# Mount Graham red squirrel

# (*Tamiasciurus fremonti grahamensis*)

# 5-Year Status Review:

# Summary and Evaluation

**U.S. Fish and Wildlife Service**

**Arizona Ecological Services Office**

**Tucson, Arizona**

**August 2024**

# 5-YEAR REVIEW

## *Mount Graham red squirrel* (*Tamiasciurus fremonti grahamensis*)

## 1.0 GENERAL INFORMATION

### 1.1 Listing History

**Species:** Subspecies
**Date listed:** June 3, 1987
**FR citation(s):** 52 FR 20994
**Classification:** Endangered

**Critical habitat/4(d) rule/Experimental population designation/Similarity of appearance listing:** 55 FR 425, Endangered and Threatened Wildlife and Plants: Designation of Critical Habitat for the Endangered Mount Graham Red Squirrel (Tamiasciurus hudsonicus grahamensis, January 5, 1990

### 1.2 Methodology used to complete the review:

In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (ESA), the purpose of a 5-year review is to assess each threatened species and endangered species to determine whether its status has changed and it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. We, the U.S. Fish and Wildlife Service (USFWS), evaluated the biology and status of the Mount Graham red squirrel (Mount Graham red squirrel, red squirrel, or squirrel) as part of a draft Species Status Assessment (SSA; in review) and announced this status review through a Federal Register notice (87 FR 5834), published on February 2, 2022. During the 90-day comment period of the Federal Register notice, new information about species' biology, habitat conditions, conservation measures implemented, threats, and trends was solicited from Federal and State agencies, tribes, nongovernmental organizations, academia, and the general public. This review was informed through the public review notification, a comprehensive review of documents regarding the Mount Graham red squirrel available to the USFWS's Arizona Ecological Services Field Office-Tucson (AZESFO), and information and analyses in the draft SSA. The primary sources of information used in this analysis were the final listing rule (52 FR 20994), draft Recovery Plan (USFWS 2011), peer reviewed scientific publications, published and unpublished reports, and information elicited from species experts.

Development of the draft SSA report was guided by the SSA Core Team. The SSA Core Team is comprised of species experts from State and Federal agencies, including the Arizona Game and Fish Department (AZGFD) and the U.S. Forest Service (Forest Service), experts who actively work with the Mount Graham red squirrel. That team reviewed the draft SSA report before we used it in the scientific basis to support our 5-year review. The draft SSA report represents our evaluation of the best available scientific information, including the resource needs and condition of the species.

### 1.3 FR Notice citation announcing the species is under active review:

87 FR 5834, Endangered and Threatened Wildlife and Plants: Initiation of 5-Year Status Reviews of 35 Species in the Southwest, February 2, 2022

## 2.0 REVIEW ANALYSIS

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species meets the definition of "endangered species" or "threatened species." The Act defines an "endangered species" as a species that is "in danger of extinction throughout all or a significant portion of its range," and a "threatened species" as a species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Act requires that we determine whether a species meets the definition of "endangered species" or "threatened species" due to any of the five factors described below.

Section 4(a) of the Act describes five factors that may lead to endangered or threatened status for a species. These include: A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; or E) other natural or manmade factors affecting its continued existence.

The identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an "endangered species" or a "threatened species." In assessing whether a species meets either definition, we must evaluate all identified threats by considering the expected response of the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The USFWS recommends whether the species meets the definition of an "endangered species" or a "threatened species" only after conducting this cumulative analysis and describing the expected effect on the species now and in the foreseeable future.

### 2.1 Distinct Population Segment (DPS) policy (1996):

Not applicable, the Mount Graham red squirrel is listed as a subspecies, not as a DPS.

### 2.2 Updated Information and Current Species Status

#### 2.2.1 Biology and Habitat:

The information found in the 2008 5-year Status Review continues to be accurate. However, changes to monitoring, additional wildfires and potential insect outbreaks, Abert's squirrel removal efforts, and further taxonomic research since then have produced new information regarding the Mount Graham red squirrel and its habitat. For

further information on historical squirrel biology, habitat, and threats, see the 2008 Mount Graham red squirrel 5-year Status Review (USFWS 2008).

Changes in the survey method for the annual interagency census for the Mount Graham red squirrel occurred in 2022, which now involves systematically surveying transects in areas throughout the subspecies' range over a three-year cycle, allowing existing middens to be counted and possible new middens to be discovered. Results of the 2023 census documented 144 Mount Graham red squirrels (AZGFD 2023b p. 1). This is an increase from an estimated 35 individuals in 2017 following the Frye Fire, although the population has not recovered to the 200 to 300 individuals that were documented annually between 2000 and 2016 before the Frye Fire (AZGFD 2018, 2021).

The Frye Fire burned approximately 48,443 acres (ac) (19,604 hectares (ha)) mountain-wide in the summer of 2017 (Lynch 2019 p. 165), including much of the Mount Graham red squirrel's habitat. Currently, there are approximately 6,400 ac (2,580 ha) of red squirrel habitat remaining in the Pinaleño Mountains, including only 34 ac (14 ha) of spruce-fir forest (Lynch 2019 p. 165; USFWS 2023a p.1), an important habitat type for the squirrel. After the Frye Fire, the average Mount Graham red squirrel home range size increased from 1.19 ac (0.48 ha) pre-fire to 15.89 ac (6.43 ha) post-fire (Figure 6 in Merrick et al. 2021 p. 168). In an effort to prevent further loss and fragmentation of red squirrel habitat post-fire, the Forest Service deployed semiochemical treatments for tree insects from 2018 through 2020 on approximately 450 ac (182.11 ha) of red squirrel habitat, and additional treatments in May 2023 to reduce the risk of Douglas-fir bark beetle outbreaks after an outbreak of Douglas-fir tussock moth (Gaylord 2024 pers.comm.).

Competition with Abert's squirrels for food and nesting resources continues, especially as suitable Mount Graham red squirrel habitat continues to degrade and fragment due to climate change and associated drought, large-scale and high-severity wildfire, and forest insect outbreaks. To offset some of this competition, AZGFD, in collaboration with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Wildlife Services Program in Arizona (WS), began implementing an Abert's squirrel removal project in 2018 focused in areas of habitat overlap between the two species. As of July 2024, this effort has removed over 1,200 Abert's squirrels from the Pinaleño Mountains since the program began (USFWS 2024b p. 1).

Regarding red squirrel taxonomy, until 2016 the Mount Graham red squirrel was considered 1 of 25 subspecies of *T. hudsonicus* (Hall 1981 pp. 441–445). In 2016, Hope et al. (2016 p. 170), through testing of competing systematic and niche-based divergence hypotheses, recognized three species of North American red squirrel within the genus *Tamiasciurus*: *T. douglasii*, *T. hudsonicus*, and *T. fremonti*, and they determined through range-wide phylogeographic analysis of molecular genetic relationships that the Mount Graham red squirrel should be considered *T. fremonti* (Hope et al. 2016 p. 173). The USFWS recognized *T. fremonti hudsonicus* as the scientific name for the Mount Graham red squirrel in 2021 and published a technical

correction in the Federal Register on November 26 of that year (USFWS 2021 pp. 67353–67355).

### 2.2.2 Threats Analysis (threats, conservation measures, and regulatory mechanisms):

Current and potential future threats to the Mount Graham red squirrel include: 1. Competition with Abert's squirrels (Factor A); 2. Road maintenance and use (Factor A); 3. Recreation, special use, and permitted activities (Factor A); 4. Fire and fuels management (Factor A); 5. Wildfire (Factor A); 6. Predation (Factor C); 7. Shooting (Factor E); 8. Climate change (Factor A); 9. Drought (Factor A); 10. Tree insects and disease (Factor A), 11. Non-native ungulates (Factor A), 12. Squirrel parasites and disease (Factor C), 13. Small population size (Factor E), and 14. Genetics (Factor E).

*1. Competition with Abert's Squirrels*

Abert's squirrels compete with Mount Graham red squirrels for food resources, nest sites, and territories. Increased predator density because of an increase in prey abundance (such as Abert's squirrels) may also result in further stress and mortality for Mount Graham red squirrels (Edelman & Koprowski 2009 pp. 358–376).

Mount Graham red squirrels and Abert's squirrels feed on many of the same food items, including fungi and conifer seeds (Froehlich 1990 pp. 20–28; Edelman & Koprowski 2005 entire). Abert's squirrel use of these food and cover resources could limit their availability for the Mount Graham red squirrel (Edelman & Koprowski 2005 p. 464). High-intensity and high-severity wildfires that burn large mature trees, snags, and other vegetation can reduce habitat, food, and nesting resources for both Abert's squirrels and red squirrels. This can lead to further competition between Mount Graham red squirrels and Abert's squirrels for remaining post-burn resources (Goldstein et al. 2018 p. 74). Additionally, because Abert's squirrels are more suited to open, fire-adapted areas, wildfire and fire management in mixed-conifer forests may improve Abert's squirrel habitat by producing these preferred habitat structures (Gwinn & Koprowski 2016 pp. 5–6).

Abert's squirrels also may reduce Mount Graham red squirrel survival by increasing predator abundance. Edelman & Koprowski (2009 p. 383) speculate that Abert's squirrels provide additional prey sources for avian predator species commonly found in the Pinaleño Mountains (northern goshawk, great horned owl, red-tailed hawk, Cooper's hawk) and might increase predator survival, reproduction, and density in the Pinaleño Mountains, leading to higher predation of red squirrels. However, they also suggest that Abert's squirrels serving as an alternate food source for these predators could decrease predation rates of red squirrels, and recommend further study (Edelman & Koprowski 2009 p. 383).

*2. Road Maintenance and Use*

The presence of roads can have a negative impact on and can influence Mount Graham red squirrel survival (Chen & Koprowski 2016b p. 38). Vehicle traffic associated with recreation, road maintenance activities, and forest management, among others, can impact Mount Graham red squirrel abundance and recruitment through negative effects to squirrel occupancy due to traffic noise, direct mortality (Chen & Koprowski 2015 p. 315), and reductions in habitat. Because roads provide a means to access the forest for a variety of purposes, roads allow for more widespread recreational and permitted activities in Mount Graham red squirrel habitat (Buenau & Gerber 2004 p. 1). Although road mortality is documented opportunistically, 14 road-killed squirrels have been reported since 1987 (USFWS 2023b entire).

Live trees and snags are used by Mount Graham red squirrels for food and nests. When live trees and snags are considered a hazard to human safety, they may be removed near roads, which impacts the Mount Graham red squirrel by removing food resources (e.g., cones, twigs, beetle larva, etc.) and cover from predators while also inhibiting movement of red squirrels. Linear features (such as roads) can be interpreted as territory boundaries, which can restrict an individual's movement to one side of a road (Burnett 1992 pp. 100–102; Trombulak & Frissell 2000 pp. 20–21), and gaps in tree cover is the main factor inhibiting small mammals from crossing roads (Chen & Koprowski 2016b p. 37). This restriction of movement can disrupt the ability of Mount Graham red squirrels to find food resources and could potentially limit dispersal into otherwise suitable habitat or genetic exchange.

Roads fragment habitat, and red squirrels are less likely to cross roads in part because predation risk is higher in more open microhabitats (Chen & Koprowski 2016b p. 37). Chen and Koprowski (2015 p. 315) found that animal occurrence decreased as traffic noise increased and noticed behavioral responses, suggesting that Mount Graham red squirrels perceive traffic noise as a threat congruent with predators (Chen & Koprowski 2016a p. 12), thereby avoiding areas with high traffic noise. Road avoidance can impact Mount Graham red squirrel abundance and recruitment as reproductive activities are the most important factors in predicting road crossings (Chen and Koprowski 2016b p. 36).

*3. Recreation, Special Use, and Permitted Activities*

Recreation, special use, and permitted activities within Mount Graham red squirrel habitat include camping, horseback riding, hiking, and hunting; special uses such as the development of the Mount Graham International Observatory on Hawk Peak and recreational residence use in the Columbine and Turkey Flat areas; and permitted activities such as collection of forest products or commercial events or use of public lands. All of these activities and permitted uses can affect the Mount Graham red squirrel through increased human presence and associated disturbance, as well as potential loss of habitat and vegetation resulting in decreased food resources and less available cover from predators. They can also lead to increased fragmentation due to the presence of roads. Recreation and permitted activities can further lead to human-caused wildfires Koprowski (2005a p. 21), which may remove red squirrel habitat.

Recreation, special uses, and permitted activities can lead to increased noise from humans, pets, and equipment, which in turn may disturb Mount Graham red squirrels because visual or auditory disturbance may temporarily alter their feeding or sheltering behavior. However, the Forest Service has observed squirrels in areas near high-disturbance activities like hazard tree removals behaving normally and continuing to inhabit the area (USFWS 2018 entire, USFWS 2022 entire). Additionally, red squirrels did not desert their territories even after multiple capture events (Koprowski 2005b p. 310; Koprowski et al. 2008 p. 228). Therefore, at this time human presence through recreation, special uses, and permitted activities do not appear to substantially disturb Mount Graham red squirrels.

Loss of habitat or vegetation can result in decreased food resources and less available cover from predators. Currently the maximum footprint of recreation, special use, and administrative sites within Mount Graham red squirrel habitat is 196.5 ac (79.52 ha). No increase in this footprint is anticipated at this time, and any future increases would require additional review through the National Environmental Policy Act (NEPA) and ESA. Hazard tree removal and removal of vegetation and fuels within 30 ft of permitted structures, required for human safety, may decrease food sources or nest sites and increase predation risk. Such activities have minor impacts to habitat because they are localized and occur infrequently in already-disturbed areas.

*4. Fire and Fuels Management*

Alterations of the historical fire regime in mixed-conifer forest from frequent but short-interval, low-severity fires to infrequent but larger, high-severity fires (O'Connor et al. 2014 p. 264) has led to the use of active fire and fuels management practices, which can impact Mount Graham red squirrels and their habitat by removing trees, snags, and other vegetation they require for food and habitat needs.

Selective thinning consists of felling trees to diminish fuel loads to a volume that reduces the likelihood of high-intensity, stand-replacing fires (Schwilk et al. 2009 p. 286). Fuel loads and understory vegetation can also be reduced on a larger, landscape-level scale as they are consumed during prescribed burn activities (Schwilk et al. 2009 p. 299), thereby further reducing the likelihood of high-severity fires into the future (Schwilk et al. 2009 p. 297). During both selective thinning and prescribed burning activities, Mount Graham red squirrels and their habitat can be negatively affected through disturbance and removal of key habitat features such as canopy cover, tree density, number of downed logs, and number of dead trees. Fire suppression responses to naturally-ignited wildfires (e.g., mechanical removal, backburning or other controlled ignitions, retardant drops) can also negatively affect Mount Graham red squirrel habitat by removing live trees, nests, and middens, and possibly killing Mount Graham red squirrels directly.

While these fire and fuels management activities (thinning, prescribed burns, and fire suppression) can negatively affect Mount Graham red squirrels and their habitat, they

can also protect them by managing understory regeneration/density and decreasing wildfire severity through fuel reductions, thereby minimizing the risk of high-severity wildfire and destruction such fires may cause (USFWS 2007 pp. 48–49). These fuels management techniques also aid in retaining mature forest and reducing risks to human health and safety, wildlife habitat, and watershed integrity and function by buffering impacts of high-severity wildfire (Swetnam et al. 2009 entire), all of which can benefit Mount Graham red squirrels and their habitat.

*5. Wildfire*

Uncharacteristic large-scale, high-severity wildfire currently poses the greatest threat to the Mount Graham red squirrel through habitat loss and direct impacts to red squirrels within the fire boundary. Since the 1880s, practices of fire suppression and exclusion, livestock grazing, and logging have resulted in a shift in the fire regime from frequent short-interval, low-intensity fires to infrequent larger, high-intensity fires (USFS 2000 pp. 9–16). Currently, mixed-conifer forests have over 100 years of fuel accumulation, increasing the likelihood of high-severity fire (O'Connor et al. 2014 pp. 274–275). This fuel accumulation, paired with the infrequency of fires and changes in ground vegetation species composition to species with lower fire tolerance and high fuel loading enables larger, more severe fires to occur (Koprowski et al. 2006 p. 59). This can directly impact squirrels through injury and death and indirectly through decreases in available food resources, habitat, and cover from predators. Avian and mammalian predators may also hunt more intensely in burned areas following fire and exacerbate direct mortalities because of the resulting lack of cover and shelter from predators (Koprowski et al. 2006, pp. 59-61), and are therefore a threat to Mount Graham red squirrel abundance.

High-severity fire can significantly reduce survivorship of Mount Graham red squirrel individuals through direct burning of individuals, middens, available foods, nests, and cavities; post-fire displacement of individuals; and predation due to lack of suitable habitat cover (Koprowski et al. 2006 p. 60). The intensity and severity of a fire are important factors in determining the likelihood of survival (Koprowski et al. 2006 p. 61). Fires that reach the canopy and crown likely lead to direct fatality of tree squirrels (Koprowski et al. 2006 p 61). In a study on the direct effects of fire on Mount Graham red squirrels, Koprowski et al. (2006 p. 59) found that of 57 radio-collared adult squirrels, 7 perished in the Nuttall-Gibson Complex Fire, and survival of squirrels over the period which included the fire was lower in burned areas than in unburned areas. The results of this study also found that 15 of 20 middens within the burn perimeter were destroyed by the fire, which applied further stress to squirrels using these middens because of the loss of food resources stored within them, potentially leading to decreased future survival and reproductive success (Koprowski et al. 2006, p 61).

Increased horizontal and vertical fuel loads escalate fire intensity, producing higher intensity and severity fires, both of which are more likely to alter and destroy key habitat features for the Mount Graham red squirrel, such as canopy cover and

interlocking branches. The development of long-term forest management strategies across fire impacted landscape are essential to conserve effected species and reduce the threat of fire-related stressors to Mount Graham red squirrel (AZGFD 2018 entire).

*6. Predation*

On Mount Graham, the major source of mortality in red squirrels comes from avian predation (Chen & Koprowski 2016a p. 21). Between June 2002 and 2016, sufficient evidence was recovered to assign cause of death for 135 individuals. Goldstein et al. (2018 p. 71) found that 67 percent of these confirmed deaths were attributable to raptors, 5 percent to mammalian predation, and 27 percent were unknown. This could indicate that the more time Mount Graham red squirrels spend in relatively open forest, the higher the risk of predation. High severity wildfire, caused in part by historical fire suppression activities and ignited either by human activity or natural sources, opens the canopy and exposes Mount Graham red squirrels to further predation. Additionally, predation risk in red squirrels may be increased, in part, by the presence of a non-native, ecologically similar prey species (Abert's squirrel) and the degradation of red squirrel habitat as a result of wide-spread tree death and fire (Koprowski et al. 2005 p. 495; Wood et al. 2007a pp. 71–72; Edelman & Koprowski 2009 pp. 380–383; Derbridge & Koprowski 2019 p. 4073).

Juvenile squirrels spend more time exposed and are 3.5 times more likely to die from avian predation than adults (Stuart-Smith and Boutin 1995 pp. 34–40; Goldstein et al. 2018 p. 71),which can negatively impact recruitment of the subspecies because fewer squirrels survive to adulthood. Although historical levels of predation are unknown in the Pinaleño Mountains, mortality due to predation appears to be at the high extreme of those reported for other populations of red squirrels (Layne 1954 pp. 262 and 264; Rusch & Reeder 1978 p. 417; Stuart–Smith & Boutin 1995 pp. 36–38; Wirsing et al. 2002 p. 712; Goldstein et al. 2018 pp. 71–72).

*7. Shooting*

The recreational shooting (hunting) of Mount Graham red squirrels is prohibited by AZGFD's A.R.S. sections 17-303 and 17-304 and Commission Rules R12-4-301, R12-4-801, R12-4-803 and their endangered status under the ESA. The shooting of Abert's squirrels is, however, permitted. Removal of Abert's squirrels can decrease the abundance of that species, thereby benefitting Mount Graham red squirrels because the presence of Abert's squirrels may increase predator densities, increasing predation risk for Mount Graham red squirrels (Edelman & Koprowski 2009 pp. 358–376). Hunting Abert's squirrels may also result in the accidental shooting (killing or injuring) of Mount Graham red squirrels instead of the intended species. This is more likely to happen in low-light conditions or in winter when the pelage of Mount Graham red squirrels acquires a gray cast that could resemble Abert's squirrels to novice hunters (Edelman & Koprowski 2009 pp. 358–376).

*8. Climate Change*

Changing global climates (IPCC 2021 p. 425) are affecting forest ecosystems throughout the world directly and indirectly through altered disturbance regimes (e.g., Ayres & Lombardero 2000 p. 268; Breshears et al. 2005 p. 15144; Raffa et al. 2008 p. 501; Bonan 2008 p. 1445; Negrón et al. 2009 pp. 1353–1354; Van Mantgem et al. 2009 p. 523; Allen et al. 2010 p. 671).

Predicted climate change impacts in the southwest include increased aridity from warmer temperatures and reduced overall precipitation, more precipitation falling in intense events, reduced snowpack, and an increased frequency and duration of extreme weather events such as heat waves and droughts (Archer & Predick 2008 entire; Hicke et al. 2022 p. 1932,1937-1938). Further, warmer nights and projected declines in snowpack, coupled with earlier spring snow melt, will reduce water supply, lengthen the dry season, create conditions for drought and insect outbreaks, and increase the frequency and intensity of wildfires as well as the duration of the wildfire season (Allen et al. 2010 entire).

Widespread tree mortality due to insect outbreaks and disease can create conditions that increase the likelihood and severity of wildfires. The resulting loss of canopy cover results in increased risk of predation and possible exposure to weather (Saab et al. 2014 p. 540). Prolonged drought combined with warmer temperatures increases the susceptibility of trees to insects and disease, amplifying insect outbreak and wildfire risk (Betancourt 2004 p. 7; Allen et al. 2010 p. 664; Bell et al. 2020 pp. 1721–1722) (Mueller et al. 2005 p. 1090; Figure 3 in Negrón et al. 2009 pp. 1360–1361; Van Mantgem et al. 2009 p. 523)

The effects of climate change on rare, endangered, and endemic species are highly variable (EPA 2009 entire) and will differ depending upon life history characteristics (Travis 2003 p. 472) and dispersal abilities. Increasing levels of drought, along with associated insect outbreaks and wildfires, could rapidly and dramatically affect Mount Graham red squirrel habitat by altering the forest structure and available food resources within the Pinaleño Mountains.

*9. Drought*

Arizona has experienced a severe, multiple-year drought and models have suggested that a 10-to-20-year (or longer) drought was anticipated (Swetnam & Betancourt 1998 p. 3128; Woodhouse & Overpeck 1998 entire; McCabe et al. 2004 entire; Seager et al. 2007 entire). More recent data confirm that drought conditions have persisted in the southwestern U.S. (EPA 2024 entire).

Drought alters habitats, contributing to food and nesting scarcity. Poor cone crops, resulting from severe drought, cause increased competition with Abert's squirrels because of the decrease in available food resources. Currently, mixed conifer forests are

overgrown due to fire suppression and are now susceptible to stand-replacing fires, especially during severe drought conditions (Westerling et al. 2006 entire; O'Connor et al. 2014 p. 264; Gonzalez et al. 2018 pp. 1115–1116). Drought can lower conifer tree defense capabilities (Gaylord et al. 2013 p. 7; Kolb et al. 2019 entire; Netherer et al. 2015 entire), allowing bark beetle outbreaks to commonly co-occur with drought conditions (Negrón et al. 2009 p. 1353). High temperatures are thought to exacerbate these impacts (Adams et al. 2009 entire).

Recent temperature increases in the southwestern U.S. are among the most rapid in the nation and are significantly greater than the global average in some areas (Guido et al. 2008 p. 5). From 2000 to 2020, average temperatures for southeastern Arizona have differed from the long-term average by an increase of 1.6 to 1.8 °F (0.89 to 1 °C) and the region has been abnormally dry, experiencing increased moderate to severe drought conditions (EPA 2024 entire). Such changes suggest that forests in the southwestern U.S. have increased vulnerability to insect and disease outbreaks and wildfires (Gonzalez et al. 2018 pp. 1115–1117). Increasing levels of drought, insect outbreaks, and wildfires will likely directly impact the red squirrel's already limited habitat and food resources.

*10. Tree Insects and Disease*

Insect outbreaks and disease can alter forest structure and composition, seed production and regeneration, and fuel loads. Mortality of large mature trees remove squirrel food resources because of the decrease in available cone crops. Resulting changes in canopy structure reduces shaded microclimates critical for epigenous fungal growth and food storage conditions in middens (Koprowski et al. 2005 p. 495). If limited, tree mortality from insect outbreaks can create snags and logs used for nest locations and shelter (Saab et al. 2014 p. 540). Widespread tree mortality, however, can create conditions that increase the likelihood and severity of wildfires (Saab et al. 2014 p. 540), and increase the risk of predation and exposure to weather due to the loss of canopy cover (Saab et al 2014 p. 540).

Insects that cause tree mortality and effects to forest health in spruce-fir habitat in the Pinaleño Mountains include spruce beetle and western balsam bark beetle; spruce aphid, a sap sucking insect that leads to premature needle loss; and Janet's looper (USFS 2021 pp. 4, 8). In mixed conifer habitat, Douglas-fir beetle in Douglas-fir, the roundheaded pine beetle (*D. adjunctus)* in ponderosa pine*,* mountain pine beetle and Ips (*Ips bonanseai*) in southwestern white pine*,* and the defoliator Douglas-fir tussock moth on both Douglas-fir and white fir can cause insect outbreaks (USFS 2021 pp. 4, 8). Defoliators affecting aspen include western tent caterpillar (*Malacosoma californicum*) and large aspen tortrix (*Choristoneura conflicata*) (USFS 2021 p. 8). All are native insects and have co-occurred in Mount Graham red squirrel habitat except for the exotic spruce aphid (Lynch 2009 p. 333), which is likely to increase in outbreak frequency with the projected warming climate in the southwestern U.S. (Seager et al. 2007 p. 1181). Douglas-fir tussock moth outbreaks were not documented in the Pinaleño

Mountains prior to 2022; however, stand hazard and risk of outbreaks are increasing with fire suppression and the subsequent increases in shade tolerant species on the landscape (USFS 2021 p. 13; Grady 2023 p. 2).

Tree diseases reduce the longevity, growth, and reproduction of host trees. Prevalent diseases in the Pinaleño Mountains include dwarf mistletoes (DM) such as spruce DM (*Arceuthobium microcarpum*), Douglas fir DM (*A. douglasii*) and southwestern DM (*A.vaginatum subsp. Cryptopodium*); root diseases such as Armillaria (*Armillaria* spp.) and Heterobasidion (*Heterobasidion* spp.); a number of stem cankers such as *Cytospora* spp. and black canker (*Ceratocystis* spp.), which are most common on aspen; and foliar diseases like black leaf spot (*Drepanopeziza populi*) in aspen as well as *Lophodermella* and *Dothistroma* spp. among many others in conifers. Forest diseases may also interact with factors such as insects and drought, further decreasing forest health. While the mixed-conifer forest has experienced outbreaks of most of these insects and pathogens previously, the reduction of Mount Graham red squirrel habitat within this forest type threatens the red squirrel population when combined with the loss of spruce-fir forest as described above. Increasing levels of drought due to climate change will likely work in combination with increasing levels of insect outbreaks and wildfires, directly impacting limited habitat and food resources.

*11. Non-native Ungulates*

Although Rocky Mountain elk are present in small numbers on Mt. Graham, during the 2008 5-Year Review there were concerns that elk numbers would increase rapidly by exploiting aspen regeneration following the 2004 and 2006 wildfires and due to the lack of natural predators (wolves). However, over the last 10 years there have only been a few reports of potential single vagrant elk in the higher elevations. There is not any indication of elk becoming established or reproducing in the high elevations of the Pinaleño Mountains (AZGFD pers com 2023a p. 1).Therefore, elk are no longer considered a potential threat.

*12. Squirrel Parasites and Disease*

Squirrel parasites and diseases were not considered a threat during the 2008 5-Year review. Jones (2022 entire) looked at the parasite loads for a sample of Mount Graham red squirrels and Abert's squirrels to assess if any "spillover" of parasites from the non-native Abert's squirrel to the native Mount Graham red squirrel has occurred. While Jones (2022 p. 46) found that ectoparasite communities differed between Abert's squirrels and Mount Graham red squirrels, indicating that spillover of these types of parasites has not occurred between the two squirrels, they did find one endoparasite in both species, a pinworm that has not been reported in red squirrels in areas where they overlap with other squirrel species. Jones (2022 pp. 46–47) concludes the potential for parasite transmissions between Abert's squirrels and Mount Graham red squirrels can occur and recommends additional studies to elucidate the potential effects of parasite spillover on Mount Graham red squirrels.

Several infectious agents have been reported for squirrels, such as tularemia (Burroughs et al. 1945 pp. 116–117) and California encephalitis (Masterson et al. 1971 p. 93), and for red squirrels, including Haplosporangium (Jellison 1950 p. 1057), adiaspiromycosis (Taylor et al. 1967 p. 515), Silverwater virus (Hoff et al. 1971 p. 328), and Powassan virus (McLean & Larke 1963 p. 182; McLean et al. 1968 p. 947). However, red squirrel mortality directly due to pathogens is not well documented (Koprowski 2003 p. 5). Therefore, while pathogens may impact individuals, we do not consider them a threat.

*13. Small Population Size*

Small, narrowly distributed populations, such as that of Mount Graham red squirrel, are vulnerable to extinction (USFWS 2011 pp. 25–26). As populations decrease in size, their vulnerability to environmental changes increases, including slow, long-term trends (deterministic) and brief, high-intensity (stochastic) events. These environmental changes can influence the demographics of a population directly, through changes in survival and recruitment rates, and indirectly, through changes in characteristics of the physical environment that affect the quantity and quality of habitat (Koprowski & Steidl 2009 p. 144). Given the unprecedented reductions in habitat area and quality due to factors such as wildfire, fire suppression, insect damage, development, and forest succession, the likelihood of reductions in population size and connectivity among habitat patches has increased concerns about persistence of this squirrel population.

Wood et al. (2007b pp. 1274–1275) speculated that tree squirrels can overcome typical ranges of environmental and demographic stochasticity and that small populations can persist and may recover from low numbers, but this scenario depends on habitat variability and food availability (Hamilton, Jr. 1939 p. 741; Sullivan 1990 p. 579). Regardless of the demographic challenges, Goldstein et al. (2017 p. 56) found a slightly positive rate of growth, but with declines in connected habitat, suggest it will be difficult for Mount Graham red squirrels to overcome increased environmental stressors. Maintaining healthy forests as well as a high degree of connectivity among forested patches in the Pinaleño Mountains appears to be an appropriate strategy for facilitating movements of dispersing individuals, and minimizing environmental and demographic effects to which small populations are vulnerable.

*14. Genetics*

The likelihood of genetic problems emerging in populations increases as population size decreases (USFWS 2011 p. 26). Most adverse genetic consequences stem from reductions in available genetic variation. Populations typically have lower genetic variation after undergoing large reductions in population size, known as population bottlenecks (Koprowski & Steidl 2009 p. 143). Populations that experience bottlenecks may be affected by inbreeding depression (Wood et al. 2007b p. 1275). Homozygosity results in the expression of deleterious recessive alleles (harmful genetic traits) or decreased heterozygosity (a condition in which two members of a gene pair differ) where heterozygote advantage is present (Crow 1948 p. 27). Smaller populations also

have a higher probability of genetic drift, which is the result of changes in allele frequencies due to random chance.

If population numbers remain low, the probability of matings between individuals with a high degree of genetic similarity increases, which can reduce rates of survival and fecundity (Koprowski & Steidl 2009 p. 143). Phenotypic variation in life-history traits that has a genetic basis, such as timing of reproduction, age at first reproduction, offspring size, and litter size, can increase population persistence (Conner & White 1999 p. 124; Allendorf & Ryman 2002 p. 61; Funk et al. 2019 entire). Therefore, loss of genetic variation reduces the potential for a population to respond to environmental changes through a shift in genotypic frequency, which has been called loss of evolutionary potential (Allendorf & Ryman 2002 p. 62; Forester et al. 2022 entire).

Fitak et al. (2013 p. 1238) suggest that while Mount Graham red squirrels appear to be randomly mating with each other, on average any two individuals are 90 percent related to each other. Mount Graham red squirrels exhibit extremely reduced measures of genetic variability and appear to have experienced a recent genetic bottleneck. The work of Fitak et al. (2013 p.1236) indicates that Mount Graham red squirrels have been isolated long enough to have accumulated mutations not present in other red squirrel populations, as well as mutations within their own population. Following the 2017 Frye Fire, the Mount Graham red squirrel population was reduced to an estimated 35 squirrels, which suggests that another, more recent, population bottleneck occurred.

Hope et al. (2016 pp. 179–180) found that evidence of demographic expansion is lacking among lineages of red squirrels and distinct diversity coincident with isolated mountain ranges indicates a potentially extinction-driven system in the future, especially if lack of connectivity is coupled with further degradation of montane forested habitats. This could apply to the Mount Graham red squirrel given its limited distribution to one isolated mountain range in southern Arizona.

### 2.3 Synthesis:

The status of the Mount Graham red squirrel has not improved since our 2008 5-year Status Review. Following the 2017 Frye Fire, which affected the quantity and quality of red squirrel habitat, the population fell to an estimated 35 individuals. Since then, the population has increased four-fold to 144 individuals in 2023, but it has not reached the level it maintained for 17 years (from 2000 to 2016) of 200 to 300 individuals prior to the fire. Threats to the Mount Graham red squirrel and its habitat continue, in particular the potential loss and fragmentation of habitat due to forest insect outbreaks and large-scale, high-severity wildfires. Climate change is likely to increase temperatures and periods of drought in the southwestern U.S., contributing to the increased risk of habitat loss from insects and wildfire. Predation remains high and competition with Abert's squirrels continues, directly affecting red squirrels through mortality and decreased recruitment rates from predation and indirectly affecting them through competition with a non-native squirrel for food, nest sites, and territories. Mount Graham red squirrels also exhibit extremely reduced measures of genetic variability, reducing their potential to respond to deterministic and stochastic events

and environmental changes. Therefore, the Mount Graham red squirrel meets the definition of an endangered species and we recommend that it remains classified as endangered.

## 3.0 RESULTS

### 3.1 Recommended Classification:

**No change is needed**

### 3.2 New Recovery Priority Number:

6

**Brief Rationale:**

Climate change and past human activities in the Pinaleño Mountains have created conditions that increase the risk of large-scale, high-severity wildfires. Such wildfires have resulted in the loss of a large amount of mixed-conifer forest and all but 34 acres of spruce-fir forest, both important habitat types for the Mount Graham red squirrel. Because high-severity wildfires can destroy and inhibit regrowth of forested areas, there is uncertainty about the extent of forest regrowth possible in the Pinaleño Mountains. Consideration of these factors and the subspecies' current status indicate there is a high degree of threat to the squirrel and its habitat, and a low recovery potential for the subspecies at this time. Although development has impacted squirrel habitat in the past, there are no current concerns regarding potential impacts from future development given the guidance provided in the Coronado National Forest's Land and Resource Management Plan and requirements for section 7 consultation on Federal activities. Therefore, a Recovery Priority Number of 6 applicable to the Mount Graham red squirrel.

### 3.3 Listing and Reclassification Priority Number: N/A

**Reclassification (from Threatened to Endangered) Priority Number:**
**Reclassification (from Endangered to Threatened) Priority Number:**
**Delisting (Removal from list regardless of current classification) Priority Number:**

**Brief Rationale:**

Not applicable

## 4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Securing the Mount Graham red squirrel population in the wild, protecting the remaining habitat for the Mount Graham red squirrel, and restoring areas where habitat has been lost are paramount for the subspecies' continued survival and recovery. To help inform these actions, we recommend reevaluating recovery strategies for the Mount Graham red squirrel and revising the recovery plan, if needed and when workloads allow.

To secure the population in the wild, the captive breeding pilot program with the Phoenix Zoo that was begun in 2014 should continue. This pilot program was established to help augment the declining wild population throughout their range in the long term, and to conserve the species in case of significant habitat and/or population loss in the short term (USFWS 2014). While breeding has not yet been successful, continued efforts to develop the program will help ensure the continued existence of the subspecies should a catastrophic loss in the red squirrel population occur.

To protect remaining habitat and restore areas where habitat has been lost, we recommend implementing the Pinaleño FireScape project. The goals of this project include decreasing the risk of large-scale, high-severity wildfire within frequent-fire-adapted vegetation types by reducing fuel loading, as well as making progress toward vegetation conditions that support a low- to moderate-intensity natural fire cycle, thereby lessening the probability of large-scale, high-severity wildfires on the landscape. This project should benefit the Mount Graham red squirrel in the long-term by promoting healthy forests and reducing the risk of forest insect outbreaks and large-scale, high-severity wildfires that remove and fragment its habitat.

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**U.S. FISH AND WILDLIFE SERVICE**

**5-YEAR REVIEW of Mount Graham red squirrel**

**Current Classification**: Endangered

**Recommendation resulting from the 5-Year Review:**

No change needed

**Appropriate Listing/Reclassification Priority Number, if applicable**: N/A

**FIELD OFFICE APPROVAL**:

**Lead Field Supervisor, Fish and Wildlife Service, Arizona Ecological Services Field Office**

Approve HEATHER WHITLAW Digitally signed by HEATHER WHITLAW Date: 2024.08.27 12:21:33 -07'00'