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ASSOCIATIONS OF SMALL MAMMALS OCCURRING IN A PLUVIAL LAKE BASIN, RUBY LAKE, NEVADA

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ABSTRACT.—Ruby Lake is a highly mesic and vegetationally diverse pluvial lake basin of east central Nevada. Small mammal associations were examined in six plant communities at Ruby Lake using transects of live traps. Small mammal activity was recorded for these six habitats plus an additional three other specialized habitats. A total of 11 species of small mammals were trapped from the six habitat types; from the entire study area 26 species were trapped or observed. Two greasewood shrub habitats and a shadscale–spiny hopsage habitat held the highest number of trapped species, 6, 5, and 7, respectively. The mesic haymeadow and spring habitats, as well as the big sagebrush–antelope bitterbrush habitat held 4 trapped species each. *Peromyscus maniculatus* and *Perognathus parvus* made up 76% of the total captures and were found in all habitat types except marshlands. *Eutamias minimus* was found in four of the six habitat types, while *Dipodomys ordii*, *Dipodomys microps*, *Perognathus parvus*, and *Microtus montanus* were limited to specialized habitats. Mesic adapted, wetland species such as *Mustela vison*, *Ondatra zibethicus*, and *Sorex vagrans* possibly dispersed into Ruby Valley from the northeastern drainages and valleys during the late Pleistocene or Holocene.

Analyses of small mammal communities in the Great Basin have added much to our knowledge of their ecology and biogeographical distributions (Hall 1946, Borrell and Ellis 1934, O'Farrell 1974). The majority of these studies have been concentrated in the more mesic, isolated mountain ranges in plant communities above 2,100 m (Brown 1978). Such research has shown that apparent relictal populations occur isolated on various mountain ranges, analogous to populations on oceanic islands, with little chance of restoring such gene pools by immigration (Brown 1978).

It has been only in recent years that the shrub steppe desert of the valley floors and pluvial lake basins has received attention. Only minor differences in species composition and abundances of small mammals have been shown to occur between the eastern and western halves of the Great Basin. The western and southern deserts are characterized by a transitional zone of desert shrubs such as *Artemisia*, *Sarcobatus*, *Atriplex*, *Larrea*, and *Chenopodium*. The small mammal communities of the Mojave and southern Great Basin deserts are dominated by such heteromyids as *Dipodomys merriami*, *D. microps*, *Perognathus longimembris*, and *P. formosus*. As one moves north and east, the plant communities lose their Mojave Desert affinities, and the small mammal composition of lower elevation communities is dominated by two species, *Peromyscus maniculatus* and *Perognathus parvus* (Durrant 1953, O'Farrell and Clark 1986, Jorgensen and Hayward 1965).

The 53 defined pluvial lake basins of central and eastern Nevada provide an environment for several plant communities that have been progressively adapting to a drier, cooler climate and more alkaline soils since the end of the Pleistocene (Mifflin and Wheat 1976). Lying within the rain shadow of the Sierra Nevada and in the rain shadow of an adjacent mountain range, the pluvial basins today are characterized by low atmospheric precipitation, no external runoff, and limited inflow from a yearly snowmelt that varies from year to year (Mifflin and Wheat 1976). Evaporation of once extensive lake waters left behind high concentrations of saline deposits and thus exposed new habitat and soils for the rapidly evolving phraeophytic shrubs of the genera *Sarcobatus* and *Atriplex* (Young et al. 1986).

While several studies have described the small mammal communities of valley floors dominated by *Artemisia tridentata* (O'Farrell 1974), few have concentrated on the phraeophytic plant communities around pluvial lake basins (Jorgensen and Hayward 1965, Young and Evans 1974). Durrant (1952) and Hall (1946) list several species collected from various localities representing pluvial lake basins in the Great Basin.

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Our purpose here is to describe associations among small mammals within six plant communities surrounding the perennial Lake Ruby, the southern remnant of pluvial Lake Franklin, in northeastern Nevada. We will also compare these small mammal associations with small mammal communities existing in other pluvial lake basins within the Great Basin and possible routes of late Pleistocene or Holocene dispersal.

METHODS AND STUDY AREA

This study was conducted in Ruby Valley, southern Elko County, on the southeastern flank of the Ruby Mountains, Nevada, latitude 40°07′30″ and longitude 115°30′00″. During the late Pleistocene, Ruby Valley, approximately 3,662 sq km, held a large pluvial lake covering some 628 sq km and had estimated depths of 60 m (Mifflin and Wheat 1979). Climatic changes over the last 500,000 years caused this large body of water to recede to its present-day level at an elevation of 1,860 m, resulting in a large seasonal lake and playa near the center of the valley. Today this remnant is called Franklin Lake (USFWS 1987). The northern half of the valley probably had some inflow of water from pluvial Clover Lake to the northeast (Mifflin and Wheat 1979). Today this end of the valley consists of big sagebrush and rabbitbrush (*Chrysothamnus* spp.) uplands, and lower-elevation hay meadows and greasewood (*Sarcobatus* sp.) shrublands.

The southern end of the valley is under the jurisdiction of the Fish and Wildlife Service, U.S. Department of the Interior. In this locality over 200 perennial carbonic rock springs, coming from the eastern flank of the Ruby Mountains, provide a relatively constant source of water for the 15,053-ha Ruby Lake National Wildlife Refuge (USFWS 1987). The perennial springs provide a water source that sustains some unique and diversified plant communities that are very mesic when compared to other pluvial lakes of the region (Mifflin and Wheat 1979).

Delineation of six habitat types was determined by the dominant plant species and comparison with plant communities described for other pluvial lake basins in Nevada (Young et al. 1986). Of the 15,053 ha of refuge, approximately 32% consists of a series of managed wetlands, dikes, and collection ditches used for both fishing and waterfowl production (USFWS 1987). This habitat was not quantitatively sampled due to its aquatic nature; however, observations of mammal use and mammal sign were recorded. All plant names were based on Cronquist et al. (1977) and Johnson et al. (1981). The following habitat types were all sampled for small mammals using quantitative techniques.

HABITAT 1.—A mixed plant community of black greasewood (*Sarcobatus vermiculatus*), big sagebrush (*Artemisia tridentata*), and rubber rabbitbrush (*Chrysothamnus nauseosus*) occupies approximately 10% of the refuge in a belt extending from the southern tip, proceeding north on the east side of the refuge, and terminating near the north end. The understory plants of this habitat are sparse but diverse, including Sandberg's bluegrass (*Poa sandbergii*) and long-leaved phlox (*Phlox longifolia*). A subunit of this habitat included a series of stabilized sand dunes with black greasewood clones on the top of the dune and big sagebrush around the perimeter. Other plants characteristic of the dunes include Indian ricegrass (*Oryzopsis hymenoides*), needle and thread grass (*Stipa comata*), and Hooker's evening primrose (*Oenothera hookeri*). The stabilized dunes make up only 1% of the refuge area, while on other pluvial lake basins in Nevada they are a much more prominent land form (Young et al. 1986).

HABITAT 2.—As one moves closer to the center of the lake from Habitat 1, the soils become noticeably more alkaline and the plant community changes. The dominant shrubs here include black greasewood, shadscale (*Atriplex confertifolia*), alkali rabbitbrush (*Chrysothamnus albidus*), and rubber rabbitbrush. Understory plants are dense but low in diversity. These include salt grass (*Distichlis spicata*), Great Basin wildrye (*Elymus cinerus*), alkali bulrush (*Scirpus paludosus*), and western seepweed (*Suaeda occidentalis*), all of which are salt-tolerant species (Young et al. 1986).

HABITAT 3.—Due to the concentration of springs on the west side of the refuge, the majority of the mesic hay meadows and seasonally wet wire rush meadows are found directly below the slopes of the Ruby Mountains. This habitat is extremely dense and

varies in height from 10 cm to 1 m. The dominant vegetation in these meadows consists of Baltic wirerush (*Juncus balticus*), sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), and grasses of the genera *Festuca*, *Hordeum*, and *Agrostis*. Seasonal grazing and mowing for hay is done in these habitats after waterfowl nesting season is over in July (USFWS 1987). This habitat makes up 10% of the total refuge area.

HABITAT 4.—The 200 springs and their drainages make up only 4% of the refuge area but are an extremely important habitat for many mammals. Not only is there a dense growth of *Juncus* and *Scirpus* in such areas but also many mesic shrubs, such as Scouler's willow (*Salix scoueriana*), Wood's rose (*Rosa woodsii*), and golden currant (*Ribes aureum*). The forb and grass species around these springs are very diverse and are usually part of an ecotone area bordered by big sagebrush or hay meadows.

HABITAT 5.—Alluvial fans coming from the eastern slopes of the Ruby Mountains at elevations between 1,800 and 2,100 m constitute 22% of the refuge. The co-dominant shrubs of the community include big sagebrush, antelope bitterbrush (*Purshia tridentata*), western serviceberry (*Amelanchier alnifolia*), and green rabbitbrush (*Chrysothamnus viscidiflorus*). The introduced cheatgrass *Bromus tectorium*, found in many of the high-valley shrub communities, is the dominant grass along with such bunchgrasses as bottlebrush squirreltail (*Sitanion hystrix*) and Indian ricegrass. A very diverse forb component is found here with such dominants as long-leaved phlox, *Aster* spp., scarlet gilia (*Ipomopsis* spp.), and western yarrow (*Achillea millefolium*). This plant community is found primarily on the west side of the refuge as well as the northern and southern ends.

HABITAT 6.—This plant community is characterized by low-growing shrubs with much bare, gravelly ground. It is confined to the eastern side of the refuge situated on the broad alluvial fans coming from the Maverick Springs hills. It is just above Habitat 1 in elevation on the eastern side and makes up 16% of the refuge area. A very dry area, this habitat is dominated by shadscale, spiny hopsage (*Grayia spinescans*), and dwarf sagebrush (*Artemisia arbuscula*). Grasses and forbs are scarce in this area, those seen most often including bottlebrush squirreltail and peppergrass (*Lepidium lasiocarpum*).

This study was conducted during the periods of June–September 1986 and April–October 1987. Its major goal was a general inventory of all small mammals inhabiting the principal habitat types on the refuge. This information was used in the compilation of a wildlife checklist (USFWS 1987).

Several data-collecting techniques were used and all possible habitat types were inventoried in compiling this general inventory. For the previously described six habitat types, a total of 100 Sherman live traps were used for a total of 2,050 trap nights. In each habitat the live traps were placed in two parallel transects of 50 stations each. Single traps were placed 15 paces apart and baited with rolled oats. Each habitat type was trapped at least three consecutive nights. Also used on selected habitats were 15 Tomahawk live traps for squirrels and rabbits and 40 pitfall traps for shrews. Mist nets were utilized on five separate occasions to capture, identify, and release species of bats. All observations of mammals seen or signs of mammals, tracks, and scats were recorded as to species and habitat.

For each animal captured on the trap lines, the sex, age, and reproductive condition were recorded. The majority of the animals were released after identification. Those that died in the traps were preserved and are now housed in the museum of NNCC. Data collected here were analyzed by species, number of captures for each species, and number of captures per 100 trap nights. The relative frequency was calculated for each species in each of the six habitats, and the total number of species captured or observed was tabulated according to habitat. Relative frequency is the number of individuals captured per species divided by the total individual captures of all species, multiplied by 100.

RESULTS

A total of 11 species of small mammals were sampled from the six habitat types in which trap lines were used. The composition of small mammal communities and the relative frequency of each species differed among habitat types (Table 1).

TABLE 1. Small mammals trapped along transects from six habitat types on the Ruby Lake National Wildlife Refuge. C = total captures during period June–September 1986 and April–October 1987. C/T = captures per 100 trap nights. RF = relative frequencies of captures within each habitat type.

	Habitat 1			Habitat 2			Habitat 3			Habitat 4			Habitat 5			Habitat 6		
	C	C/T	RF%	C	C/T	RF%	C	C/T	RF%	C	C/T	RF%	C	C/T	RF%	C	C/T	RF%
Peromyscus maniculatus	75	23	67	98	46	86	29	6	37	48	16	84	60	11	32	1	0.6	1
Eutamias minimus	7	2.2	6	6	2.8	5							14	2.5	7	1	0.6	1
Dipodomys ordii	19	6	17										5	1.0	2	1	0.6	1
Dipodomys microps	8	2.5	7													28	19	33
Microdipodops megacephalus	2	0.6	2															
Perognathus parvus	1	0.3	1	8	3.8	6	1	0.2	1	3	1	5	110	20	59	49	33	57
Perognathus longimembris																5	3.3	6
Reithrodontomys megalotis				2	1.0	2												
Microtus montanus							36	7.4	46	5	1.7	9						
Sorex vagrans				1	0.5	1	12	2.5	16	1	0.3	2						
Onychomys leucogaster																1	0.6	1
Totals	112	34.6		114	54.3		78	16.1		57	19		186	33.5		86	57.1	
Number of species	6			5			4			4			4			7		

Peromyscus maniculatus and *Perognathus parvus* made up 76% of the total captures within the six habitat types. These two species occurred in all six habitat types, with *P. maniculatus* being most common in Habitat 1 (greasewood and big sagebrush); the smallest number of captures was in Habitat 6 (shadscale and spiny hopsage). *Perognathus parvus* occurred in the largest numbers and in approximately equal frequencies in Habitat 5 (big sagebrush and antelope bitterbrush) and Habitat 6 (shadscale, spiny hopsage, and dwarf sagebrush), while in all other habitats this species was represented in very small numbers (Table 1).

Other habitats that contained species in relatively large numbers were specialized habitats tending toward mesic conditions (*Microtus montanus* and *Sorex vagrans* in Habitat 3), sand dunes and sandy soils (*Dipodomys ordii* in Habitat 1), and dry habitats with low-statured shrubs (*Dipodomys microps* in Habitat 6) (Table 1).

Our data, based on species composition among the six habitat types, indicate that Habitats 3 (hay meadows) and 4 (springs) were identical in the species of small mammals present. In addition, both had the lowest number of captures of all the habitat types (Table 1). The greasewood–big sagebrush habitat (1) and the big sagebrush–antelope bitterbrush habitat (5) were also similar because of the presence of species that find both greasewood and big sagebrush suitable habitats. Habitat 1 is enriched with the addition of two heteromyids, *Dipodomys microps* and *Microdipodops megacephalus*, not present in Habitat 5 (Table 1).

The remaining habitats, 6 and 2, were dissimilar in species composition with those described above. Habitat 6 had the highest number of species (seven) with two, *P. parvus* and *D. microps*, making up 90% of the total captures. Habitat 2 (greasewood and grass), although similar in vegetational structure to Habitat 1, lacked three of the heteromyid species and contained two specialized species, *Reithrodontomys megalotis* and *Sorex vagrans*. *Dipodomys ordii* did occur on the periphery of this habitat in a specialized habitat of sandy soils and rubber rabbitbrush, as suggested by kangaroo rat tracks found on the road each day. None were captured on the transect, however.

Besides *P. maniculatus* and *P. parvus*, three other species of mammals proved to be almost as ubiquitous on the refuge. *Eutamius minimus* was most common in the big sagebrush–antelope bitterbrush habitat but was also present in Habitats 1, 2, and 6. *Dipodomys ordii* preferred any habitat containing sandy soils, which included the sand dunes of Habitat 1 and the roadsides of Habitats 5 and 6. Finally, *Sorex vagrans*, an inhabitant of mesic hay meadows (Habitat 3) and springs (Habitat 4), also occurred in the much drier habitat of greasewood and grass (Habitat 2) (Table 1).

TABLE 2. Small mammals trapped or observed on the Ruby Lake National Wildlife Refuge and associated plant communities, 1986–1987.

Species	Habitat 1	2	3	4	5	6	Marsh-lands	Cliff sites	Home-steads
Sorex vagrans		x	x	x					
Myotis evotis								x	x
Myotis leibii								x	x
Mustela frenata			x	x					
Mustela vison				x			x		
Taxidea taxus	x				x			x	
Lepus californicus	x	x			x				
Sylvilagus nuttelli				x	x			x	x
Sylvilagus idahoensis	x				x				
Eutamius minimus	x	x			x	x		x	x
Spermophilus lateralis								x	x
Spermophilus townsendii				x	x				
Spermophilus beldingi				x	x				
Thymomys talpoides		x	x	x		x			
Dipodomys ordii	x				x	x			
Dipodomys microps	x					x			
Microdipodops megacephalus	x								
Perognathus parvus	x	x	x	x	x	x		x	
Perognathus longimembris						x			
Peromyscus maniculatus	x	x	x	x	x	x		x	x
Reithrodontomys megalotis		x							
Onychomys leucogaster						x			
Neotoma cinereus								x	x
Microtus montanus			x	x			x		
Ondatra zibethicus							x		
Total species	9	7	6	10	10	8	3	9	7

Although information on sex, reproductive status, and age by pelage was recorded for most individual captures, only data for *P. maniculatus* and *P. parvus* proved significant enough for comparison within Habitats 1, 2, and 5.

Table 2 shows the occurrence of all 25 mammal species trapped or observed during the study period. Included are the six habitat types used in Table 1 as well as three others where trap lines were not used. These three habitats include the large cattail (*Typha* sp.) and bulrush (*Scirpus* sp.) marsh, cliff sites and carbonaceous rock caves around the periphery of the refuge, and homestead that includes the refuge headquarters and Gallegher Fish Hatchery (USFWS 1987). Two common species of bats in the area include a bachelor roost of *Myotis evotis* and *Myotis leibii* from the Cave Creek grotto and a series of lactating females from the Maverick Springs area. Small carnivores captured or observed are listed according to habitat (Table 2). These include *Mustela frenata*, *Mustela vison*, *Canis latrans*, and *Taxidea taxus*. Ground squirrel species were limited to colonies and to a short season of activity in both years. These species include *Spermophilus townsendii*, *S. beldingii*, and *S. lateralis*. Leporids included *Lepus californicus*, *Sylvilagus nutellii*, and *S. idahoensis* (Table 2). The pygmy rabbit was closely associated with stands of big sagebrush around the periphery of the sand dunes in Habitat 1, while Nuttell's cottontail occurred in dense cover along sagebrush roadsides, cliff sites, and homesteads. Large rodents that can be considered habitat specialists include *Ondatra zibethica* in the marsh lands, *Neotoma cinerea* in cliff sites and homesteads, and *Thomomys talpoides* in Habitats 2, 3, and 4 (Table 2).

DISCUSSION

Ruby Lake has been shown to have a large number of diverse plant communities and to be one of the most perennial and mesic of the pluvial lake basins still existing in Nevada today (USFWS 1987). Mifflin and Wheat (1979) suggest that the flora and hydrologic makeup of Ruby Lake as seen today may be reminiscent of what the drier pluvial lakes of west

central Nevada looked like during the more mesic late Pleistocene era. This may account for the similarities in small mammal communities seen at Ruby Lake, as compared to the Carson Sink basin in western Nevada (Hall 1946) and the Mono Lake basin of California (Harris 1982).

Both of these pluvial lakes are much drier and contain more seasonal, ephemeral wetlands. The only major difference between these pluvial lakes and the western Great Basin desert in general (Kenagy 1973, Jorgensen and Hayward 1965) is that the small mammal communities are dominated by four to five species of heteromyid rodents, whereas the more eastern pluvial lake mammal communities are dominated by only two species, *P. maniculatus* and *P. parvus*, both adapted to a wide range of habitats but less frequent in hot desert environments (O'Farrell 1974).

River valleys and Pleistocene lake connections allowed easy dispersal routes for wetland- and shrubland-adapted mammals (Hall 1946). This would account for the many similarities in species composition between pluvial lake basins in the Great Basin. While we recorded 24 species of small mammals at Ruby Lake, Young and Evans (1980) list 22 species for pluvial Lake Gilbert in Grass Valley of central Nevada, Hall (1946, 1981) lists 24 species for the Carson Sink desert of western Nevada, and Harris (1982) lists 26 species for the lower elevation habitats of the Mono Lake basin. All of these basins contain a majority of the same species, with only a few differences due primarily to the influx of Mojave Desert fauna into the western Great Basin (Jorgensen and Hayward 1965).

Few studies have been done which permit a quantitative comparison of small mammal communities in pluvial lake basins. O'Farrell (1986) studied five habitat types in Whirlwind Valley, a nonpluvial basin, 120 km NW of Ruby Lake. Here O'Farrell trapped 11 species of small mammals, compared with 14 species in Grass Valley (Evans and Young 1986), and 11 species for Ruby Lake (Table 1). Species composition between these three localities varied only slightly; *P. maniculatus* and *P. parvus* made up the majority of the individuals for each locality in all habitats sampled. Kenagy (1973) and Harris (1982) found that heteromyid rodents were the dominant species in the western deserts and at Mono Lake, but *P. maniculatus* and *P. parvus* were present and widespread. The contribution and relative frequency of each species varied among habitat types at Ruby Lake. We found that the greasewood–big sagebrush habitat had the largest number of species present during the study period. This was also the case in Grass Valley (Evans and Young et al. 1986) and in Whirlwind Valley (O'Farrell 1986). Rodent species diversity has been correlated with resource abundance (Whitford 1976) and with vegetation structure and diversity of a habitat (Rosenzweig and Winakur 1969). Our data agree with these studies in reference to the complexity and relative abundance of forbs and grasses in the greasewood–big sagebrush habitat.

Data recorded for the reproductive activity of *P. maniculatus* in the greasewood–big sagebrush habitat show that the sex ratios did not differ significantly from a 1:1 ratio. Pregnant females and scrotal males, some in juvenile pelage, were common in both May and mid-August, suggesting at least two litters for this habitat during the two years. This would indirectly suggest a habitat rich in resources.

The big sagebrush–antelope bitterbrush habitat has been attributed with a community complexity and richness capable of supporting a small mammal community of 7 (Lent and Eckert 1982) to 12 (O'Farrell 1974) species. At Ruby Lake we captured only 4 species of small mammals in a habitat that seemed to be structurally diverse and rich in forbs and grasses. One possible explanation for the low diversity in this habitat could be the comparatively low number of trap nights. Another possibility is that the high frequency of *P. parvus* (59%) may limit the numbers of other rodent species, such as *Onychomys leucogaster* and *Lagurus curtatus*, which have been captured from this locality and habitat by Borrell and Ellis (1934). Also *P. parvus* has been shown to have an intricate relationship with the antelope bitterbrush in collecting and caching its seeds (Evans et al. 1982). From our data we found that sex ratios for *P. parvus* did not differ significantly from a 1:1 ratio. The greatest reproductive activity occurred in mid-June, and the largest number of juveniles appeared in August. This suggests only one litter for each of the two seasons we sampled in this habitat and agrees with the findings of O'Farrell et al. (1974) in a similar habitat.

The shadscale-spiny hopsage habitat was unusual in that its low stature and low plant complexity nonetheless maintained a high species diversity of seven species. O'Farrell (1986) found that species composition of any one of the five habitats in Whirlwind Valley experienced seasonal changes in species composition. We suspect that this is also the case with the shadscale habitat at Ruby Lake, which was trapped only twice during the late summer. Four of the seven species in this habitat were probably wandering from adjacent greasewood habitats. Two dominant species within this habitat, *P. parvus* and *D. microps*, were also found to be co-dominants at Grass Valley (Young et al. 1980) and Whirlwind Valley (O'Farrell 1986) in a similar shadscale community. *Perognathus longimembris* was found only in the shadscale habitat at Ruby Lake. It did not occur in Whirlwind Valley (O'Farrell 1986) but was found in greasewood habitat in Grass Valley (Young et al. 1980). We found four of the five captured individuals to have interesting patterns of pure white spots on the dorsum, the backs of the ears, and the anterior flanks. These spots are white down to the integument and vary from a coverage of 1/3 of the pelage to minute spots. This pelage has been recorded elsewhere in specimens of *P. longimembris* from the desert of Millard County, Utah (Durrant 1952). *Dipodomys microps* has been shown to have a dietary reliance on the leaves of *Atriplex* rather than on seeds. This accounts for the large numbers of this heteromyid in the shadscale habitat (Kenagy 1973).

Other small mammal associations on Ruby Lake suggest habitat expansions and historical changes in status of some species. At Ruby Lake we found *Eutamias minimus* in four of the six habitat types, being most common in the big sagebrush–bitterbrush habitat. O'Farrell (1986) found the least chipmunk restricted to a greasewood habitat by the presence of the antelope ground squirrel (*Ammospermophilus leucurus*), which occurred in three habitat types. At Grass Valley the least chipmunk was found both in greasewood and in sagebrush but not in all sagebrush habitats or in shadscale because of the presence of the antelope ground squirrel. Robey et al. (1986) showed the least chipmunk to occupy a narrow niche breadth in a desert shrub community shared with the antelope ground squirrel, a species occupying a wide niche. These observations suggest that the least chipmunk at Ruby Lake has expanded into all available shrub habitats in the absence of competition with the antelope ground squirrel, a species not known from Ruby Valley. Brown (1978) describes another instance of habitat expansion in three species of montane chipmunks whose irregular distributions on mountain ranges in eastern Nevada result in atypical habitat utilization by these species and expansion into habitats they normally do not occupy.

Borrell and Ellis (1934) trapped and collected data on mammals from the western flank of the Ruby Mountains along the west edge of Ruby Lake. They found both the mink (*Mustela vison*) and the muskrat (*Ondatra zibethicus*) present in 1927, years before the lake came under government management. This suggests that both are native and possibly dispersed south from the Columbia basin into Mary's River and the wetlands of Pleistocene Clover Lake. This wetland possibly had a Pleistocene connection with pluvial Franklin Lake and Ruby Lake (Mifflin and Wheat 1979).

The same route of dispersal could be applied to the vagrant shrew and the montane vole, both of which occur in the Mary's River basin, the Humboldt River basin, the South Fork and North Fork of the Humboldt River, and the western flank of the Ruby Mountains, all below 1,590 m in elevation (Ports, unpublished data). The presence of *Sorex preblei*, a rare shrew of shrublands and wetlands, in the vicinity of the Great Salt Lake (Tomasi and Hoffmann 1984) and in the Mary's River basin (Ports, unpublished data) suggests the possible occurrence of this species in Clover Valley as well as Ruby Valley.

The pluvial lake basins of the Great Basin provide many mosaic and diverse plant communities for the development of small mammal communities. Similar in species composition and plant communities, these basins have undergone similar climatic changes and have provided easy dispersal routes for populations of wetland- and desert-adapted mammals. Unlike their contemporaries on nearby isolated mountain ranges in subalpine and alpine habitats, the lower-elevation populations of small mammals can be expected to experience a wide range of population mixing and a wider range of dispersal than previously supposed,

as seen in the vagrant shrew (Ports, unpublished data). However, we must consider not only the effects of long-term climatic changes on these populations but also their effects on species composition. Studies of greater detail and of longer duration are necessary to understand the influence man has made on the pluvial basin plant and animal communities of the Great Basin.

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