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STATUS OF RED SQUIRRELS IN GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

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ABSTRACT—The Pinaleno Mountains of southeastern Arizona contain the southernmost population of red squirrels (*Tamiasciurus hudsonicus*) in North America. Red squirrels historically inhabited the Guadalupe Mountains in Trans-Pecos Texas during the Pleistocene and the possibility that red squirrels currently persist has been suggested by several biologists visiting the upper-elevation forests. Herein, we report results of an assessment of small mammals in coniferous forest where we used observational line transects, playback calls, and live trapping to determine status of red squirrels. We surveyed 132 ha of coniferous forest along 8.9 km of transects and observed and found evidence of 10 species of mammals. We detected no evidence of red squirrels inhabiting high-elevation coniferous forest.

RESUMEN—Las montañas Pinaleno en el sudeste de Arizona contienen la población más sureña de la ardilla roja (*Tamiasciurus hudsonicus*) en Norteamérica. Históricamente las ardillas rojas habitaban las montañas Guadalupe en el Trans-Pecos de Texas durante el Pleistoceno y la posibilidad de que las ardillas rojas todavía estén ha sido sugerida por varios biólogos que han visitado los bosques de la parte alta. Aquí reportamos los resultados de un muestreo de mamíferos pequeños del bosque conífero donde utilizamos observaciones en transectos de línea, emisiones de grabaciones de vocalizaciones, y trapeo vivo para determinar el estatus de las ardillas rojas. Muestreamos 132 ha de bosque conífero a través de 8.9 km de transectos y observamos y encontramos evidencia de 10 especies de mamíferos. No encontramos ninguna evidencia de que las ardillas rojas habiten el bosque conífero de las alturas superiores.

Mountains of the southwestern United States and northwestern Mexico serve as hotspots of biodiversity at an intersection of the Sierra Madre to the south and Rocky Mountains to the north (Turner et al., 1995). Termed sky islands due to mesic conditions relative to surrounding desert (Gehlbach, 1993), species of this terrestrial archipelago, especially boreal forms (Patterson, 1995), have been isolated for 7,000–10,000 years since the Wisconsin glaciation (Van Devender and Spaulding, 1979). During glacial maxima, ranges of northern-boreal-obligate mammals expanded into southern Arizona, New Mexico, and Trans-Pecos Texas as evidenced in the fossil record (Harris, 1990; Gehlbach, 1993; Patterson, 1995). Guadalupe Mountains National Park in Trans-Pecos Texas

lies on the eastern boundary of the sky island province and is one of the southernmost locales in which Pleistocene range expansions of boreal mammals occurred. Due to southerly latitude and isolation, the boreal mammalian fauna in the Guadalupe Mountains suffered widespread extirpation at the end of the Pleistocene (Patterson, 1995), as little mesic coniferous forest remained. Despite several surveys conducted within the park (Bailey, 1905, 1931; Davis and Robertson, 1944; Genoways and Baker, 1979), the status of a few mammalian species remains unknown.

Red squirrels (*Tamiasciurus hudsonicus*) are considered boreal obligates and are distributed widely across North America (Steele, 1998). The present patchy distribution of boreal vegetation,

especially in southerly latitudes, likely contributes to the existence of 25 subspecies. Currently, the southernmost subspecies is restricted to the Pinaleno Mountains in southeastern Arizona (Steele, 1998). Fossil records indicate that the southern limit of distribution was once as far south as Trans-Pecos Texas, including Guadalupe Mountains National Park (Harris, 1990; Gehlbach, 1993; Patterson, 1995). Whether red squirrels persist in the park is unclear, as their presence is suggested only briefly with little supporting evidence. Davis and Robertson (1944) noted that *Tamiasciurus* was reported in the region in the late 1800s; however, these authors provided no reference. Early accounts by Bailey (1905, 1931) reported a sighting of a small tree squirrel in 1902 in the southern part of the Guadalupe Mountains, an observation later discounted by Davis (1940) who claimed the squirrel was probably a chipmunk (*Tamias*). Findley (1961) stated that it would be unlikely for red squirrels to occur within Guadalupe Mountains National Park due to the lack of habitat, and Patterson (1995) listed red squirrels as locally extinct within the park. Recent surveys in Guadalupe Mountains National Park revealed no red squirrel, but reported that it possibly occurs or has occurred (Genoways and Baker, 1979); range maps often include Trans-Pecos Texas (e.g., Hall, 1981). Determining the status of red squirrels in Guadalupe Mountains National Park remains a priority as it would establish the southern distributional limit of red squirrels and highlight a species of special management concern.

We surveyed for evidence of feeding and caches of red squirrels, including use of visual observations and broadcasts of vocalizations. Additionally, we established trapping grids within areas where potential sightings of red squirrels likely occurred. Herein, we report our results regarding the status of red squirrels within Guadalupe Mountains National Park.

MATERIALS AND METHODS—There are 3,461 ha of coniferous forests in Guadalupe Mountains National Park, Texas; most is on dry slopes with piñon-juniper (*Pinus-Juniperus*) associations, which are not habitat of red squirrels (Findley, 1961). Mixed-coniferous forests within the park occur at 2,200–2,700 m elevation and are on top of a large plateau (Sakulich and Taylor, 2007). Within this zone, we surveyed between Frijole Ridge and Juniper Trail with transects radiating from a central, mesic depression known as The Bowl (Genoways and Baker, 1979; Sakulich and Taylor, 2007).

Much of the mixed-coniferous forest surrounding The Bowl is dominated by Douglas-firs (*Pseudotsuga menziesii*), ponderosa pines (*Pinus ponderosa*), and southwestern white pines (*P. strobiformis*), all of which are sources of food for red squirrels (Findley, 1961). A large proportion of the Douglas-fir forest surrounding The Bowl was burned or affected by recent fires, both prescribed and otherwise. Of the 973 ha of mixed-coniferous forest near The Bowl, 775 ha (80%) were burned at some level in the 1990s.

Red squirrels, like other tree squirrels, are diurnal (Gurnell, 1987; Steele, 1998) and leave evidence of their presence, such as nests, feeding sites, vocalizations, and middens (Finley, 1969; Gurnell, 1984). Surveys for evidence, especially middens, are the best method to detect red squirrels (Finley, 1969; Vahle and Patton, 1983; Price, 1994; Mattson and Reinhart, 1996; Gutzwiller and Riffell, 2008), as the animal itself may not be observed during surveys or be represented in trapping efforts. Our team was part of the University of Arizona Red Squirrel Monitoring Program with collectively >12 years of experience in the southwestern United States. We surveyed coniferous forest near The Bowl for evidence of red squirrels including leaf nests, middens, and recent feeding sites, which may include cores and scales of cones, cut tips of branches, and remains of epigeous fungi. We focused on the most mesic and dense stands of relatively unburned mixed-coniferous forest containing mature Douglas-firs and few or no junipers. For each area surveyed, four observers spaced 20-m apart walked slowly on the same compass bearing through potential habitat. Topography and type of forest dictated the transects surveyed; we walked up slope until we reached a ridge and the vegetation changed at which point we realigned, took a new bearing, and walked an adjacent section down slope. We also used drainages as transects and, in these cases, mesic forest was only in narrow swaths with piñon-juniper forest on the steep slopes above. We scanned the ground for evidence of middens, caching, or feeding on conifer cones and scanned trees for presence of leaf or grass nests.

While surveying, we used FOXPRO FP-38 digital game callers (FOXPRO, Inc., Lewistown, Pennsylvania) to broadcast calls of red squirrels. Calls were broadcast every 15–20 min, once in the direction of travel and once perpendicular to direction of travel toward the highest-quality habitat. Each calling event consisted of a series of barking calls and territorial chatters lasting 1 min, followed by 2 min of silence while we listened for response and while we watched for activity in trees. Depending on topography, habitat, and wind, each call was audible for ≥ 100 m. We recorded observations and evidence of mammals and, when encountered, we examined middens of Mexican woodrats (*Neotoma mexicana*) for bones of red squirrels.

In addition to our surveys, we established three trapping grids, each with 30 Sherman live traps (large-folding aluminum traps, H. B. Sherman Traps, Tallahassee, Florida) and two Tomahawk collapsible single-door live traps (Model 201, Tomahawk Live Trap Co., Tomahawk, Wisconsin) to further aid in detection of squirrels and other small mammals in three habitats: dense coniferous forest, open forest, and open meadow. We baited Sherman traps with rolled oats,

shelled peanuts, and peanut butter, spaced traps 10 m apart in a 6 by 5 grid array, and placed cotton batting in each trap. We set Sherman traps in the evening (1700–1830 h) for 4 consecutive nights and checked traps the following morning (0630 h). We conducted a second check of traps in the late morning (1100 h). We baited Tomahawk traps with peanuts and peanut butter and placed two traps at random in the central area of each trapping grid. We set Tomahawk traps each morning upon arrival at a trap grid (0630 h) during 4 consecutive mornings and checked them twice, closing each in the late morning (1100 h).

RESULTS—During 17–22 May 2007, we dedicated >152 person-hours to surveying 132 ha of potential habitat of red squirrels within mixed-coniferous forests in Guadalupe Mountains National Park. Of the 973 ha of Douglas-fir forest near The Bowl, nearly 80% (775 ha) was burned in the 1990s. The 132 ha that we surveyed represented forest that we considered to be most likely to support red squirrels and that had not burned in recent decades. Within this surveyed area, we broadcast 52 sessions of calls. We detected no response to calls or evidence of activity of red squirrels. We did not observe remains, nests, middens, caches, or evidence of feeding by red squirrels. We only observed evidence of feeding by gray-footed chipmunks (*Tamias canipes*) on cones of Douglas-firs and seeds of southwestern white pines, as determined by pattern of feeding on cobs of cones and hulls of seeds (Rasmussen et al., 1975).

During 384 trap nights (Sherman and Tomahawk traps), we captured three species of small mammals, but did not capture or observe red squirrels. We trapped, directly observed, or found evidence of 10 species of mammals near The Bowl: brush deermouse (*Peromyscus boylii*), Mexican vole (*Microtus mexicanus*), western harvest mouse (*Reithrodontomys megalotis*), gray-footed chipmunk (*Tamias canipes*), eastern cottontail (*Sylvilagus floridanus*), hog-nosed skunk (*Conepatus leuconotus*), mule deer (*Odocoileus hemionus*), Mexican woodrat (*Neotoma mexicana*), gray fox (*Urocyon cinereoargenteus*), and American black bear (*Ursus americanus*).

DISCUSSION—Based on our surveys of the remaining mesic, Douglas-fir forests surrounding The Bowl, red squirrels do not inhabit Guadalupe Mountains National Park. Red squirrels leave conspicuous, identifiable evidence of feeding in the form of remnants of cones, clipped cones and tips of branches, cached cones, and

piles of scales from cones (Finley, 1969; Rasmussen et al., 1975; Gurnell, 1984; Steele, 1998). They also make bolus nests made of leaves, grasses, and lichens (Steele, 1998; Young et al., 2002) that are visible in the canopy of trees. Surveys such as ours are the best method for detecting red squirrels (Finley, 1969; Vahle and Patton, 1983; Price, 1994; Mattson and Reinhart, 1996; Gutzwiller and Riffell, 2008). Our survey was the most extensive attempt to determine the status of red squirrels within the Guadalupe Mountains of Texas. Members of our team were trained to recognize evidence of red squirrels and, during 152 person hours of observations, we detected only evidence of chipmunks with no evidence of red squirrels. Playback of calls elicits responses from red squirrels that use vocalizations to maintain territorial boundaries (Price, 1994; Steele, 1998). We did not detect a response to any broadcast; when this evidence is combined with the lack of evidence for feeding and nesting, we conclude that it is highly unlikely that red squirrels occupy Guadalupe Mountains National Park.

Red squirrels historically occurred in the Guadalupe Mountains during the Pleistocene (Harris, 1990; Patterson, 1995) and as recently as the late 1800s (Davis and Robertson, 1944). Reports of recent sightings are unsubstantiated (Findley, 1961; Patterson, 1995). Because red squirrels occur <200 km away in the Sacramento Mountains of New Mexico, it is possible that a small population persisted in the Guadalupe Mountains. At the turn of the 20th century, the Guadalupe Mountains experienced a dramatic shift in land-use practices from use for subsistence by native peoples to European-American settlements (Sakulich and Taylor, 2007). The high-elevation mixed-coniferous forests were privately owned and heavily grazed beginning in the 1920s and ceased when the area became a national park in 1972, at which point comprehensive faunal surveys commenced (Genoways and Baker, 1979; Sakulich and Taylor, 2007). Pre-settlement records of fires obtained from mixed-coniferous forests within Guadalupe Mountains National Park indicate an average historical fire-return interval of 2.7 years, expanding to 8.4 years during the settlement period. Extent and frequency of fires have steadily decreased from the 1920s to present (Sakulich and Taylor, 2007), and modern practices to suppress fires may increase the

likelihood of larger, more severe fires. Fires within the past 20 years have altered much of the mixed-coniferous forest near The Bowl, further decreasing the chances that red squirrels might persist there.

We observed a similar suite of mammals to those previously documented for the area around The Bowl (Davis and Robertson, 1944; Genoways and Baker, 1979). Range maps include red squirrels (e.g., Hall, 1981) in the Guadalupe Mountains region of Trans-Pecos Texas based on fossil evidence, historic documentation, and the suggestion of earlier surveys. We detected no evidence that red squirrels occur within the park. That much of the fauna described in the 1930s and 1970s from mixed-coniferous forests in the park remains intact is encouraging, and further efforts to preserve the unique faunal assemblages of Guadalupe Mountains National Park should be made.

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