Western North American Naturalist 64(4), © 2004, pp. 471–481

MARMOT DISTRIBUTION AND HABITAT ASSOCIATIONS IN THE GREAT BASIN

Chris H. Floyd[1]

ABSTRACT.—In this study I describe the distribution and habitat associations of yellow-bellied marmots (*Marmota flaviventris*) in the Great Basin, compare my findings with those of E.R. Hall during his 1929–1936 survey and later surveys, and discuss potential reasons for changes in marmot distribution over time. I found 62 marmot burrow sites in 18 mountain ranges, mostly in rocky meadows situated on well-drained slopes between 2100 m and 3000 m elevation. Marmots were generally found near burrows dug within talus slopes, talus-like rock piles, or clusters of massive boulders. Oceanspray (*Holodiscus discolor*) was the shrub most commonly associated with occupied rock formations. Marmots were most abundant in the Ruby/East Humboldt Range and were common in the Desatoya, Shoshone, Toiyabe, Toquima, Cherry Creek, Schell Creek, Deep Creek, and Stansbury Ranges. Marmots appeared to be uncommon in the Monitor Range and rare in the Clan Alpine, Roberts, and Snake Ranges. I was unable to find marmots in the Diamond, Egan, Spruce-Pequop, White Pine, and Oquirrh Ranges, although I located old, weathered marmot scats in all but the latter 2 ranges. Other evidence confirms that marmots do actually occur in the Oquirrh Range, but extensive searches of the White Pine Range, including some of the same rock formations where E.R. Hall collected marmots, revealed no sign of marmots. My distribution data suggest that marmots may have gone extinct in some Great Basin mountain ranges during the last century. These disappearances may represent a natural extinction-recolonization dynamic, but a more alarming possibility is a recent die-off linked to climate change, which is predicted to force montane vegetation zones further upslope, shrinking the habitat of associated faunas. However, marmots in this study were observed as low as 1550 m elevation, indicating an altitudinal flexibility that may allow this species to survive climatic change better than more specialized boreal species such as pikas (*Ochotona princeps*) and water shrews (*Sorex palustris*).

Key words: Marmota flaviventris, *marmot, Great Basin, climatic change, boreal mammals, talus,* Holodiscus discolor.

Climatic change over the next several decades is predicted to force boreal life zones higher into the mountaintops, imperiling the resident faunas by fragmenting and constricting their habitats (Gottfried et al. 1999, Hill et al. 2002, Kullman 2002). Boreal mammals in the Great Basin may face an especially high extinction risk by being restricted to small islands of montane/alpine habitat surrounded by arid lowlands (McDonald and Brown 1992). To detect altitudinal movements and extinctions, it is crucial to have accurate ecological information on present-day distributions (Kodric-Brown and Brown 1993). Such data are lacking for most Great Basin mountain ranges (Rickart 2001).

E.R. Hall conducted the first wide-ranging study of mammalian distributions in the Great Basin during 1929–1936, focusing mainly on Nevada (Hall 1946). Subsequent surveys focusing on boreal mammals were conducted by Brown (1971, 1978) during the late 1960s and early 1970s and Lawlor (1998) during 1982–1995, as part of their studies of Great Basin insular biogeography. In this study I investigated distributions of yellow-bellied marmots (*Marmota flaviventris*) and characterized habitat associations of marmots in the Great Basin during 1999–2002. These large rodents, widely distributed throughout western North America, including the Great Basin, Rocky Mountains, Cascade Range, and Sierra Nevada (Frase and Hoffman 1980), are most commonly found in montane and alpine meadows in close association with rocks. Burrows are dug beneath rocky outcrops or talus slopes (Svendson 1974, Frase and Hoffmann 1980). Marmots are active only during the season of vegetative growth and hibernate for approximately 8 months of the year (Frase and Hoffman 1980). My objective was to compare my findings to earlier surveys and discuss explanations for any apparent shifts in marmot distribution.

[1]Department of Wildlife, Fish and Conservation Biology, University of California, Davis, CA 95616. Present address: Department of Biology, University of Wisconsin–Eau Claire, Eau Claire, WI 54702.

METHODS

I searched Great Basin mountain ranges for marmots during July–August 1999, May–August 2000 and 2001, and May–June 2002 as part of a genetic study to test the "nonequilibrium" model of island biogeography (Brown 1971, 1978, Lawlor 1998, Floyd 2003). Thus, I focused on the ranges surveyed in earlier studies (Fig. 1), except the White Mountains, where marmot distributions are well known (Stallman and Holmes 2002), and the Grant-Quinn Canyon Range, where marmots do not occur (Lawlor 1998). Following Brown (1971) and Lawlor (1998), I refer to the Ruby and East Humboldt Ranges as the same mountain complex because of their proximity. The authors did the same with the Toiyabe and Shoshone, Toquima and Monitor, and Egan, Cherry Creek, and Schell Creek Ranges, but I treat these separately here because they are geologically and ecologically distinct (Charlet 1996, NVGAP 1996).

I searched for marmots by walking up major drainages (defined as valleys containing primary or secondary branches of a watercourse that emerges at the base of a mountain range), from the mouth of the drainage (ca. 1800–2100 m elevation) to the highest surrounding peak or ridgeline, listening and looking for marmots along the way. Because my initial surveys suggested that marmots frequently inhabited open areas, I attempted to thoroughly explore all unforested ridges, slopes, and valley bottoms within view. Targeting open areas did not unduly bias my characterization of marmot habitat, however, because reaching them required me to extensively traverse other habitat zones such as riparian areas, sagebrush (*Artemisia tridentata*) scrublands, pinyon-juniper woodlands (*Pinus monophylla* and *Juniperus osteosperma*), and boreal forests (e.g., aspen [*Populus tremuloides*], limber pine [*Pinus flexilis*], and white fir [*Abies concolor*]). From the high points, I was able to comprehensively scan (using 10 × 40 binoculars) the surrounding landscape for several kilometers around, often down to the bottom of the drainage.

As was the case with previous studies (Hall 1946, Brown 1971, 1978, Lawlor 1998), no attempt was made to search every major drainage, nor were all ranges searched with equal effort, because my main purpose was to obtain adequate genetic representation from marmots in each mountain range. In each range except for 2 (the Oquirrh and Roberts, discussed below), I thoroughly explored at least 2 major drainages, especially those that were known to have marmots or appeared to have potential marmot habitat. Marmots tended to sit on prominent rocks and give loud alarm calls at the moment they detected me, thus making it easy to find most occupied marmot burrows within about 100–500 m. Marmot burrows without visible marmots were identified by hole size and presence of marmot scats. Generally, 2–8 hours were spent at each "burrow site," here defined as a location (usually a slope, ridge, or small valley) in which marmots or marmot burrows were found. Burrows separated by less than 500 m walking distance were considered to be within the same burrow site, unless they occupied slopes in different major drainages (e.g., on opposite sides of a ridge). Burrow sites were reported as latitude-longitude coordinates estimated to the nearest second using a GPS unit or 1:25,000 topographic maps. Elevations were estimated to within 50 m. More detailed location descriptions, including information on all drainages searched, are available from the author upon request. When there were multiple observations from a single burrow site, I reported the coordinates and elevation of the burrow that would be easiest for another observer to locate and that would lead to neighboring marmots. The minimum-maximum elevation range was reported when the burrows within a location were distributed across an altitudinal gradient greater than 100 m. To characterize marmot habitat, I estimated slope aspect (exposure) and described vegetation and rock features in the immediate vicinity of sites where marmots or scats were found.

RESULTS

Habitat Associations

A total of 62 marmot burrow sites were found in 18 mountain ranges (Table 1). Burrows primarily were located in rocky meadows situated on well-drained slopes within the montane vegetation zone, which begins at the upper margin of the pinyon-juniper zone at approximately 2400 m elevation (Charlet 1996, NVGAP 1996). Marmots were almost always found <10 m from exposed rock formations that were generally of 3 types: (1) stable talus

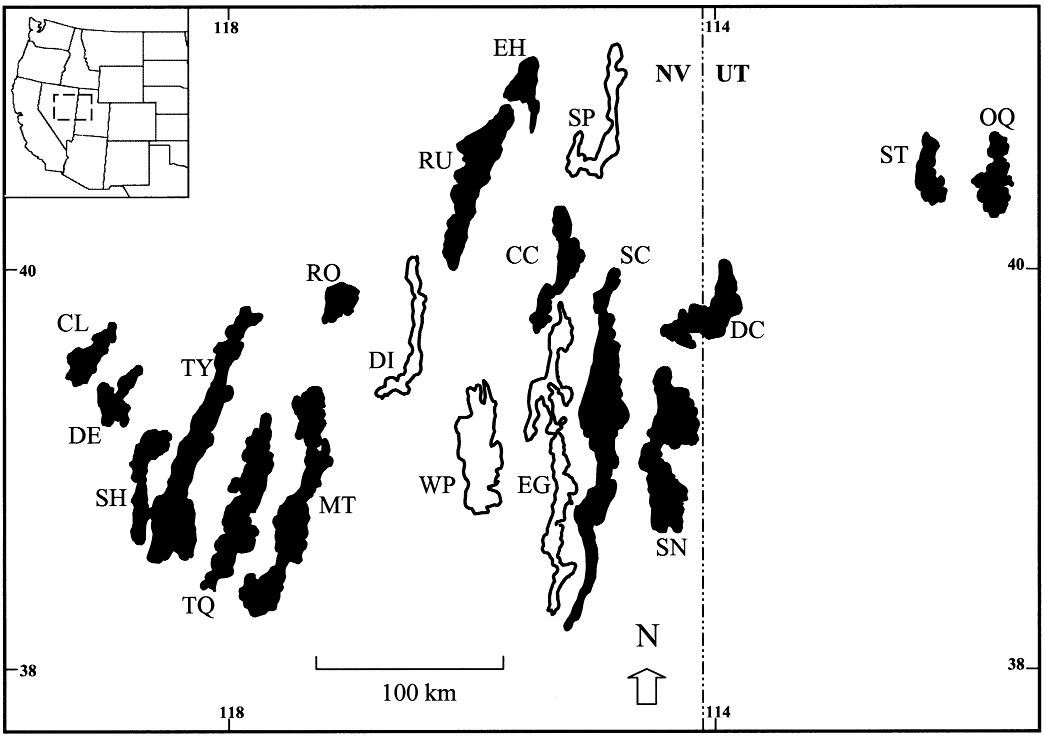

Fig. 1. Map of Great Basin mountain ranges where yellow-bellied marmot (*Marmota flaviventris*) distributions and habitat associations were studied. Abbreviations for mountain ranges: CC, Cherry Creek; CL, Clan Alpine; DC, Deep Creek; DE Desatoya; DI, Diamond; EG, Egan; EH, East Humboldt; MT, Monitor; OQ, Oquirrh; RO, Roberts; RU, Ruby; SC, Schell Creek; SH, Shoshone; SN, Snake; SP, Spruce-Pequop; ST, Stansbury; TY, Toiyabe; TQ, Toquima; WP, White Pine. Outlined ranges are those in which marmots were not observed but old marmot scats were found.

slopes made up of coarse, angular rocks ≥20 cm in length, associated with outcrops or crags of volcanic or sedimentary strata (Fig. 2); (2) talus-like rock piles derived from glacial deposits or in situ bedrock erosion (A. Wilcox personal communication; Fig. 3); (3) clusters of massive boulders, often of intrusive granitic origin, containing multiple deep crevices that were inaccessible to larger animals (Fig 4).

Occupied rock formations usually were deeply embedded in the soil and separated from each other by ≥40 m of montane meadow vegetation dominated by mountain sagebrush (*A. tridentata vaseyana*) and occasionally by woodlands (especially aspen and curleaf mountain-mahogany [*Cercocarpus ledifolius*]). The heterogeneous distribution of rock formations resulted in a correspondingly patchy distribution of marmots.

Marmots were almost never found in talus that was gravelly or composed of small, platy stones, apparently because such soils prevent the construction of workable burrows (Svendsen 1974). Single boulders and rock outcrops without associated talus usually lacked marmots unless there were multiple crevices throughout the boulder or outcrop. Talus-dwelling marmots generally burrowed within the talus itself and not in the outcrop above. However, marmots frequently used outcrops or prominent rocks for lookout posts, as evidenced by the abundance of scats and the fact that marmots when approached generally alarm-called from the outcrop before fleeing into the talus below (Hall 1946, CHF personal observation). The actual burrow entrances in talus were seldom discernable because of the many possible entry-exit routes through the jumbled rocks.

Elevations of marmot locations ranged from 1560 m to 3500 m; both the mean and median were approximately 2550 m, and about 81% of locations were located between 2100 m and

TABLE 1. Locations of marmot burrow sites on 18 Great Basin mountain ranges listed west to east among ranges, and south to north within ranges. All ranges are in Nevada except the Deep Creek, Stansbury, and Oquirrh Ranges, which are in Utah. Sites marked with an asterisk (*) are sites where only marmot scats (not marmots themselves) were found. Sightings in the Oquirrh Range were those reported by T. Becker. Where there were multiple observations within a valley, the location of a single representative location is given. The range of elevation is listed where there were multiple localities across an altitudinal gradient of ≤100 m.

Mountain range	County	Drainage or feature	Latitude (N)	Longitude (W)	Elevation (m)
Clan Alpine	Churchill	Mouth of Cherry Creek	39°32′33″	117°50′23″	1900
Clan Alpine	Churchill	Upper Cherry Valley	39°34′41″	117°56′24″	2300
Clan Alpine	Churchill	Cherry Creek / War Canyon road	39°35′18″	117°54′45″	2500
Desatoya	Lander	Carroll Summit / Bald Mountain	39°16′46″	117°43′41″	2400
Desatoya	Churchill	Eastgate	39°18′16″	117°52′53″	1560
Desatoya	Lander	North of Carroll Summit	39°18′36″	117°44′42″	2750
Desatoya	Lander	Haypress Creek	39°19′40″	117°42′18″	2500
Desatoya	Churchill	Topia Creek	39°24′42″	117°46′06″	2500
Desatoya	Churchill	Cedar Creek	39°26′32″	117°46′45″	2250
Shoshone	Lander	North Shoshone Peak	39°09′16″	117°27′59″	2500–2600
Shoshone	Lander	Underdown Canyon*	39°09′51″	117°27′03″	2600
Toiyabe	Nye	Stewart Cr. Trail / Arc Dome area	38°52′07″	117°20′52″	3300
Toiyabe	Nye	N. Twin River*	38°53′06″	117°18′19″	2600
Toiyabe	Nye	San Juan Creek	39°06′02″	117°14′53″	2600
Toiyabe	Nye	Toiyabe Range Pk / Alice Gendron Cr.*	39°06′29″	117°12′38″	2150–2700
Toiyabe	Lander	South of Bob Scott Summit–US 50	39°26′29″	117°00′16″	2350
Toiyabe	Lander	Communications Towers road	39°28′26″	117°03′04″	2400
Toiyabe	Lander	Austin Summit–US 50 (east)	39°28′34″	117°01′48″	2100–2350
Toiyabe	Lander	Austin Summit–US 50 (west)	39°29′22″	117°02′55″	2200
Toiyabe	Lander	Amadour Canyon	39°33′48″	117°04′15″	2250
Toquima	Nye	Antone Creek	38°39′09″	116°56′00″	2600–2700
Toquima	Nye	Jefferson Summit and Shoshone Mt.	38°41′34″	116°56′45″	2650–2750
Toquima	Nye	Mount Jefferson	38°45′05″	116°55′44″	3500
Toquima	Nye	Upper Pine Creek	38°46′59″	116°55′49″	3300
Toquima	Nye	Moores drainage*	38°49′14″	116°55′06″	3100
Monitor	Nye	Big Cottonwood Canyon	38°22′49″	116°45′05″	2500–2600
Monitor	Nye	Table Mountain*	38°47′20″	116°35′00″	3000
Monitor	Eureka	N. Fork Allison Creek / Summit Mt.	39°22′02″	116°28′23″	2750–2900
Roberts	Eureka	Vinini Creek / Roberts Peak	39°51′51″	116°17′36″	2700–2800
Diamond	White Pine	Sadler Canyon*	39°34′37″	115°48′28″	2600
Diamond	Eureka	Threemile Canyon*	39°50′43″	115°47′58″	2750

3000 m elevation (Fig 5). For slopes with marmot locations, aspect (exposure) was significantly clumped (Rayleigh test: $z = 2.99$; $N = 93$; $P < 0.05$), with a mean east-facing (89°) direction (Batschelet 1981).

Almost without exception marmot burrow sites were closely associated with oceanspray, *Holodiscus discolor.* As is characteristic of this shrub, *H. discolor* typically ringed the outer boundaries of talus slopes and rock piles or protruded from the interstices of granitic boulder piles (Mozingo 1987; Figs. 2–4). Talus and boulder piles without associated *H. discolor* generally lacked any sign of marmots. These oceanspray-free areas usually were found on sparsely vegetated or woodland-covered slopes at lower elevations.

Elderberry (*Sambucus cerulea*) and mountain sagebrush often were present at marmot burrow sites. Plants less commonly present included chokecherry (*Prunus virginiana*), currants (*Ribes* sp.), wild rose (*Rosa woodsii*), snowberry (*Symphoricarpos* sp.), perennial grasses (often *Leymus cinereus*), and prickly pear (*Opuntia polyacantha*).

Exceptions to the association with oceanspray occurred chiefly in the northern half of the Ruby/East Humboldt Range, where

TABLE 1. Continued.

Mountain range	County	Drainage or feature	Latitude (N)	Longitude (W)	Elevation (m)
Ruby	Elko	Harrison Pass*	40°22′41″	115°30′05″	2850
Ruby	Elko	Battle Creek mines / Myers Creek	40°30′19″	115°23′33″	2500
Ruby	Elko	Island Lake	40°36′53″	115°23′00″	2750–3200
Ruby	Elko	Thomas Canyon	40°37′25″	115°24′31″	2700
Ruby	Elko	Upper Lutt's Creek / Thompson Creek	40°39′05″	115°20′49″	2750–3100
Ruby	Elko	Lamoille Canyon	40°39′39″	115°26′08″	2350
Ruby	Elko	Soldier Creek (upper)	40°45′53″	115°15′14″	2750
Ruby	Elko	Soldier Creek (trailhead)	40°46′34″	115°19′33″	2000
Ruby	Elko	Gardner Creek/Secret Peak	40°48′40″	115°15′08″	2550
E. Humboldt	Elko	Franklin River / N. Ruby Valley Rd.	40°48′45″	115°08′33″	1970
E. Humboldt	Elko	Horse Creek	40°48′54″	115°06′48″	2250–2450
E. Humboldt	Elko	Secret Pass	40°51′51″	115°15′00″	1850
E. Humboldt	Elko	Angel Lake	41°01′32″	115°05′03″	2500–2750
Egan	White Pine	Telegraph Peak*	39°40′39″	114°54′01″	2750
Cherry Creek	White Pine	Goshute Basin	40°03′46″	114°51′06″	2000
Cherry Creek	White Pine	Goshute Basin–continued	40°04′58″	114°50′50″	2750
Spruce-Pequop	Elko	Basco Springs–water tank*	40°31′09″	114°50′21″	2850
Schell Creek	White Pine	Success Summit (S)*	39°15′24″	114°40′59″	2750
Schell Creek	White Pine	Success Summit (N)	39°15′52″	114°41′18″	2850
Schell Creek	White Pine	McCoy Creek*	39°22′30″	114°33′39″	2750
Schell Creek	White Pine	N. Fk. Muncy Canyon	39°37′11″	114°37′24″	2350
Schell Creek	White Pine	Fitzhugh Canyon	39°38′32″	114°39′00″	2800
Schell Creek	White Pine	McMaughn Creek*	39°50′59″	114°39′54″	2550
Snake	White Pine	Baker Cr. Campground / Trailhead–GBNP	38°58′38″	114°14′37″	2400
Snake	White Pine	Ohio Creek*	39°02′38″	114°22′14″	2500
Snake	White Pine	Cottonwood Springs / O'Neal Peak	39°25′32″	114°17′23″	2650
Deep Creek	Juab, UT	Middle Canyon	39°53′11″	113°51′43″	2550
Deep Creek	Juab, UT	Basin Creek / Scotts Basin	39°53′29″	113°52′20″	2250–2400
Stansbury	Tooele, UT	E. Hickman Creek / Morgan Canyon	40°24′55″	112°34′08″	2050–2200
Stansbury	Tooele, UT	S. Willow Creek	40°29′09″	112°36′26″	2250–2500
Oquirrh	Tooele, UT	Mercur Canyon (townsite)	40°19′	112°12′	2000

snowbrush (*Ceanothus velutinus*) largely replaced oceanspray and big sagebrush as the dominant montane shrub around occupied sites. In addition, the few marmots that I found on alpine plateaus and talus fields above 3300 m elevation usually occupied rocky outcrops lacking sizable shrubs. Vegetation associated with marmots in this study roughly corresponds with the montane shrub zone category of the Nevada Gap Analysis Program (Charlet 1996, NVGAP 1996).

Distribution

Marmots were abundant throughout the Ruby/East Humboldt Range, where multiple individuals were observed in almost every drainage surveyed and it was rare to find a rock outcrop without marmot scats. Among Great Basin ranges in Nevada, the Ruby/East Humboldt Range has the largest area of montane shrub cover (Table 2) and an abundance of rocky outcrops, talus, and glacial moraines surrounded by open montane/subalpine meadows (Charlet 1996, NVGAP 1996).

Marmots were common throughout the Desatoya Range, though not as abundant as in the Ruby/East Humboldt Range. The Desatoya is the 2nd smallest mountain range of those surveyed (Table 2) but has 3 well-watered drainages with much marmot habitat (Smith, Topia, and Campbell Creeks). Marmots were common in the Shoshone, Toiyabe, Toquima, Cherry Creek, Schell Creek, Deep Creek, and Stansbury Ranges. Each of these ranges had at least

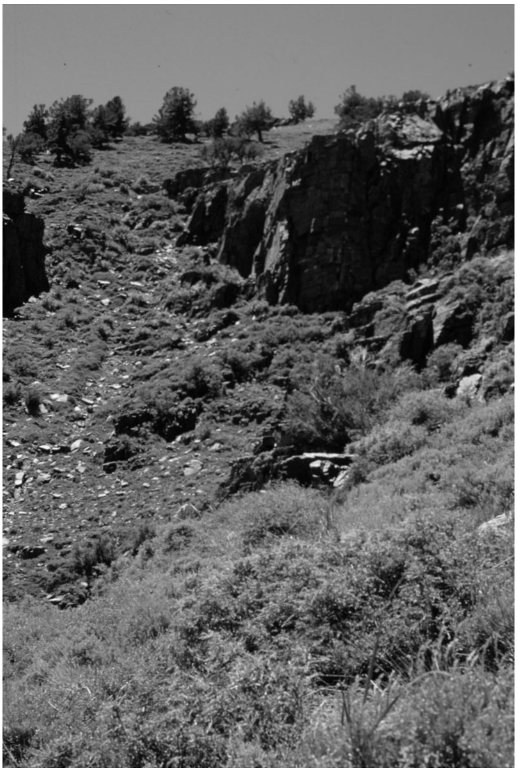

Fig. 2. Rocky outcrops and talus studded with oceanspray (*Holodiscus discolor*) and surrounded by meadows dominated by mountain sagebrush (*Artemesia tridentata vaseyana*), at ca. 2600 m elevation in Sadler Canyon in the Diamond Range, NV.

Fig. 3. Talus field ringed with oceanspray (*Holodiscus discolor*) above Cottonwood Springs Canyon, below O'Neal Peak, at ca. 2650 m elevation in the Snake Range, NV.

2 drainages with 15 or more marmot burrows. Marmots seemed to be uncommon in the Monitor Range, where I found burrows in only 2 drainages, each of which appeared to have fewer than 10 marmots.

Marmots were rare in the Clan Alpine, Roberts, and Snake Ranges. I found evidence of no more than 10 marmots in each range and believe that total abundance may be less than 20 individuals in each, because I searched almost every open area to be found. The rarity of marmots in the Clan Alpine and Roberts Ranges may be a consequence of each having only a single drainage containing substantial marmot habitat. Furthermore, these ranges support relatively little montane shrub cover among the surveyed ranges (Table 2). Compared to the nearby (smaller) Desatoya Range, the Clan Alpine Range has less than half the area of montane shrub cover (Table 2).

Although the Snake Range is one of the largest ranges in the Great Basin, montane shrub cover comprises just 8.5% of the range; only the Clan Alpine range has proportionally less montane shrub cover (Table 2). I found only a single drainage with extensive marmot habitat, in the northern half of the range in the basin above Cottonwood Springs (Table 1), where there are several hectares of limestone outcrops and talus fields (Fig 3). I observed only 1 marmot there, though dried scats were abundant among some of the outcroppings.

Marmots appeared to be equally rare in the southern half of the Snake Range, mostly encompassed by Great Basin National Park. I found only 3 marmots in the park, all living in the roadbed of the Baker Creek road, near the Baker Creek campground and trailhead. Extensive searches of other drainages in and around the park turned up only old, weathered scats in a single location (Ohio Creek; Table 1), supporting the opinion of park officials that the Baker Creek and nearby Lehman Creek campgrounds are probably the only places in the park that support marmots (K.

Fig. 4. Rock outcrops embedded in meadows with mountain sagebrush (*Artemesia tridentata vaseyana*), oceanspray (*Holodiscus discolor*), and Great Basin wild rye (*Leymus cinereus*) in Antone Creek at ca. 2600 m elevation in the Toquima Range.

Heister personal communication). Surprisingly, there was no sign of marmots in the large patches of subalpine meadows at the base of the moraines above the park's high-elevation lakes (>3200 m), habitat that often supports marmots in other parts of their range (Frase and Hoffman 1980). Hall (1981) reported a marmot at 3700 m elevation above Treasure Lake, but he was unable to find marmots anywhere else in the Snake Range (E.R Hall unpublished field notes). The fact that Hall extensively trapped the Baker Creek drainage and, except for the Treasure Lake sighting and a single unconfirmed account of a marmot in the Hendry's Creek drainage, reported no evidence of marmots anywhere in the range, suggests that marmots have been rare in the Snake Range for most of the last century. A local rancher whose family has grazed cattle in the Snake Range for several decades affirmed that the Baker Creek campground was the only location where he had seen *M. flaviventris* (D. Eldridge personal communication).

I was unable to find marmots in the Diamond, White Pine, Egan, Spruce-Pequop, and Oquirrh Ranges, although I located old scats in all ranges except the White Pine and Oquirrh. Grayson and Livingston (1993) reported the 1st known record of *M. flaviventris* in the Diamond Range, in Sadler Canyon. My own extensive explorations of this canyon (1999–2000, 2002) revealed only weathered scats on a small cluster of rock outcrops and talus comprising what appeared to be the only suitable marmot habitat there. During 2003, in a valley in the northern part of the Diamond Range (Table 1), I found another burrow site with abundant marmot scat, all of which looked ≤2 years old. A local rancher, who worked as a trapper in the Diamond Range for 40 years, related that he had never observed marmots there (G. Parman personal communication).

Hall (1946) documented the only marmots ever reported for the White Pine Range, where he collected 2 individuals and found plentiful marmot scats in the abandoned mining town of Hamilton (E.R. Hall unpublished field notes). I searched this same area, including some of the same rock piles reported by Hall, and found no marmots or scat, which is noteworthy because of the presence of numerous rocky outcrops and talus studded with oceanspray. A search of the southern half of the White Pine Range around Duckwater Peak, the highest, wettest, and most ecologically diverse portion of the range, revealed no sign of marmots and very little suitable habitat, except for a small patch of meadows and talus at the base of the east slope of Current Mountain.

I can make only cautious generalizations about marmots in the Egan, Spruce-Pequop, and Oquirrh Ranges because my investigations

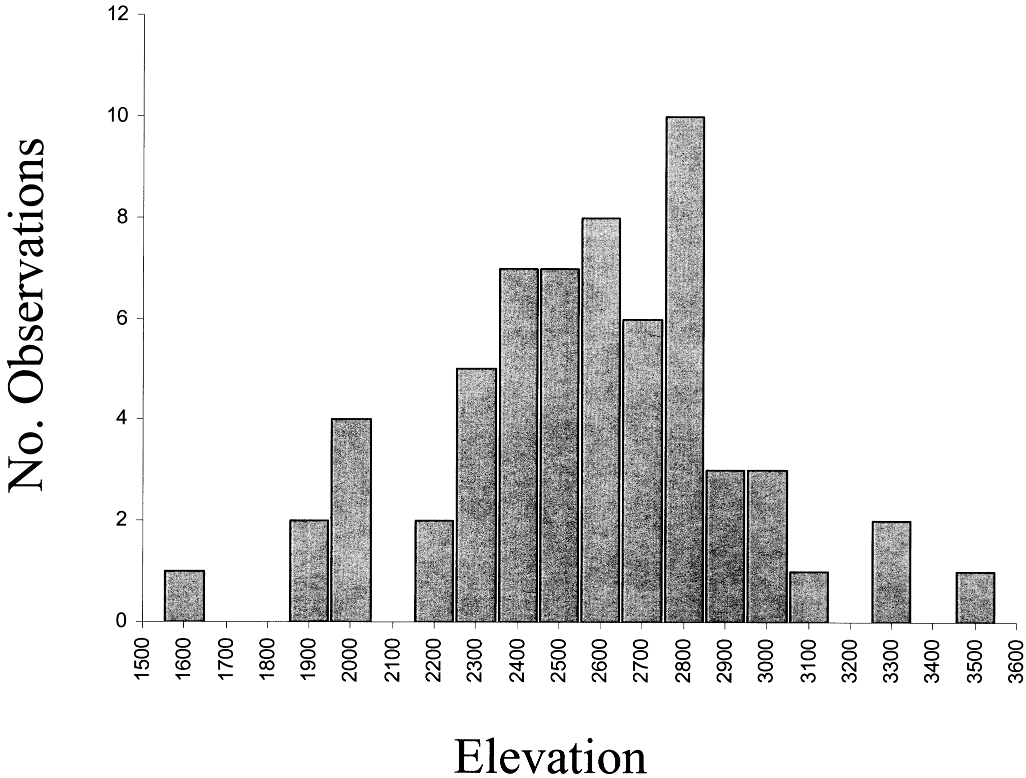

Fig. 5. Distribution of elevations (m above sea level) of 62 locations where yellow-bellied marmots (*Marmota flaviventris*) or marmot scats were found on 18 Great Basin mountain ranges during 1999–2002.

there were not as extensive as elsewhere. The Egan Range is rich in montane shrub habitat (Table 2), but the combination of montane meadows and suitable rock formations appears to be rare. I explored only the Spruce Mountain portion (the highest, least arid part) of the Spruce-Pequop Range and found no sign of marmots except for a few weathered scats on a dry ridge in the southeast portion of Spruce Mountain. Marmots were not observed in the Spruce-Pequop Range during Brown's (1971) study (J. Brown personal communication).

Most of the Oquirrh Range has been subject to open-pit mining and is off limits to the public, preventing a thorough search. *Oquirrh* is reputedly a Goshute or Paiute word meaning "wooded mountain" or "brush mountain" (B. Bosworth personal communication), and the latter is an accurate description of most of the montane zone, where almost all rocky outcrops and talus that I found were covered in tall (≥2 m) shrubs. Durrant (1952) and Durrant et al. (1955) commented that *M. flaviventris* had not been found in the Oquirrh Range as of 1955 but suspected that marmots were there undetected. I found no marmots there as well, but apparently they are locally common near the ghost town of Mercur, in upper Mercur Valley, and are considered a pest because they chew through pipes and tailing pond liners (T. Becker personal communication). Mining activity in the Oquirrh Range may have created marmot habitat by clearing woodlands and heavy brush and by producing extensive fields of artificial talus.

Discussion

Global climate change models predict that montane and subalpine vegetation zones in the Great Basin will creep upslope, reducing habitat area and forcing the resident faunas to shift their distributions accordingly (McDonald and Brown 1992, Fleishman et al. 2001). Because of their habitat requirements, however, yellow-bellied marmots may be unable to

TABLE 2. Size of 14 Great Basin mountain ranges and amount of montane shrub cover per range, as estimated by NVGAP (1996). Data on ranges in Utah were not available.

Mountain range	Total mountain area (km²)	Montane shrub cover: Absolute area (km²)	Montane shrub cover: Relative area (km²)
Cherry Creek	559	150.1	26.9
Clan Alpine	1149	49.7	4.3
Desatoya	705	106.9	15.2
Diamond	760	189.6	24.9
Egan	2295	296.1	12.9
Monitor	3046	604.9	19.9
Roberts	448	93.5	20.9
Ruby / E. Humboldt	2708	935.6	34.6
Schell Creek	2429	329.8	13.6
Shoshone	1852	179.5	9.7
Snake	2109	178.8	8.5
Toiyabe	3126	855.3	27.4
Toquima	1753	409.6	23.4
White Pine	1523	381.4	25.0

adapt by merely shifting upslope. The rock formations that marmots prefer are stationary, and in many ranges they become less common with increasing elevation above the montane zone (CHF personal observation). In addition, over the last century pinyon-juniper woodlands have drastically expanded their range in the Great Basin, both up- and downslope (Tausch et al. 1981, Miller and Wigand 1994, Wall et al. 2001). Presently occupied talus and rock outcrops may become enclosed by pinyon-juniper woodland, precluding the suitability of these areas for marmots. In fact, many of the lower-elevation rock formations presently surrounded by pinyon-juniper woodlands likely were embedded in montane meadows during cooler portions of the Holocene (Grayson 1993). Drastic changes in species composition of the herbaceous understory are also predicted (Gottfried et al. 1999, Bartlein et al. 2003).

Nonetheless, several observations of *M. flaviventris* at low elevations suggest that marmots may survive climatic change better than mountain-dwelling mammals that are more strictly limited to the montane/alpine zones (e.g., ermines [*Mustela erminea*] and pikas [*Ochotona princeps*]; Beever et al. 2003). Four marmot sightings in my study were below 2000 m elevation (Table 1), and the lowest was at 1560 m near Eastgate, Nevada, where Hall (1946) also found marmots in 1938. Local residents informed me that marmots at Eastgate forage in rock-bordered pastures that extend from the base of the Desatoya Range into the desert basin. In addition, radiotelemetry studies in the southern Rocky Mountains have found that marmots will disperse as far as 15 km (Van Vuren and Armitage 1994), which is on par with the distances separating several of the mountain ranges in this study. Low-elevation sightings of marmots in this study, coupled with recent sightings of bushy-tailed woodrats (*N. cinerea*) well below the montane zone (Grayson et al. 1996, Grayson and Madsen 2000), suggest that some boreal species are not as restricted to high elevations as previously assumed (Brown 1971), supporting Lawlor's (1998) argument that desert lowlands separating Great Basin mountain ranges may not be impermeable barriers to dispersal.

The apparent present-day absence of marmots in the Diamond, White Pine, Egan, and Spruce-Pequop Ranges, in combination with evidence of past occurrences (from historical records or old scats), suggests 1 of 2 possibilities: (1) that there are undetected marmots persisting in some uninvestigated part of the range, or (2) extinctions have occurred in recent times. The 1st possibility cannot be ruled out, as demonstrated by evidence that marmots do indeed occur in the Oquirrh Range, after I had searched there and found none. However, the fact that my extensive investigation of Sadler Canyon over multiple summers revealed only desiccated scats, and the fact that I found no marmot sign at all in the White Pine Range, including some of the same rock formations that were occupied in 1938, indicate that marmots have disappeared from a substantial portion of the Diamond Range and perhaps all of the White Pine Range. These "extinctions" may be part of a natural extinction-recolonization dynamic, as was found to occur among yellow-bellied marmot colonies in the Rocky Mountains of Colorado, where sites periodically became vacant when the previous years' residents died and were not replaced by immigration; some colonies there went extinct more frequently than others, while others have persisted for more than 40 years (D.H. Van Vuren and K.B. Armitage personal communication). The most extinct-prone sites in the Colorado system generally were thought to be suboptimal because of higher predation or hibernation mortality rates (DHVV personal communication). Habitat in the Diamond and White Pine Ranges (and other ranges where marmots are rare) may be suboptimal and thus only occasionally inhabited.

The altitudinal flexibility of *M. flaviventris* may bode well for the species in the presumably warmer decades to come, because if arid lowlands can be crossed, then declining populations can be rescued (Brown and Kodric-Brown 1977) and extinct sites recolonized. However, the probability of successful cross-basin dispersal may decrease as low-elevation environments become more arid, eventually transforming the Great Basin mountain ranges into the strictly isolated islands that Brown (1971) originally hypothesized them to be.

ACKNOWLEDGMENTS

This work was supported by funds from the American Museum of Natural History, American Society of Mammalogists, Sigma Xi, and UC Davis Jastro Shield Research Awards. My sincere appreciation to R. Miller, T. Platt, S. Coppeto, and D.H. Van Vuren for assisting me in the field, and to the following individuals who provided valuable information or other assistance: C. Baughman, L. Crabtree, J. Casey, K. Heister, K.B. Armitage, G. Parman, E. Beever, A. Wilcox, T. Becker, J. Brown, D. Stoner, B. Bosworth, V. Bakker, T. Lawlor, P. Bradley, as well as the Nevada Department of Wildlife, Utah Division of Wildlife Resources, USDA National Forest Service, National Park Service, and the Bureau of Land Management. I thank C. Conroy and the UC Berkeley Museum of Vertebrate Zoology for access to E.R. Hall's field notes, and D. Charlet and K. Taylor for assisting with plant identification. T. Lawlor, D.H. Van Vuren, and an anonymous reviewer provided very helpful comments on previous versions of the manuscript.

LITERATURE CITED

BARTLEIN, P.J., C. WHITLOCK, AND S.L. SHAFER. 2003. Future climate in the Yellowstone National Park region and its potential impact on vegetation. Conservation Biology 11:782–792.

BATCHELET, E. 1981. Circular statistics in biology. Academic Press, New York. 371 pp.

BEEVER, E.A., P.F. BRUSSARD, AND J. BERGER. 2003. Patterns of apparent extirpation among isolated populations of pikas (*Ochotona princeps*) in the Great Basin. Journal of Mammalogy 84:37–54.

BROWN, J.H. 1971. Mammals on mountaintops: nonequilibrium insular biogeography. American Naturalist 105:467–478.

______. 1978. The theory of insular biogeography and the distribution of boreal birds and mammals. Great Basin Naturalist Memoirs 2:209–227.

BROWN, J.H., AND A. KODRIC-BROWN. 1977. Turnover rates in insular biogeography: effect of immigration on extinction. Ecology 58:445–449.

CHARLET, D.A. 1996. Atlas of Nevada conifers: a phytogeographic reference. University of Nevada Press, Reno. 320 pp.

DURRANT, S.D. 1952. Mammals of Utah: taxonomy and distribution. University of Kansas, Museum of Natural History 6:1–549.

DURRANT, S.D., M.R. LEE, AND R.M. HANSEN. 1955. Additional records and extensions of known ranges of mammals from Utah. University of Kansas, Museum of Natural History 9:69–80.

FLEISHMAN, E., G.T. AUSTIN, AND D.D. MURPHY. 2001. Biogeography of Great Basin butterflies: revisiting patterns, paradigms, and climate change scenarios. Biological Journal of the Linnean Society 74:501–515.

FLOYD, C.H. 2003. Ecological genetics of dispersal and mating system in populations of yellow bellied marmots (*Marmota flaviventris*). Doctoral dissertation, University of California, Davis.

FRASE, B.A., AND R.S. HOFFMANN. 1980. *Marmota flaviventris.* Mammalian Species 135:1–8.

GOTTFRIED, M., H. PAULI, K. REITER, AND G. GRABHERR. 1999. A fine-scaled predictive model for changes in species distribution patterns of high mountain plants induced by climate warming. Diversity and Distributions 5:241–251.

GRAYSON, D.K. 1993. The desert's past: a natural prehistory of the Great Basin. Smithsonian Institution Press, Washington, DC. 356 pp.

GRAYSON, D.K., AND S.D. LIVINGSTON. 1993. Missing mammals on Great Basin mountains: Holocene extinctions and inadequate knowledge. Conservation Biology 7:527–432.

GRAYSON, D.K., S.D. LIVINGSTON, E. RICKART, AND M.W. SHAVER III. 1996. Biogeographical significance of low-elevation records for *Neotoma cinerea* from the northern Bonneville Basin, Utah. Great Basin Naturalist 56:191–196.

GRAYSON, D.K., AND D.B. MADSEN. 2000. Biogeographic implications of recent low-elevation recolonization by *Neotoma cinerea* in the Great Basin. Journal of Mammalogy 81: 1100–1105.

HALL, E.R. 1946. Mammals of Nevada. University of California Press, Berkeley. 710 pp.

______. 1981. The mammals of North America. Volume 1. 2nd edition. John Wiley and Sons, New York. 606 + 90 pp.

HILL, J.K., C.D. THOMAS, R. FOX, M.G. TELFER, S.G. WILLIS, J. ASHER, AND B. HUNTLEY. 2002. Responses of butterflies to twentieth century climate warming: implications for future ranges. Proceedings of the Royal Society of London Series B 269:2163–2171.

KODRIC-BROWN, A., AND J.H. BROWN. 1993. Incomplete data sets in community ecology and biogeography: a cautionary tale. Ecological Applications 3:736–742.

KULLMAN, L. 2002. Rapid recent range-margin rise of tree and shrub species in the Swedish Scandes. Journal of Ecology 90:68–77.

LAWLOR, T.E. 1998. Biogeography of Great Basin mammals: paradigm lost? Journal of Mammalogy 79:1111–1130.

MCDONALD, K.A., AND J.H. BROWN. 1992. Using montane mammals to model extinctions due to global change. Conservation Biology 6:409–415.

MILLER, R.F., AND P.E. WIGAND. 1994. Holocene changes in semiarid pinyon-juniper woodlands. BioScience 44:465–474.

MOZINGO, H. 1987. Shrubs of the Great Basin: a natural history. University of Nevada Press, Reno. 342 pp.

NVGAP. 1996. Nevada Gap GIS database. Utah Cooperative Fish and Wildlife Research Unit, Utah State University, Logan. (http://www.brrc.unr.edu/mtn/html/ref/gapref.html)

RICKART, E.A. 2001. Elevational diversity gradients, biogeography and the structure of montane mammal communities in the intermountain region of North America. Global Ecology and Biogeography 10: 77–100.

STALLMAN E.L., AND W. G. HOLMES. 2002. Selective foraging and food distribution of high elevation yellow-bellied marmots (*Marmota flaviventris*). Journal of Mammalogy 83:576–584.

SVENDSEN, G.E. 1974. Behavioral and environmental factors in the spatial distribution and population dynamics of a yellow-bellied marmot population. Ecology 55:760–771.

TAUSCH, R.J., N.E. WEST, AND A.A. NABI. 1981. Tree age and dominance patterns in Great Basin pinyon-juniper woodlands. Journal of Range Management 34:259–264.

VAN VUREN, D., AND K.B. ARMITAGE. 1994. Survival of dispersing and philopatric yellow-bellied marmots: what is the cost of dispersal? Oikos 69:179–181.

WALL, T.G., R.F. MILLER, AND T.J. SVEJCAR. 2001. Juniper encroachment into aspen in the northwest Great Basin. Journal of Range Management 54:691–698.

Received 1 April 2003
Accepted 15 December 2003