Survey for the New Mexico Meadow Jumping Mouse (Zapus hudsonius luteus) at Selected Locations in the Jemez Ranger District, Santa Fe National Forest

Technical Report · January 2007

DOI: 10.13140/RG.2.2.30515.22567

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FINAL REPORT

(Professional Services Contract AG-8379-P-06-0044)

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10 January 2007

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Cover photograph: *Zapus hudsonius luteus* female #Z78 from the lower Rio Cebolla. Photograph by J.K. Frey 15 August 2006

I. EXECUTIVE SUMMARY

The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is a herbaceous wetland specialist that is listed as a sensitive species by the US Forest Service and as an endangered species in New Mexico. Historical locations for this species on the Jemez Ranger District, Santa Fe National Forest were reviewed. Field surveys for this species were conducted at three locations in the Jemez Ranger District, Santa Fe National Forest, including: McKinney Pond, lower Rio Cebolla, and Lake Fork Canyon. Jumping mice were only captured at the lower Rio Cebolla location. Habitat at capture sites was tall, dense herbaceous emergent wetland created by beaver activity. This location had the highest diversity and abundance of riparian small mammals. In contrast, the McKinney Pond and Lake Fork Canyon locations had relatively low diversity and abundance of riparian small mammals. These locations lacked suitable herbaceous ground cover, which is necessary for riparian small mammals, primarily as a result of livestock grazing. A diverse and abundant riparian small mammal community is a desirable management goal. It is recommended that riparian habitats be restored, with a special focus on emergent wetlands, through appropriate management of livestock and management that benefits beaver populations. It is recommended that a study be developed to assess the effects of livestock grazing and beaver on jumping mice. Further, it is recommended that additional survey work and long-term monitoring of populations and habitat be completed.

II. BACKGROUND

The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is listed as an endangered species in New Mexico, a species of concern (i.e., former category 2 candidate species) by the US Fish and Wildlife Service, sensitive by the US Forest Service Region 3, and it has a Natural Heritage conservation status of critically imperiled (S1) in New Mexico. It is a morphologically and genetically distinctive subspecies that occurs as relict populations in the American Southwest, including the Jemez Mountains in northern New Mexico (Miller 1911; Hafner et al. 1981; Hoffmeister 1986; Morrison 1992; Frey 2004, King et al. 2006). *Z. h. luteus* is an extreme habitat specialist that occupies herbaceous riparian wetland habitats (Frey 2005). Identified threats include negative impacts to wetland habitats from livestock grazing, drought and climate change, development, water development, recreation, forest fire, and conversion of riparian habitat to agricultural crops (Morrison 1990, 1992; Hafner and Yensen 1998; NMDGF 2004; Frey 2005).

The first documentation of *Z. h. luteus* in the Jemez Mountains was on basis of a incidental captures in the late 1960's and 1970's from upper Rio Cebolla 1 mile below the Seven Springs Fish Hatchery vicinity of Redondo Creek, the former Baca Location, and Fenton Lake (Table 1). Following the 1983 listing of the species as threatened in New Mexico, surveys for *Z. h. luteus* were conducted by Joan Morrison during the mid to late 1980's (Morrison 1992). In the Jemez Mountains, these included distribution surveys in 1985 and 1989 and a population and habitat study of the Fenton Lake population in 1986 (Morrison 1985, 1987, 1989). During the 1985 survey, which was Morrison's first study of *Z. h. luteus*, Morrison (1985) surveyed 13 locations using a total of 1,277 trap-nights (type of trap not specified by likely snap-traps; traps were baited with "seeds"). A total of 21 *Z. h. luteus* were captured from 6 locations (Table 1). Locations where *Z. h. luteus* was not captured during surveys are listed in Table 2. Overall relative abundance of *Z. h. luteus* during the 1985 survey was 1.64 % (i.e., 1.64 captures per 100 trap-nights; range 0 - 6.67 %), although relative abundance at locations where it was present averaged 3.78 % (range 1.82-6.67 %; calculated from data in Morrison 1985). Morrison (1985) noted that captured sites had the following characteristics: permanent running water; stream banks flat or gradually sloped; soil moist, dense grass and forb vegetation in marshy moist grasslands; dense riparian vegetation. She further noted that no captures occurred where there was evidence of "heavy grazing", but were caught in areas with evidence of "moderate grazing". She thought that trampling of streamside vegetation by anglers was a potentially serious threat.

In 1986 Morrison (1987) conducted a mark-recapture study of *Z. h. luteus* at Fenton Lake that provided important natural history information about the subspecies. Aboveground activity was documented from 13 June to at least 3 October, with males emerging from hibernation first. Peaks of activity occurred in late June-early July and in mid-September. There was only one breeding period with pregnancies in late July and early August. The population consisted of a minimum of 50 mice that over-wintered from 1985 and 79 that entered hibernation in 1986. Pre-hibernation weight gain by adults occurred in late August with subsequent disappearance (presumably into hibernation). Juveniles gained weight in September. Animals likely hibernated at the edge of the marsh and did not travel far to find hibernation sites. Movement patterns included relatively large

distances between successive captures relative to other small mammals (i.e., maximum 225 feet for females and 500 feet for males). Some animals, especially males, may have been transients. Average home ranges were 0.63 acres for males and 0.45 acres for females; home ranges tended to follow the creek border. Most individuals were caught along the creek or at beaver ponds rather than in the middle of the marsh, which was dominated by sedges with few forbs, less grass, and no shrubs. It was concluded that the preferred habitat was along the stream where there was a high diversity of grasses, sedges, forbs and areas of willow and alder shrubs. Animals tolerated trapping and handling well. *Z. h. luteus* was not captured during a survey on the East Fork of the Jemez River.

Morrison (1989) surveyed 9 locations using a total of 671 trap-nights (551 snap-trap, 120 live-trap) during 14 July to 1 September 1989. A total of 5 *Z. h. luteus* were captured from 4 of the locations (see Table 1 for capture locations and Table 2 for locations where it was not captured). Survey effort for most locations was not given so it was not possible to calculate relative abundance at each site. The exception was at Virgin Canyon, where initially 120 live-trap-nights were used with no captures, followed by a single capture using 50 snap-trap-nights (i.e., relative abundance = 0.59 % overall; relative abundance = 2.0% using snap-traps). These results were attributed to *Z. h. luteus* being more easily captured using snap-traps. Snap-traps were used at all the remaining sites. Thus, overall relative abundance (snap-traps only) was 0.91 %. Traps were removed as soon as *Z. h. luteus* was captured at a location. Where *Z. h. luteus* was not captured, trapping was done for at least 3 nights with a total of 75 to 90 trap-nights, indicating that the normal trap effort at a site was 25 to 30 traps each night. At the locations where *Z. h. luteus was* captured, vegetation cover was described as good (i.e., ground covered by dense vegetation) at 2 locations, and very good (i.e., ground covered by dense vegetation at least waist high) at 2 locations. However, cover at Virgin Canyon was reduced to fair (i.e., ground incompletely covered by vegetation or vegetation not too tall or dense) after 2 weeks of grazing by cattle. Soil moisture was moderate at 3 locations (i.e., soil damp or spongy but no standing water) and dry (i.e., soil dry or nearly so) at 1 location. Morrison (1989) concluded that, although *Z. h. luteus* was captured at locations where livestock grazing was occurring, livestock grazing that altered streamside habitat was the most serious threat to *Z. h. luteus*. She recommended 1) that numbers and duration of grazing should be closely controlled and involve monitoring of riparian habitat conditions, 2) that rotation between grazing periods be long enough to allow plants to grow tall and seed, and 3) that fences should be used to create cattle exclosures (1 mile long, at least 50 feet either side of stream) along the Rito Penas Negras, Rio de las Vacas, Virgin Canyon, San Antonio Creek, and Rio Cebolla. She noted that the capture of *Z. h. luteus* on the Rio Cebolla in 1985 occurred within a cattle exclosure that existed south of the junction of Forest Road 376 (i.e., at junction of Lake Fork Canyon).

These and other surveys conducted by Morrison during the 1980's served to ease concern about the conservation status of the subspecies (Morrison 1992, NMDGF 1998). However, NMDGF (1998) considered that threats to this taxon's mesic habitats might be most severe in montane areas. In 2005 it was recognized that there had been few subsequent documentations of the species' persistence in New Mexico and that montane riparian habitat conditions may have declined. Consequently, Frey (2005) conducted a status assessment of montane populations of the species in New Mexico. She found that in the 15 years since Morrison's studies, *Z. h. luteus* had disappeared from 67% of its

historical localities surveyed in the Jemez Mountains, and from 91% of its historical localities surveyed in the Sacramento Mountains (Frey 2005). Surveys in the Jemez Mountains included the collection of habitat data and the accumulation of 2,153 trap-nights at 19 total locations, in addition to habitat data collection at an additional 6 locations. Sampling methods involved the use of Sherman live traps baited with horse sweet feed. Surveys included all but 2 of the historical locations and 9 new locations. *Z. h. luteus* was found to persist at only 4 historical localities (Seven Springs State Fish Hatchery, upper end of Fenton Lake, tributary at Lake Fork Day Use Area at Fenton Lake, and lower Rio Cebolla at junction with Lake Fork Canyon; Table 1). It should be noted that the 2005 capture of *Z. h. luteus* on the Rio Cebolla at the junction with Lake Fork Canyon was within a new cattle exclosure above Forest Road 376, but that it was not captured below Forest Road 376 at the site of the former cattle exclosure where Morrison captured the species in 1985 (which was no longer present). The species was also captured at 2 new locations including San Antonio Creek at San Antonio Campground and in a wetland improvement enclosure on the lower Rio Cebolla (Table 1). Across all locations surveyed, overall relative abundance was 0.42 % (range = 0 – 1.45 %), although relative abundance at locations where it was detected averaged 1.12 % (range 0.48 -1.45 %).

Frey (2005) provided the first rigorous quantitative analysis of *Z. h. luteus* habitat. She found that the species is a habitat specialist that uses tall, dense herbaceous riparian vegetation, especially dominated by sedges, with a minimum vertical cover of at least 24 inches and minimum vertical stubble height of 27 inches. She concluded that the reason for the dramatic decline in distribution and abundance of *Z. h. luteus* was loss of this habitat due to livestock grazing. Statistical analyses indicated that the single best predictor of the species' presence was presence of a livestock exclosure (Frey 2005). All areas where the species persisted were in areas that received protection from livestock grazing.

The purpose of this study was to conduct survey for *Z. h. luteus* at additional locations on the Jemez Ranger District, Santa Fe National Forest.

III. METHODS

Survey.—Field surveys occurred between 14 and 19 August 2006. Surveys focused on documenting presence of *Z. h. luteus* at 3 new localities. Survey localities were identified by the Jemez Ranger District and included the upper Rio Cebolla in vicinity of McKinney Pond, the lower Rio Cebolla outside of existing habitat improvement enclosures, and Lake Fork Canyon. At each trapping location, traps were placed in areas with the best-developed habitat. Further, specific trap placement was targeted at microhabitats most likely to produce *Z. h. luteus*. Traps were standard-size Sherman live traps and these were baited with horse sweet feed (i.e., 3 or 4 grains mixed with molasses). Traps were checked for captures as frequently as logistically feasible. Each animal captured was identified to species by J. Frey, sexed, and measured (tail length, hind foot length, ear length, mass). Individuals were assigned to age classes on basis of mass (Brown 1967, Morrison 1987): juvenile (< 18 g); subadult (18 – 21 g); adult (>21 g). These age class were based on *Z. princeps*, a larger species, and hence individuals at the upper end of a weight class may in fact be referable to the next older age class. Trapping stopped at a location when *Z. h. luteus* was captured. A representative (non-pregnant) *Z. h. luteus* was collected as a voucher specimen from each location. A clipping of ear tissue was taken from jumping mice that were not collected as voucher specimens. Representatives of other species captured were also collected as voucher material. All animals that were not euthanized were released as quickly as possible at their place of capture. A handheld global positioning system unit (NAD 83) was used to record the specific site where each *Z. h. luteus* was captured. Capture and collection of wildlife was conducted under New Mexico scientific collecting permit (#2868) issued to Jennifer Frey. Taxonomy follows Frey et al. (2006). Relative abundance was a percentage of animals captured per 100 trap-nights and was calculated: relative abundance = (captures/trap-nights) x 100. Richness was the number of species captured at a site. Following recommendations in Frey (2005) *Z. h. luteus* was considered to be absent (i.e., functionally extirpated) from a location if it was not captured within 400 trap-nights.

Habitat.—Habitat data were collected at each traps where *Z. h. luteus* was captured. At the habitat collection site, 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 1-10 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 from 3 random azimuths away from the trap site. Plants generally afforded vertical cover, although in some cases, inanimate objects (e.g., rocks, banks, logs) contributed to the measured cover. Four 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 open water, sedges/rushes, forbs, grass, litter, rocks, gravel, bare ground, and alder (*Alnus* sp.) /willow (*Salix* spp.). 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 for 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. For each trap location, measurements of canopy cover, soil moisture, vertical cover, stubble height, and ground cover class estimates were averaged.

At McKiney Pond, general habitat conditions along the Rio Cebolla were assessed by reading vertical cover measurement with a Robel pole at stations approximately every 20 m (i.e., 25 paces) below the dam on the west side of the stream. The stations began 20 m below the dam and extended to 520 m below the dam (i.e., there were 26 stations). At each station, the Robel pole was positioned 0.5 m from the edge of the stream and was read at a 1 m eye-level from a position 4 m from the pole and perpendicular to the stream. Next the Robel pole and eye positions were exchanged so that the robel pole was positioned 4.5 m from the stream and was read at the 1 m eye-level from the position 0.5 m from the stream edge. Thus at each station there were 2 vertical cover measurements that were 0.5 m (= 20 inches) and 4.5 m (15 feet) from the stream edge.

Habitat data analysis.—I used principal components analysis to examine the relationship among locations where *Z. h. luteus* (*N = 40*) was captured during 2005 - 2006 based on a reduced subset of 13 habitat variables including: elevation, canopy cover, soil moisture, mean vertical cover, litter depth, number of shrubs and 7 ground cover classes (sedge, rush, willow/alder, water, forb, grass, bare). The ratio of number of samples to the number of variables (3:1) was considered suitable for descriptive purposes (McGarigal et al., 2000). Missing values were replaced with the mean of that variable so that all locations could be included in analyses. There was no rotation of the variables and only components that had eigenvalues greater than or equal to 1.0 were extracted because these usually sufficiently to describe the variance within the variables (Chatfield and Collins, 1980; McGarigal et al., 2000). Components retained for interpretation were based on the scree plot criterion (McGarigal et al. 2000, McCune and Grace 2002). Loadings with a minimum absolute value of 0.50 were considered significant (McGarigal et al., 2000).

IV. RESULTS

McKinney Pond

The McKinney Pond survey location was: "New Mexico: Sandoval Co.; Rio Cebolla, McKinney Pond, 3.2 miles (by Forest Road 314) northeast of the junction with New Mexico Highway 126, 20.4 km N, 1.7 km E Jemez Springs, T20N, R2E, SE ¼ of NE ¼ Sec. 24; N 35˚ 57.128, W 106˚ 40.414, 2,460 m elev." McKinney Pond was a small pond (ca 3 acres) that was created by damming the Rio Cebolla with an earthen dam; the dam serves as a fish barrier for upstream cutthroat trout restoration. The pond was located near the middle of a large montane meadow system associated with a relatively long, broad valley that extended along the Rio Cebolla ca 2.6 linear miles from vicinity of Road Canyon downstream to the Seven Springs Recreation Area. There was conspicuous sign of cattle grazing throughout the area and there were cattle in the area during the survey. Riparian habitat was poorly developed throughout the meadow system. Decadent alder were sparsely distributed along the stream. Recently planted willow poles showed extensive sign of browsing by ungulates. Herbaceous vegetation consisting primarily of short sparse grasses and forbs generally occurred to the edge of the stream. There were very small patches of sedges and tall grasses sparsely distributed along the stream. Invariably, these patches were growing in standing water, but did not extend onto firmer soils. At the pond, tall, dense sedge was present at various places around the edge of the pond. The upper end of the pond and along the Rio Cebolla where the water slowed before entering the pond were dominated by a large area of tall, dense, nearly monotypic sedges. However, in virtually all cases, sedges were found only in standing water with a sharp contrast to short, sparse grasses and forbs beyond the water's edge. Thus, there was virtually no cover for small mammals on areas where they would not have to swim. Sedges at the water edge showed signs of grazing by ungulates. Uplands consisted of short grasses and abundant forbs such as yarrow, dandelion and clover with much exposed bare ground. Three beaver were observed together in the pond and it appeared they had a den along the west bank of the pond in the roots of a large ponderosa pine snag.

McKinney Pond was sampled 17 to 19 August 2006 using a total of 520 trap-nights. A total of 100 traps (=200 trap-nights) were set in tall, dense, nearly monotypic sedge at the upper end of the pond and along the Rio Cebolla where it entered the pond. A total of 20 traps (40 trap-nights) were set in a small patch of tall, dense sedges, grass, and forbs along the dam near the pond edge. A total of 120 traps (240 trap-nights) were set below the dam. Of these, 80 (160 trap-nights) were set along the Rio Cebolla within 1 m of the stream and in small patches of sedges, around alder and gooseberry (*Ribes* sp.) bushes, and in short grass; 60 (120 trap-nights) were set in a small seep with moving water below the dam that was dominated by sedges.

No *Z. h. luteus* were captured. Diversity and abundance of riparian species was low and included only two species: the water shrew (*Sorex palustris*) and montane vole (*Microtus montanus*; Table 3). The exceptionally low density of montane voles reflected the absence of adequate terrestrial herbaceous cover. Further, deer mice (*Peromyscus maniculatus*) dominated the small mammal community and they reached their highest

abundance at this location. In well-developed, "healthy" montane riparian communities, deer mice are typically absent or at low abundance. In contrast, in degraded riparian systems, deer mice typically dominate the small mammal community, as was observed at McKinney Pond.

Adequate vegetation cover is a key habitat requirement for *Z. h. luteus* and other riparian small mammals. However, vertical cover along a 520 m reach of the Rio Cebolla below McKinney Pond dam was low. Average vertical cover 20 inches from the stream edge was only 14.3 inches (SD = 5.5; range = 4 – 23 inches), while average vertical cover 15 feet from the stream edge was but 9.0 inches (SD = 6.2; range = 1- 21; Fig. 1). To put these numbers into context, the average vertical cover at 40 *Z. h. luteus* captures sites during 2005 and 2006 was 42.1 inches and the lower bound of the 95% confidence interval was 38.0 inches (Frey 2006). Thus, all vertical cover measurements taken along the Rio Cebolla below McKinney Pond fell short of the minimal cover required by *Z. h. luteus* by at least 15 inches.

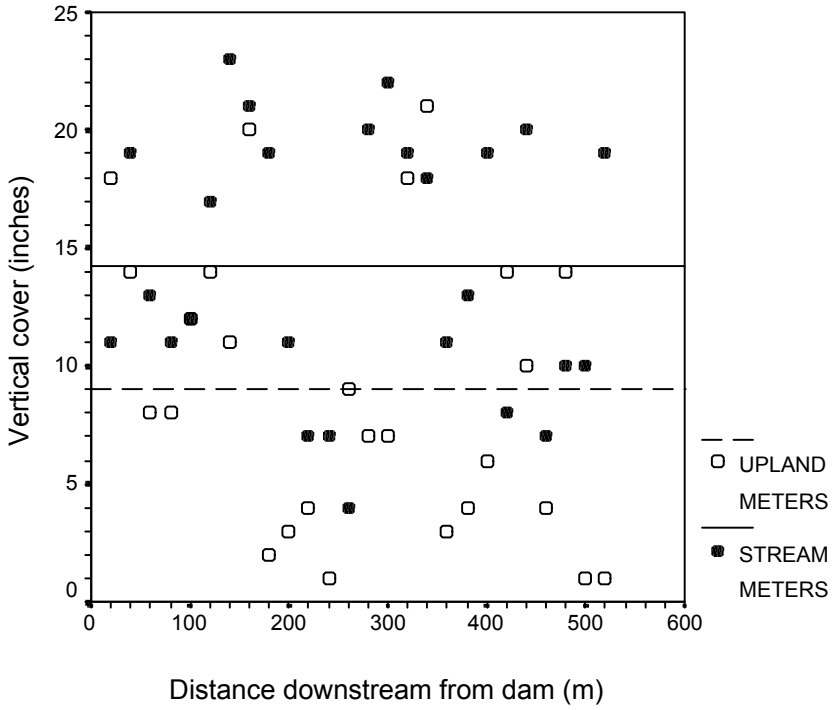

Figure 1. Vertical cover along the Rio Cebolla below the McKinney Pond dam. Solid points represent vertical cover measurements taken 20 inches from the stream edge and open circles represent vertical cover measurements taken 15 feet from the stream edge. The solid line represents the mean vertical cover 20 inches from the stream and the dashed line represents the mean vertical cover 15 feet from the stream edge.

Lower Rio Cebolla

The lower Rio Cebolla survey location was: "New Mexico: Sandoval Co.; Rio Cebolla, 0.6 miles (by Forest Road 376) southwest of Forest Road 376 bridge over Rio Cebolla, which is located at the junction of Lake Fork Canyon, 9.5 km N, 6.5 km W Jemez Springs, T19N, R2E, W ½ of NE ¼ Sec. 30". At the survey location, the Rio Cebolla flowed through a long, fairly broad valley. There was recent beaver activity that created a complex network of channels, ponds, marsh and wet meadow habitats. Riparian shrubs (willow and alder) were sparse and scattered and generally were large decadent individuals. Fairly tall, dense grasses and forbs dominated adjacent uplands. A herd of cattle was present in the valley.

The lower Rio Cebolla was sampled 14 to 15 August 2006 using a total of 280 trap-nights. Three trap lines were set at the upper end of the survey area: 1) 40 traps set in shin-deep standing water dominated by sedge; 2) 40 traps set along a main stream channel below a beaver dam on sodden mats of litter in vegetation dominated by sedges with some grasses; 3) 40 traps set along a main stream channel (ca 5 feet deep) dominated by sedge, grass and cutleaf coneflower (*Rudbeckia laciniata*). Five trap lines were set at the lower end of the survey area, 4) 40 traps were set in sedge and rush in shin-deep standing water; 5) 40 traps were set in sedge with saturated soils to shin-deep water; 6) 40 traps were set along a small channel edged with sedge and forbs of which 11 were set in the adjacent uplands in tall dense patches of iris, rush, and grass, 7) 25 traps were set in small patches of sedge and forb along a small channel and on the adjacent uplands under the edges of alder and gooseberry shrubs where herbaceous vegetation was protected from grazing; 8) 15 traps were set in area of saturated to shallow standing water dominated by patches of rush and bur marigold (*Bidens cernua*).

A total of 3 *Z. h. luteus* were captured. Two were captured at the upper end of the survey area. An adult male (field number = Z79; tissue number = FT613; capture location = N 35˚ 51.262, W 106˚ 45.829, 2,273 m elev.) was captured on trap line 3. It was captured ca 1.0 m from the main channel (ca 2 m wide and 1 m deep) in a tall, dense stand of sedge mixed with cutleaf coneflower and grasses. At the trap, soil moisture was 10; vertical cover averaged 36.3 inches; vertical stubble height was 122.5 cm, laid-over stubble height was 54.0 cm, and litter depth was 10 mm. An adult female (field number = Z80; tissue number = FT614; capture location = N 35˚ 51.176, W 106˚ 45.899, 2,269 m elev.) was captured on trap line 2. It was captured at the edge of the main channel just above a small beaver dam. The trap was set ca 20 cm from the stream edge in a large patch of tall, dense nearly monotypic sedge. There were adjacent small patches of cattail (*Typha latifolia*) and willow herb (*Epilobium ciliatum*). At the trap, soil moisture was 10; vertical cover averaged 29.3 inches; vertical stubble height was 104 cm; laid-over stubble height was 66.5 cm; and litter depth was 15 mm. At the lower end of the survey area, a subadult female (field number = Z78; tissue number = FT612; capture location = N 35˚ 51.116, W 106˚ 45.125, 2,278 m elev.) was captured on trap line 8. The trap was set 20 cm from the edge of a wide channel with slowly moving ankle-deep water that had bur marigold growing as an emergent. The trap was in a large patch of mixed species of rushes, diverse forbs including an emergent spreading watercress, mint, amaranth, willow herb, and some grass.

The small mammal community at the lower Rio Cebolla was notable for its very high diversity and high abundance of riparian small mammals (Table 3). Species diversity of riparian mammals was twice as high as at any other survey location. Further, there were no typically upland or disturbance species captured, including deer mice. The two most common species were the montane vole and meadow jumping mouse. The small mammal community included the long-tailed vole (*Microtus longicaudus*; trap lines 2 and 3) and ermine (*Mustela erminea*; trap line 7), which were not captured at any other survey location. No mammals were caught in trap lines 1 and 4, which were both areas of standing shin-deep water.

Lake Fork Canyon

Lake Fork Canyon forms a tributary drainage to the Rio Cebolla. Water apparently arose from various springs and the water was intermittent. Isolated and semi-isolated wetlands were present in broad valleys in the canyon. Three of these isolated wetlands, located 1.4, 1.8, and 2.4 miles (by Forest Road 376) above the junction with the Rio Cebolla, were sampled using a total of 560 trap-nights from 15 to 17 August 2006. There was considerable sign of cattle grazing throughout the area. Herbaceous vegetation was generally grazed short to the edge of the water, which created a sharp transition with the taller sedge dominated habitat in standing water. A herd of cattle was observed being rounded up during the survey. No *Z. h. luteus* were captured at Lake Fork Canyon.

The location of the lowest wetland was "New Mexico: Sandoval Co.; Lake Fork Canyon, 1.4 miles (by Forest Road 376) above the Forest Road 376 bridge over Rio Cebolla, which is located at the junction of Lake Fork Canyon, 10.1 km N, 3.9 km W Jemez Springs, T19N, R2E, middle of S ½ of SW ¼ Sec. 21, N 35˚ 51.514, W 106˚ 44.142, 2,376 m elev.". Running surface water was present in this valley for ca 0.3 miles before it disappeared just below a point where the valley narrowed and the surrounding ponderosa pine and mixed coniferous forest converged. The wetland was dominated by sedge but also included poison hemlock (*Conium maculatum*) and cattail. A total of 80 traps were set (=160 trap-nights) in 3 lines: 1) 27 traps set in an broad area of 2 – 8 inch deep standing water that was dominated by sedge and also including small patches of cattail and poison hemlock; 2) 13 traps set on an adjacent area of higher ground that was dominated by gooseberry bushes, cutleaf coneflower, and grass; 3) 40 traps set along the lower portion of the drainage where the water was confined to channel ca 3 inches deep and 6 to 8 feet wide and edged with tall sedge and some grass and forbs. All captures except 1 montane vole (captured on line 2) and the water shrew were on line 3. The only animal captured in the marsh on line 1 was a water shrew, which was captured at an old tree snag in the water.

The location of the middle wetland was "New Mexico: Sandoval Co.; Lake Fork Canyon, 1.8 miles (by Forest Road 376) above the Forest Road 376 bridge over Rio Cebolla, which is located at the junction of Lake Fork Canyon, 10.3 km N, 3.4 km W Jemez Springs, T19N, R2E, W ½ of SW ¼ Sec. 21, N 35˚ 51.645, W 106˚ 43.764, 2,380 m elev. ". This large wetland consisted of nearly monotypic beaked sedge with some small patches of cattail. The adjacent terrestrial habitat was dominated by relatively short grass, diverse forbs including occasional water hemlock (*Cicuta douglasii*), and some rush. In areas without standing water it was difficult to find herbaceous vegetation tall enough to

hide traps. A total of 120 traps (240 trap-nights) were set in 2 lines: 4) 60 traps (120 trap-nights) set along the north edge of the wetland westward from the GPS point, 5) 60 traps set in a broken meandering line along the north edge of the wetland and then southward across the wetland in generally shin deep water. The overall relative abundance and richness at this site was the lowest. The montane vole was the only species captured, and all were captured at the edge of the wetland generally in areas with some non-graminoid structure such as logs, boulders, and shrubs. No small mammals were captured in the standing water of the wetland.

The location of the upper wetland was "New Mexico: Sandoval Co.; Lake Fork Canyon, 2.4 miles (by Forest Road 376) above the Forest Road 376 bridge over Rio Cebolla, which is located at the junction of Lake Fork Canyon, 10.6 km N, 2.4 km W Jemez Springs, T19N, R2E, NW ¼ of SW ¼ Sec. 22, N 35˚ 51.810, W 106˚ 43.160, 2,406 m elev.". This site was a large wetland area located above the Fogan Canyon Corral. The wetland consisted of shin-deep water dominated by nearly monotypic sedges. As was observe at the other two wetland, the uplands were grazed and the upland meadow vegetation was relatively sparse and short, especially along the north side of the wetland along Forest Road 376. However, along the south side of the wetland the steep mountainside came into contact with wetland. This resulted in a number of large downed trees crossing the water's edge, which, together with the steep slopes, prevented cattle from grazing some areas. A total of 80 traps (160 trap-nights) were set in 2 lines: 6) 40 traps (80 trap-nights) set across the meadow in 1 to 8 inches of water, with 15 of those along the north edge of the wetland, 7) 40 traps (80 trap-nights) set in sedge along the south side of the wetland adjacent to the steep forested upland and often near downed logs. Overall species richness and abundance was relatively high at this site. However, the species composition included only 2 typically riparian species, the montane vole and the montane shrew (*Sorex monticolus*; more than one species of *Sorex* may have been captured during this study; additional study will be required to confirm identifications of these shrews). Surprisingly, the normally rare montane shrew was the most common species captured. All but 1 was captured on line 7. This concentration may have been due to the juxtaposition of both downed logs and mesic herbaceous habitat. The only animals captured on line 6 were 1 montane shrew and one montane vole. The disproportionately higher diversity and abundance of small mammals on lines 7 likely reflects the greater herbaceous cover and diversity of habitats.

Habitat

A total of 5 principal components were extracted, which together accounted for 72.2% of the variation in habitat among sites where *Z. h. luteus* was captured. Based on the scree plot criterion, the first 3 components were required to describe habitat, which accounted for 19.9%, 17.5%, and 15.2% of the variation respectively (cumulative variation explained = 52.6%).

Significant positive loadings on component 1 included: canopy cover, number of shrubs, forb ground cover, and vertical cover. The significant negative loading on component 1 was sedge ground cover. This component was interpreted as a wetland community type gradient of sites characterized as persistent emergent herbaceous wetland (i.e., sedge marsh) to sites characterized as scrub-shrub wetland (i.e., willow and alder

stands [see Muldavin et al. 2000 for a classification of wetland vegetation communities in New Mexico]). Willow and alder riparian zones have high canopy cover, vertical cover and forb cover.

On component 2, litter depth and grass ground cover were significant positive loadings; there were no significant negative loading. In order to interpret this component, correlations among variables were examined. Grass cover and litter depth were not correlated (r_s = -0.004, P = 0.978). The only significant correlate of grass cover was soil moisture, which was negative. Significant positive correlates of litter depth included vertical and laid-over stubble height. Unlike measures of vertical cover using the robel pole, stubble height pertains only to the height of herbaceous plants. In contrast, vertical cover may include any component of the local environment including trees, shrubs, and rocks. Significant negative correlates of litter depth included ground cover of rush, leafy equisetum, and shrubs, and the number of shrubs. Thus, this component can be interpreted as a gradient of sites with much tall grass and deep litter on relative dry soil to sites with little grass and little litter depth that may also be on relatively moist soil with much rush, equisetum or shrubs.

On component 3 number of shrubs, ground cover of willow and alder, and vertical cover were the significant positive loadings while forb ground cover was the significant negative loading. Both forb cover and number of shrubs were significantly negatively correlated with sedge cover. Thus, this component can be interpreted as a gradient of non-graminoid communities that varied from forb-dominated sites to shrub-dominated sites having relatively high cover of leafy equisetum.

A scatter plot of habitat points on components 1 and 2 revealed that most capture sites in the Jemez Mountains had negative scores on component 1 (Figure 2). This indicates that most capture locations in the Jemez Mountains during 2005 and 2006 have been associated with persistent emergent herbaceous wetland communities rather than scrub-shrub (i.e., willow/alder) wetlands. The extreme Jemez outliers with high positive scores on component 2 were two 2005 captures in the marsh above Fenton Lake, which was unique in being dominated ere in tall, dense reed canary grass (*Phalaris arundinaceae*). Captures along the lower Rio Cebolla during 2006 were within the range of variation for *Z. h. luteus*. However, two of these capture locations had extremely low values on component 2, indicating that they were in well-developed sedge wetland habitat.

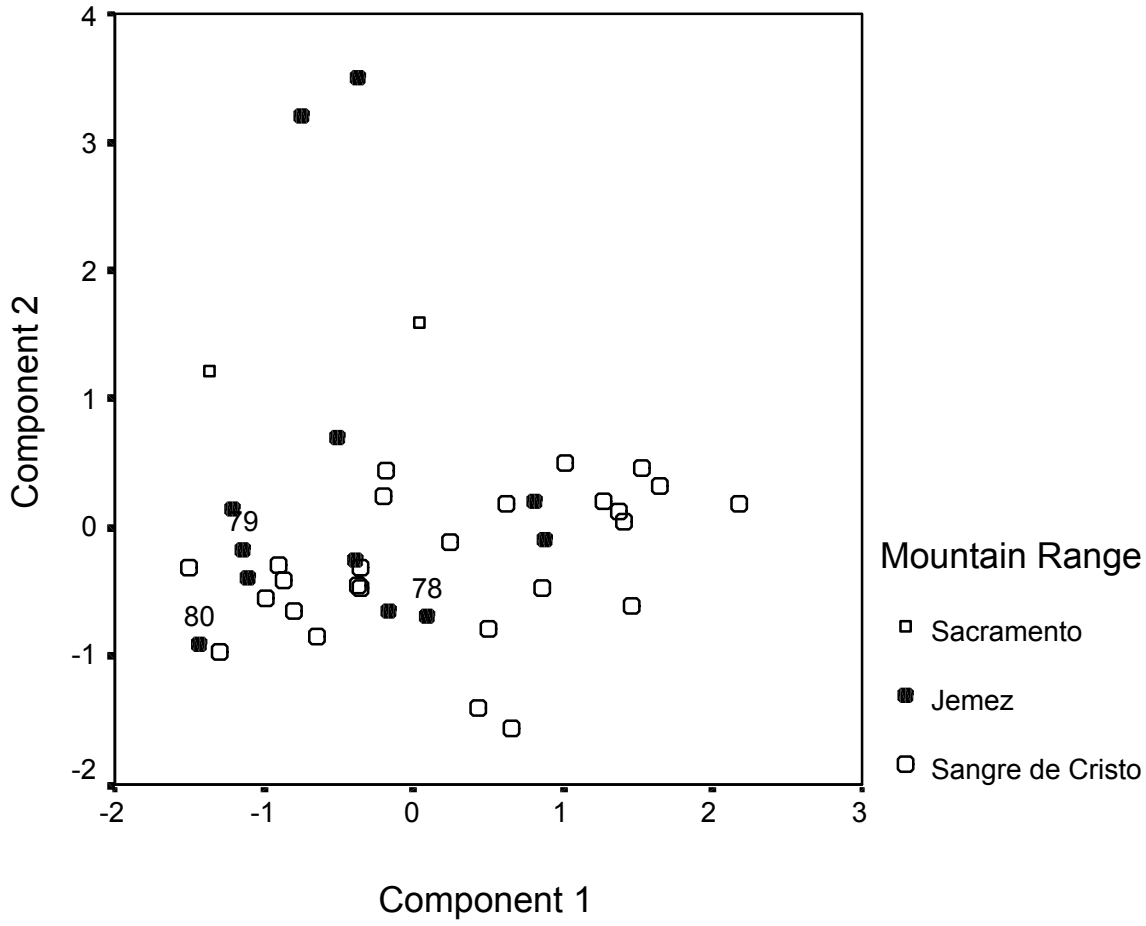

Figure 2. Scatter plot of habitat at all *Z. h. luteus* capture locations during surveys in New Mexico during 2005 and 206 based on principal components analysis. Capture sites of individual *Z. h. luteus* in the Jemez Ranger District during 2006 are indicated by their respective field numbers (i.e., Z78, Z79, Z80).

V. DISCUSSION

The capture of *Z. h. luteus* at the lower Rio Cebolla location was the first time during the extensive surveys of 2005 and 2006 (Frey 2005, 2006) that the species was captured in an area that was not protected from livestock grazing by fencing. Frey (2005) found that total exclusion of livestock was the single best predictor of the species' occurrence. However, Morrison occasionally captured *Z. h. luteus* at locations where livestock were present, including in the Jemez Mountains (Morrison 1985, 1988, 1989a, 1989b). Thus, on the surface the evidence suggests that *Z. h. luteus* can occur, at least briefly, in at least some areas with some level of livestock grazing. However, this does not necessarily imply that *Z. h. luteus* can persist in areas that are grazed, including even areas that are only lightly grazed. Definite conclusions about the relationship between livestock grazing and *Z. h. luteus* cannot be drawn at this time because of the paucity of data and because Morrison's observations were generally anecdotal and lacking in detail.

However, it is clear that *Z. h. luteus* has exceptionally specialized habitat requirements and that this habitat is especially prone to modification by livestock grazing. Frey (2005) found that *Z. h. luteus* is restricted to riparian wetland habitats with vertical plant cover, especially as provided by sedges, of at least 24 inches (mean vertical cover was 34 inches). Frey (2006) further found that while *Z. h. luteus* utilizes both willow/alder and persistent emergent (i.e., dominated by sedges or reed canary grass) wetland communities, in the scrub-shrub community type it uses herbaceous (usually sedge-dominated) microhabitats typically found as narrow stringers between the water's edge and the shrubs. Further, the expanded data set in Frey (2006), which included data from both 2005 and 2006, found that mean vertical cover at capture sites was even higher (i.e., 38 inches) than previously determined. These stringent cover requirements likely can only be met when wetlands are allowed to achieve their full potential of herbaceous growth. Grazing directly reduces this cover through consumption of plants and trampling.

Although cattle grazing was occurring at the lower Rio Cebolla location, there was no sign of ungulate grazing at the *Z. h. luteus* capture sites. Further, statistics indicated that habitat conditions at capture sites were similar to other locations where the species was captured and livestock were excluded. Reason for this was likely due to the extensive complex of channels, ponds, shallowly flooded areas, and other moist to wet habitats created by beaver at this location. At other wetlands with simpler aquatic structure, such as McKinney Pond and Lake Fork Canyon, grazing effects were starkly delimited at water's edge. Sedges and other plants were tall and ungrazed in standing water but on adjacent firmer ground were either absent or sparse and cropped low. Livestock are likely reticent to walk in areas with saturated soils due to potential for becoming bogged in the mud. Thus, even in the presence of some livestock grazing, extensive beaver activity may be able to maintain the habitat required by *Z. h. luteus*. This may not be the case in situations where grazing pressure is heavy or the situation forces animals to graze disproportionately in the riparian zone. Upland habitat at the Rio Cebolla was well developed and cattle were observed to graze both in uplands and the wetland edge.

The primary reason for the failure to capture *Z. h. luteus* and the depauperate riparian mammal communities at McKinney Pond and Lake Fork Canyon was likely due to the influence of cattle grazing. At both locations, tall, herbaceous vegetation was present

only in areas with deep (i.e., > 4 inches) standing water. Although *Z. h. luteus* readily takes to water and is a good swimmer, it (and other small mammals) has not been captured in large expanses of deep standing water, even if sedges and other tall plants are present to provide cover. The species is invariably captured either on saturated soils immediately adjacent to water or in very shallow (< 1 inch) standing water with interspersed mats of vegetation or other higher places that may be used for travel. Riparian small mammals need adequate herbaceous vegetation for cover in terrestrial areas that can use for movement, nesting, or burrowing. Grazing effects that extend to water's edge do not provided the required cover. Because livestock typically preferentially graze in riparian areas, adequate vegetation cover may become limited unless livestock grazing is severely restricted or entirely excluded, or beaver activity provides the complex of aquatic habitat that limits livestock access.

A diverse and abundant riparian small mammal community is a desirable management goal. Because many small mammals are habitat specialists, such communities indicate a healthy functioning system. Further, these communities can provide some of the highest animal biomasses found in any ecosystem. Such areas of concentrated animal biomass, especially of small mammals, are critical for maintaining terrestrial and avian predator populations. This is especially true for energetically demanding species such as ermine. It is no surprise that this species was captured in the same area as *Z. h. luteus*. Perhaps due to attention placed on willow flycatchers (*Empidonax traillii*) and other riparian birds as well as stream restoration for fishes, much of the recent focus on riparian restoration and management has been on woody species. The needs of small mammals require that the restoration and management of the herbaceous component of riparian systems also be considered.

VI. RECOMMENDATIONS

1. **Restoration of riparian habitat.—**Riparian habitat at McKinney Pond and Lake Fork Canyon should be restored. This is especially important for the entire upper Rio Cebolla pasture that includes McKinney Pond. Currently, *Z. h. luteus* is only known from 2 areas with the Jemez Mountains: 1) San Antonio Campground, which is in the Jemez River watershed, and 2) Rio Cebolla from Seven Springs Recreation Area downstream 7.5 miles to about 1 mile above Porter. Thus, the largest core area of occupied habitat is along the Rio Cebolla, although many areas of unsuitable habitat fragment this reach. Restoration of the upper Rio Cebolla pasture would dramatically expand the species' distribution, which would dramatically decrease the probability of extirpation of the Jemez Mountain population. The most rapid and successful means to restore this area is likely via the complete removal of livestock.

2. **Livestock grazing.—**Livestock grazing should be managed to allow for the full development of herbaceous wetlands that maintain an average vertical cover of 36 inches. This may only be possible by completely excluding cattle, which can be done through establishment of additional buck and pole fencing.

3. **Beaver.—**Habitat should be managed to encourage proliferation of beaver populations. A beaver management plan should be developed that focuses on the functional aspects of beaver presence in an ecosystem. Such a plan should consider maintaining an ecologically appropriate density of active beaver areas within each drainage that are spatially arranged to support a metapopulation of beaver and its co-associates such as jumping mice and ermine.

4. **Emergent wetland management.—**Attention and efforts should be placed on increasing the distribution and quality of emergent wetland habitats.

5. **Surveys.—**Additional surveys for *Z. h. luteus* should be conducted in the Jemez Ranger District. Other areas observed with potentially suitable habitat included: La Cueva Picnic Area, Sulphur/Redondo Creek, Calaveras Canyon, Seven Springs Recreation Area, Rio Cebolla below Seven Springs, Rio Cebolla below Fenton Lake State Park, lower Rio Cebolla above Porter Landing.

6. **Monitoring.—**Localities of record for *Z. h. luteus* should be periodically (i.e., at least every 3 years) monitored for habitat conditions and presence of the species following recommendations in Frey (2005).

7. **Grazing and beaver studies**.—Studies designed to investigate the effects of livestock grazing and beaver on jumping mice should be conducted. Such studies should examine the relationships among grazing strategies, beaver structures, wetland habitat structure, small mammal community structure, and the occurrence and key biological features (e.g., persistence, reproduction, movement) of *Z. h. luteus*.

VII. ACKNOWLEDGMENTS

Special thanks to Jo Wargo for facilitating this study. Thanks are given to Zachary Schwenke for field assistance, the New Mexico Department of Game and Fish for permits to survey for Zapus hudsonius, Richard Spellenberg for identification of bur marigold, and Pamela J. Reynolds for information about specimens in the NM Department of Health Zoonoses program.

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Table 1. Historical localities of record for *Zapus hudsonius luteus* in the Jemez Mountains, Sandoval Co., New Mexico. For records with associated voucher material, locality information is presented as recorded on specimen tags. Data in brackets are from Morrison (1985) for captures in 1985 and Morrison (1989) for captures in 1989 and include her descriptive location, elevation (in feet) and number of *Z. h. luteus* captured/number of trap-nights.

						Frey 2005				
Locality Number	Drainage	Ownership / Management	Locality	Specimen or Report	Date	Habitat data collected	Trap nights	Number *Zapus* captures	*Zapus* capture rate	Notes
J1	San Antonio Creek (Jemez River)	Valles Caldera	near base Redondo Peak	W. Whitford pers. comm	1970's	n	0	na	na	Possibly vicinity Redondo Creek; no specimen saved
J2	San Antonio Creek (Jemez River)	Santa Fe NF, Jemez RD	San Antonio Creek, T20N, R3E, Southcentral Sec 20 [San Antonio Creek, 8250; 2/30]	MSB 56991-56992	5-Sep-85	y	0	na	na	
J3	San Antonio Creek (Jemez River)	Santa Fe NF, Jemez RD	Jemez Mountains, San Antonio Creek, south end San Antonio Campground, 1.2 mi N, 0.5 mi W junction NM Hwy 4 and NM Hwy 126; T19N, R3E, NE1/4 of NW 1/4 of NW 1/4 Sec 17; N 35˚ 53.041, W 106˚ 38.865, 2,370 m	Frey 2005	28-Jun-05	y	210	1	0.48	
J4	Virgin Canyon (Guadalupe River)	Santa Fe NF, Jemez RD	Virgin Canyon, T18N, R2E [lower Virgin Canyon, below the old cabins near the spotted owl site; 1]	MSB 62096	2-Aug-89	y	118	0	0.00	
J7	Rio Cebolla	Santa Fe NF, Jemez RD	Rio Cebolla, T20N, R2E, Sec 24 near Hay Canyon [Rio Cebolla near Hay Canyon; 1]	MSB 62101	4-Aug-89	y	0	na	na	mapped ca 0.75 miles above Hay Canyon in vicinity of junction sectons 18, 19, 13, 24 in Morrison (1989)
J9a	Rio Cebolla	NMDGF	Seven Springs Fish Hatchery, T20N, R2E, NW 1/4 Sec 35 [Severn Springs Fish Hatchery, 7880; 2/97]	MSB 56993-56994	23, 27 Aug 85	y	160	2	1.25	

J10	Rio Cebolla	private	1 mi S Seven Springs Hatchery	Findley et al. 1975	17-Sep-69	n	0	na	na	Specimen at NM Department of Health Zoonoses program
J12	Rio Cebolla	NMDGF/State Parks	12.5 mi N Jemez Springs, Fenton Lake	MSB 41055	5-Aug-79	-	-	-	-	specimen missing
J12a	Rio Cebolla	NMDGF/State Parks	Fenton Lake, marsh e of lake, W of rt 126, T19N, R2E, SW 1/4 Sec. 10 [Fenton Lake, 7674; 10/445]	MSB 56979-56983	23, 27, 28-Aug-1985	y	150	2	1.33	
J12b	Rio Cebolla	NMDGF/State Parks	Fenton Lake - creek that runs into lake from South, T19N, R2E, NW 1/4 Sec 15 [included in previous entry J12a]	MSB 56984	27-Aug-85	y	80	1	1.25	
J13b	Rio Cebolla	Santa Fe NF, Jemez RD	Rio Cebolla at intersection of Rt 376 & lake fork creek, T19N, R2E, NE 1/4 Sec 30 [Rio Cebolla south of Fenton Lake, 7480; 1/55]	MSB 56985	30-Aug-85	y	208	2	0.96	Capture location in 1985 was south of Forst Road 376, capture location in 2005 was north of Forest Road 376
J14	Rio Cebolla	Santa Fe NF, Jemez RD	Jemez Mountains, Rio Cebolla, 1.7 N, 0.4 mi W jct Rio Cebolla and Rio de las Vacas; T19N, R1E, SE 1/4 of SE 1/4 Sec 25; N 35˚ 50.628, W 106˚ 46.888; 2,249 m	Frey 2005	4-Jul-05	y	69	1	1.45	
J15	Rio Cebolla	Santa Fe NF, Jemez RD	Rio Cebolla, T19N, R1E, 1 mi up from Rio de las Vacas [Rio Cebolla about 1 mile above the junction of FR 376 and 539; 2]	MSB 62097-62098	24-Aug-89	y	240	0	0.00	
J18b	Rio de las Vacas	Santa Fe NF, Cuba RD	Rito Penas Negras, T20N, R2E NE 1/4 Sec 3 [Rito Penas Negras at pipe-line road, 8360; 5/90]	MSB 56987-56990	5-6-Sep-1985	y	220	0	0.00	
J19	Rio de las Vacas	Santa Fe NF, Cuba RD	17 km SE Cuba, T20N, R1E, S 12, elev 2600 m	MSB 67525	12-Jul-85	y	100	0	0.00	in MSB as *Z. princeps*
J20	Rio de las Vacas	Santa Fe NF, Cuba RD	Rito Penas Negras, T20N, R1E, Sec 13, int. Rio de las Vacas [Rito Penas Negras at the junction of FR 126; 1]	MSB 62102	3-Aug-89	y	0	na	na	
J21	Rio de las Vacas	Santa Fe NF, Cuba RD	Rio de las Vacas x Turkey Creek, T20N, R1E Westcentral Sect 25 [Rio de Las Vacas, 7889; 1/23]	MSB 56986	6-Sep-85	y	100	0	0.00	
-	unknown	unknown	unknown	MSB 56995-56997	unknown	-	-	-	-	collected by JL Morrison; likely Fenton Lake and/or Rito Penas Negras in 1985

Table 2. Localities where *Zapus hudsonius luteus* was not captured during surveys in the Jemez Mountains, Sandoval Co., New Mexico.

Locality Number	Drainage	Locality	Trap-nights	Date	Reference	Trap type and bait	Notes
	Rio Cebolla	Calaveras Creek, 8,150 ft	44	21-23 Aug. 1985	Morrison 1985	presumably snap-traps	
	Rio Cebolla	Rio Cebolla at Barley Canyon, 7,680 ft	45	22-23, 26-28 Aug. 1985	Morrison 1985	presumably snap-traps	
	Rio Cebolla	Rio Cebolla south of Fenton Lake, 7,800 ft	15	29-30 Aug. 1985	Morrison 1985	presumably snap-traps	mapped in Lake Fork Canyon, T19N, R2E, NE 1/4 of NW 1/4 sec 29
J6	Rio Cebolla	Rio Cebolla at pipe-line road, 8,500 ft	90	4-6 Sep. 1985	Morrison 1985	presumably snap-traps	no habitat in 2005
	Rio de las Vacas	Rito Penas Negras off 103, 8,080 ft	35	5-6 Sep. 1985	Morrison 1985	presumably snap-traps	no habitat in 2005
	San Antonio Creek (Jemez River)	La Cueva, 7,680 ft	148	10-13 Sep. 1985	Morrison 1985	presumably snap-traps	mapped ca 0.75 miles NE La Cueva at junction Sulphur and Redondo creeks, T19N, R3E, jct secs 16 and 17
	Rio Grande	Los Alamos (Bayo Canyon), 6,300 ft	160	16-18 Sep. 1985	Morrison 1985	presumably snap-traps	
	Jemez River	East Fork of Jemez River below Las Conchas Campground	189	early Sep.	Morrison 1987	snap-traps; cracked oats and wheat bait	no habitat in 2005
J8	Rio Cebolla	Rio Cebolla about 1 mile above the Seven Springs Fish Hatchery	?	14 Jul - 1 Sep 1989	Morrison 1989	Museum special snap-traps; oats bait	
	Rio de las Vacas	Rio de las Vacas about 1/2 mile above the junction of FR 376 and 539	90	14 Jul - 1 Sep 1989	Morrison 1989	Museum special snap-traps; oats bait	no habitat in 2005
	Rio de las Vacas	Rio de las Vacas about 1 mile south of the Girl Scout Camp	93	14 Jul - 1 Sep 1989	Morrison 1989	Museum special snap-traps; oats bait	no habitat in 2005

	Rio Guadalupe	a wet meadow along the Rio Guadalupe about 3 miles above the Gilman tunnels	75	14 Jul - 1 Sep 1989	Morrison 1989	Museum special snap-traps; oats bait	
	Rio de las Vacas	Bales Canyon in the vicinity of Rito de la Cueva Spring	93	14 Jul - 1 Sep 1989	Morrison 1989	Museum special snap-traps; oats bait	no habitat in 2005
J4	Virgin Canyon (Guadalupe River)	Jemez Mountains, Virgin Canyon, 6.0 mi (by roads FS Rd 607 and FS Rd 938F) SW jct FS Rd 604 and FS Rd 607, ca 3 mi N, 1.5 mi W Jemez Springs; T18N, R2E, NE 1/4 Sec 10; 2,317 m	118	4-5 Jul 05	Frey 2005	Sherman live-traps; sweet feed bait	
J5	Canon Cebollita (Guadalupe River	Jemez Mountains, Cebollita Spring, head of Canon Cebollita, 4.5 mi N, 1.75 mi W Jemez Springs; T19N, R2E, SE 1/4 Sec 33; 2,473 m	79	4-5 Jul 05	Frey 2005	Sherman live-traps; sweet feed bait	
J6	Rio Cebolla	Jemez Mountains, Rio Cebolla above jct Twin Cabin Canyon, 15.5 mi N, 2.75 mi E Jemez Springs; T20N, R3E, NE 1/4, SW 1/4 Sec 5; 2,584 m	0	2-Jul-05	Frey 2005	Habitat analysis	
J7	Rio Cebolla	Jemez Mountains, Rio Cebolla above jct Hay Canyon, 12.5 mi N, 1.0 mi E Jemez Springs; T20N, R2E, SW 1/4 of NE 1/4 of SE 1/4 Sec 24; 2,473	0	11-Aug-05	Frey 2005	Habitat analysis	
J8	Rio Cebolla	Jemez Mountains, Rio Cebolla, 1.25 mi ENE Seven Springs State Fish Hatchery; T20N, R2E, NW 1/4 of SW 1/4 Sec 25; 2,455 m	170	29 Jun - 1 Jul 05	Frey 2005	Sherman live-traps; sweet feed bait	
J11	Rio Cebolla	Jemez Mountains, Barley Canyon, 0.5 mi W jct Rio Cebolla, 8.5 mi N, 1.25 mi W Jemez Springs; T19N, R2E, NW 1/4 of SE 1/4 Sec 10; 2,252 m	180	28 Jun -1 Jul 05	Frey 2005	Sherman live-traps; sweet feed bait	
J15	Rio Cebolla	Jemez Mountains, Rio Cebolla, 1.0 mi N Porter (= jct Rio Cebolla and Rio de las Vacas); T19N, R1E, center of Sec 36; 2,224 m	240	10-11 Aug 05	Frey 2005	Sherman live-traps; sweet feed bait	

J16	Rio de las Vacas	Jemez Mountains, beaver ponds on tributary to Rito Cafe that heads on Mining Mountain, E in hairpin turn on FS Rd 70, 18.25 mi N, 2.0 mi W Jemez Springs; T21N, R2E, SE 1/4 of SE 1/4 Sec 21; 2,739	0	3-Jul-05	Frey 2005	Habitat analysis
J17	Rio de las Vacas	Jemez Mountains, pond on headwaters Rito Penas Negras, W of FS Rd 103, 17.5 mi N, 0.5 mi W Jemez Springs; T21N, R2E, SW 1/4 of NW 1/4 Sec 26; 2,662	69	2-3 Jul 05	Frey 2005	Sherman live-traps; sweet feed bait
J18a	Rio de las Vacas	Jemez Mountains, Rito Penas Negras above FS Rd 527 crossing, 16.25 mi N, 1.0 mi W Jemez Springs; T21N, R2E, SW 1/4 of SE 1/4 of SE 1/4 Sec 34; 2,572	140	1-3 Jul 05	Frey 2005	Sherman live-traps; sweet feed bait
J18b	Rio de las Vacas	Jemez Mountains, Rito Penas Negras below FS Rd 527 crossing, 16.0 mi N, 1.0 mi W Jemez Springs; T20N, R2E, NW 1/4 of NE 1/4 of NE 1/4 Sec 3; 2,557 m	80	1-2 Jul 05	Frey 2005	Sherman live-traps; sweet feed bait
J19	Rio de las Vacas	Jemez Mountains, Rio de las Vacas above jct Burned Canyon; T20N, R1E, NW 1/4 of SW 1/4 Sec 12; 2,471 m	100	11-12 Aug 05	Frey 2005	Sherman live-traps; sweet feed bait
J20	Rio de las Vacas	Jemez Mountains, mouth of Rito Penas Negras at NM Hwy 126 crossing, 13.75 mi N, 5.5 mi W Jemez Springs; T20N, R1E, NE 1/4 of SE 1/4 of NW 1/4 Sec 13; 2,434 m	0	1-Jul-05	Frey 2005	Habitat analysis
J21	Rio de las Vacas	Jemez Mountains, Rio de las Vacas at jct Turkey Creek; T20N, R1E, NW1/4 of SW 1/4 Sec 25; 2,400 m	100	11-12 Aug 05	Frey 2005	Sherman live-traps; sweet feed bait
J22	Rio de las Vacas	Jemez Mountains, Trail Creek, 1.25 mi above jct with Rio de las Vacas, 7.5 mi W, 10.25 mi N Jemez Springs; T20N, R1E, NE 1/4 of SW 1/4 Sec 34; 2,469	0	1-Jul-05	Frey 2005	Habitat analysis

Table 3. Relative abundance (%) of small mammals captured in the Jemez Ranger District during August 2006.

		Riparian Species[1]						Non-riparian Species[1]					
Location	trap-nights	ZAHU	MILO	MIMO	SOMO	SOPA	MUER	NEME	PEMA	PENA	Overall Abundance	Overall Richness	Riparian Species Richness
McKinney Pond	520	0	0	0.4	0	0.6	0	0	3.1	0	4.0	3	2
lower Rio Cebolla	280	1.1	0.7	1.4	0.4	0.7	0.4	0	0	0	4.6	6	6
1.4 mi up Lake Fork Canyon	160	0	0	3.1	0.6	0.6	0	0	0	0.6	5.0	4	3
1.8 mi up Lake Fork Canyon	240	0	0	2.9	0	0	0	0	0	0	2.9	1	1
2.4 mi up Lake Fork Canyon	160	0	0	1.3	3.1	0	0	0.6	2.5	0	7.5	4	2

1*Zapus hudsonius* (ZAHU), *Microtus longicaudus* (MILO), *Microtus montanus* (MIMO), *Neotoma mexicana* (NEME), *Peromyscus maniculatus* (PEMA), *Peromyscus nasutus* (PENA), *Sorex monticolus* (SOMO), *Sorex palustris* (SOPA); *Mustela erminea* (MUER).