Draft Recovery Plan for the Mount Graham Red Squirrel (*Tamiasciurus fremonti grahamensis*), First Revision

U.S. Fish and Wildlife Service
Southwest Region
Albuquerque, New Mexico
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PURPOSE AND DISCLAIMER

This document presents the U.S. Fish and Wildlife Service's (USFWS) plan for the recovery of Mount Graham red squirrel. The recovery plan is the second part of the USFWS 3-part recovery planning framework, and includes the statutorily required elements pursuant to section 4(f) of the Endangered Species Act (ESA). This recovery plan is informed by the first part of the framework, a Species Status Assessment (SSA). The SSA report delivers foundational science for informing decisions related to the ESA and includes an analysis of the best available scientific and commercial information regarding a species' life history, biology, and current and future conditions that characterize the species' viability (i.e., ability to sustain populations in the wild over time) and extinction risk. We have also prepared a Recovery Implementation Strategy (RIS), the third part of the framework. The RIS is an easily updateable operational plan that is separate and complimentary to the recovery plan that details the on-the-ground recovery activities needed to complete the recovery actions contained in the recovery plan.

Recovery plans describe the envisioned recovered state for a listed species (when it would no longer meet the ESA definitions of a threatened species or endangered species) and include a recovery strategy, recovery criteria, recovery actions, and the estimates of time and cost needed to achieve it. Plans are published by the USFWS and are often prepared with the assistance of recovery teams, contractors, State agencies, and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in plan formulation, other than the USFWS. They represent the official position of the USFWS only after they have been signed by the Regional Director as approved. Recovery plans are guiding and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings or changes in species status.

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RECOMMENDED CITATION AND ELECTRONIC AVAILABILITY

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An electronic copy of this Final Recovery Plan will be made available at:

https://ecos.fws.gov/ecp/species/8370.

1. INTRODUCTION

This recovery plan describes criteria for determining when the Mount Graham red squirrel should be considered for delisting, lists site-specific actions that will be necessary to meet those criteria, and estimates the time and cost to achieve recovery. Additionally, a brief summary of information on the species' biology and status are included, along with a brief discussion of factors limiting its populations. A detailed discussion of these and other topics pertinent to the recovery of Mount Graham red squirrel can be found in the Species Status Assessment (SSA) (USFWS 2025 entire). Detailed on-the-ground activities implementing recovery actions can be found in the Recovery Implementation Strategy (RIS). These supplemental documents are available on the ECOS species profile page. The RIS and SSA are finalized separately from the Recovery Plan and will be updated on a routine basis.

The Mount Graham red squirrel (*Tamiasciurus fremonti grahamensis*; red squirrel or squirrel), endemic to the Pinaleño Mountains in Graham County, Arizona (Steele 1998 p. 1), depends on mixed conifer and spruce-fir forests for all its life history needs. Due to habitat loss, small and reduced population size, and competition with the introduced Abert's squirrel, the Mount Graham red squirrel was listed as endangered in 1987 (USFWS 1987 entire). Critical habitat was designated for the subspecies in 1990 (USFWS 1990 entire). The Mount Graham red squirrel is also a Species of Greatest Conservation Need, Tier 1 in Arizona. Tier 1 species are identified as those most at risk of extinction or extirpation and are prioritized for conservation (Arizona Game and Fish Department 2022 p. 14 [AZGFD]).

Historically, these high-elevation habitats may have included up to approximately 11,000 acres (ac) (4,452 hectares [ha]) of mixed conifer and spruce-fir forest across the Pinaleño Mountains, including areas on West Peak (USFWS 2025 p. 44). Regular surveys for the squirrel were conducted beginning in 1986. Following survey protocol development, the peak population estimate for the Mount Graham red squirrel was 549 ($\pm$11) individuals in 1998 (Hatten 2014 p. 109). In 2017, the Frye Fire burned 48,443 ac (19,604 ha: forest, shrub, and grassland), leaving only approximately 34 ac (14 ha) of spruce-fir forest (Lynch 2019 p. 165; Hollingsworth and Panunto 2020 p. 123) in the Pinaleño Mountains. Following the Frye Fire, the red squirrel population was estimated to be 35 squirrels (AZGFD 2018 p. 1). Because Mount Graham red squirrels were likely part of one metapopulation with limited connectivity, in the SSA, analysis units were used as a surrogate for populations to assess population resiliency (USFWS 2025 pp. 49-50, 54). Currently, Mount Graham red squirrels occupy mixed conifer and remaining spruce-fir forest in 6 of 7 analysis units. (Figure 1: USFWS 2025 p. 52).

Across the Pinaleño Mountains, in 6 of the 7 analysis units, we estimate that less than 30% of predicted midden capacity is currently occupied (8-42 middens in each unit: USFWS 2025 pp. 54-67). There is currently between approximately 600 to 1,200 ac (243 to 486 ha) of squirrel habitat in each unit; however, compared to the amount of potential habitat that was historically present, 3 units have lost up to 25%, 2 units have lost between 25-50%, and 2 units have lost more than 50% of the squirrel's habitat (USFWS 2025 pp. 54-67). Mount Graham red squirrels use forested habitats, which support the subspecies' life history needs and facilitate movement and dispersal (USFWS 2025 pp. 30-42, 44, 50). We consider squirrel habitat capable of

supporting all the subspecies' life history needs, and connective habitat as necessary for maintaining connectivity between patches of squirrel habitat (i.e., it primarily facilitates dispersal but can support the subspecies life history needs). In two units, up to 25% of these habitats have high risk of high-severity fires or insect outbreaks. In four units, between 25 and 50% of these habitats have high risk of high-severity fires or insect outbreaks, and in one unit between 50 and 90% of these habitats have high risk of high-severity fires or insect outbreaks (USFWS 2025 pp. 54-67). Of current squirrel habitat, in one unit at least 70% is considered favorably connected, in 4 units between 30 and 70% is considered favorably connected, and in 2 units between 5 and 30% is considered favorably connected (USFWS 2025 pp. 54-67). Of the seven units, one has a moderate level of resiliency to stochastic events, five have low resiliency, and Mount Graham red squirrels are considered unknown occupancy on West Peak (USFWS 2025 p. 67).

Redundancy of Mount Graham red squirrel units with multiple groups of squirrels (i.e., patches of middens) that are well distributed across favorably connected squirrel habitat is lacking. Although six of seven units are occupied by Mount Graham red squirrels, groups of squirrels are not well-distributed across available squirrel habitat. Four patches contain 12 to 21 middens, 1 patch contains eight middens, 3 patches contain 6 middens, 2 patches contain 5 middens, and the remaining patches contain between 2 and 4 middens (USFWS 2025 pp. 72-74). Only one unit, the Lower Cottonwood/Grand View, contains multiple large patches, a small patch, and single middens that are well distributed across available squirrel habitat with high connectivity (USFWS 2025 p. 73). All other units, Turkey Flat, Grant Creek, and Goudy Canyon/Merrill Peak, would benefit from efforts to increase the amount of favorably connected habitat in areas of squirrel occupancy.

Mount Graham red squirrels likely lost genetic diversity following the 1974 Lindsey Fire, which reduced connectivity between West Peak and the rest of the Pinaleño Mountains, and during bottlenecks before and after that event. Fitak et al. (2013 p. 1236, 1238) reported levels of relatedness (75%) indicative of reduced genetic variation and matings between genetically similar individuals, and inbreeding depression can result in reduced fecundity or survival (Lande 1988 p. 1456; Jiménez et al. 1994 p. 272). Following large-scale insect outbreaks and wildfires, further losses of Mount Graham red squirrel genetic diversity likely occurred, as the population was estimated at 35 individuals (AZGFD 2018 p. 1), and ecological diversity was reduced through the loss of most of the spruce-fir forest (USFWS 2025 pp. 74-75). Although squirrel numbers have increased (estimated 232 individuals: AZGFD 2025 p. 1), Mount Graham red squirrel occupancy on West Peak remains unknown, regeneration of spruce-fir forest takes upwards of several decades, and remaining squirrel habitat is at risk of further degradation and loss from insect outbreaks and wildfires, suggesting representation is limited (USFWS 2025 p. 75).

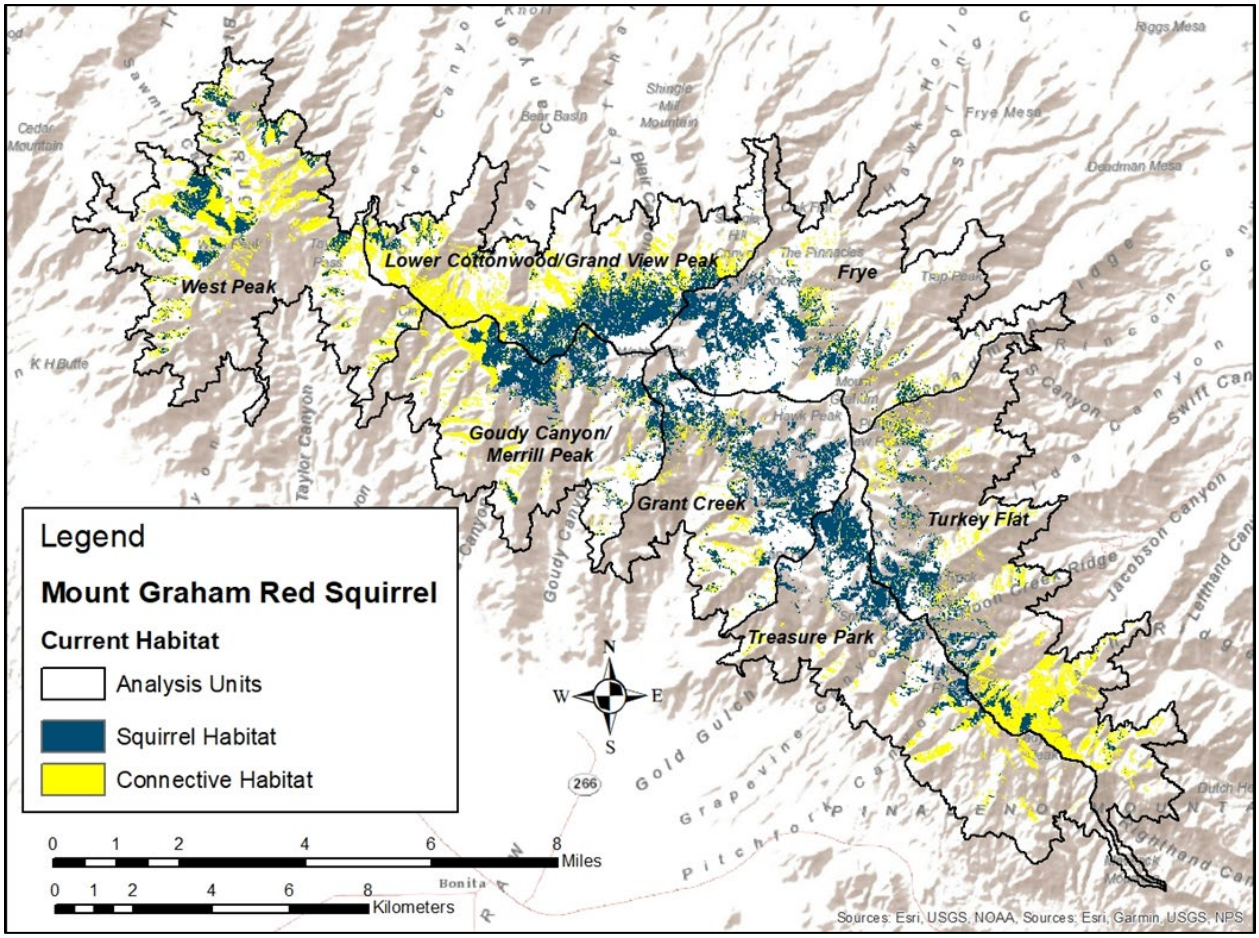

Figure 1. Mount Graham red squirrel analysis units and modeled squirrel habitat and connective habitat within the range of the Mount Graham red squirrel.

Threats

The SSA (USFWS 2025 pp. 75-90) discusses, in depth, the myriad threats (environmental and anthropogenic) that influence Mount Graham red squirrel viability. The primary threats to the subspecies that need to be abated or managed include wildfire, tree insects and disease, fire and fuels management, road maintenance and use, and competition. We briefly discuss these primary threats below. The SSA (USFWS 2025 pp. 75-90) contains additional and more detailed information on threats to the subspecies.

Uncharacteristic, large-scale, high-severity wildfire poses the greatest threat to the Mount Graham red squirrel through direct impacts to individuals and the degradation and loss of habitat. A long history of fire suppression and exclusion and forest uses (i.e., livestock grazing and logging) have altered the fire regime from frequent short-interval, low-intensity fires to infrequent larger, high-intensity fires (USFS 2000 pp. 9-16). Additionally, the mixed conifer forest has become denser, and its composition has shifted from fire-tolerant to fire-intolerant species (USFWS 2011 p. 21). Further influencing fire risk and severity, warming temperatures and drought will likely increase incidence of tree disease and insect outbreaks, creating larger fuel loads due to widespread tree mortality (Betancourt 2004 p. 7; Allen et al. 2010 p. 664; Bell

et al. 2020 pp. 1721–1722). High-severity fire and loss of canopy can impact Mount Graham red squirrels by reducing survival through direct burning of individuals, middens, available foods, nests, and cavities, resulting in the post-fire displacement of surviving individuals (Koprowski et al. 2006 p. 60) and increasing the risk of predation from loss of suitable cover used for predator avoidance (Koprowski et al. 2006 p. 60; Saab et al. 2014 p. 540). 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, including the efficacy of middens, within the Pinaleño Mountains.

Several insects and tree diseases naturally co-occur in Mount Graham red squirrel habitat. Risk of insect outbreaks, however, is increasing (USFS 2021 p. 13; Grady 2023 p. 2), and non-native species such as the spruce aphid are now present (Lynch 2009 p. 333). Insect outbreaks and disease affect tree health, longevity, and seed production, which can alter forest structure and composition through changes in seed production and regeneration. Tree mortality and the resulting changes in canopy structure can decrease cone crops and available food resources, alter microclimates critical for fungal growth and food storage conditions in middens, increase risk of predation, and increase fuel loadings (Betancourt 2004 p. 7; Koprowski et al. 2005 p. 495; Allen et al. 2010 p. 664; Saab et al. 2014 p. 540; Bell et al. 2020 pp. 1721–1722). Tree diseases reduce the longevity, growth, and reproduction of host trees, and may interact with insects and drought to decrease forest health. Mount Graham red squirrel habitat has previously experienced outbreaks of insects and pathogens; therefore, rising drought conditions in combination with increasing insect outbreaks and wildfires could severely impact the Mount graham red squirrel's already limited habitat and food resources.

Thinning, burning, and fire suppression management practices are necessary to mitigate the risk of large-scale, high-severity wildfires and retain mature forest. Although beneficial in the long-term, such activities negatively impact the Mount Graham red squirrel in the short-term. They disturb and remove important elements of habitat, such as canopy cover, tree density, downed logs, and snags, and alter microclimates necessary for food storage (USFWS 2025 pp. 78-79). Additionally, direct loss of nests and middens, as well as the occurrence of Mount Graham red squirrel fatalities, may occur during fire and fuels management activities.

Road maintenance and use pose multiple threats to Mount Graham red squirrels by increasing mortality risk, reducing habitat quality, and fragmenting populations (USFWS 2025 pp. 76-77). Traffic noise and vehicle activity can decrease squirrel occupancy and abundance, with evidence of individuals showing avoidance behavior and perceiving noise as a predator-like threat (Chen & Koprowski 2015 p. 315; Chen & Koprowski 2016a p. 12; Chen & Koprowski 2016b pp. 36-38). Tree and snag removal associated with road maintenance affects available resources, and roads may act as barriers that limit movement and influence territories, resulting in more limited genetic exchange due to avoidance of open areas (Burnett 1992 pp. 100-102; Trombulak & Frissell 2000 pp. 20-21; Chen & Koprowski 2016b p. 37). Several Mount Graham red squirrel deaths have been reported from vehicle strikes; however, this number is likely underestimated due to limited reporting and rapid scavenging of dead animals (USFWS 2025 p. 77).

Competition with the non-native Abert's squirrels threatens Mount Graham red squirrels both directly and indirectly through competition for food and nesting resources and territories, and through midden raiding and potential disease transmission (Edelman & Koprowski 2009 pp. 358-376). Abert's squirrels may indirectly increase predation pressure by boosting predator density as a result of an increase in prey abundance (e.g. Abert's squirrels) (Edelman & Koprowski 2009 p. 383). Overlap in dietary needs of key food resources such as conifer seeds and fungi can limit availability for Mount Graham red squirrels, especially in poor cone crop years (Froehlich 1990 pp. 20–28; Edelman & Koprowski 2005 entire). Additionally, wildfire and forest management practices that create more open forest structure can favor Abert's squirrels over Mount Graham red squirrels, reducing the availability of dense, closed-canopy habitat preferred by Mount Graham red squirrels, and thereby could intensify competition for limited available habitat and resources (USFWS 2025 p. 76).

2. RECOVERY STRATEGY

The recovery strategy provides a concise overview of the envisioned recovered state for Mount Graham red squirrel, describes the USFWS's chosen approach to achieve it, and includes the rationale for why the approach was chosen. Specifically, the recovery strategy articulates how the plan's statutory elements (e.g., recovery criteria, recovery actions, and estimates of time and cost) will work together to achieve Mount Graham red squirrel recovery.

To maintain long-term viability of the Mount Graham red squirrel so that protections under the ESA are no longer warranted, threats to the subspecies need to be abated such that it can rebound from stochastic and occasional catastrophic events. Red squirrel home ranges are heavily influenced by the presence of mature seed-producing conifers (Kemp & Keith 1970 p. 763; Vahle 1978 p. 78); for example, approximately 15 inches DBH for Englemann spruce as reported by Uchytil (1991 p. 11). A forest comprised primarily of mature stands of old growth mixed conifer and spruce-fir may support the highest squirrel densities and provide the greatest availability of food resources and micro-climates needed for middens; however, this forest structure also poses the greatest risk of impacts from insect outbreaks and catastrophic wildfires (Bigler et al. 2005 p. 3027; Lynch 2019 p. 165; O'Connor et al. 2015 p. 148; Stromberg and Patten 1991 p. 46). Via work with partners and adaptive management, forested habitat must be protected, grown, and managed for low to moderate risk of uncharacteristic large-scale insect outbreaks and high-severity wildfires. A forest that is heterogenous both spatially and structurally (e.g., multiple stands that vary in composition) should minimize risk of predation, provide connectivity between patches of squirrel habitat, facilitate dispersal and recolonization of impacted areas, and ensure sufficient food and nesting resources to sustain squirrels over time. To increase the abundance and distribution of Mount Graham red squirrels, adaptive management should also be implemented to improve captive-husbandry practices and facilitate captive breeding, thereby supporting releases that augment abundance in currently occupied areas and establish new breeding areas. When an average of at least 600 squirrels are observed for at least 9 years (3 survey cycles) and are distributed across effectively managed habitat in at least 5 of 7 analysis units in the Pinaleño Mountains, Mount Graham red squirrels are expected to be resilient to environmental stochasticity and have sufficient redundancy (i.e., multiple areas with moderate to high density of squirrels and breeding activity) and ecological representation to persist following disturbance events (e.g. wildfires).

Maintaining existing and building new partnerships is key to Mount Graham red squirrel recovery. Activities such as monitoring, growth and augmentation, and the restoration, protection, and maintenance of habitat require close coordination among a variety of partners such as the Arizona Game and Fish Department, Phoenix Zoo, University of Arizona, USDA Animal and Plant Health Inspection Service, and U.S. Forest Service (Coronado National Forest). Education and outreach will establish support and public understanding for the recovery program by developing public information about Mount Graham red squirrel recovery for use at zoological institutions, and by fostering conservation partnerships with land managers, zoological or other animal husbandry facilities, and the public that use and enjoy public lands. These coordination and outreach activities will increase awareness, understanding, and appreciation of Mount Graham red squirrel ecology, conservation, and recovery.

To guide development of effective forest management practices for Mount Graham red squirrel viability, we need to better understand the subspecies' use of mixed-conifer and connective habitat, changes to food storage strategies, effectiveness and use of unusual food storage mechanisms or habitats (e.g., atypical use of holes, cavities, and talus), breadth of habitat use flexibilities (e.g., slope steepness, burned areas), and the subspecies' demographic and predation rates. Further, we need to develop successful techniques and procedures for captive propagation, releases, and translocations. We assume that effective captive propagation techniques will be developed, efforts to mitigate competition and insect outbreaks will continue, and that forest management to supplement natural regeneration of mixed-conifer and spruce-fir forest will be successful. Although these efforts will expedite time to recovery, habitat growth and connectivity and Mount Graham red squirrel abundance and distribution can be improved through effective protection and management of existing habitat, reliance on natural forest regeneration, and use of translocations.

3. RECOVERY CRITERIA

Recovery criteria are objective, measurable descriptions of a recovered state for Mount Graham red squirrel, as described in 4(f)(1)(b)(ii) of the ESA. Recovery criteria describe the conditions of resiliency, redundancy, representation, and threat abatement that indicate when Mount Graham red squirrel may no longer meet the ESA definitions of an endangered species or threatened species. Recovery criteria represent our best understanding of a species' recovered condition at the time of recovery plan development. Changes in available information, technologies, and our understanding of the species over time might mean that the recovered state envisioned by the recovery criteria differs from our assessment in a later status determination.

Downlisting Criteria

The following downlisting criteria, when met collectively, would indicate that Mount Graham red squirrel may be reclassified as a threatened species.

Downlisting Recovery Criterion 1:

1. An average of at least 400 Mount Graham red squirrels is observed over the last 9 years (during 3 consecutive survey cycles immediately preceding the status recommendation). The following conditions are also met:

a. 4 out of 7 Mount Graham red squirrel analysis units are occupied.
b. 2 analysis units each have a minimum abundance of at least 100 Mount Graham red squirrels.

Rationale for Downlisting Criterion 1

Criterion 1 establishes an initial benchmark for abundance and spatial distribution needed to indicate that the Mount Graham red squirrel has moved beyond the immediate risk of extinction. The requirement for an average of at least 400 individuals observed across 9 years (during 3 consecutive survey cycles immediately preceding the status recommendation) provides evidence that the subspecies can persist through multiple cycles of variable cone production, predation pressure, and environmental stochasticity. This criterion ensures that improvements in abundance are representative of a sustainable increase supported by functioning forest conditions, applied adaptive management, reduced impacts of competition, and improved survivorship. Requiring occupancy in at least 4 out of 7 analysis units, with at least 2 of the units each supporting at least 100 individuals, ensures that the subspecies is not concentrated in a single area, but occurs in multiple areas with higher abundance, improving resiliency and redundancy. Currently, most of the mixed-conifer and spruce-fir habitat in the Pinaleño Mountains is fragmented, vulnerable to high-severity wildfire, and at risk of insect outbreak; therefore, distribution across multiple units provides a buffer against localized stochastic events that have historically driven declines in abundance. Having at least two units contain at least 100 individuals further ensures that multiple areas are capable of supporting robust reproduction and providing sufficient offspring to support recolonization or augmentation following stochastic or catastrophic events. Collectively, these conditions indicate that threats have been partially abated, habitat conditions are sufficient to increase or improve resiliency and redundancy, and the species has reached a point where extinction risk is reduced but remains within the foreseeable future.

Downlisting Recovery Criterion 2:

2. Four analysis units each have at least 1,000 acres of squirrel habitat. For this squirrel habitat, the following conditions are also met for each unit:
   a. 50% has low to moderate risk of crown fire.
   b. At least 70% is considered favorably connected.

Rationale for Downlisting Criterion 2

Criterion 2 ensures that a sufficient amount of Mount Graham red squirrel habitat is available across multiple analysis units to support existing abundance, growing abundance, and ecological representation. Depending on the quality and configuration of squirrel habitat, 1,000 acres could support approximately 130 individuals based on the average home range size of 7.51 acres (USFWS 2025 p. 19). Requiring at least 1,000 acres of squirrel habitat in each of four units provides a buffer for natural variability in resource availability, supports multiple breeding groups and, in conjunction with adjacent connective habitat, provides pathways for dispersal and recolonization following stochastic events. Given the average territory size of Mount Graham red squirrels, approximately 4,500 acres of squirrel habitat may be sufficient to support 600

individuals; however, additional squirrel and connective habitat is necessary to sustain a robust population capable of withstanding environmental variability, promoting genetic diversity, and maintaining squirrel populations during and following events resulting in habitat loss.

The requirement that at least 50% of each unit's squirrel habitat be at low to moderate risk of crown fire directly addresses the primary threat of large-scale high-severity wildfire, effectively reducing the probability that such catastrophic events would result in the loss of all or the majority of the habitat. Having at least 70% of squirrel habitat favorably connected (habitat that gives squirrels at least a 50% probability of evading predation while moving within favorably connected habitat) supports movement and facilitates dispersal. Together these metrics ensure sufficient high-quality habitat and a mosaic of wildfire risk which together increase resilience post-disturbance. That is, these metrics create an environment where continued management and maintenance of habitat will increase the likelihood that Mount Graham red squirrels will be able to persist and disperse across the landscape following high-severity wildfires. These conditions reduce the likelihood that the species will revert to endangered status.

Delisting Criteria

The following delisting criteria, when met collectively, may indicate that Mount Graham red squirrel no longer meets the ESA definitions of either a threatened species or endangered species, and may be able to be removed from the Federal Lists of Endangered and Threatened Wildlife and Plants:

Delisting Recovery Criterion 1:

1. An average overall abundance of at least 600 Mount Graham red squirrels is reached and is self-sustaining for at least 9 years, and a stable or increasing trend in abundance across the Pinaleño Mountains is observed over the last 15 Years (during 5 consecutive survey cycles immediately preceding the status recommendation). The following conditions must also be met:

    a. The last six years must not trend downward, within which no three consecutive years show decline.
    b. 5 out of 7 Mount Graham red squirrel analysis units are occupied.
    c. 4 units each have a minimum abundance of at least 100 Mount Graham red squirrels.

Rationale for Criterion 1

Criterion 1 establishes a measurable threshold of an average of at least 600 individuals maintained over 9 years, which exceeds the historical recorded peak of 549 individuals in 1998, and a stable or increasing trend over the last 15 years (5 consecutive survey cycles, immediately preceding the status recommendation). This provides high confidence in successful recruitment and buffering against stochastic events such as environmental changes (i.e. variability in annual precipitation and temperatures which influence cone crops and midden efficacy), as well as an ability to rebound following catastrophic events

(e.g., large-scale high-severity wildfire which destroys habitat needed to sustain all the subspecies life history needs). We consider fifteen years is sufficient time to account for the subspecies' response to fire-cycles in mixed-conifer forest.

Requiring a self-sustained average across a 9-year period corresponds to three full survey cycles under the current survey protocol, ensuring the trend is biologically and statistically robust. This average needing to be "self-sustaining" secures the population from being reliant on human involvement for the long-term persistence of the subspecies (e.g. frequent captive-bred releases, constant supplemental feeding, etc.). In addition, we include that the last six years (2 consecutive survey cycles immediately preceding the status recommendation) must not trend downward, within which no three consecutive years show decline in population, and that at least 5 of the 7 analysis units are occupied, with at least 4 units supporting 100 or more individuals. This arrangement ensures that we continue to monitor the subspecies to ensure a downward trend in abundance is not indicative of population collapse prior to reconsideration of its status, and that its abundance is not only high but spatially distributed across their habitat. This supports functional connectivity, provides opportunity for dispersal, and reduces the risk that localized catastrophic events (e.g., large-scale high-severity wildfire, insect outbreak) will result in subspecies-level collapse.

Delisting Recovery Criterion 2:

1. A mosaic of heterogenous forest habitat is managed such that there is at least a 90% probability of 600 Mount Graham red squirrels persisting over 30 years.

Rationale for Criterion 2

Criterion 2 ensures that forest habitat across the Pinaleño Mountains is managed such that there is at least a 90% modeled probability of persistence of 600 squirrels over 30 years (30 years post-status recommendation), addressing Mount Graham red squirrel viability in the long-term by focusing on habitat quality and configuration, which we have established are essential elements to sustaining gains in abundance over time. Forest habitat includes squirrel habitat and connective habitat, which are habitats that support Mount Graham red squirrel breeding, feeding, and sheltering. We consider squirrel habitat capable of supporting all the subspecies' life history needs, and connective habitat as necessary for maintaining connectivity between patches of squirrel habitat (i.e., facilitates dispersal and can support most life history needs). This timeframe (30 years) accounts for projections across 4 to 6 fire cycles in the mixed conifer forest and more than 10 generations of Mount Graham red squirrels, ensuring that habitat configuration and management can sufficiently buffer against catastrophic events and be able to support reproduction, dispersal, and food caching behaviors into the future. We have not yet developed a model to determine probability of persistence for the squirrel; however, its future creation will provide a tool to assess how habitat management actions support population viability.

Since Mount graham red squirrel individuals are highly dependent on structural habitat features such as large trees for nesting, mid-story cover for predator avoidance, enough habitat to support individual territories, and suitable midden sites for year-round food storage, a mosaic of heterogenous forest habitat ensures the spatial and structural heterogeneity necessary for maintaining viable home ranges. It also accounts for the need for connective and additional habitat that helps facilitate squirrel movement following disturbances such as insect outbreak or large-scale high-severity wildfire.

4. RECOVERY ACTIONS

Recovery actions are the site-specific management actions needed to achieve recovery criteria, as described in section 4(f)(1)(B)(i) of the ESA. The USFWS assigns recovery action priority numbers (1-3) to rank recovery actions. The assignment of priorities does not imply that some recovery actions are of low importance but instead implies that lower priority items may be deferred while higher priority items are being implemented. Recovery action priority numbers are based on the following:

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species

Acronyms:

APHIS	U.S. Department of Agriculture-Animal and Plant Health Inspection Services
AZGFD	Arizona Game and Fish Department
SSA	Species Status Assessment
UA	University of Arizona
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service

436 **Table 1.** Recovery action summary table

Related Recovery Criterion	Recovery Priority Number	Recovery Action Number	Recovery Action	Additional Information	Site	Potential Partners
1 and 2	1	1	Within potential habitat, continue standardized population surveys on an annual basis to assess Mount Graham red squirrel abundance, distribution, and trends.	Use most recent survey protocol to estimate the population size and continue annual population surveys to provide reliable data for evaluating population status and informing management decisions.	Known range; in-person or virtual meetings.	USFWS, USFS, AZGFD, Phoenix Zoo, UA, other supporting partners
1	1	2	Develop and maintain a captive breeding program to support population augmentation and reintroduction.	To support the establishment of a captive population capable of producing genetically and demographically needed individuals of MGRS to introduce into Pinaleño Mountains.	Phoenix Zoo or other breeding facility.	USFWS, USFS, AZGFD, Phoenix Zoo, UA, other supporting partners
1 and 2	2	3	Reintroduce Mount Graham red squirrels to habitat on West Peak.	No Additional Information.	West Peak; breeding facility; known range.	USFWS, USFS, AZGFD, Phoenix Zoo, UA, other supporting partners
1 and 2	1	4	Implement restoration efforts that promote forest structure, food and nesting resources, and resilience to disturbance throughout the range.	Restoring habitat throughout the range enables dispersal.	Pinaleño Mountains.	USFS
1 and 2	2	5	Maintain routine working group meetings to ensure continued interagency coordination of Mount Graham red squirrel recovery.	Continuing interagency collaboration is necessary to support monitoring, research, and recovery implementation.	In person or virtual meetings.	USFWS, USFS, AZGFD, Phoenix Zoo, UA, other supporting partners
1 and 2	1	6	Protect and manage habitat throughout the subspecies' range.	No Additional Information.	Pinaleño Mountains.	USFWS, APHIS, USFS
1	1	7	Continue collection of Mount Graham red squirrel samples to assess population health, contaminants and disease, and long-term conservation through biobanking living tissues.	Biobanking preserves viable (living) cells and genetic material for long-term conservation and research use. The conservation value of biobanked materials is expected to increase over time as technologies advance, improving opportunities for species recovery and management.	Known range; Phoenix Zoo or other breeding facility.	USFWS, San Diego Frozen Zoo, AZGFD, UA, USFS, partnering facilities

1 and 2	3	8	Develop alternative conservation strategies to provide contingency for events with the potential to preclude recovery as envisioned.	Catastrophic events such as large-scale high-severity wildfires, uncharacteristic long-term drought, or disease outbreaks have the potential to preclude recovery as envisioned; therefore, contingency planning provides the opportunity for USFWS and partners to consider such events and plan alternative strategies for the subspecies persistence.	Known and potential range.	USFWS, AZGFD, USFS, UA, Phoenix Zoo, partnering facilities
1 and 2	2	9	Develop a Population Viability Analysis Model to inform recovery criteria 2 and develop scenarios for future habitat management.	No Additional Information.	Known and potential range; breeding facility.	USFWS, UA, USFS
1 and 2	1	10	Conduct research to improve understanding of Mount Graham red squirrel life history and ecology.	No Additional Information.	Known and potential range; breeding facility.	USFWS, UA, USFS
1 and 2	1	11	Investigate and implement methods to reduce Mount Graham red squirrel mortality (e.g., vehicle collision risk, predation risk).	No Additional Information.	Known and potential range.	USFWS, USFS, AZGFD, UA
1 and 2	2	12	Determine occupancy of Mount Graham red squirrels on West Peak.	No Additional Information.	West Peak.	USFWS, USFS, AZGFD, UA
1 and 2	3	13	Develop and implement education and outreach efforts to increase public awareness and understanding of Mount Graham red squirrels.	Develop public information about the recovery program at zoological institutions, which may include (but not be limited to) informational kiosks, exhibiting red squirrels, and providing photos and video of captive-rearing efforts to the press and management agencies for educational use (Listing Factor E).	Known range and breeding facility.	USFWS, AZGFD, Phoenix Zoo, other supporting partners

1 and 2	3	14	Prepare an annual summary report to document recovery progress and identify upcoming priorities.	Producing an annual summary report provides a clear, accessible record of recovery progress that can be referenced over time and used to inform management decisions, including forest management actions and future 5-year status reviews. This report functions as a brief, synthesized progress update to help partners remain informed of recent activities, outcomes, and upcoming priorities.	Not Applicable.	USFWS

437 **Table 2.** Threats summary table (for the complete list of threats, refer to the SSA)

Threats Description	4(a)(1) Factor(s)	Recovery Criterion/a ID Number(s)	Recovery Action ID Number(s)
Wildfire	A, E	1 and 2	1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13
Tree insects and disease	A, C	1 and 2	1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13
Fire and fuels management	A	1 and 2	1, 3, 4, 5, 6, 8, 9, 10, 13, 14
Road maintenance and use	A	1	1, 6, 7, 11, 13
Competition	A	1 and 2	1, 5, 6, 11

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5. ESTIMATED TIME AND COSTS TO ACHIEVE RECOVERY

Estimates of time and cost, as defined in section 4(f)(1)(B)(iii) of the ESA, must reflect, to the maximum extent practicable, the total amount of time and costs it will take to achieve the recovery (delisting) of Mount Graham red squirrel. The cost estimates provided do not account for possible future inflation, and they include many activities and management practices that benefit the Mount Graham red squirrel but are not conducted solely for the subspecies.

We estimate that the full implementation of the recovery actions would improve the status of Mount Graham red squirrel so that it could be delisted within 60 to 100 years following the adoption of this recovery plan and cost $24,536,000. Mount Graham red squirrels can respond quickly to changes in food availability and can exploit pulses in food resources, resulting in population-level responses to boomer (high-yield) cone crop years (USFWS 2025 pp. 21-22, 44-46). Therefore, we estimate time to recovery based on anticipated forest regrowth. Continued management of coniferous forest on Mount Graham is needed and should involve site preparation, soil recovery, and adaptive management to facilitate forest regeneration and resilience and to mitigate the risk of large-scale high-severity wildfires and maintain a viable forest mosaic resilient to wildfires. We estimate that it may take up to 20 years to refine these management approaches.

Optimal habitat conditions for the Mount Graham red squirrel occur in mixed conifer and spruce-fir forest, where large, cone-bearing trees provide essential food and nest resources (USFWS 2025 pp. 30-41). Tree species within these forest types may begin producing cones between 15 and 40 years of age, but larger cone crops typically occur when trees mature (40 or more years of age), depending on species (USFWS 2025 pp. 36, 39-40). While older trees supply cone production and dense canopy cover, stands containing a range of age classes are essential contributors to forest resilience, future cone production, and the structural heterogeneity needed to support a viable population of Mount Graham red squirrel (USFWS 2025 pp. 36-37, 41-42). Although mixed conifer and spruce-fir forest may take 150-350 years to mature to old growth (USFWS 2025 pp. 36, 38), a dynamic habitat and forest structure is necessary to ensure continuous resource availability, forest regeneration, improved connectivity, and resilience to disturbances.

We estimate that planting, regrowing, and managing a mosaic of heterogenous forest to sufficient conditions to support a viable population of Mount Graham red squirrels and that has a likely trajectory for improvement for the subspecies will take at least 60 to 100 years. We note that the recovery program may change over time, or the timeframe estimated to implement the recovery actions to achieve recovery of the species may be different than estimated. The recovery of Mount Graham red squirrel will depend largely on the commitment and the ability of the USFWS and partners to implement the recovery actions necessary to achieve the recovery criteria.

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