Abert's Squirrel Management in Support of Endangered Mount Graham Red Squirrel Recovery in Arizona

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ABSTRACT: Recovery of the endangered Mount Graham red squirrel (MGRS) will likely be long and challenging. Its limited habitat, isolation to Pinaleño Mountain range, and demographic characteristics restrict its ability to rebound quickly from threats that impact both the squirrel and its habitat. Currently, threats to the MGRS include habitat degradation and loss through high-severity wildfire, fire suppression activities, insect outbreaks, climate change, and human development, and predation, as well as competition with Abert's squirrels. The most recent wildfire in 2017 impacted over 48,000 acres of already reduced habitat. A critical first step is to protect and manage the remaining population of the MGRS and its habitat. Management includes but is not limited to maintaining and improving the spruce-fir and mixed conifer biomes, while balancing the need to reduce risk of catastrophic wildfire with the needs of the squirrel. The U.S. Department of Agriculture, Animal and Plant Health Inspection Service Wildlife Services is conducting an Abert's Squirrel Removal Project at the request of the Arizona Game and Fish Department and the U.S. Fish and Wildlife Service (USFWS), in collaboration with a team of Mount Graham red squirrel experts and managers, to reduce the number of Abert's squirrels in historical MGRS habitat throughout the Pinaleño Mountains to assist in meeting the needs of the USFWS' 2011 MGRS draft recovery plan. Abert's squirrel removals are conducted monthly to minimize competition with MGRS.

KEY WORDS: Abert's squirrel, endangered species, habitat management, Mount Graham red squirrel, population management, *Sciurus aberti*, *Tamiasciurus fremonti grahamensis*

Proceedings, 30th Vertebrate Pest Conference (D. M. Woods, Ed.)
Paper No. 19. Published December 20, 2022. 6 pp.

INTRODUCTION

The Mount Graham red squirrel (*Tamiasciurus fremonti grahamensis*; MGRS) is an endangered species whose habitat is restricted to the coniferous forest areas of the Pinaleño Mountains in southeastern Arizona. Depending upon food resources, habitat quality, and threats to the population, the population experiences large fluctuations. According to the Arizona Game and Fish Department (AGFD) the current population is 109 individuals (AGFD 2021).

Recovery of the MGRS will be a long process. Many factors influence the MGRS population including habitat degradation, wildfires, fire suppression activities, insect outbreaks, climate change, human development, as well as competition with Abert's squirrels (*Sciurus aberti*) and predation. Limited habitat, isolation to Pinaleño Mountain range, and demographic characteristics all restrict its ability to rebound quickly from threats that impact both the squirrel and its habitat.

Of most relevance to the management project, the non-native Abert's squirrel (introduced in the Pinaleño Mountains in the 1940s) likely impacts MGRS through competition for food resources (Hutton et al. 2003, Edelman 2004, Edelman and Koprowski 2005), nest sites (Edelman and Koprowski 2006), and dispersal territory (Steele and Koprowski 2001), and potentially can increase predator density by providing an additional food source, leading to higher predation rates for red squirrels (Goldstein et al. 2018). Rushton et al. (2006) determined that competition with Abert's squirrels has the potential for a much greater impact on MGRS population size when compared to plausible increases in predation.

Legal Status

The MGRS was listed as endangered by the US Fish and Wildlife Service (USFWS) in 1987 (52 FR 20994) (USFWS 1987). The final rule concluded that the MGRS was endangered because its range and habitat were reduced, and its habitat was threatened by several factors, including the (then) proposed construction of an astrophysical observatory, occurrences of high-severity wildland fires, proposed road construction and improvements, and recreational developments at high elevations on the mountain. The rule noted that the subspecies might also suffer due to resource competition with the introduced Abert's squirrel. The USFWS recently concluded in a five-year review on the status of the MGRS that the species is still endangered (USFWS 2022).

Habitat

Surrounded by the Sonoran Desert, the Pinaleño Mountains and its habitat are unique, as it is isolated. Mount Graham red squirrels inhabit a narrow selection of habitats in the high-elevation areas of the Pinaleño Mountains in Southeastern Arizona, that support primarily Engelmann spruce (*Picea engelmanii*) and corkbark fir (*Abies lasiocarpa var. arizonica*); in the mixed-conifer stands dominated by Douglas fir *(Pseudotsuga menziesii*), with white fir (*Abies concolor*) and Mexican white pine (*Pinus strobiformis*) sub-dominants; and in the ecotone life zone

between these community types. The MGRS apparently do not inhabit pure stands of ponderosa pine (*Pinus ponderosa*) (USFWS 1993). The highest peak in the Pinaleño Mountains, Mount Graham stands 3,269 m tall with the majority of the MGRS above 2,438 m in mixed conifer.

The habitat for MGRS depends on the availability of conifer cone crops to maintain the habitat, for food for MGRS as well as the correct conditions for food storage. Mount Graham red squirrels perch on a branch to chew off cone scales to get seeds inside the cones. The scales will fall to the ground and create a midden. Red squirrels are extremely territorial, especially over middens. The dropped scales will keep the midden cool and moist, keeping the stored cones from drying out and losing their seeds. Territories are usually centered around middens likely because they contain one to two years of cone resources. Other factors will include downed logs, snags, and interlocking branch networks. The MGRS will use the logs, snags and branches as pathways or routes to and from middens and to escape predation.

The habitat, critical to MGRS, has been reduced due to forest fire and competition from the Abert's squirrel. Historically, the MGRS was common above 2,591 m. Recently a midden was found near the cabins in the Upper Turkey Flat summer home area at approximately 2,286 m. This behavior could be a direct result for the habitat loss at higher elevations and the excessive competition from Abert's squirrels for habitat.

On January 5, 1990, the USFWS designated approximately 769 hectares as MGRS critical habitat (Figure 1; 55 FR 425) (USFWS 1990). Critical habitat includes three areas: the area above 3,048 m in elevation surrounding Hawk and Plain View peaks and a portion of the area above 2,987 m; the north-facing slopes of Heliograph Peak above 2,804 m; and the east-facing slope of Webb Peak above 2,957 m.

Distribution, Abundance, and Population Trends

Mount Graham red squirrels are found only in the high-elevation forests of the Pinaleño Mountains (Hoffmeister 1986) (Figure 1) in the Safford Ranger District of the Coronado National Forest in southeastern Arizona. As recently as the 1960s, the species ranged possibly as far east as Turkey Flat and as far west as West Peak, but it is now located as far west as Clark Peak. A local extirpation occurred on West Peak, possibly due to a fire in the mid-1970s that both isolated the West Peak subpopulation from the rest of the range and destroyed red squirrel habitat. Suitable habitat on West Peak is thought to currently exist (Hatten 2009), but no systematic surveys have been conducted there.

The population size of MGRS throughout its range has been estimated and tracked since 1986 by an interagency team. Due to changes in analysis, population estimates before and after 1990 may not be comparable. Midden surveys show increasing numbers of MGRS into 1998-2000, with peaks over 500, after which the population declined due to a decrease in habitat from multiple insect outbreaks and wildfires (see Threats, below). Population estimates dropped 42% in 2001 as compared from 1998-2000; from then until 2017, population estimates remained relatively stable, varying from 199 to 346. In summer of 2017, however, the Frye Fire burned through the majority of the squirrel's habitat. The last survey (conducted in Fall 2019) resulted in a conservative estimate of 78 MGRS (AGFD 2019).

Abert's Squirrel

The Abert's squirrel is the principal non-native vertebrate species of potential indirect and direct importance to the MGRS because it inhabits a similar niche in both low and high-elevation forests. Both Abert's and MGRS are members of the squirrel family (Sciuridae), subfamily Sciurinae, tribe Sciurini, with a divergence time estimated as prior to the Pleistocene and likely some three million years before present (Hafner 1984). Abert's squirrels are native to the northern Sierra Madre Occidental of Mexico and parts of Arizona, Colorado, New Mexico, Utah, and Wyoming (Nash and Seaman 1977). Although Abert's squirrels are often sympatric with red squirrels in the United States and are naturally found to the north in the Mogollon Rim in Arizona and to the south in the northern Sierra Madre Occidental, no evidence currently exists to suggest that Abert's squirrels coexisted with red squirrels naturally in the Pinaleño Mountains in recent geologic times (approximately 10,000 years before present).

Forty-nine Abert's squirrels were trapped in October 1941 and 20 in May 1943 at Fort Valley north of Flagstaff and released in the Pinaleño Mountains by the AGFD and is likely the origin of the Abert's squirrel population in the Pinaleños (Hoffmeister 1956, Davis and Brown 1988). Abert's squirrels occur throughout the highest elevations in the Pinaleño Mountains, including the spruce-fir forests (Hoffmeister 1956, 1986, Hutton et al. 2003), but also use Gambel oaks in riparian areas low on Mount Graham (Brown 1986). Since the loss of most of the spruce-fir forest on the mountain, Abert's and Mount Graham red squirrels are in closer association and likely compete more for resources (Rushton et al. 2006).

Abert's squirrels likely impact Mount Graham red squirrels through competition for food resources (Hutton et al. 2003, Edelman 2004, Edelman and Koprowski 2005), nest sites (Edelman and Koprowski 2006), and dispersal territory (Steele and Koprowski 2001), and potentially can increase predator density by providing an additional food source, leading to higher predation rates for red squirrels (USFWS 2018). Rushton et al. (2006) determined competition with Abert's squirrels has the potential for a much greater impact on MGRS population size. As such, we believe this project will have a beneficial effect to MGRS in the long term.

The recovery plan (USFWS 2011) is currently under revision. The Draft Mount Graham Red Squirrel Recovery Plan, Recovery action 3.4 states, "Investigate and analyze the effects of Abert's squirrels on Mount Graham red squirrels, including the possibility of reducing and/or eliminating the threat to the MGRS due to competition with the Abert's squirrel."

The main attribute of these areas at that time was the existing dense stands of mature (about 300 years old) spruce-fir forest. The MGRS Refugium established by the Arizona-Idaho Conservation Act (1988) has the same boundary as the designated critical habitat boundary surrounding Hawk and Plain View peaks (about 688 hectares)

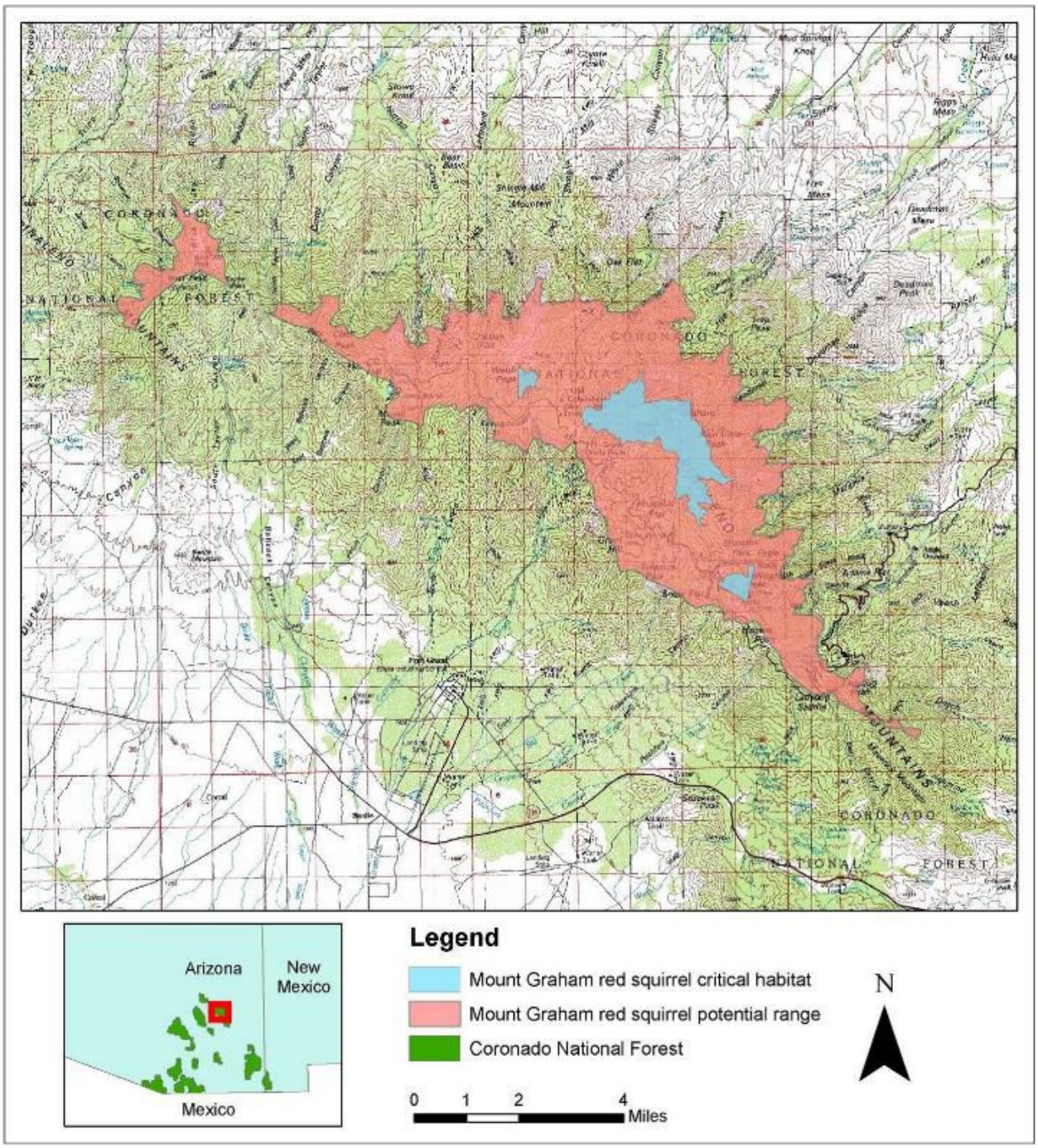

Figure 1. Mount Graham red squirrel potential range and critical habitat boundary, Pinaleño Mountains, Arizona (potential range boundary determined by Hatten 2009).

but does not include critical habitat on Heliograph or Webb Peaks. Unfortunately, most of the habitat in the Refugium and in critical habitat has been impacted by wildland fire and insect damage.

Management Objective

The US Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services program is conducting the Abert's Squirrel Removal Project at the request of AGFD and USFWS in collaboration with a team of Mount Graham red squirrel experts and managers to reduce the number of Abert's squirrels in historical MGRS habitat throughout the Pinaleño Mountains to assist in meeting the needs of the MGRS recovery plan (USFWS 1993) and Draft Recovery Plan 3.4 for the Mount Graham Red Squirrel, First Revision (USFWS 2011).

It may be impossible to eliminate Abert's squirrels in the Pinaleño Mountains, as parts of the mountain range are extremely rugged and inaccessible to humans. However, it may be appropriate to target areas for Abert's squirrel reductions during important life cycles of the MGRS. Priority management areas (Figure 2) for the removal of

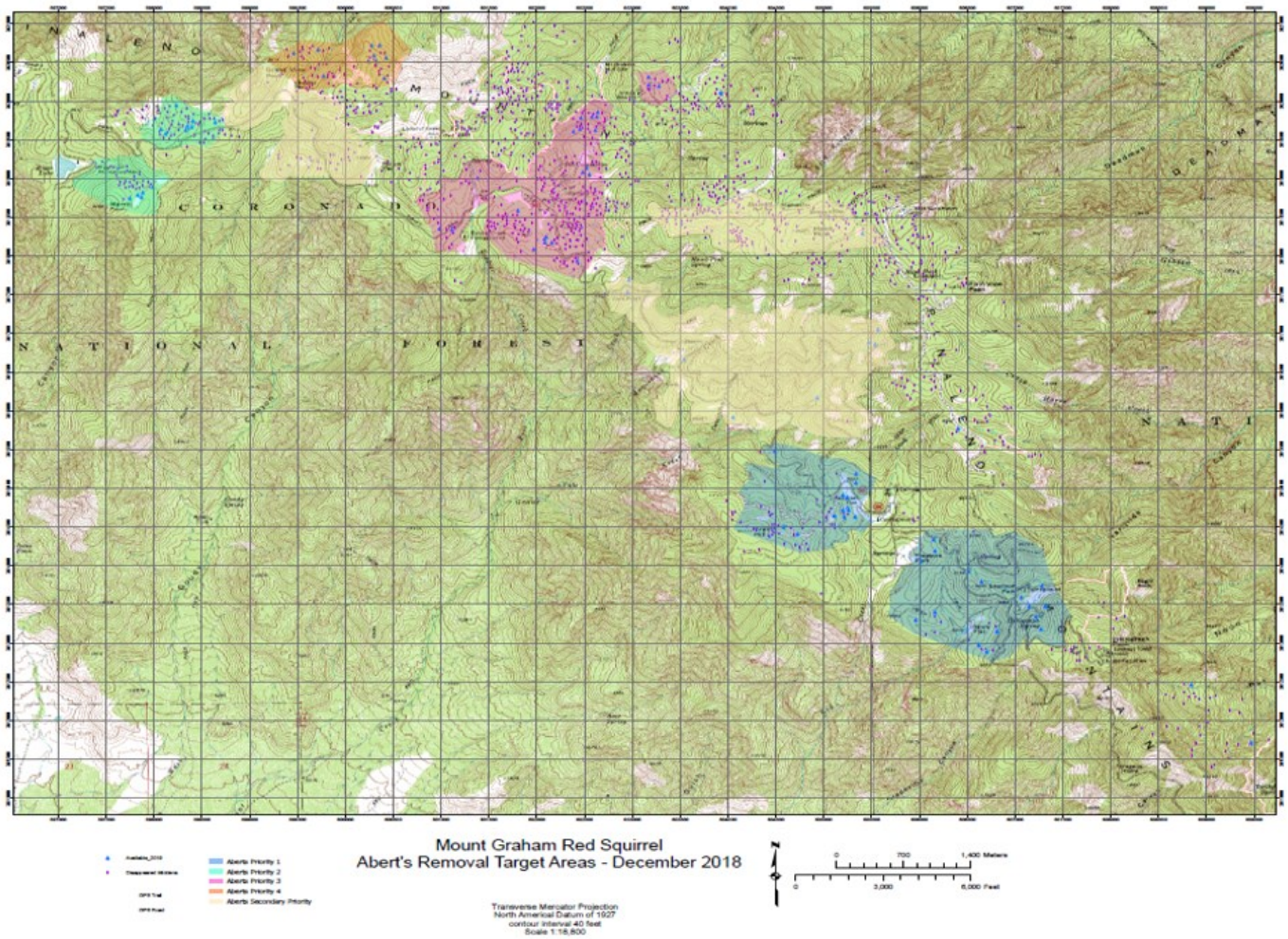

Figure 2. Map showing the priority areas for removal of Abert's squirrels in the Pinaleño Mountains of the Coronado National Forest. The area includes all areas within the Mount Graham red squirrel's potential range as determined by Arizona Game and Fish Department.

Abert's squirrels in the Pinaleño Mountains were developed in consultation with AGFD and USFWS as determined to be of the most benefit to MGRS.

METHODS

Prior to implementation of the project, WS personnel are trained to identify the differences between Abert's tree squirrels and MGRS by the USFWS. Project personnel used suppressed firearms to minimize potential noise disturbance. Shooting occurred only during daylight hours and was limited to locations where it is legal and safe to discharge firearms. WS personnel made every effort to recover Abert's carcasses to be used for scientific research.

The project areas were accessed via roads and on foot. WS coordinated with the U.S. Forest Service to access the MGRS Refugium (areas above 3,048 m on some peaks for which a permit may be required) and areas beyond gates that are shut during seasonal closures (November 15-April 15). Project activities occurred on average four days/month and included one to two people conducting these activities.

RESULTS AND DISCUSSION

The objective of the MGRS Recovery Plan (USFWS 1993) is "to increase and stabilize the existing Mt. Graham red squirrel population by protecting existing habitat and restoring degraded habitats". The Recovery Plan does not contain recovery criteria for MGRS, as the goal of the plan is to first increase and stabilize the population by providing sufficient habitat to maintain a population of squirrels that never fluctuates below 300 adults and is distributed throughout the Pinaleño Mountains.

The results from the management activities indicate the removal of Abert's squirrels has had a positive effect on the MGRS populations. The MGRS population increased from 33 individuals in 2017 following the Frye Fire and to an increase of 109 individuals in 2021 (Table 1).

Priority areas 1, 2, and the secondary priority had the highest removal numbers recorded for Abert's squirrels followed by the area outside of the priority areas (Table 2). The higher numbers of Abert's squirrel managed could be a result of the larger zones and supportive habitat of both

Table 1. Annual Mount Graham red squirrel population from 2017 to 2021.

Year	Population Size
2017	33 individuals
2018	75 individuals
2019	78 individuals
2020	109 individuals
2021	109 individuals

Table 2. Number of Abert's Squirrels removed from the target areas from FY2019 to FY 2022 in the Pinaleño Mountains.

Year	Population Size
Priority 1	155 Abert's Squirrels
Priority 2	172 Abert's Squirrels
`Priority 3	86 Abert's Squirrels
Priority 4	19 Abert's Squirrels
2nd Priority	168 Abert's Squirrels
Outside of priority areas	143 Abert's Squirrels

Table 3. Total number of Abert's Squirrels removed from FY2019 to FY 2022 in the Pinaleño Mountains.

Year	Population Size
FY 2019	200 Abert's squirrels
FY 2020	216 Abert's squirrels
FY 2021	145 Abert's squirrels
FY 2022	182 Abert's squirrels
Total	743 Abert's squirrels

MGRS and Abert's squirrels. Priority 3 and 4 cover less of an area, however the zones are still productive and continue to support Abert's tree squirrels.

Since beginning the project in FY 2019 a total of 743 Abert's tree squirrels (Table 3) have been removed from the Pinaleño Mountains of the Coronado National Forest. This reduction in the numbers of Abert's squirrels will reduce the competition between the Mount Graham red squirrel and Abert's squirrels.

CONCLUSION

Many factors will influence the MGRS population, but is not limited to, maintaining, and improving the spruce-fir and mixed conifer biomes while balancing the need to reduce risk of catastrophic wildfire with the needs of the squirrel. Since the loss of most of the spruce-fir forest on the mountain, Abert's and MGRS are in closer association and likely compete more for resources (Rushton et al. 2006). Thus, the removal of Abert's squirrels will assist the MGRS population by decreasing the competition for the same resources. This reduction in numbers may also decrease predation rates. Goldstein et al. (2018) postulate that it is likely that introduced Abert's squirrels subsidize a diverse array of avian and mammalian predators in the Pinaleño Mountains, and that this is of concern for MGRS persistence. Removal of Abert's squirrels from areas with MGRS should therefore contribute to decreasing predation pressure on MGRS.

In a continued effort to further understand Abert's squirrel biology, the University of Arizona is conducting research into the biology of the Abert's squirrels. The research projects are being conducted to study the morphometric patterns in Abert's squirrels with the goal of documenting the morphological measurements and related characteristics to reproductive organ size in Abert's squirrels. Additional research is evaluating potential parasite loads that could be shared with MGRS. The research is being conducted on carcasses collected during management activities and provided to the University of Arizona.

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