and can render the habitat largely unsuitable for *Z. h. luteus*.

- **Near existing roads.** To facilitate logistics associated with setting and tending large numbers of traps.

Several sites were recommended by Carson NF district biologists that were removed from further consideration based on discussions between Carson NF and Frey:

Middle Ponil Creek, junction Shuree Creek (Questa RD). Removed due to very high elevation (9,280 ft), mixed coniferous forest zone, and recent documented occurrence of *Z. princeps* at a lower elevation on this stream (i.e., Elliot Barker Wildlife Area).

McCrystal Creek grazing exclosure (Questa RD). Removed due to high elevation (> 8,000 ft), general lack of well-developed riparian habitat on McCrystal Creek and North Ponil Creek, and documented recent occurrence of *Z. princeps* at a lower elevation on a nearby stream within same watershed (i.e., Middle Ponil Creek, Elliot Barker Wildlife Area).

Lower Middle Ponil Creek (Questa RD). Removed because *Z. princeps* is known to occur at a lower elevation on this stream (i.e., Elliot Barker Wildlife Area).

La Cuerva Park, head Jiron Canyon, headwaters Cabresto Creek (Questa RD). Removed due to very high elevation (10,900 ft), upper mixed coniferous forest zone, and isolation of meadow in headwaters.

Alamitos Creek (Camino Real RD). Removed due to very high elevation (9,400 ft), spruce-fir forest zone, conifer trees in riparian zone, and documented recent occurrence of *Z. princeps* downstream on the Rio Pueblo.

Ojo del Oso, head Chamisal Creek (Camino Real RD). Removed due to very high elevation, (9,680 ft), upper mixed coniferous forest zone, and isolation of meadow in headwaters.

Rio Tusas, above Las Tablas (Tres Piedras RD). Removed due to stream confined to narrow canyon and high elevations (> 7,600 ft).

Skousen Spring grazing exclosure (Jicarilla RD). Removed because of very small size of grazing exclosure, recency of exclosure (i.e., Fall 2011), rushes are a dominant riparian species, lack of opportunity for recolonization from any potential source populations in San Juan River basin due to absence of quality riparian habitat along La Jara Creek; and La Jara Creek is ephemeral.

Field Methods

Each of the 17 pre-selected survey sites was visited in the field in order to evaluate suitability of site conditions and habitat for occupancy by *Z. h. luteus*. Trapping occurred at sites that offered the best opportunity to document *Z. h. luteus*, which included having both proper site condition and habitat for *Z. h. luteus*. Site condition describes landscape-level and biogeographic factors such as elevation, biotic community (i.e., life zone) surrounding the site, stream gradient and valley shape, and nature of riparian connection to potential source populations. Habitat describes the vegetation composition and structure of the riparian zone. Site conditions at Stewart Meadows were not ideal due to high elevation, nearness to mixed coniferous forest, and lack of suitable riparian connection to potential lower elevation source populations. However, this site was trapped because it offered suitable jumping mouse habitat, prior survey efforts at this site had not documented jumping mice (of either species), and it was a priority area for Carson NF.

At sites where trapping occurred, transects were established in the habitat judged to be best available for *Z. h. luteus*. Trapping was to be curtailed if *Z. h. luteus* was captured in order to allow time for more areas to be surveyed. Survey methods followed those developed by Frey based on >25 years of field experience, which included the most comprehensive series of field studies ever conducted on *Z. h. luteus*. *Z. h. luteus* is considered difficult to capture during baseline surveys. Success is dependent on both ability to identify suitable microhabitat and trap placement (Morrison 1991, Frey unpublished data). Trapping occurred in the most suitable *Z. h. luteus* habitat present at a site. This judgment was based on prior experience by Frey, which included her collection and analysis of habitat data at hundreds of jumping mouse survey locations. Traps were set in loose transects within the best habitat, with placement designed to maximally sample ideal *Z. h. luteus* microhabitats as well as representation of other available microhabitats. In general, traps were spaced ca 2 m apart, although trap spacing varied depending on specific site features and habitat complexity (i.e., further apart in less complex habitat). Close trap spacing better saturates available habitat and may reduce the proportion of more common non-target species captured in a given area. In order to both conceal traps from humans and to maintain cool trap temperatures in the morning, any exposed traps were covered with surrounding vegetation or debris. *Z. h. luteus* habitat is easily trampled by survey activities. Consequently, every effort was made to reduce vegetation trampling. Where possible, traps were set by wading through the water and setting into the adjacent streamside vegetation. When vegetation was walked through, an effort was made to step in the original footsteps.

Standard-sized Sherman live-traps were used to trap *Z. h. luteus*. These traps have proven effective in previous inventories for *Z. h. luteus* (e.g., Morrison 1991; Frey and Malaney 2009). Based on recommendations of Frey (2005) the target survey effort at each site

was 400 trap-nights over at least 3 consecutive nights. This effort vastly exceeded the mean number of trap-nights required by Frey to capture *Z. h. luteus* during prior studies and encompassed the maximum range of variation (Frey unpublished data). *Z. h. luteus* is nocturnal and tends to be tolerant of cool, damp conditions, but intolerant of heat. Consequently, traps were set in the evening and were checked as early as possible after sunrise. Traps were baited with Onate brand horse sweet feed (i.e., 4 grains mixed with molasses) and re-baited daily as needed. Because *Z. hudsonius* may avoid areas frequented by voles (Boonstra and Hoyle 1986), an effort was made to keep traps clean. In addition, traps were periodically disinfected with Lysol or 10% bleach as a precaution against hantavirus.

Every effort was made to reduce stress in captured animals. All trapping and handling of animals conformed to standards for humane animal care and use as recommended by the American Society of Mammalogists (Gannon et al. 2007). A zippered mesh lingerie bag was used to aid in animal handling. Species identifications were based on Frey (2007, 2008). GPS location, sex, reproductive condition, standard external measurements, and mass were collected for each *Zapus* captured. An ear snip was taken to provide a DNA reference sample. Animals were released at the capture location as quickly as possible. Torpid animals were rehabilitated and released, while animals that were seriously injured or in distress, and any animals that were retained as specimen, were euthanized using chloroform (Gannon et al. 2007). Euthanized animals and those that died in traps were prepared as voucher specimens with associated tissue samples (Yates et al. 1996).

At survey sites where trapping occurred, macrohabitat and microhabitat data were collected, as logistically feasible, following standard methods described in Frey (2011 a, b). General site descriptors of survey areas included location, elevation, watershed, presence and type of beaver workings, presence and type of livestock, surrounding biome, and riparian community types. Two methods were used to describe habitat at survey sites: stream reach cover and microhabitat. Stream reach cover data were collected in a manner generally following Frey (2007a) and also used in Frey (2010a,b, 2011). Paired transects were established paralleling the stream course and located 0.5 m and 4.5 m from the edge of the water. Transects were located on the same side that trapping occurred; if trapping occurred on both sides of the waterway, streamside was randomly determined. A cover sample station was established each 10 m along the transects. At each station, a robel pole (Robel et al. 1970) was read from the opposing transect (i.e., 4 m away) at 1 m eye level. The measurement recorded was the lowest 1 inch segment that was not obstructed by cover. In addition, the dominant plant type (e.g., sedge, rush, grass, forb, willow, alder, etc) that covered the robel pole was recorded. Transects varied in length depending on site characteristics but were generally 250 – 500 m. This method was only applicable to situations where traps were set immediately along a stream.

Microhabitat data were collected at traps where jumping mice were captured. Methods followed those developed by Frey and Malaney (2009). At the trap, slope and aspect were visually estimated with the aid of a compass. Canopy cover was measured with a densitometer in the 4 cardinal directions. An index of soil moisture ranging from 1 (dry) to 10 (saturated) was obtained using a soil moisture probe inserted into the ground approximately 40 mm. Vertical cover was assessed with a robel pole (read in inches) from a 4 m distance at a 1 m eye level. The robel pole was read at the trap site from 3 random azimuths as well as away from the trap along 3 random azimuths. Plants generally afforded vertical cover, although in some cases inanimate objects (e.g., rocks, banks, logs) contributed to the measured cover. Two 4-m perpendicular transects were established at a random azimuth from the trap. At each 1 m interval along a

transect, a Daubenmire frame was used to assess the percent cover of sedges (*Carex*), rushes (*Juncus*, *Eleocharis*), cattail (*Typha*), field horsetail (*Equisetum arvense*), forbs, grass, riparian shrub (*Salix* and *Alnus*), litter, rocks, gravel, bare ground, open water, and other. Cover classes were 1 for 0-5% cover, 2 for 5-25% cover, 3 for 25-50% cover, 4 for 50-75% cover, 5 for 75-95% cover, and 6 for 95-100% cover. In addition, soil moisture, litter depth and stubble height were recorded in each frame. Stubble height was measured with a ruler and was recorded as both the laid-over stubble height and vertical stubble height (in mm). Laid-over stubble height was measured as the representative height of the vegetation as it naturally lay. Vertical stubble height was obtained by measuring the height of a representative blade of the dominant herbaceous vegetation that was fully extended vertically from the ground. Finally, the number and identity of each tree and shrub within 1 m of the transect were recorded.

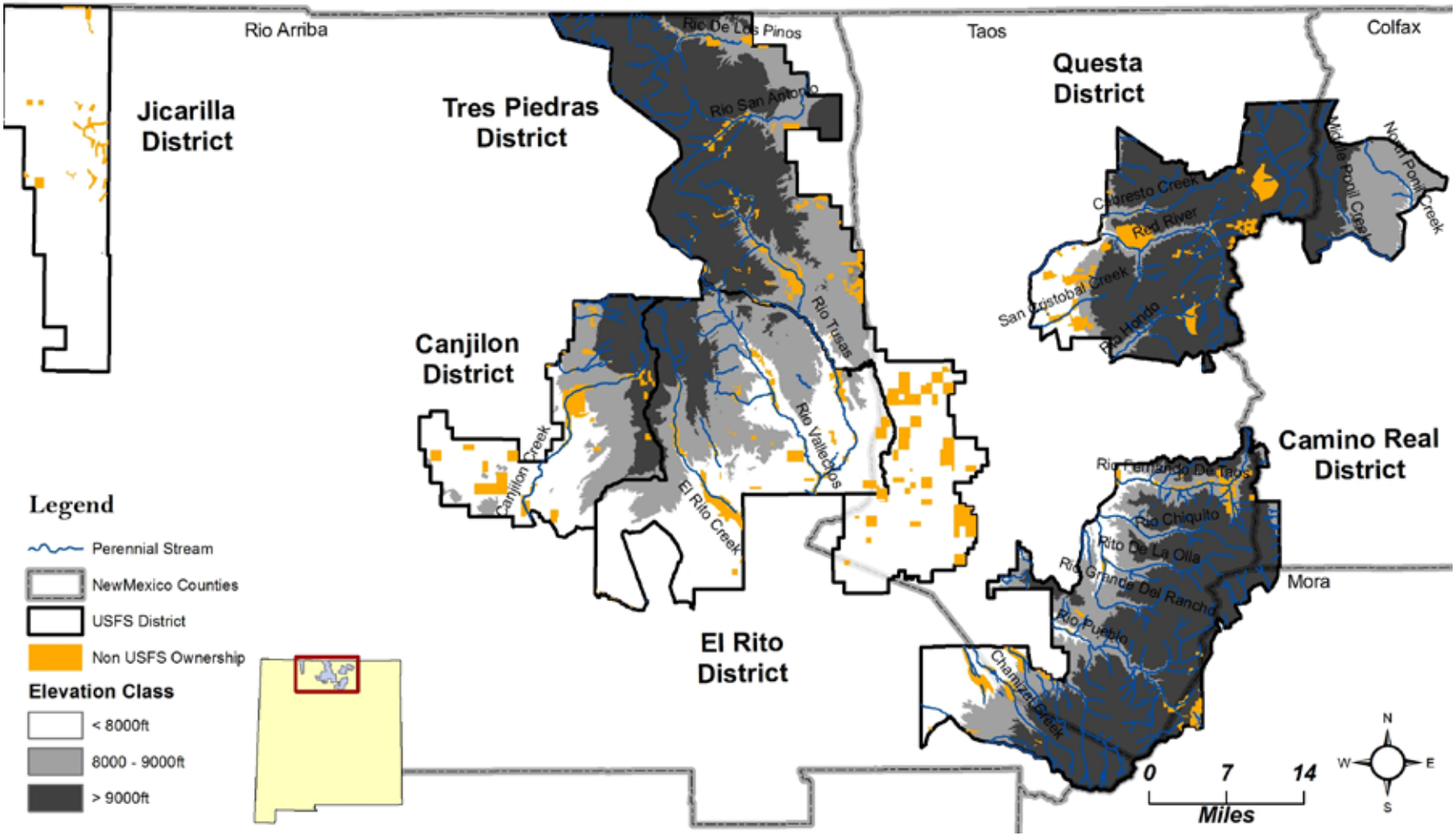

Figure 4. Map of Carson National Forest showing perennial streams (Carson NF Stream Arc GIS data) in relation to elevation and private land in holdings. Some private lands on streams are so narrow that they cannot be seen beneath the stream lines. Some streams shown on this map were dewatered. Counties are indicated by dashed line and named in small font. Map by D. Kopp.

Table 3. Sites surveyed for the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) on Carson National Forest in summer 2012. UTM coordinates are taken from a Delorme map and indicate the upper and lower elevation bounds of the survey area.

			Upper End			Lower End		
District	Location	Summary of results	Easting	Northing	Elev.	Easting	Northing	Elev.
Questa	Fawn Lakes	site conditions not suitable	459850	4062397	8442	459583	4062306	8442
Questa	Eagle Rock Lake	site conditions not suitable; no suitable habitat	448987	4062102	7441	448638	4062119	7448
Camino Real	Rio Fernando de Taos, Taos Canyon (especially vicinity former La Vinateria site)	no suitable habitat	465392	4025308	8320	450718	4025757	7179
Camino Real	lower Rio Chiquito	habitat very marginal; alternate sites trapped	452605	4019646	7789	447460	4021423	7139
Camino Real	lower Rito de la Olla	habitat/situation potential; caught *Z. princeps*	452124	4013186	7854	448849	4014343	7464
Camino Real	lower Rio Grande del Rancho; Tierra Azul	habitat marginal; alternate sites trapped	447892	4016293	7280	446971	4020640	7067
Camino Real	Rio Grande del Rancho; FR 439 Wetland Restoration Project	habitat/situation potential; no *Zapus* caught	446761	4009562	7841	447973	4012387	7543
Tres Piedras	Rio de los Pinos	site conditions not suitable; no suitable habitat	395106	4090713	8294	407411	4095002	7979
Tres Piedras	Rio San Antonio, Stewart Meadows grazing exclosure	habitat/situation potential; caught *Z. princeps*	397582	4079990	8842	401483	4079516	8752
El Rito	Rio Tusas, below Las Tablas	site conditions not suitable; no suitable habitat	408101	4046151	7543	409815	4040900	7247
El Rito	Rio Tusas, below Petaca	no suitable habitat	409815	4040900	7247	410958	4035373	6955
El Rito	Rio Tusas, below Servilleta	no access; presume site conditions not suitable due to stream in narrow canyon; presume no suitable habitat based on satellite imagery and no known livestock exclusion	410471	4029514	6719	408317	4027975	6585
El Rito	Rio Vallecitos, below Vallacitos	site conditions not suitable; no suitable habitat	400377	4039399	7364	402788	4035856	7097
El Rito	Rio Vallecitos, below Olguin	site conditions not suitable; no suitable habitat	402788	4035856	7097	406284	4028102	6536
El Rito	upper El Rito, junction FR 559 and FR 106	site conditions not suitable; no suitable habitat	386601	4039686	8540	386074	4036810	8291
Canjilon	upper Canjilon Creek, above jct FR 124	no suitable habitat	380151	4042259	8855	374397	4041020	8192
Canjilon	lower Canjilon Creek, vicinity US 84	no suitable habitat	367111	4030737	6997	365949	4029209	6864
El Rito	upper Rio Vallecitos	site conditions not suitable; no suitable habitat	394052	4050269	8025	396556	4046554	7800
El Rito	lower El Rito	no suitable habitat	386074	4036810	8291	389538	4027242	7330
Questa	Cabresto Creek	no suitable habitat	454333	4065557	8383	449542	4065050	7749
Questa	Red River	no suitable habitat	464379	4062115	8671	448638	4062119	7448

RESULTS AND DISCUSSION

Survey Results

Overall, 17 sites were pre-selected for surveys. However, based on field inspection of site conditions and habitat, only 3 sites were deemed suitable for trapping surveys, including Rio Grande del Rancho FR 439 wetland restoration project, lower Rito de la Olla, and the Rio San Antonio Stewart Meadows grazing exclosure. No *Z. h. luteus* was captured (Table 2). However, in a total of 1,320 trap-nights there was a total of 146 captures of 9 species of small mammals. The overall capture rate was 11.1%, which is similar to the rate during other major surveys of riparian small mammals on Carson NF by Frey (Frey 2003, 2006), but higher than the 3.25% obtained by Ecosphere (2011). The small mammal communities were typical of montane riparian habitats in the Southwest. During other major surveys for montane populations *Z. h. luteus*, the most abundant mammals captured are either voles (*Microtus* spp.) or the North American deermouse (*Peromyscus maniculatus*; Frey 2005, 2006, 2011a,b). For voles, the "grass-tunneling" species (*M. montanus* and *M. pennsylvanicus*) are typically more abundant than the long-tailed vole (*M. longicaudus*). The deermouse is typically more abundant than voles in riparian habitats that are disturbed (e.g., impacted by livestock grazing). During this study, the deermouse was the most abundant species, even when compared to all species of voles combined; abundance of the deermouse was particularly high at Stewart Meadows.

In well developed riparian habitat in southern Colorado and northern New Mexico, jumping mice (*Zapus* spp.) are typically the next most abundant small mammal, following voles and deer mice (Frey 2006, 2011a). However, those results could be biased because the studies specifically targeted jumping mice. During this study, *Z. princeps* also was next most abundant small mammal following deer mice and voles. However, this was primarily due to influence of Stewart Meadows where *Z. princeps* was the third most common species. At Rito de la Olla *Z. princeps* was rare, while at Rio Grande del Rancho no jumping mice were captured despite a very large targeted trapping effort. Other species captured included long-tailed shrews (*Sorex* sp.), which are primarily (but not exclusively) associated with riparian areas, two primarily upland species, the least chipmunk (*Tamias minimus*) and Mexican woodrat (*Neotoma mexicana*), and the western harvest mouse (*Reithrodontomys megalotis*), which is typical of tall, dense grass-dominated habitats, frequently in lower elevation riparian zones.

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Table 4. Relative abundance (captures/100 trap nights) of mammals captured during surveys for the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) on Carson National Forest, 2012.

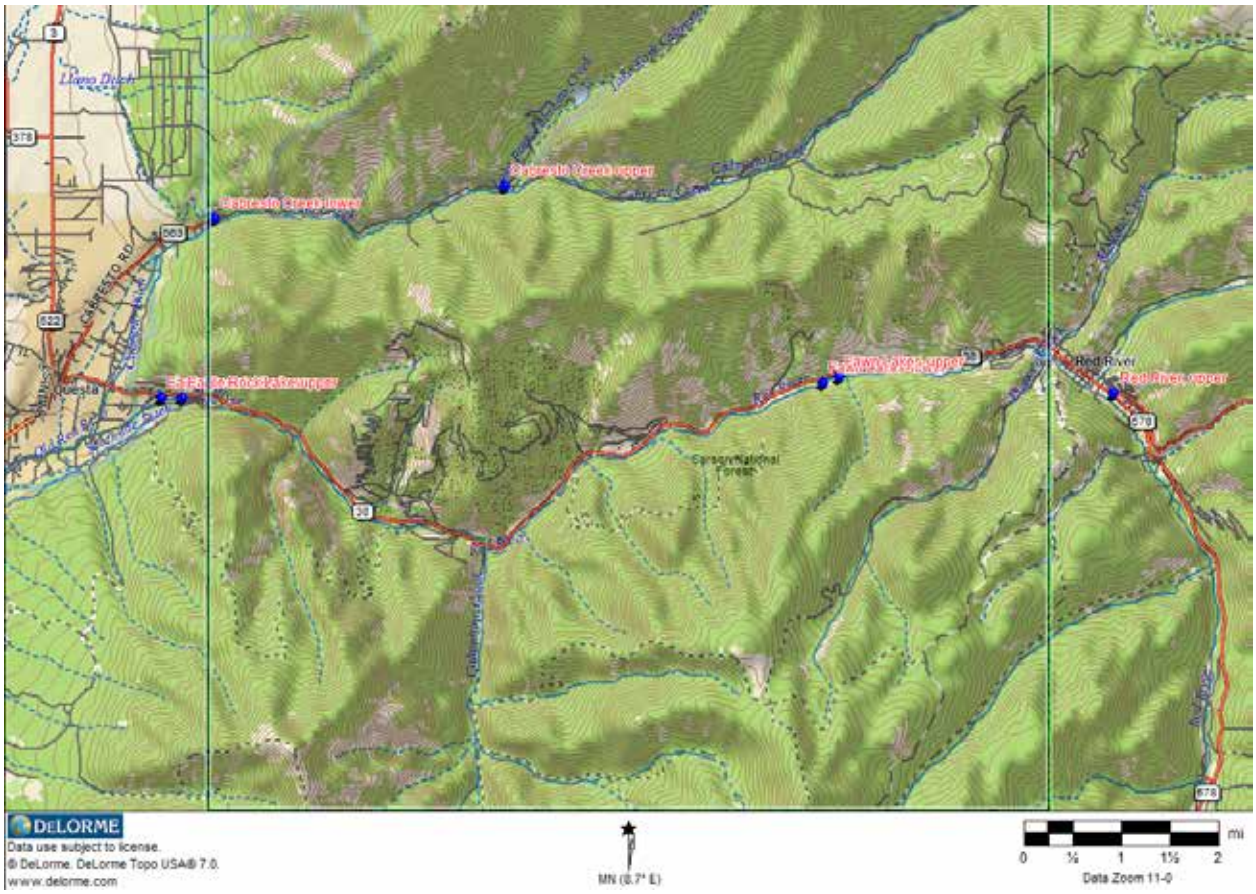
Survey site	Trap nights	Species[a]										Richness[b]	Relative abundance
		Sosp	Tami	Pema	Neme	Reme	Milo	Mimo	Mipe	Zapr	Zahu		
Rio Grande del Rancho, FR 439	520	0.19	1.15	4.23	0.00	0.00	1.54	0.00	0.96	0.00	0.00	3, 5	8.08
Rito de la Olla	400	0.95	0.24	5.48	0.71	0.24	0.00	0.00	2.86	0.24	0.00	4, 7	11.25
Stewart Meadows	400	0.24	0.00	9.05	0.00	0.00	1.19	1.90	0.00	1.67	0.00	4, 5	14.75
Total	1,320	0.45	0.53	6.29	0.23	0.08	0.98	0.61	1.29	0.61	0.00	9	11.06

[a]Sosp (small long-tailed shrew of genus *Sorex*), Tami (least chipmunk, *Tamias minimus*), Pema (deer mouse, *Peromyscus maniculatus*), Neme (Mexican woodrat, *Neotoma mexicana*), Reme (western harvest mouse, *Reithrodontomys megalotis*), Milo (long-tailed vole, *Microtus longicaudus*), Mimo (montane vole, *Microtus montanus*), Mipe (meadow vole, *Microtus pennsylvanicus*), Zapr (western jumping mouse, *Zapus princeps*), Zahu (meadow jumping mouse, *Zapus hudsonius luteus*).

[b]Richness (=number of species) is reported for typically riparian species (i.e., *Sorex*, *Microtus*, *Zapus*) and all species, respectively.

Site Descriptions

Questa District



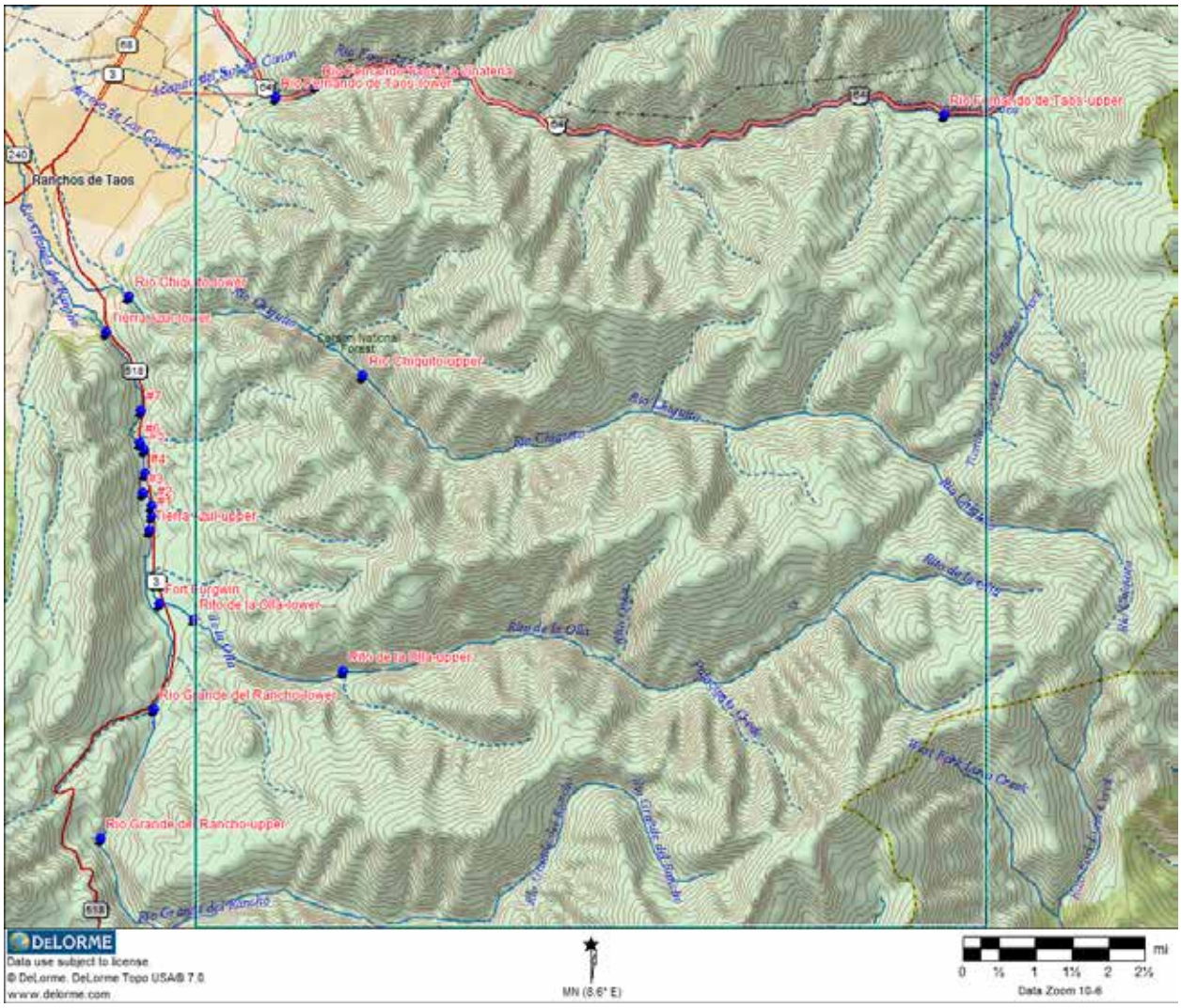
Questa District, map of survey reaches. *Surveyed stream reaches are designated by blue dots labeled upper and lower blue dots which correspond to data in Table 3.*

Fawn Lakes.—Fawn Lakes is a series of three small interconnected impoundments (ca 1.4 ha total) formed by diversion of Red River (Figure 7). It is heavily used for recreation and hence the shoreline of the more accessible upper end of the lakes is largely devoid of herbaceous riparian vegetation. At the lower end of the lakes there are relatively large patches of herbaceous vegetation, especially where beaver have created a more complex landscape. However, to some extent the habitat suffers from the same problem as Eagle Rock Lake in that the tall herbaceous vegetation exists primarily on standing water; drier areas are usually disturbed and compacted as foot paths. Regardless, because of the relatively large size of the area and complexity of the wetland habitat at the lower end, it was judged suitable for jumping mice—although ideally suited for *Z. princeps* rather than *Z. h. luteus*. The lakes are located at an elevation of ca 8,412 ft (2,564 m) within the upper mixed coniferous forest zone. In addition, the relatively well-developed herbaceous riparian vegetation at this site was isolated from other areas. I did not observe any potential habitat for *Z. h. luteus* on Red River below this site. In contrast,

suitable habitat for *Z. princeps* existed upstream of the site. Thus, source populations would be *Z. princeps* and not *Z. h. luteus*. Consequently, this site was eliminated from further consideration.

Eagle Rock Lake.—Eagle Rock Lake is a small impoundment (ca 1 ha) formed by a dam on a short diversion (460 m total length including lake) off Red River (Figure 8). It is at a suitable elevation (7,575 ft; 2,309 m) and surrounding biotic community zone (ponderosa pine forest). However, the site was judged to lack suitable habitat for *Z. h. luteus*. The lake is heavily used for recreation and the vast majority of the shoreline is devoid of herbaceous vegetation. However, at the lake inlet there was a small (a 500 m^2) wetland dominated by sedge (*Carex* spp.). The sedges were in deep (relative to a mouse) standing water that extended to the dry, relatively barren upland. Small mammals cannot maintain home ranges on standing water. In order to support *Z. h. luteus*, there must be a moist soil zone that supports tall, dense herbaceous vegetation. *Z. h. luteus* has not been documented to use situations where the riparian herbaceous plants are in standing water and where the adjacent area is devoid of herbaceous cover either due to disturbance such as grazing or steep banks. Adjacent alder stands along the lake shore and inlet were dense and there was no suitable herbaceous vegetation in those areas. No suitable habitat for *Z. h. luteus* was observed on Red River. This site was eliminated from further consideration due to: small size of the area, lack of suitable riparian corridor to potential source populations, and inadequate microhabitat. We observed stumps cut by beaver along the lake inlet and along Red River, but did not observe any other habitat modifications made by beaver in this area (presumably they live in the banks of the lake).

Camino Real District

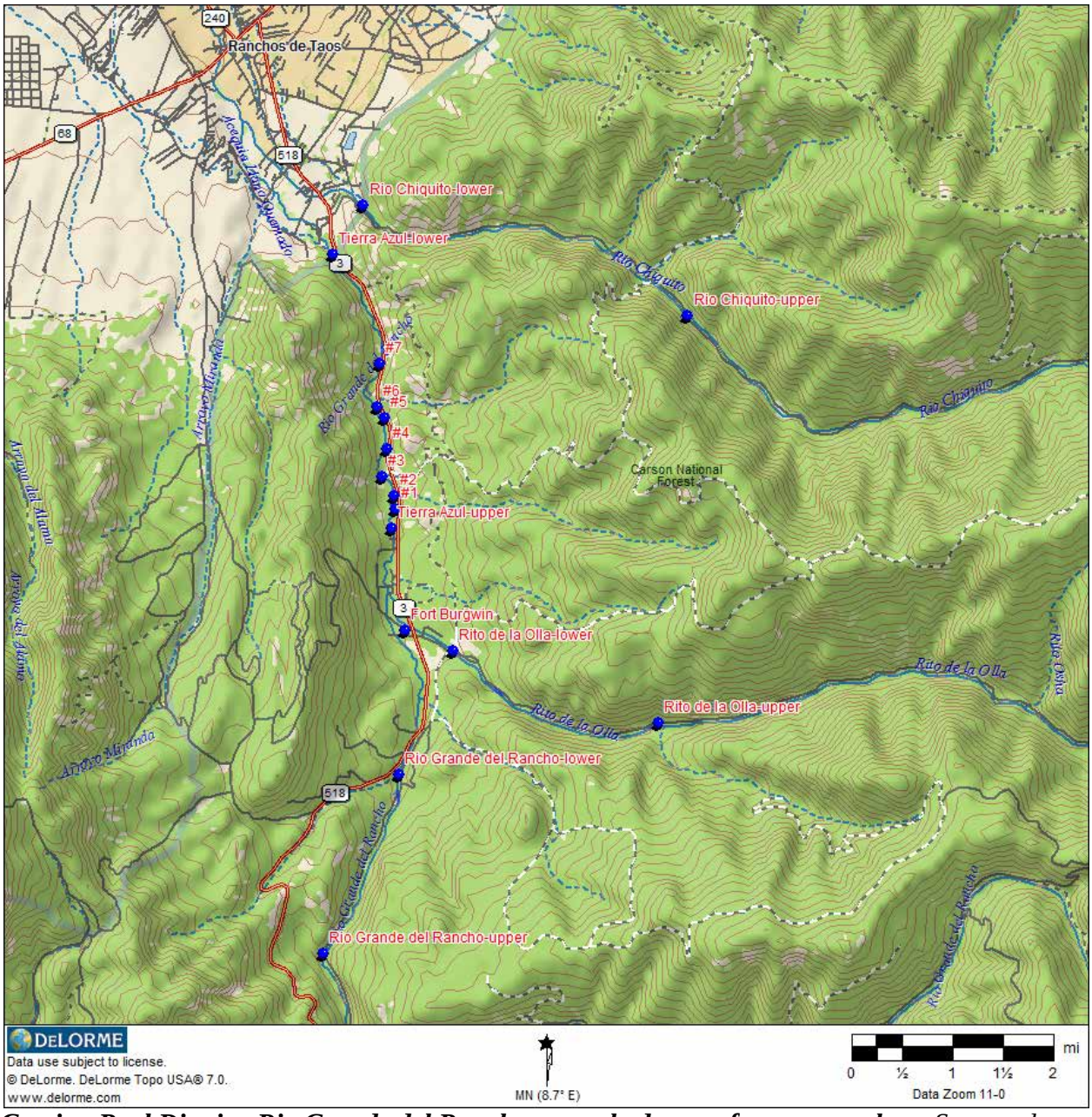


Camino Real District overview map of survey reaches. *Surveyed stream reaches are designated by blue dots labeled upper and lower blue dots which correspond to data in Table 3.*

Camino Real District, Rio Fernando de Taos map of survey reach. *Surveyed stream reaches are designated by blue dots labeled upper and lower blue dots which correspond to data in Table 3.*

Rio Fernando de Taos.—Rio Fernando de Taos (also known as Taos Creek) is a small tributary to Rio Pueblo de Taos that heads on the crest of the Sangre de Cristo Range. It is confined to a narrow canyon (Taos Canyon) and US highway 64 parallels the stream for most of its length. There is considerable private land along this stream, while sections managed by Carson NF typically have picnic areas and campgrounds. Consequently, there was substantial recreational activity and disturbance within the canyon. The stream was visually assessed along the length of the highway and no suitable jumping mouse habitat was observed except at the upper end of the canyon, where there is suitable (but not ideal) habitat for *Z. princeps*. Presence of *Z. princeps* in the canyon was confirmed in 2002 when one specimen (ENMUNHM 11597) was collected within the riparian restoration project at mile marker 271.

Within the lower end of the canyon in the piñon-juniper woodland and ponderosa pine zone the best developed herbaceous habitat was in vicinity of the former La Vinateria picnic area at ca 7,218 ft (2,200 m) elevation (Figure 9). However, no suitable habitat for *Z. h. luteus* was observed. The stream was entrenched ca 1.0 - 1.5 m and hence there was no moist soil zone to allow for the establishment of herbaceous riparian plants. Much of the stream was shaded under cover of narrowleaf cottonwoods and decadent alders and willows, which further limited opportunity for herbaceous growth. There were grassy areas in the adjacent upland, but these were almost exclusively dominated by smooth brome (*Bromus inermis*) which is an exotic, invasive that is sometimes used for range restoration. Smooth brome is not a riparian species and it does not provide good overhead cover for small mammals. Typical riparian grasses, including the exotic timothy (*Phleum pratense*) and the native redtop (*Agrostis gigantea*), were only observed in a very small area of moist soil at a seep. Elsewhere in the lower canyon, such as at El Nogal picnic area, herbaceous vegetation consisted almost exclusively of very sparse smooth brome. No sign of beaver was observed on this stream.



Camino Real District, Rio Grande del Rancho watershed map of survey reaches. *Surveyed stream reaches are designated by blue dots labeled upper and lower which correspond to data in Table 3.*

Introduction to the Rio Grande del Rancho watershed.—The Rio Grande del Rancho (also known as Little Rio Grande) is a major tributary of the Rio Pueblo de Taos, which is a major tributary of the upper Rio Grande. Three major tributaries contribute to this river (Rio Chiquito, Rito de la Olla, Rio Grande del Rancho). These perennial streams head along the main crest of the Sangre de Cristo Mountains between Osha Mountain and Cerro Olla and flow generally westward. The three converge above Rancho de Taos in a long, broad valley of the Rio Grande del Rancho along New Mexico Highway 518.

These three streams have particular significance to *Z. h. luteus* because the original description of the taxon was based on a specimen collected from vicinity of Fort Burgwin, which was located at the confluence of the Rito de la Olla and Rio Grande del Rancho at an elevation of 7,400 ft. Historically, the biotic community surrounding the fort was ponderosa pine forest. However, after the trees were cut, the pine forest did not regenerate, perhaps due to heavy livestock grazing, and it was replaced with piñon-juniper woodland. Regardless, the ecological situation of the lower elevation reaches of these tributaries are ideal for *Z. h. luteus*. Of additional relevance is the fact that these streams are almost entirely on lands managed by Carson NF and are all in the Olla Ranchos Allotment (Figure 5). This allotment is of special relevance because it has not been grazed by livestock since 1991. Thus, overall, riparian habitat conditions were much better in this watershed compared to most other places on the Forest. Separate discussions are included herein for each of the three tributaries (Rio Chiquito, Rito de la Olla, Rio Grande del Rancho) as well as for a reach of the Rio Grande del Rancho known as Tierra Azul.

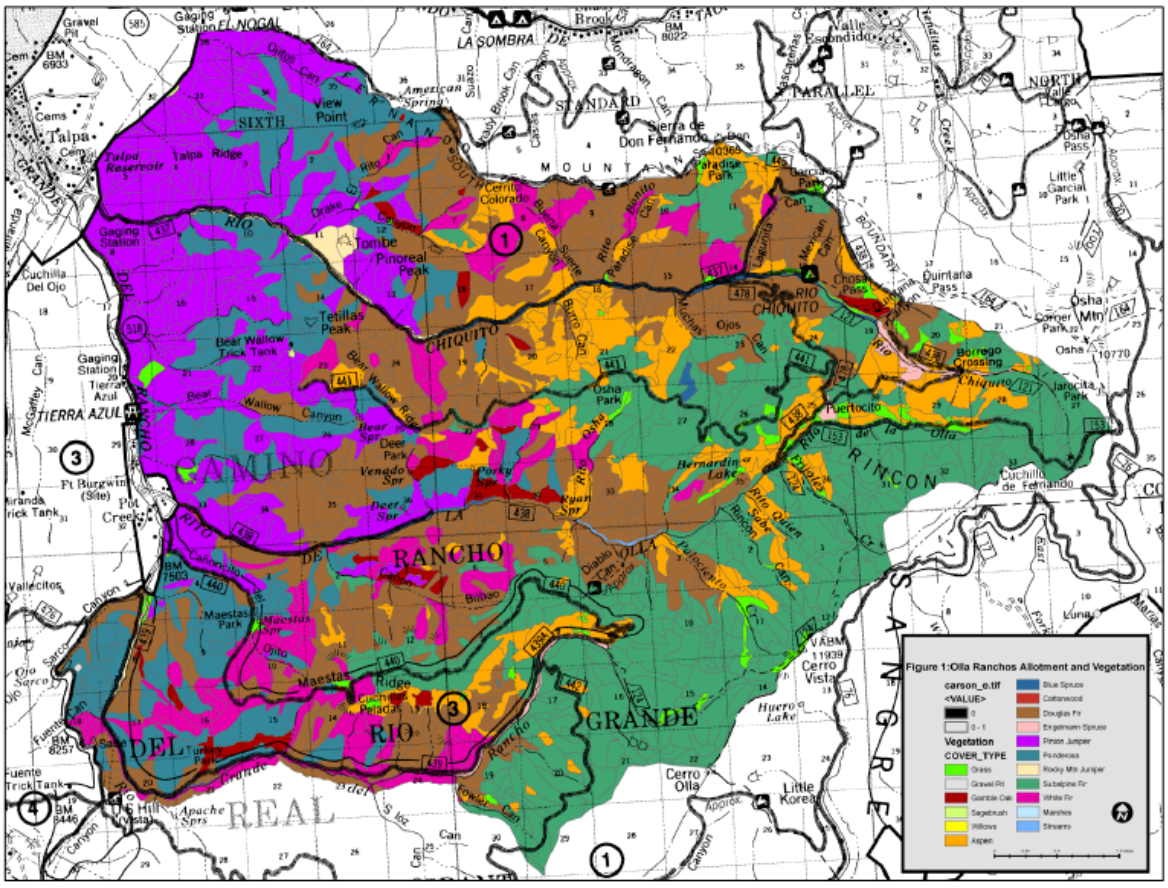
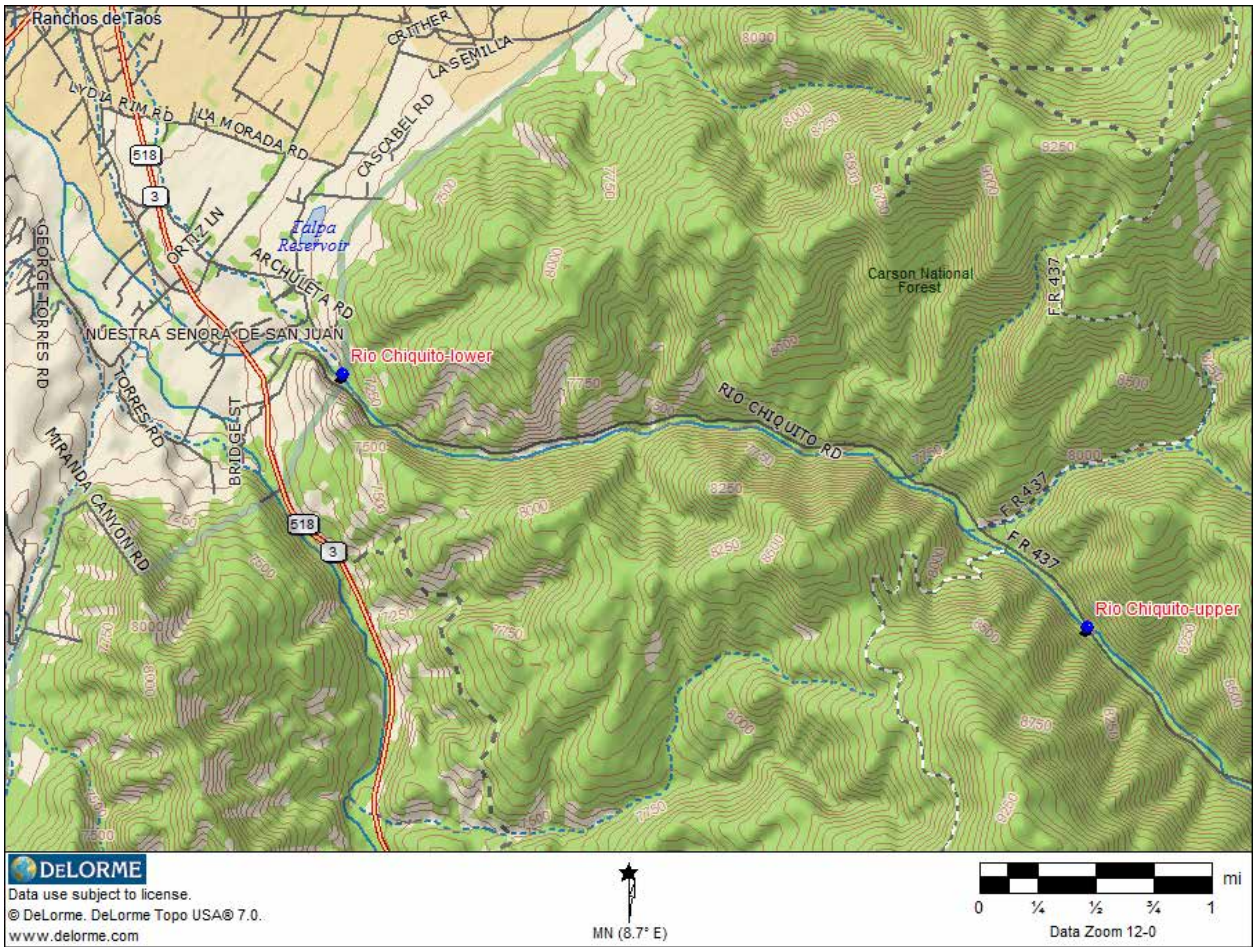
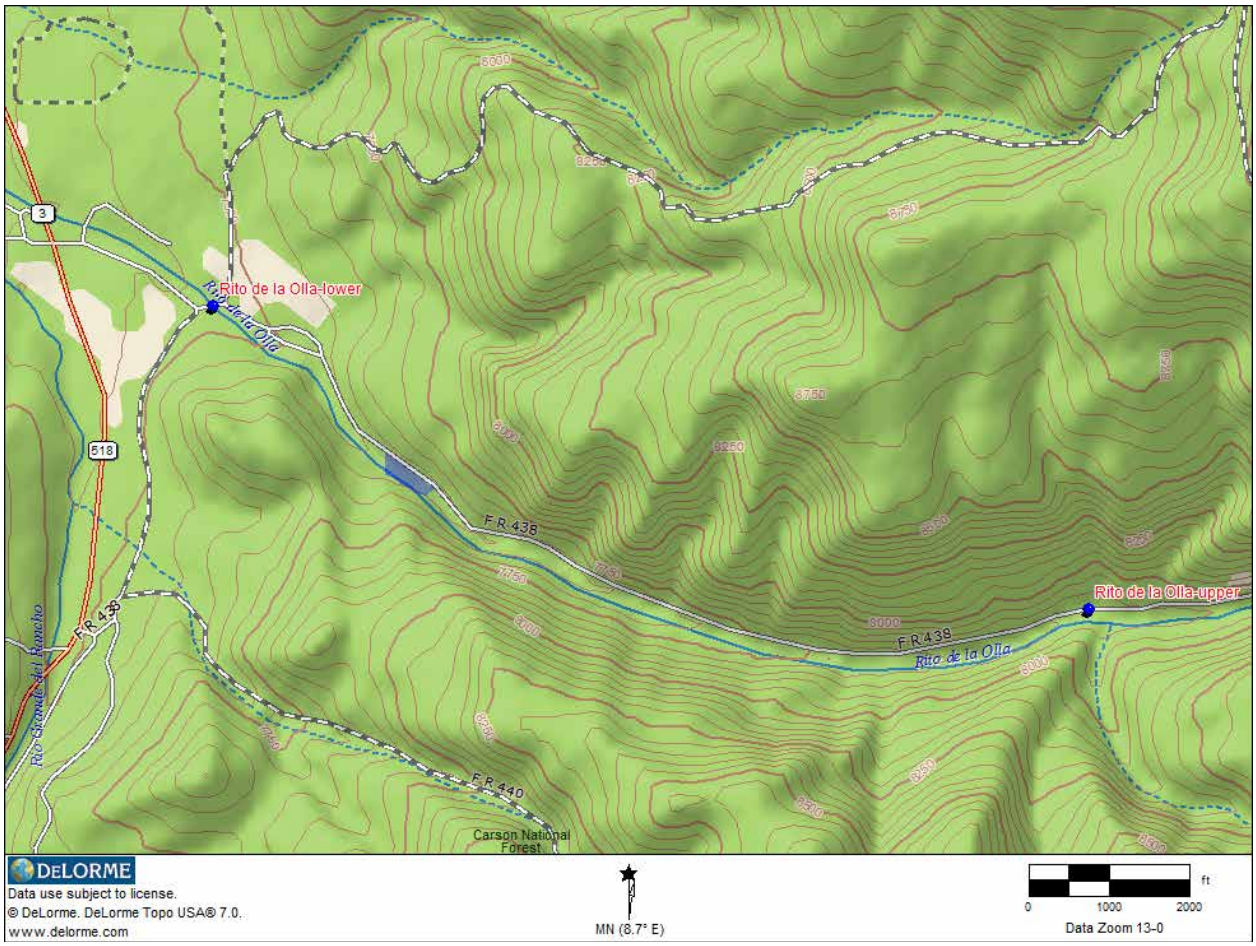


Figure 5. Olla Ranchos grazing allotment includes most of the watershed of the Rio Grande del Rancho. Map provided by Carson NF.



Camino Real District, Rio Chiquito map of survey reach. *Surveyed stream reach is designated by blue dots labeled upper and lower, which correspond to data in Table 3.*

Rio Chiquito.—The Rio Chiquito is the northernmost of the three tributaries and its confluence with the Rio Grande del Rancho is furthest downstream (between Ranchos de Taos and Talpa). On Carson NF the stream is confined to a very narrow canyon and it is paralleled by Forest Road 437. I visually surveyed the stream below the mixed coniferous forest zone, which started at the second stream crossing ca 4.4 miles by road above junction with NM 518. Within this reach the stream was entrenched about 1 m and was usually forced through the narrow passage between road and canyon side. Consequently, most of the stream was enveloped by a dense thicket of willow, alder, box elder, and juniper, which prevented growth of herbaceous riparian plants (Figure 10). The dominant herbaceous plant along most of the reach was sparse smooth brome. The best potential habitat for *Z. h. luteus* was located ca 2.2 miles by road above the junction with NM 518 (elevation 7,379 ft; 2,249 m). Here, beaver had created a small wetland complex that included patches of herbaceous riparian plants (Figure 10). This site was not trapped because areas on the other two branches of the Rio Grande del Rancho offered better developed habitat. Further, this beaver complex on the Rio Chiquito was isolated from other potential habitat within the watershed by the relatively poor habitat downstream from this site.



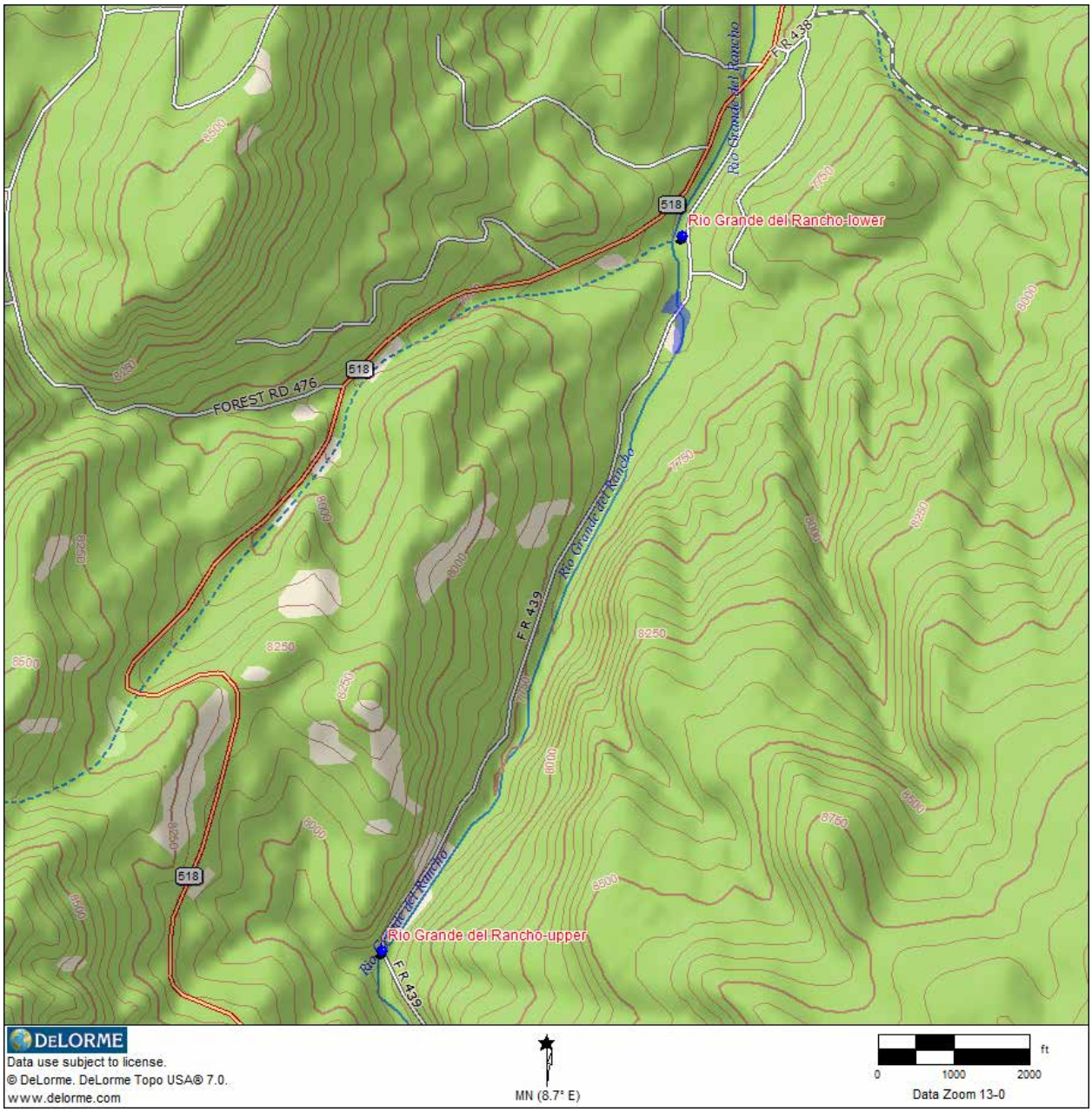
Camino Real District, Rito de la Olla map of survey reach. *Surveyed stream reach is designated by blue dots labeled upper and lower, which correspond to data in Table 3. The blue shaded polygon is area that was trapped for Z. h. luteus.*

Rito de la Olla.—The Rito de la Olla confluences with the Rio Grande del Rancho just below Fort Burgwin. The stream was surveyed from the lower boundary of Carson National Forest (ca 0.3 miles by road from NM 518; ca 0.5 miles above Fort Burgwin; 7,465 ft elevation) to within the mixed coniferous forest zone at the junction of Canon Bilbao (7,860 ft elevation). Many beaver impoundments were found along the lower ca 1.0 miles of this stream where the valley bottom was fairly broad and there was no overstory of conifer trees (Figure 11). Conifer trees came down into the valley bottom about 1.1 miles east of NM 518 and the stream was within mixed coniferous forest at 1.3 miles east of NM 518. The most extensive beaver wetland complex with the best diversity of herbaceous wetland vegetation was found 0.9 miles by road east of NM 518 (ca 0.5 mi above the Carson NF boundary) at 7,575 ft elevation. This site was selected for trapping. This site was at the upper end of habitat judged to be potentially suitable for *Z. h. luteus*; above this site the habitat became more typical of *Z. princeps*. *Z. princeps* was previously captured on this stream within the mixed coniferous forest zone at 7,987 ft elevation (Frey 2003).

At the trapping site, the adjacent vegetation was piñon-juniper woodland on the south-facing aspects and lower mixed coniferous forest on north-facing aspects. The

valley floor was a complex of beaver impoundments and side channels that resulted in a diversity of quality early seral-stage riparian habitats. Herbaceous vegetation was particularly well developed and diverse, and included important species such as diverse sedges, redtop, and cutleaf coneflower. Woody vegetation included alder, willow, redosier dogwood (*Cornus stolonifera*), boxelder (*Acer negundo*), and narrowleaf cottonwood (*Populus angustifolia*). This is a location where syntopy between the two species of jumping mice likely would be possible. Patches of sedges and wetland grasses in more open areas appeared suitable for *Z. h. luteus*, while patches of shrubs with high canopy cover and forb understories appeared suitable for *Z. princeps*. No sign of livestock grazing or other major sources of disturbance were observed at the site.

The documented small mammal community at this site was the highest of any of the survey sites. This was primarily due to the capture of typically upland species, such as the Mexican woodrat (*Neotoma mexicana*), in addition to typically riparian species. This is not uncommon in situations such as this location where the riparian zone is in close proximity to coniferous forest. However, the presence of the western harvest mouse (*Reithrodontomys megalotis*) signifies the quality of the graminoid habitat at the site. In the Southwest, this harvest mouse usually is associated with habitats dominated by tall, dense grasses, often in riparian situations. *Z. princeps* was a rare component of the small mammal community at this site. This rare presence was not unexpected given that the site was near the lower elevation limits for the species, but the site had quality riparian habitat. In addition, in 2006 two *Z. princeps* were captured at an even lower elevation (7,408 ft; 2,258 m), ca 1.0 miles downstream from this site on the campus of Southern Methodist University-Taos, which is the site of old Fort Burgwin (Frey 2006). Those two captures were the first documentation of *Z. princeps* on the campus despite prior small mammal field work by faculty member, Dr. John Ubelaker.

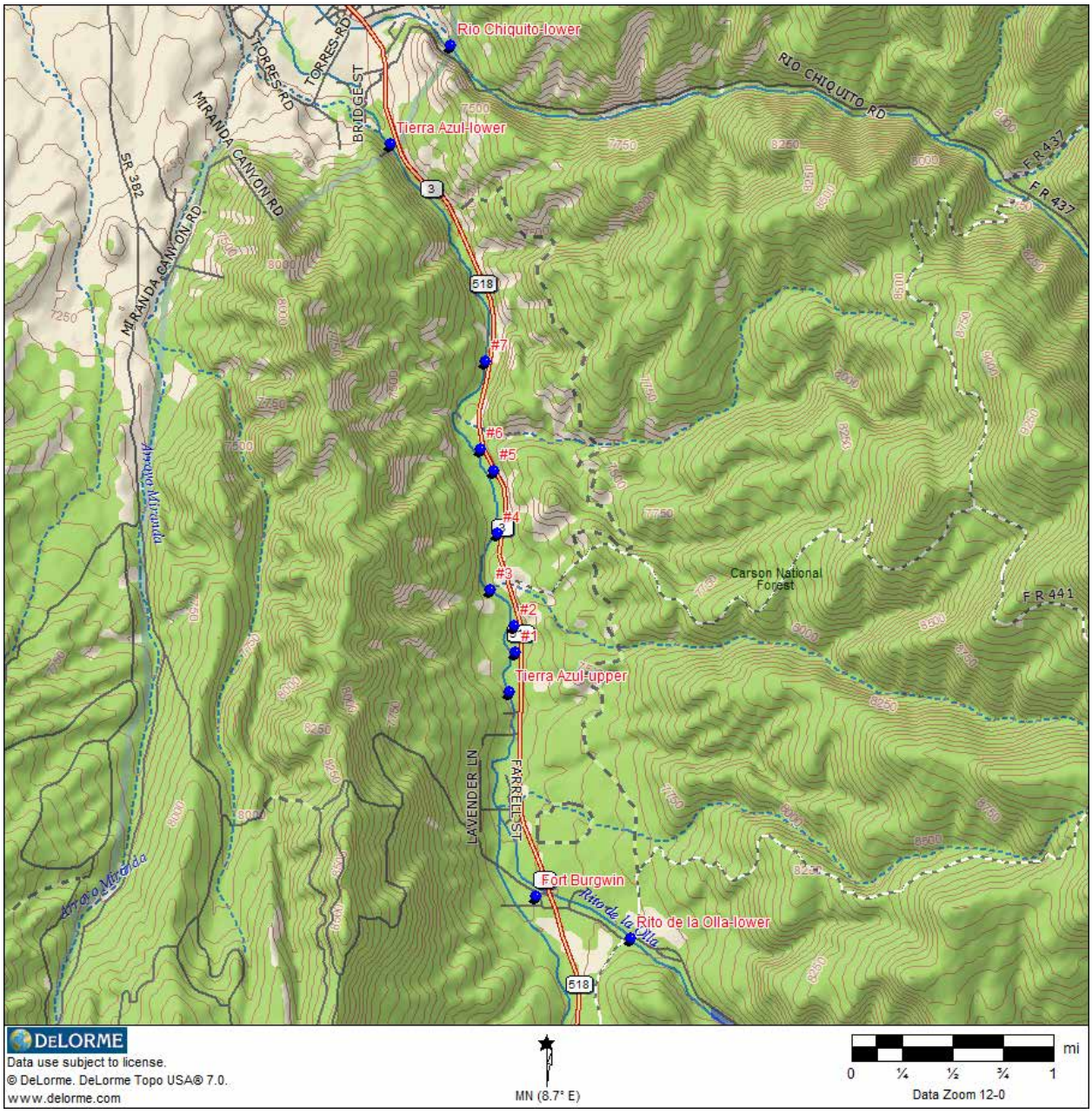


Camino Real District, upper Rio Grande del Rancho map of survey reach. *Surveyed stream reach is designated by blue dots labeled upper and lower, which correspond to data in Table 3. The blue shaded polygon is area denotes the FR 439 Wetland Restoration Project area that was trapped for Z. h. luteus.*

Rio Grande del Rancho, FR 439 Wetland Restoration Project.—The mainstem of the Rio Grande del Rancho was surveyed from the FR 439 stream crossing near junction Fuente Canyon (7,850 ft elevation) downstream to the lower border of Carson NF (7,070 ft elevation) near Talpa. Most of the stream above 7,080 ft elevation is on lands managed by Carson NF except a ca 2.7 mi reach that includes the SMU campus and other private in holdings. The reach below the private land is discussed in the Teirra Azul section below. This portion of the report pertains to the reach above the private land. Within this

reach, the only potential habitat for jumping mice was found at the lower end of the reach within a wetland restoration project area (Figure 12). The wetland restoration area encompassed a ca 0.3 mile reach between 7,540 – 7,600 ft elevation. The reach was within the piñon-juniper woodland and ponderosa pine forest zone and there was continuous habitat to other potential source populations downstream. Hence, the site was ideally situated for *Z. h. luteus*. Habitat improvement actions at the site have included controlling vehicle access with guard rails and boulders, obliterating and rehabilitating old roads and stream crossings, and removing culverts (DeLucas 2011). There was a large complex of beaver dams and side channels, although there was no fresh sign of beaver activity. Much of the willows near the stream were regenerating and had a lush understory of diverse herbaceous wetlands plants. In addition, there were seeps on the west side of the valley that created a large moist meadow system dominated by species such as sedges, redtop, and timothy. Habitats in the wetland restoration area were judged to be ideal for *Z. h. luteus* (i.e., this site represented the best situation and potential habitat observed on Carson Nation Forest). Consequently, this site was selected for trapping.

Because of the ideal ecological situation and habitat afforded by this site, the sampling effort was increased to 520 trap-nights. All prior jumping mouse captures by Frey have occurred within 400 trap-nights (Frey unpublished data). However, no jumping mice of either species was captured at this site. Other mammal species captured were typical of the situation and habitat (Table 2).



Camino Real District, lower Rio Grande del Rancho, Tierra Azul reach, map of survey reach. *Surveyed stream reach is designated by blue dots labeled upper and lower, which correspond to data in Table 3. Numbers correspond to specific site descriptions in the text.*

Rio Grande del Rancho, Tierra Azul reach.—The Tierra Azul reach of the Rio Grande del Rancho extends ca 3 mi on lands managed by Carson NF between the private land near Fort Burgwin downstream to the private land near Talpa. This site has been regarded as important for *Z. h. luteus* because it is a large area of riparian habitat on public land and it is near a historical location (Fort Burgwin) for the species. Further, site conditions are ideal due to low elevation (7,080 – 7,280 ft) and ecological situation, which is entirely within the piñon-juniper zone. However, several prior surveys involving a total of 886

trap-nights failed to produce any captures of jumping mice on this reach (Table 5). All of the surveys documented typical riparian small mammal communities for the region, with exception of Ecosphere (2011). The Ecosphere (2011) study documented a single deermouse beside a juniper tree, which suggests that at least some traps were placed in non-jumping mouse habitat (upland). Further, it is unlikely that proper surveys for jumping mice at this site would not capture voles (*Microtus*), which have ranged in abundance from 2.5-33.0 per 100 trap-nights at this site. Thus, results of Ecosphere (2011) should be regarded as unreliable.

The 2006 survey (Frey 2006) was particularly noteworthy because it was a very large effort of 628 trap-nights by a taxon expert. All captures of *Z. h. luteus* by Frey have required < 400 trap-nights (Frey unpublished data). Thus, the 2006 survey results provided convincing evidence that *Z. h. luteus* was not present at Tierra Azul. The goal of this study was to identify and trap only the very best potential habitat for *Z. h. luteus* within the entire Tierra Azul riparian ecosystem, which includes the lower elevations of the Rio Grande del Rancho watershed (including tributaries). The best habitat was *not* found on the Tierra Azul reach. Rather, the best habitat selected for trapping included the Rio Grande del Rancho at the FR 439 Wetland Restoration Project site and on the lower Rito de la Olla (trapping results are described in those sections of the report).

This section of the report focuses on habitat conditions within the ca 3.0 mi Tierra Azul reach, which extends from 7,282 ft - 7,067 ft elevation. The entire reach was visually surveyed with more in-depth habitat descriptions at 9 locations within the reach (see below; Figures 13-15). In general, riparian habitat conditions were better near the upper end of the reach and deteriorated markedly towards the lower end of the reach. Reason for the variation in riparian habitat conditions was likely due to natural site conditions and its synergism with presence of active beaver dams. The upper end of the reach was in relatively broad valleys with low gradient, which is an ideal situation for beaver to build dams. Beaver activity then causes the development of both a greater area and greater diversity of riparian habitats. In contrast, at the lower end of the reach the valley was both narrower and had a steeper gradient. Steeper gradients cause water to move faster which limits the moist soil zone that is necessary for development of riparian vegetation and which can make it difficult for beavers to establish dams. In addition, upland habitat conditions were overall poor, but were especially poor towards the lower end of the reach. All capture locations of *Z. h. luteus* by Frey have occurred at sites where there was quality upland habitat, which could be characterized as lush meadow dominated by diverse grasses and forbs, adjacent to a quality riparian zone. In contrast, upland habitat at Tierra Azul was dominated by smooth brome or was mostly bare ground with scattered grasses, forbs and juniper. The poor quality of the adjacent upland habitat contributed to ranking Tierra Azul as not having ideal habitat conditions for *Z. h. luteus*.

Tierra Azul #1 (13S 447940 4016608; 7,271 ft elevation).— At site #1 there was an active (i.e., fresh mud on dam) beaver impoundment (Figure 13). Around the edges of the pond there was a narrow, patchy margin of herbaceous riparian habitat, which included patches of sedges and redtop. However, the majority of the habitat consisted of decadent willow with an understory dominated by sparse, montypic short grass with few forbs. The adjacent upland was nearly monotypic short sparse grass. This site was judged to be sub-marginal for *Z. h. luteus*.

Tierra Azul #2 (13S 447934 4016819; 7,262 ft elevation).— At site #2 the riparian habitat was better developed than at site #1 (Figure 13). It included regenerating willow and a diverse mixture of grasses and forbs including species such as redtop which are often found with *Z. h. luteus*. However, the stream appeared incised with some outside banks 0.5 m or more above water level. In addition, no beaver activity was observed at this site. This caused the soil to be relatively dry which limited the development of tall dense herbaceous riparian plants that are required by *Z. h. luteus*. This site had few sedges which also indicated lack of moist soil. Due to the low plant cover, this site was regarded as marginal for *Z. h. luteus*.

Tierra Azul #3 (13S 447745 4017110; 7,249 ft elevation).—Site #3 was upstream of a gaging station. Much of the riparian habitat in this area consisted of a nearly impenetrable thicket of decadent (woody) willow with an understory of short sparse cover of low diversity (Figure 14). No beaver activity was observed at this site. The stream was slightly entrenched and the elevated banks were relatively dry which caused the herbaceous cover to be relatively short and sparse with bare ground showing. This site was regarded as marginal for *Z. h. luteus*.

Tierra Azul #4 (13S 447809 4017552; 7,235 ft elevation).—At site #4 the riparian zone was very narrow (ca 1-2 m wide) and consisted of willow and sparse grass and forbs (Figure 14). No sign of beaver of was observed. The upland was mostly bare ground with sparse grass, sagebrush and junipers. There was no suitable cover or food plants for *Z. h. luteus*; this site was judged as unsuitable for *Z. h. luteus*.

Tierra Azul #5 (13S 447782 4018055; 7,228 ft elevation).—Site #5 was judged to have the best potential habitat for *Z. h. luteus* observed within the Tierra Azul reach (Figure 15). This site was surveyed for jumping mice during two prior survey efforts (Frey 2003, 2006). This site (and adjacent site #6) had better habitat than other areas within the Tierra Azul reach because the valley is relatively wide and the gradient is low. There also was extensive modification of the riparian zone by beaver. There was little to no sign of human activity at this site. The beaver activity created more area of impounded water which both raised the water table and increased the area of moist soil. Moist soil along some sections of the stream were dominated by tall dense herbaceous riparian vegetation, including a relatively high diversity of graminoids. Similarly, in some place along the stream the willows at water's edge were regenerating and had an understory of tall dense herbaceous vegetation as the understory. However, the total area of potentially suitable habitat for *Z. h. luteus* was limited in extent. We attempted to quantify riparian habitat at this site using the riparian cover technique. However, we only were able to collect data along 150 m of stream that had an herbaceous zone along the water's edge. Beyond this section the water's edge was dominated by either dense willow or cattails, neither of which are suitable habitats for *Z. h. luteus*. Further, within the 150 m section where habitat data were collected only 22% of the dominant cover was herbaceous plants (i.e., grass, rush, forbs). The majority was tall (> 61 inches) willows. Thus, while this site offered some potentially suitable habitat for *Z. h. luteus*, the majority of the habitat was unsuitable due to dense stands of willow.

Tierra Azul #6 (13S 447677 4018219; 7,206 ft elevation).— Site #6 was judged to have the second best potential habitat for *Z. h. luteus* observed within the Tierra Azul reach (Figure 15). This was just downstream from site #5 and it shared many of the same characteristics with that site. It also occurred in a broad, low gradient valley and was modified by abundant beaver activity. Thus, the banks were low in relation to the water table and hence there was relatively more moist soil to promote growth of herbaceous riparian vegetation. This site was unique in that it had stands of dead old willow with a new re-growth of willows. Herbaceous cover was somewhat diverse and moderately tall and dense.

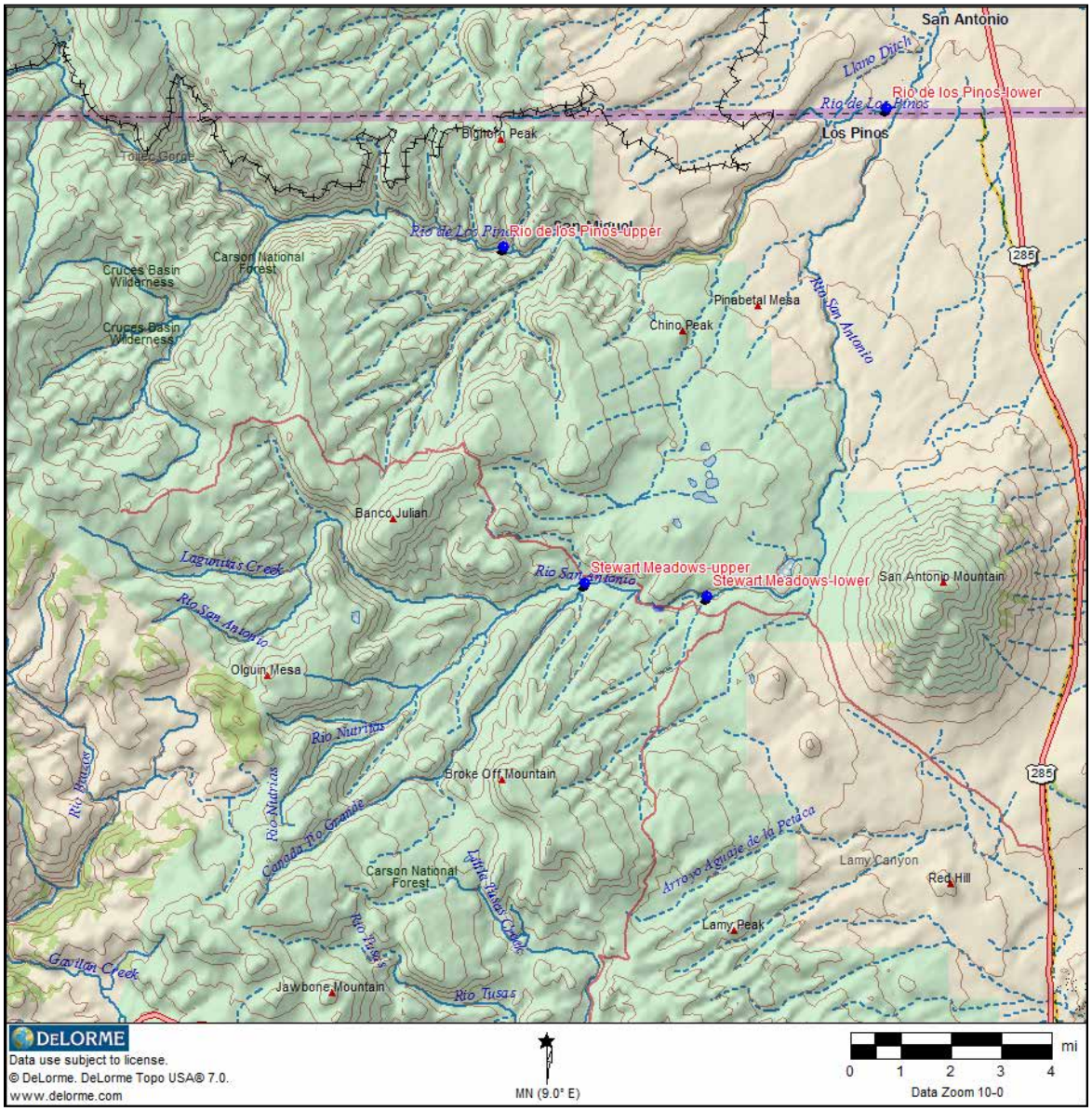
Tierra Azul #7 (13S 447717 4018917; 7,156 ft elevation).—The riparian zone at this site was very narrow (< 1 m) and consisted of willows and sparse grass and forbs (Figure 15). The upland was mostly bare ground with scattered forbs, juniper and sagebrush. There was no potential habitat for *Z. h. luteus* at this site.

Table 5. Results of surveys for the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) in the lower Rio Grande del Rancho watershed, Taos County.

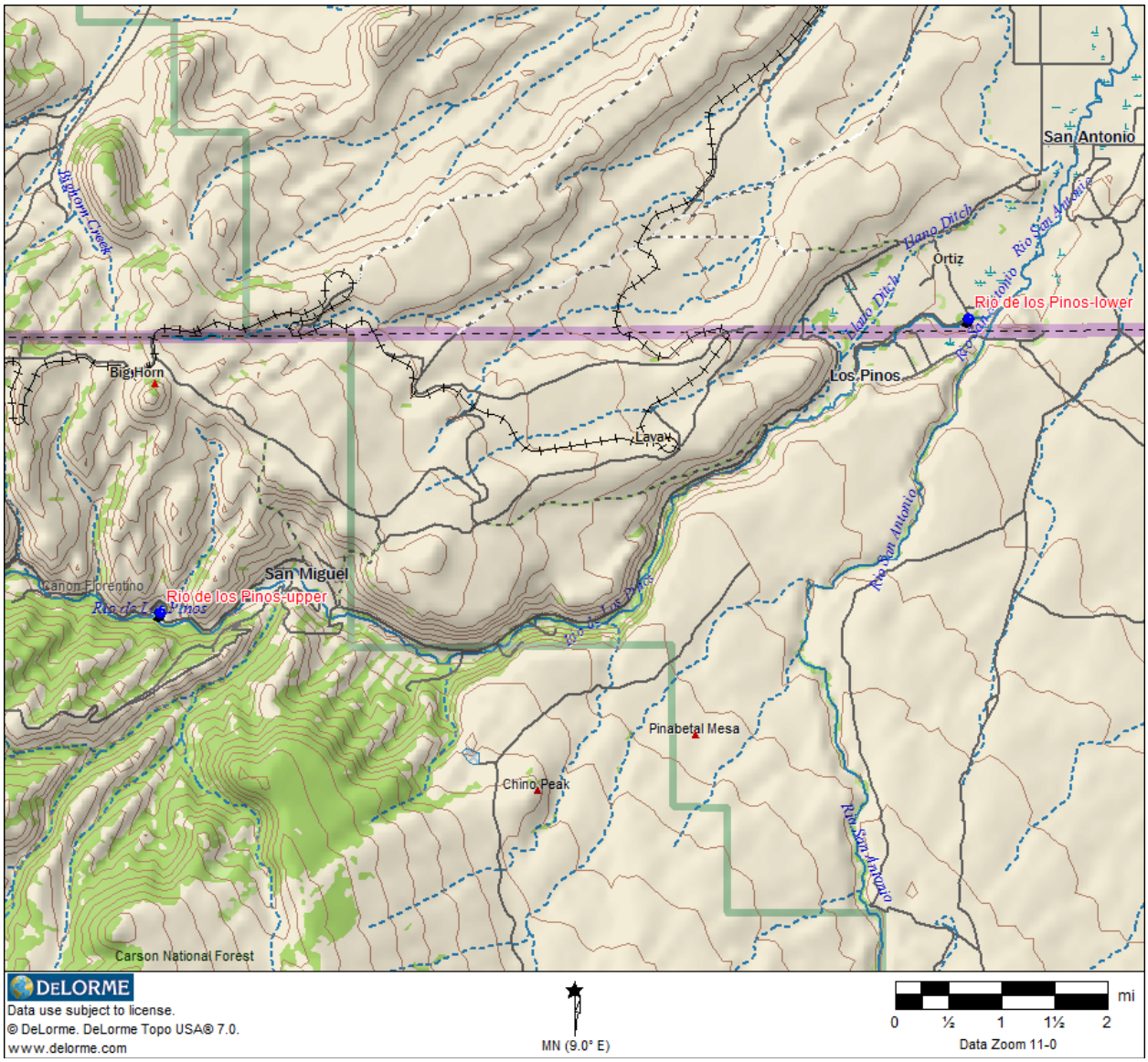
Study	Survey site	Elevation ft.	Trap nights		Abundance (captures/100 trap-nights)[a] Sosp	Tami	Pema	Neme	Reme	Milo	Mipe	Zapr	Zahu	Total
Frey 2003	Tierra Azul	7,255	148		0	0	0	0	0.7	0.0	33.1	0	0	33.8
Frey 2006	Tierra Azul	7,250	258		0.8	0	1.2	0	0	0	17.0	0	0	19.0
Frey 2006	Tierra Azul	7,215	240		0.4	0	5.8	0	0.4	2.9	12.9	0	0	22.4
Ecosphere 2011	Tierra Azul	7,200	240		0	0	0.4	0	0	0	0	0	0	0.4
Frey 2006	Fort Burgwin	7,408	130		0	0	16.2	0	0	4.6	3.8	1.5	0	26.1
Frey current	Rito de la Olla	7,464	400		1.0	0.2	5.5	0.7	0.2	0	2.9	0.2	0	10.7
Frey current	FR 439 wetland	7,543	520		0.2	1.2	4.2	0	0	1.5	1.0	0	0	8.1
		Total =	1,936	X=	0.3	0.2	4.8	0.1	0.2	1.3	10.1	0.2	0	17.2

[a]Sosp (small long-tailed shrew of genus Sorex), Tami (least chipmunk, *Tamias minimus*), Pema (deer mouse, Peromyscus maniculatus), Neme (Mexican woodrat, *Neotoma mexicana*), Reme (western harvest mouse, *Reithrodontomys megalotis*), Milo (long-tailed vole, Microtus longicaudus), Mipe (meadow vole, *Microtus pennsylvanicus*), Zapr (western jumping mouse, *Zapus princeps*), Zahu (meadow jumping mouse, *Zapus hudsonius luteus*).

Tres Piedras District



Tres Piedras District, overview map of survey reaches. *Surveyed stream reaches are designated by blue dots labeled upper and lower, which correspond to data in Table 3.*

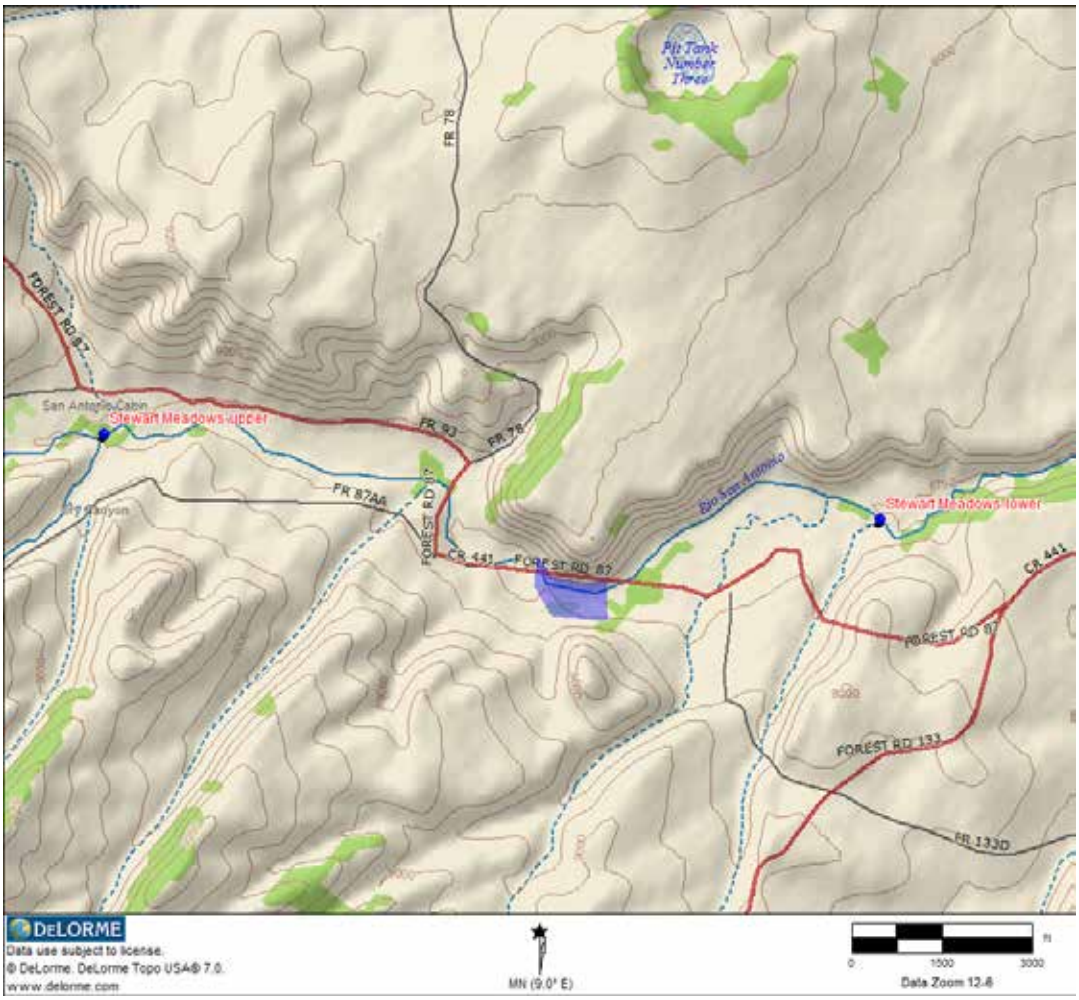


Tres Piedras District, Rio de los Pinos map of survey reaches. *Surveyed stream reaches are designated by blue dots labeled upper and lower, which correspond to data in Table 3.*

Rio de los Pinos.—The Rio de los Pinos is a major tributary to the Rio San Antonio that heads in the Cruces Basin. I visually surveyed this river from near its confluence with the Rio San Antonio in Colorado (13S 0407370, 4095015, 7,910 ft, 2,411m) upstream to an elevation of near 8,300 ft (13S 0395126 4090702, 8,264 ft, 2,519 m). The lower 7.3 km reach was mostly on private land and potentially suitable habitat for *Z. h. luteus* was observed at several locations along the river and in association with irrigation canals. The next higher 2.6 km reach was in the Los Pinos State Recreation Area, which is managed by the New Mexico Department of Game and Fish (13S 0402280, 4090942, 8,199 ft, 2,499 m to 13S 0399897, 4090115, 8,113 ft, 2,473 m). Although the elevation was appropriate for *Z. h. luteus* and there was a riparian corridor to potential source populations downstream, there was no potentially suitable habitat for *Z. h. luteus* observed within the recreation area (Figure 16). The river was entrenched ca 2 m. In general, there was little to no

moist soil area and herbaceous riparian vegetation was sparse and patchy. There was copious sign of cattle grazing (feces) and the riparian habitat appeared degraded. Other than old cut stumps, I observed no sign of beaver. Metal pipes used to control vehicle access in the riparian zone appeared to have had a positive impact on the habitat.

At the lower border of Carson NF on the river, the surrounding biotic community had switched to mixed coniferous forest, though piñon-juniper woodlands was still present on steep south facing slopes (Figure 17). The habitat on forest service land was marginally suitable for *Z. princeps*, but was not suitable for *Z. h. luteus*. Cattle were grazing in the riparian zone which was generally cropped short and lacked well-developed herbaceous vegetation. Other than cut stumps, no sign of beaver was observed.



Tres Piedras District, Rio San Antonio, Stewart Meadows, map of survey reaches. *Surveyed stream reaches are designated by blue dots labeled upper and lower, which correspond to data in Table 3. The blue shaded polygon is area that was trapped for Z. h. luteus. FR 87 placement is a map error; the road actually is south of the trapping area.*

Rio San Antonio, Stewart Meadows.—The Rio San Antonio is a major tributary to the Conejos River, which is a major tributary to the upper Rio Grande in Colorado. It heads on the crest of the San Juan Mountains, south of Cruces Basin. Stewart Meadows is a ca 325 acre wetland complex situated in a relatively broad, low gradient valley of the Rio San Antonio between ca 8,750 and 8,850 ft elevation. Most of the rest of the Rio San Antonio in New Mexico is confined to a narrow canyon, especially below Stewart Meadows. Water to the wetland is provided by canals and runoff from side arroyos. It appeared that a dike had been constructed along a portion of the south side of the river, which served to keep the water spread out on the valley floor, rather than flowing into the river. Livestock grazing was restricted by fences and a bluff along the north side of the area. However, cattle were not completely excluded. We observed a fair amount of cattle feces in drier areas within the exclosure (e.g., on the old dike along the river). Prior researchers (Frey 2003; Ecoshpere 2011) also reported sign of cattle. However, riparian habitat conditions appeared to have improved since a prior small mammal survey during 2002 (i.e., Frey 2003). During 2002 the stream was intermittent, while in 2012 the

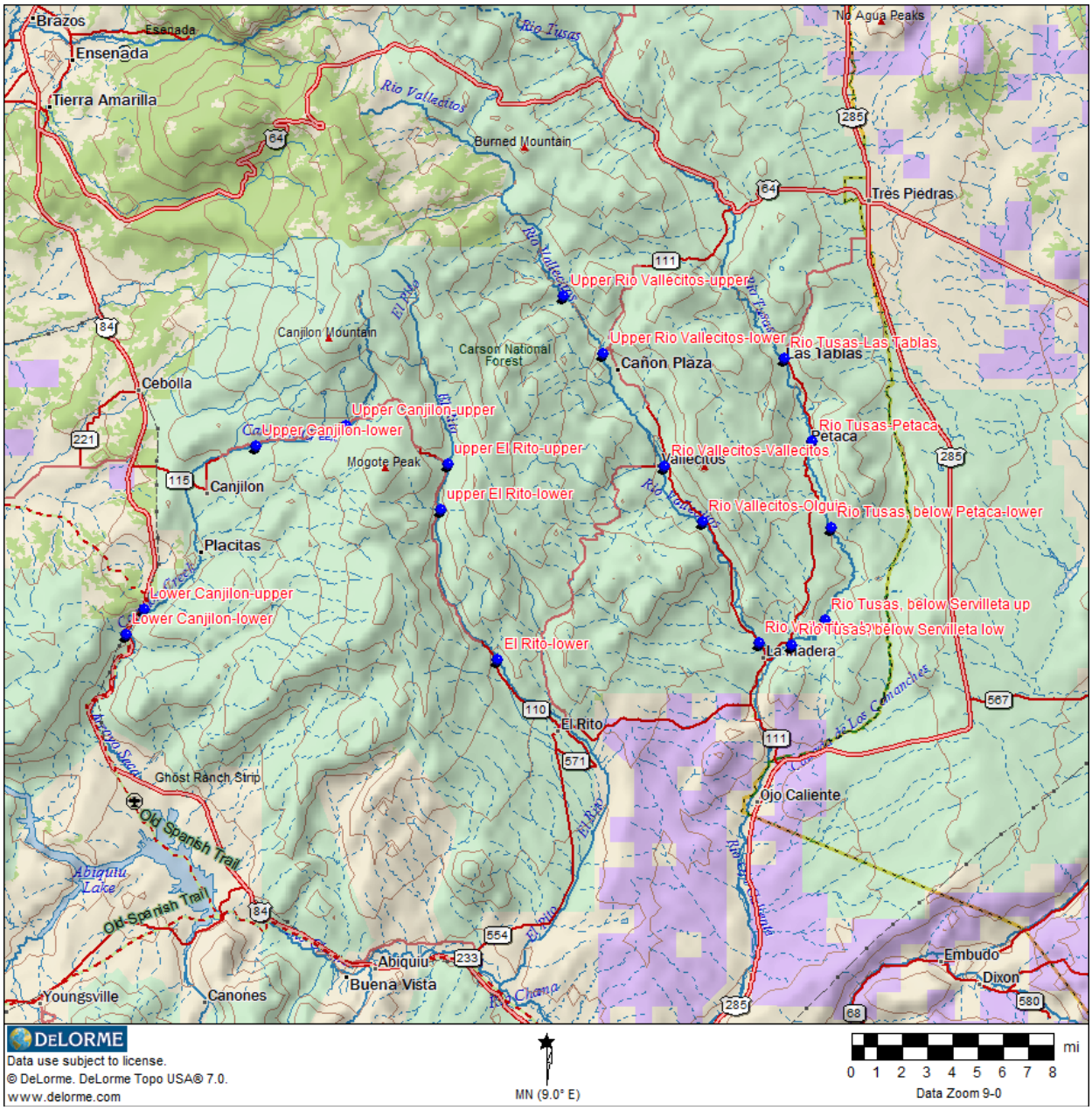
stream ran continuously through the area and there were a number of beaver impoundments on the stream. McGrath (2009) provided a helpful list of plants of Stewart Meadows.

The ecological situation of Stewart Meadows was judged to not be particularly appropriate for *Z. h. luteus*. The location is high in elevation and, although the site was surrounded by grassland and juniper woodland, downstream in the canyon of the Rio San Antonio there is mixed coniferous forest. In addition, the western jumping mouse (*Zapus princeps*) has been captured far downstream (7,540 ft, 2,300 m elevation) near the confluence of the Conejos River with the Rio Grande (Frey 2011). Regardless, this was a priority site for Carson NF because it represents a significant wetland restoration area. Further, prior survey efforts failed to document any jumping mice at this site (Frey 2003, Ecosphere 2011) and the habitat was judged to be suitable for jumping mice. Consequently, this site was selected for trapping.

Riparian habitat at this site was extensive and complex (Figure 18). Trapping was focused on a section of the area (13S 0399875, 4079054) that appeared to provide the best diversity of riparian habitat types, including those preferred by jumping mice. Four riparian habitat types were sampled including: herbaceous riparian along river; willow-smooth brome association on the river dike, herbaceous vegetation with scattered riparian shrubs on canals, and emergent sedge meadow. Ideal habitat for jumping mice was present along the Rio San Antonio where banks were low and in backwater areas associated with beaver impoundments. These areas were dominated by a diversity of herbaceous plants including sedges, riparian grasses, and forbs. Riparian shrubs, including willows (*Salix* spp.) and thinleaf alder (*Alnus incana*), were generally sparse and were regenerating from past beaver cutting. Three *Z. princeps* were caught in this habitat. On the south side of the dike along the river there was a dense thicket of coyote willows that were regenerating due to past cutting by beaver. The understory was dominated by dense grasses (appeared to be *Bromus*), which became especially tall and dense in low spots between willow hummocks. There were few other species of plants. Three *Z. princeps* were caught in the dense grass in this habitat type. One *Z. princeps* was caught in a situation that was intermediate between the herbaceous riparian and willow-grass habitat. This animal was caught at the edge of the dike where a small channel of water returned from the wetland to the river. The trap that caught the animal was set in a dense patch of sedges on shallow standing water.

A line of traps was set across the middle of the emergent sedge meadow. The vast majority of the meadow consisted of sedges growing on deep (i.e., relative to a mouse) standing water, which averaged about 10 cm or more in depth. *Z. h. luteus* is known to use the canopy of herbaceous vegetation for travelling and foraging (Frey and Wright 2012). Consequently, traps were set in the canopy of the sedges where water was deep and on islands of ground within the wetland. A single montane vole was captured in this habitat in an edge situation where solid ground was available. Traps also were set in association with canals. *Z. h. luteus* is known to use canals (Frey and Wright 2012). Habitat on canals ranged from areas with decadent willows and sedges on standing water, to areas with well-developed diverse herbaceous riparian vegetation with scattered riparian shrubs. No jumping mice were captured in this habitat, although it seems likely that *Z. princeps* utilizes that herbaceous canal-side habitat.

El Rito District

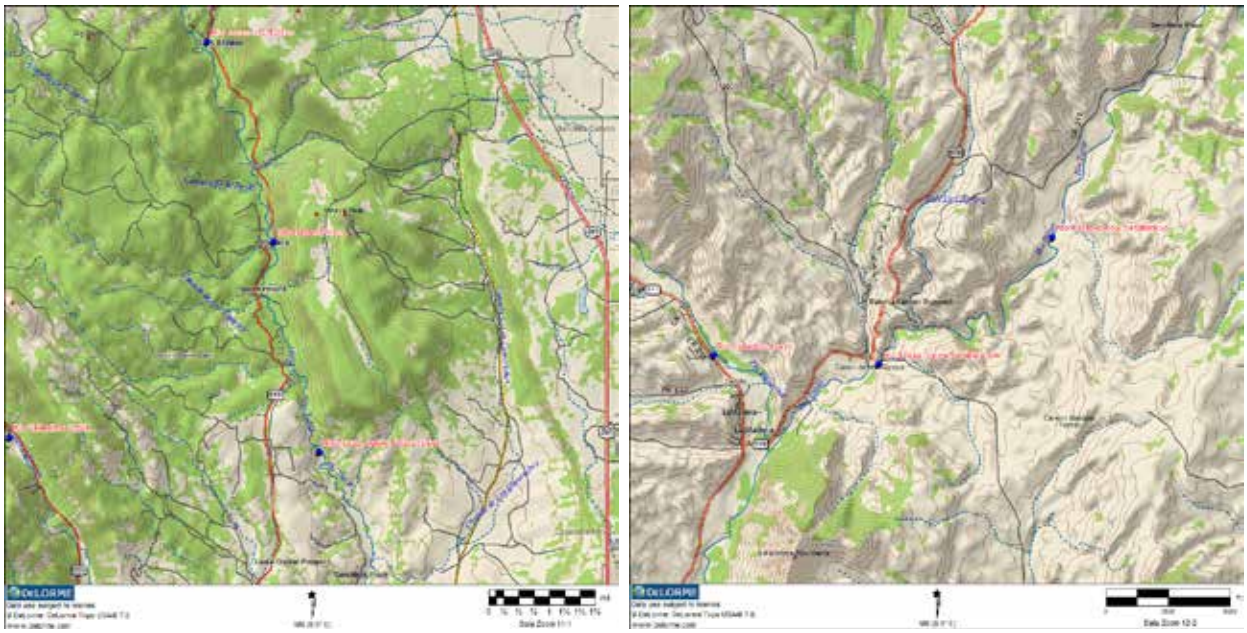


El Rito District, overview map of survey reaches. *Surveyed stream reaches are designated by blue dots labeled upper and lower, which correspond to data in Table 3. Map includes surveyed reaches in the Canjilon District.*

Introduction to Rio Tusas, Rio Vallecitos, and El Rito Creek.—The three major perennial streams of the El Rito District—the Rio Tusas, Rio Vallecitos, and El Rito Creek—are similar in many ways. Each heads in the high country of the southern San Juan Mountains and flows southward as major tributaries to the Rio Chama. The Rio Tusas and Rio Vallecitos converge as the Rio Ojo Caliente before meeting the Rio Chama.

Further, as elsewhere in northern New Mexico where there is a long history of European settlement, there is a patchwork of private and forest service land along the streams. Private lands usually are located in broad, level valleys that were originally selected for settlement because they could be farmed. In contrast, stream reaches within narrow rugged canyons were not settled and so ended up being included within the national forests. This is relevant because the riparian habitat used by *Z. h. luteus* is best developed in the wide, low-gradient valley bottoms, most of which are under private ownership in this region. In contrast, *Z. h. luteus* rarely occurs in narrow canyons or along swifter stream reaches because conditions do not allow for the development of moist soil conditions that allow herbaceous riparian plants to flourish.

There are historical records of *Z. h. luteus* from both the Rio Chama and its tributary El Rito. This suggests that the species likely formerly occurred in all suitable habitat within the Rio Chama watershed. However, *Z. princeps* is also known from the higher elevations in the San Juan Mountains which limits the potential distribution of *Z. h. luteus* at higher elevations. No potentially suitable habitat for *Z. h. luteus* was found on Carson NF on any of these rivers, although some areas of potential habitat were observed on private lands.



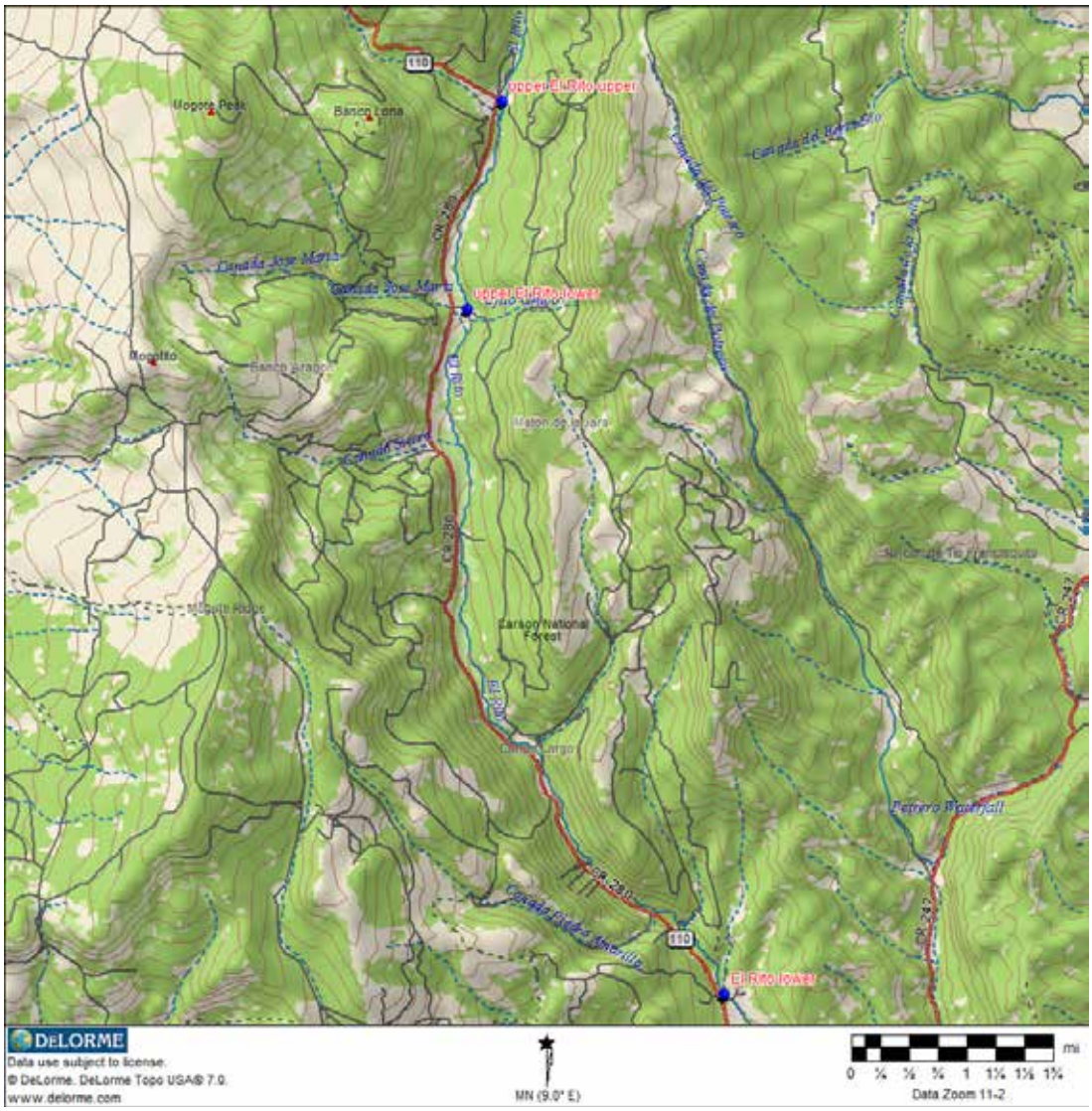
El Rito District, Rio Tusas map of survey reaches. *Surveyed stream reaches of the upper (left panel) and lower (right panel) are designated by blue dots labeled upper and lower, which correspond to data in Table 3.*

Rio Tusas.—The Rio Tusas was surveyed below Las Tablas. This reach of the Rio Tusas was not suitable for *Z. h. luteus* due to high elevation, mixed coniferous forest, and much of the river was confined to a canyon. Below Las Tablas, the river flowed through ca 1.1mi of Carson NF. Here, the upper half of the reach flowed through a narrow, rocky canyon that supported mixed coniferous forest on north and east facing slopes. The lower portion was impacted by heavy grazing. Below Petaca, there was a ca 2.0 mile reach on Carson NF land (Figure 19). The upper ca 1.0 mile of this reach had site conditions suitable for *Z. h. luteus* in that it was low elevation (ca 7,180 ft), surrounded by piñon-juniper woodland biotic community, and the gradient was gentle and valley bottom somewhat wide (wide enough to support a matrix of beaver impoundments). However, the area was heavily grazed and there was no development of riparian vegetation and the water was intermittent. The lower ca1 mile reach in this section was in a narrow canyon and hence was less ideally suited to develop riparian habitat that can be used by *Z. h. luteus*. No sign of beaver was observed and current habitat conditions are likely too degraded to support beaver. The reach below Petaca provides a good opportunity to restore riparian and aquatic habitat and stream function. One important reason is that, despite the heavy grazing, the stream still has not become significantly entrenched and soil is present. Further, there was an upstream source for riparian plants to colonize the site. Once riparian habitat elements are restored, this would be an ideal site to restore beaver, which would further enhance the habitat. Beaver prefer low gradient small order streams that have non-rocky substrate (mud is used in construction of dams). Restored riparian vegetation would improve water quality and likely would improve stream flow as well as aquatic and terrestrial ecosystem function. The site is low enough in elevation that *Z. princeps* would not be able to colonize. Thus, it could provide a potential repatriation site for *Z. h. luteus*. The reach below Servilleta Plaza was inaccessible. However, based on topographic maps and inspection of Google Earth satellite imagery,

most of this reach was confined to a narrow rocky canyon and is not likely to contain suitable habitat for *Z. h. luteus*.

El Rito District, Rio Vallecitos map of survey reaches. *Surveyed stream reaches of the upper (left panel) and lower (right panel) are designated by blue dots labeled upper and lower, which correspond to data in Table 3.*

Rio Vallecitos.—The Rio Vallecitos was surveyed downstream from the Forest Road 274 bridge. The vast majority of the Rio Vallecitos is on private land. Most reaches managed by Carson NF are very short (ca < 0.5 miles). The three longest reaches managed by Carson NF are above Forest Road 274 bridge, above Olguin (=below Vallecitos) and below Olguin. The reach above Forest Road 274 is not suitable for *Z. h. luteus* due to high elevation (> 8,030 ft) and it is within mixed coniferous forest; it is ideal habitat for *Z. princeps*. Above and below Olguin, the river is mostly confined to narrow, rocky canyons, which precludes development of herbaceous riparian habitat on moist soil (Figure 20). No suitable habitat for *Z. h. luteus* was observed. No sign of beaver was observed.



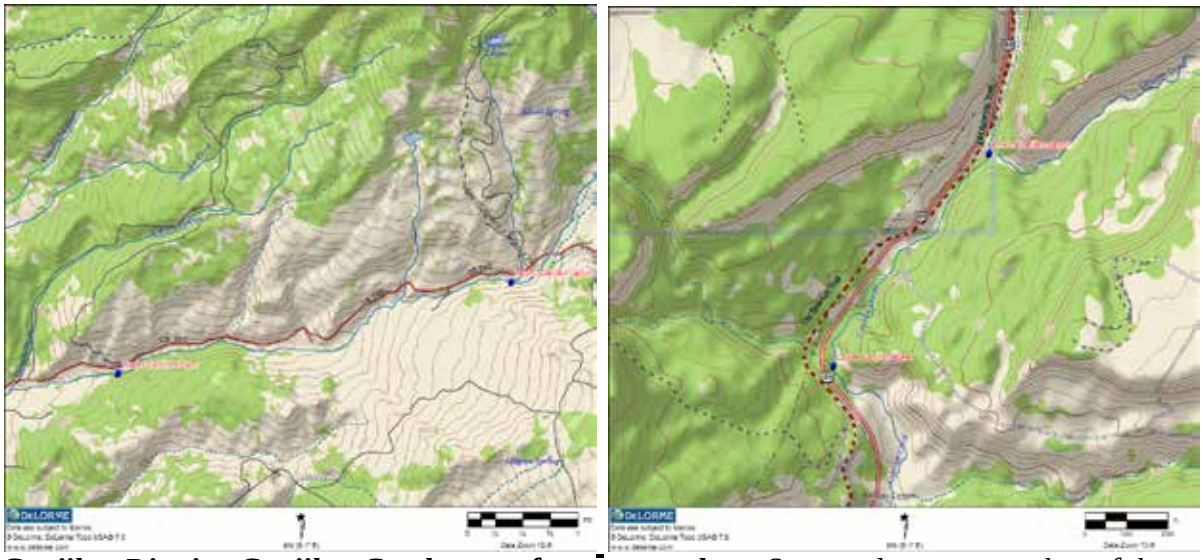
El Rito District, El Rito Creek map of survey reaches. *Surveyed stream reaches are designated by blue dots labeled upper and lower, which correspond to data in Table 3.*

El Rito Creek.—El Rito Creek was surveyed downstream from Forest Road 106 bridge (elevation 8,533 ft). The bridge was on private land, and there was fairly good development of riparian habitat including moderate density of riparian shrubs and a diverse and fairly well developed herbaceous layer. Below this private land there were two stream reaches managed by Carson NF. The upper reach was located ca 0.25 miles below the Forest Road 106 bridge and extended ca 1.5 miles downstream to vicinity junction Canada Jose Maria. This reach ranged in elevation from 8,275 to 8,450 ft and was surrounded by mixed coniferous forest. Thus, the ecological site conditions were favorable for *Z. princeps* rather than *Z. h. luteus*. Further, there was no suitable jumping mouse habitat observed in this reach. There appeared to be impacts from heavy livestock grazing and consequently there was no tall herbaceous vegetation and few riparian shrubs (Figure 21). Beaver impoundments were present, but even these were not able to produce

riparian vegetation that out-paced the grazing pressure. It seems likely that under current grazing and climate conditions that the habitat will not be able to sustain beaver colonies indefinitely in this reach (due to lack of herbaceous riparian plants and willows).

The lower reach extended ca 2.8 miles below the junction of Canon Largo. The site conditions were ideal for *Z. h. luteus* as the reach was in a fairly broad valley with low gradient, and it varied in elevation from ca 7,340 to 7,750 ft within the piñon-juniper woodland and lower ponderosa pine forest zones. This site is especially important because there are historical records of *Z. h. luteus* from the lower end of this reach. However, no potential habitat for jumping mice was observed in this reach. El Rito Campground is located near the middle of this reach, which formally consists of 11 sites. However, most of this reach is heavily used for dispersed camping, which, along with a history of heavy livestock grazing, has contributed to significant negative impacts to the stream and riparian zone (Figure 21). We observed a Youth Conservation Corp Project consisting of rail fencing to exclude vehicles that had resulted in improvement to adjacent upland habitat within the fenced area. No sign of beaver was observe on this reach. Additional efforts are needed to control impacts due to human recreation and livestock grazing, and to restore aquatic, riparian, and upland ecosystem function in this area.

Canjilon District



Canjilon District, Canjilon Creek map of survey reaches. *Surveyed stream reaches of the upper (left panel) and lower (right panel) are designated by blue dots labeled upper and lower, which correspond to data in Table 3.*

Canjilon Creek.—Canjilon Creek is a major tributary to the Chama River (Rio Grande watershed) that heads on Canjilon Mountain in the southern San Juan Mountains and flows generally southward demarking the southwestern edge of the mountain range. Two reaches of the creek were evaluated for potential occurrence of *Z. h. luteus*. The upper reach extended along Forest Road 559 (= County Road 280) from near the junction of Forest Road 124 to junction of Forest Road 129, which ranged in elevation from ca 8,150 to 8,860 ft. The lower ca 2.3 miles in this reach (< 8,585 ft elevation) was managed by Carson NF; the upper ca 1.8 miles in this reach (> 8,585 ft elevation) was on private land. Like Stewart Meadows, upper Canjlion Creek is surrounded primarily by grassland. However, the grassland was interspersed with patches of Gamble oak and conifer forest— ponderosa pine forest on south facing slopes and mixed conifer forest on north facing slopes. The site conditions were considered only marginally suitable for *Z. h. luteus* due to the high elevation, proximity to mixed coniferous forest, and known occurrence of *Z. princeps* higher in the watershed (i.e., Upper Canjilon Lakes, Middle Canjilon Lakes). In addition, no suitable habitat for *Z. h. luteus* was observed (Figure 22). On private land, grazing appeared heavy and there was little to no herbaceous cover. On the reach managed by Carson NF, the riparian zone was divided by barbwire fencing into small pastures. At the time of the survey, cattle appeared to be confined into two of these pastures, suggesting short-term, but intensive grazing pressure. In comparison with similar elevations on El Rito Creek, riparian habitat on Canjilon Creek was better developed. However, it still was not suitable for *Z. h. luteus*. The stream showed evidence of erosion with some sections entrenched ca 0.5 m and some outer banks eroded ca 1.5 m. The stream substrate was often large cobble suggesting occasional high flows. Consequently, there was little to no moist soil zone along the stream, which is needed for the development of quality herbaceous riparian vegetation.

There was an overstory of narrowleaf cottonwood along most of the Carson NF reach of the stream, but there was no sign of beaver activity. An old beaver pond was present on private land.

The lower reach of Canjilon Creek extended downstream from junction of Navajo Canyon ca 1.2 miles along US Highway 84 to the private land in the southeast corner of section 15 (T25N, R4E). The upper 0.4 miles was managed by the Bureau of Land Management. Elevation ranged from 7,010 to 6,865 ft and the surrounding biotic community was piñon-juniper woodland. This site lacked suitable riparian habitat and site conditions make its future development unlikely (Figure 23). The stream was entrenched between the steep canyon wall and the highway. The stream showed evidence of extensive erosion and there was little to no development of herbaceous riparian vegetation. No sign of beaver was observed.

Other notable mammal records

On the morning of 17 August 2012 I observed three white-tailed jackrabbits (*Lepus townsendii*) in upland grassland near Stewart Meadows (Figure 5). The first was observed off of Forest Road 87 (= County Road 441) ca 500 m west junction Forest Road 133 (13S 0401659, 4078865 8,911 ft, 2,716 m elevation). A pair was observed off of Forest Road 87 ca 950 m west of junction Forest Road 118 (13S 0403786, 4078915, 8,816 ft, 2,687 m elevation). These jackrabbits were distinguished from the more common black-tailed jackrabbit (*Lepus californicus*) by larger size, stockier build, shorter appearing appendages, more fluffy pelage that was overall grayish in color, and pale gray patch on dorsal surface of tail (rather than large black patch). Both species have black tips on the dorsal surfaces of the ears. When the first jackrabbit was startled, it flattened its ears, and then flattened its head and body into the grass until it was totally concealed. When it was approached to within ca 6 m it ran away with a slower, more clunky gait and heavier body appearance than the black-tailed jackrabbit. The white-tailed jackrabbit is recognized as a Forest Service sensitive species in the Southwestern region, where it is known only from Carson NF (USFS 2007). NatureServe ranks it as imperiled (S2) in New Mexico. It has been extirpated from several states at its southeastern range limits as well as at some locations within its core range in the Rocky Mountains (Berger 2008). Prior, the only record of this species from the San Juan Mountains was a specimen collected in 1904 from near Hopewell Lake. Thus, these observations provide important information on the current distribution and status of this species on the forest.

I observed a thirteen-lined ground squirrel (*Spermophilus tridecemlinatus*) in a burrow along Forest Road 78, north of Stewart Meadows (13S 0399352, 4081019, 9,072 ft, 2,765 m elevation). The burrow was in short grasses mixed with forbs (30-40% bare ground) and within 100 m of spruce and aspen trees on a nearby ridgeline (Figure 6). The animal was taken as a specimen, which represents the first for the San Juan Mountains. Further, the only prior specimen record for Rio Arriba County was an animal collected in 1873 from Tierra Amarilla. Thus, although not a Forest Service sensitive species, this specimen provides important information on the current distribution and status of this rare species in the region. The specimen was notably small and had dark pelage, typical of forms found in montane grasslands in New Mexico.

Gunnison's prairie dogs (*Cynomy gunnisoni*) were observed to be sparsely distributed along Forest Road 78, north of Stewart Meadows. This is a Forest Service sensitive species in the Southwest region (USFS 2007).

Ecosphere Environmental Services (2011) reported capturing a single prairie vole (*Microtus ochrogaster*). It is unclear where the animal was actually captured because the capture location was reported as both Midnight Meadows (see their Table 2) and Sawmill Park (see their report section 4.3 and 5.2). Regardless, both of those sites were wet subalpine meadows (elevation >10,170 ft, 3,100m) near the crest of the Sangre de Cristo Mountains. The authors acknowledged having difficulty identifying voles and this animal was undoubtedly misidentified. Prairie voles occur in low elevation plains grasslands; they do not occur at high elevations (see Frey 2006 for a review of the distribution of the prairie vole in New Mexico). The authors based their identification on 3 pairs of mammae. However, the second pair of pectoral mammae is often difficult to find, especially on a live animal that is being held. I examined a photograph of the animal which was provided by Carson NF. I identified the animal as *M. pennsylvanicus* based on its blackish gray rather than buff venter, blackish rather than

buffy tops of hind feet, and overall dark brown coloration. The photograph was labeled Sawmill Park and so the bulk of evidence indicates that as the capture location (rather than Midnight Meadows as listed in the table).

The heather vole is easily confused with short-tailed *Microtus*, such as *M. montanus* (Frey 2010). The western heather vole primarily occurs in high elevation subalpine wetlands and herbaceous riparian habitats (Frey 2010). A vole reported captured at Stewart Meadows by Ecosphere (2011) was likely *M. montanus* and not *P. intermedius* as they suggested it could be. Stewart Meadows is not typical habitat for *P. intermedius* due to relatively low elevation (compared to preferred *P. intermedius* habitat) and due to the abundance of *Microtus* (*P. intermedius* rarely co-occurs with *Microtus* in New Mexico; Frey 2010) The western heather vole is a Forest Service sensitive species in the Southwestern region (USFS 2007). It is a poorly known species in New Mexico with only 25 records from 17 location (Frey 2010). Future studies aimed at this rare Forest Service sensitive species should be conducted by a taxon expert and must provide assurance that identifications can be verified. Otherwise, survey results will be unreliable.

Figure 5. Locations of observations of the white-tailed jackrabbit (*Lepus townsendii*) off of Forest Road 87, near Stewart meadows.

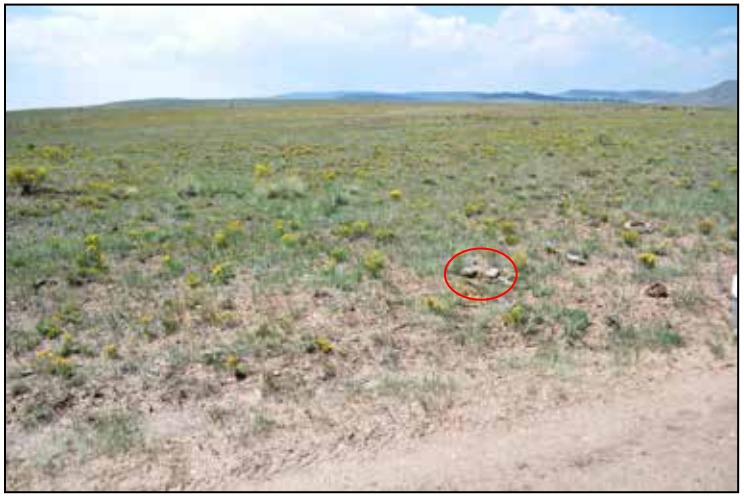


Figure 6. Capture location of a thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) off of Forest Road 78 north of Stewart Meadows.

CONCLUSIONS

The method for site selection used in this study was different from those used in most other surveys for *Z. h. luteus* (but see Frey 2011a). Most prior studies focused on sampling historical locations (e.g., Frey and Malaney 2009, Frey 2011b), sampling sites of special management interest (which might not have ideal site conditions or appropriate habitat; e.g., Frey 2007, Ecosphere 2011), or were baseline investigations to establish distribution, habitat relations, and other patterns (e.g., Frey 2006c). In contrast, this study used a collaborative, systematic process of site selection based on known natural history information, along with knowledge of a taxon expert and local habitat specialists, to determine the sites on Carson NF that offered best opportunity for occurrence of *Z. h. luteus*. In essence, this survey provided a methodical survey of the entire Forest, but it failed to confirm presence of *Z. h. luteus*. However, this does not necessarily mean that *Z. h. luteus* is not present on the Forest or that *Z. h. luteus* could not become present at sites in the future. First, it is possible that there were locations on the forest that had both suitable site conditions and habitat that were not known about and hence did not make the initial list of sites that were considered. Second, recent surveys on Lincoln NF revealed that *Z. h. luteus* recolonized a site after the riparian habitat was restored (J. Williams, personal communication). The likely source population for that recolonization was on adjacent private land. Thus, shifting habitat conditions could lead to future occurrences on Carson NF where none occur now.

The primary factors contributing to the paucity of records of *Z. h. luteus* on Carson NF, include natural site conditions and degraded riparian habitat. Most perennial streams on Carson NF are located above the upper elevation distributional limit for *Z. h. luteus* in the zone of sympatry (see shaded area [i.e., > 8,000 ft] in Figure 4). Further, within the appropriate elevations for *Z. h. luteus*, many of the low-gradient, broad valleys (which have the greatest potential to develop suitable habitat) are within private land inholdings (see gold areas on Figure 4), since these valleys are valued for agricultural production and were often homesteaded or settled. Thus, there is a relatively small proportion of stream reaches that are at the proper elevation, have the proper topography, and are on lands administered by Carson NF. Secondly, of those lands, most have seriously degraded riparian habitat; this was particularly true on the west side of the forest (El Rito and Canjilon districts). The only extensive area on Carson NF that currently meets all of the needs for *Z. h. luteus* (i.e., suitable elevation, site conditions, and habitat) is the watershed of the Rio Grande del Rancho on the Camino Real District. A major contributing factor to the quality of the riparian habitat in this watershed was that it has not been grazed by livestock for more than 20 years. Not coincidentally, this watershed also was the only (except Stewart Meadows, which also has been excluded from livestock grazing) with extensive evidence of beaver. Livestock grazing can diminish beaver habitat (Baker et al. 2005; Dieter and McCabe 1989a,b; Leary 2012). On the other hand, beaver help to create more of the early seral stage herbaceous habitat preferred by *Z. h. luteus*. Thus, there is a synergism between absence of livestock, presence of beaver, and potential for *Z. h. luteus*.

MANAGEMENT RECOMMENDATIONS

1) **Restoration.** Though *Z. h. luteus* historically occurred throughout much of the Southwest, currently there are only 20 populations known to persist throughout its range (Frey 2012, unpublished data). The species continues to face many ongoing and serious threats that could jeopardize additional populations. Consequently, it is critically important to identify any populations of *Z. h. luteus* that have persisted. Further, recovery of *Z. h. luteus* will require restoration of riparian habitats and likely will involve introductions to create additional populations throughout its historical range. Carson NF was historically occupied by *Z. h. luteus* and populations of *Z. h. luteus* could still persist on the forest or in areas adjacent to the Forest. Consequently, it is important that riparian habitat restoration occur on the Forest at locations with suitable elevation and site conditions (broad, low-gradient valleys). The highest priority areas for riparian habitat restoration include the **Rio Grande del Rancho watershed, Rio Tusas,** and **El Rito Creek**; however other priority sites include Rio Vallecitos and Canjilon Creek.

2) **Livestock grazing.** Livestock grazing has been identified as the single greatest threat to *Z. h. luteus* (Morrison 1990, Frey and Malaney 2009). Virtually all currently known populations are confined to areas that are physically excluded from grazing by fences (Frey and Malaney 2009, Frey 2010a,b, Frey and Wright 2012). Ideally, livestock grazing should be excluded from riparian zones in areas where presence of *Z. h. luteus* is desirable or likely to occur. Given that the only suitable riparian habitat found within the proper elevation for *Z. h. luteus* on Carson NF was on the **Olla Ranchos Allotment**, it is strongly recommended that this allotment remain ungrazed. Minimally, livestock should be excluded from the riparian zone in the Rio Grande del Rancho watershed below 8,000 ft elevation. Another priority area for changing the current grazing management is along the **Rio Tusas**, especially the reach below Petaca. Although there currently is no functioning riparian habitat present in this reach, the stream bed was not severely degraded. Native riparian communities were observed upstream on private land which could provide a source for downstream dispersal of riparian plants and animals. Restoration of the riparian habitat has the potential to restore stream flows and riparian and aquatic communities, such as *Z. h. luteus* and sensitive species of fishes.

3) **Beaver.** Beaver can create new *Z. h. luteus* habitat and ameliorate the impacts of livestock grazing on *Z. h. luteus* habitat. For instance, the only two occasions where *Z. h. luteus* was captured during recent surveys in areas that were grazed by livestock occurred at beaver wetland complexes. Beaver wetlands can function to naturally exclude livestock from riparian habitats, which can allow *Z. h. luteus* to exist in otherwise grazed areas. Consequently, presence of beaver on small order (i.e., 1-5) streams at low elevation (< 8,000 ft) should be encouraged. Excessive grazing can make sites unsuitable for beaver. Hence, grazing management may need to be modified to encourage growth of plants used by beaver for food and building material (i.e., willows). Further, the Carson NF Land and Resource Management Plan should be amended to prohibit beaver trapping within the **Rio Grande del Rancho watershed** (i.e., includes Rio Chiquito and Rito de la Olla) in order to maintain outstanding wildlife value. The **Tierra Azul reach**, in

particular, could benefit from a more robust beaver population in order to restore riparian habitat. When beavers are regularly trapped and removed, they cannot maintain dams and expand their influence to undammed areas. Beaver colonies expand by successive generations expanding to new sites. Thus, harvesting can prevent beaver from expanding their realm of influence.

4) **Recreation.** Camping and vehicles should be excluded from riparian zones. This is a particular concern on **El Rito Creek** where recreation is having significant negative impacts to upland and riparian habitats.

5) **Upland habitat restoration.** Although *Z. h. luteus* is a riparian species, all locations where it has been recently captured have had healthy upland habitats dominated by lush and diverse grasses and forbs (no bare ground). Restoration of grasslands and meadows surrounding riparian zones should be a priority. This is especially true at the **Tierra Azul** reach where upland restoration appears to be lagging behind the riparian restoration. Seeding with native grass and forb species and removal of juniper should be implemented.

6) **Surveys and monitoring.** Riparian habitats are prone to rapid changes due to human land use and other factors. It is known that *Z. h. luteus* can respond to beneficial shifts in habitat and recolonize sites that improve. Likewise, *Z. h. luteus* can be quickly extirpated from sites if habitat changes abruptly (Frey 2011b). Consequently, trends in riparian habitats should be monitored on all perennial streams < 8,000 ft elevation. Further, because *Z. h. luteus* can respond to changes and because it is possible that suitable sites were not identified during this survey, it will be necessary to survey sites for *Z. h. luteus* in the future. Riparian zones and perennial streams below 8,000 ft elevation should be considered potentially occupied by *Z. h. luteus*.

7) **Research needs.** There is a paucity of knowledge about small mammal communities in different habitat types and their response to various land management practices (e.g., livestock grazing) in northern New Mexico. Additional studies on relationships between habitat and small mammal communities are needed. Small mammals are very sensitive to changes in habitat. Consequently, such studies can help evaluate if management actions are achieving desired results with respect to wildlife.

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Figure 7. Fawn Lakes, Questa RD. Left: Overview of upper lake with heavy recreational impacts. Right: Emergent sedge wetland at lower end of lakes. Note upper mixed coniferous forest zone.

Figure 8. Eagle Rock Lake, Questa RD. Left: overview of emergent sedge wetland at lake inlet. Right: Close-up of emergent sedge wetland showing standing water adjacent to upland.

Figure 9. Rio Fernando de Taos, Camino Real RD. Left: Riparian zone at former location of La Vinateria picnic area. Right: Close-up of the poor cover provided by exotic smooth brome (*Bromus inermis*), which was the dominant grass at this location; note that the tops of the person's feet are visible.

Figure 10. Rio Chiquito, Camino Real RD. Left: The stream is confined to a narrow passage between the road and the canyon wall; most of the stream is inaccessible within a dense canopy of shrubs (stream runs on right side of road). Right: Rare patch of herbaceous vegetation associated with a beaver complex in a wider area of the canyon ca 2.2 miles east of junction with NM 518.

Figure 11. Rito de la Olla, Camino Real RD. Top left: Well developed herbaceous vegetation on a beaver-altered segment of lower Rito de la Olla. Top right: Capture location for western jumping mouse (*Zapus princeps*). Bottom: Close-up of habitat at *Z. princeps* capture location (the area in front of the Robel pole has been trampled; the two pink bands on the pole correspond to 24 and 36 inches.

Figure 12. Rio Grande del Rancho 434 wetland, Camino Real RD. Top left: Guard rail vehicle barrier. Top right: Diverse herbaceous habitat under regenerating willows. Bottom left: Potential habitat for *Z. h. luteus* along a seep channel. Bottom right: Potential habitat for *Z. h. luteus* beside beaver impoundment.

Figure 13. Rio Grande del Rancho, Tierra Azul, Camino Real RD. Top left: Site #1 beaver pond with narrow margin of herbaceous riparian habitat. Top right: Site #1 herbaceous cover within willows was short sparse grass. Bottom left: Site #2 view of stream with incised bank and moderate development of herbaceous riparian vegetation: Bottom right: Site #2 close-up of herbaceous layer which was somewhat diverse but short and sparse.

Figure 14. Rio Grande del Rancho, Tierra Azul, Camino Real RD. Top left: Site #3 Overview showing dense thicket of decadent willow near gaging station. Top right: Above the gaging station at Site #3 high stream banks resulted in short herbaceous cover. Bottom left: Site #4 riparian zone if very narrow and poorly developed; person is standing at edge of water. Bottom right: Site #4 upland was mostly bare ground.

Figure 15. Rio Grande del Rancho, Tierra Azul, Camino Real RD. Top left: Site #5 overview showing extensive riparian zone, beaver activity, and lower bank/higher water table structure. Top right: Site #5 showing tall, dense herbaceous vegetation on moist soil besides beaver pond. Bottom left: Site #6 showing overview of extensive beaver activity and lower bank/higher water table structure. Bottom right: Site #7 showing willow growth only at waterline (bare ground seen through willows on left side photo).

Figure 16. Rio de los Pinos, New Mexico Department of Game and Fish Los Pinos State Recreation Area. Left: Overview of river at lower boundary of area showing entrenchment and bare bank. Right: Riparian zone adjacent to river (river in background) is mostly bare ground with copious evidence of cattle grazing.

Figure 17. Rio de los Pinos, Tres Piedras RD. Left: Lower elevation boundary of Carson NF on the river; cows can be seen grazing in the riparian zone. Right: Dispersed camping area on river at ca 8,300 ft elevation (13S 0395126 4090702, 2,519 m).

Figure 18. Rio San Antonio, Stewart Meadows, Tres Piedras RD. Upper Left: Overview of Stewart Meadows from Forest Road 87. Here, the Rio San Antonio flows along the base of the hillside in the background, which is evident by the stringer of riparian shrubs. Riparian shrubs in foreground are associated with canals. The emergent sedge meadow in the interior of this portion of the valley has deep standing water and hence is generally not suitable habitat for small mammals. Upper Right: Beaver impoundment on the Rio San Antonio. Lower Left: Capture location for *Zapus princeps* in herbaceous riparian habitat between dike (left) and Rio San Antonio (right). Lower Right: Capture location for *Zapus princeps* in dense willow-grass riparian habitat associated with the dike between the Rio San Antonio and the wet meadow.

Figure 19. Rio Tusas, El Rito District. Upper left: Edge of narrow canyon through which the Rio Tusas flows on Carson NF below Las Tablas. Upper right: Potential habitat for *Z. h. luteus* on private land at Petaca. Bottom row: A ca 2.0 mile reach of the Rio Tusas on Carson NF land below South Petaca that offers good potential for riparian habitat and stream restoration.

Figure 20. Rio Vallecitos, El Rito RD. Left: View of stream in canyon within ponderosa pine zone near Olguin. Right: View of stream in pinon-juniper woodland zone below Olguin. Note rocky substrate.

Figure 21. El Rito Creek, El Rito RD. Top left: Stream on private land at Forest Road 106 bridge. Top right: Stream on land managed by Carson NF below Forest Road 106; note closely cropped herbaceous layer. Bottom left: Dispersed camping in riparian zone near El Rito Campground. Bottom right: Youth Conservation Corps Project to improve upland habitat adjacent to stream by restricting vehicles near El Rito Campground.

Figure 22. upper Canjilon Creek, Canjilon RD. Upper left: Private land above Carson NF. Upper Right: Cattle were confined to very small pastures in riparian zone. Lower left: Typical habitat on creek; note rocks. Lower right: Better habitat on creek.

Figure 23. lower Canjilon Creek, Canjilon RD. Left: lower Canjilion Creek showing entrenchment and proximity to US Highway 84. Right: close-up of streambed showing poor development of riparian habitat.