Mount Graham Red Squirrel
(Tamiasciurus hudsonicus grahamensis)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Arizona Ecological Services Field Office
Phoenix, Arizona

5-Year Review
Mount Graham red squirrel/*Tamiasciurus hudsonicus grahamensis*

1.0 GENERAL INFORMATION

1.1 Peer Reviewers:

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Cooperating Field Office(s): None

Cooperating Regional Office(s): None

1.2 Methodology used to complete the review:

This review was completed by Thetis Gamberg, U.S. Fish and Wildlife Service (Service), Tucson Suboffice of the Arizona Ecological Services Office. In addition to the general solicitation of public comments published in the Federal Register (71 FR 1765), we sent a specific request for new information related to habitat, natural history, and conservation of the Mount Graham red squirrel (MGRS) (*Tamiasciurus hudsonicus grahamensis)* to the Technical Subgroup of the MGRS Recovery Team.

We conducted a review of past and recent literature, public comments, the listing rule, and the 1993 recovery plan (U.S. Fish and Wildlife Service, 1993). We note that the MGRS Recovery Team is preparing a revised recovery plan for the species. An internal draft is expected by December 2007. This review reflects our current state of knowledge regarding the status of MGRS, including information in the working draft of the revised recovery plan and information used to prepare that draft. This 5-year review reflects comments and suggested revisions received from peer reviewers.

1.3 Background

1.3.1 FR Notice citation announcing initiation of this review: 71 FR 1765

1.3.2 Listing history:

<u>Original Listing</u>
FR notice: 52 FR 20994
Date listed: June 3, 1987
Entity listed: subspecies
Classification: endangered

1.3.3 Associated rulemakings

Critical habitat was designated in a January 5, 1990, Federal Register notice (55 FR 425).

1.3.4 Review History

This is the first review for this subspecies since the 1993 recovery plan was published.

1.3.5 Species' Recovery Priority Number at start of 5-year review

The recovery priority is 3.

1.3.6 Recovery Plan or Outline

Name of plan or outline: Mount Graham Red Squirrel Recovery Plan
Date issued: May 1993 (U.S. Fish and Wildlife Service, 1993)
Dates of previous revisions, if applicable: None. The May 1993 recovery plan is currently undergoing update and revision, and an internal draft is expected by December 2007.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy:

Non-applicable; MGRS is not a designated DPS.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan[1] containing objective, measurable criteria?

_X_ ***Yes***, *continue to section 2.2.2.*
___ ***No***, *consider recommending development of a recovery plan or recovery criteria in section IV, Recommendations for Future Actions, and go to section 2.3., Updated Information and Current Species Status.*

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

____ ***Yes,*** *go to section 2.2.2.2.*
_X_ ***No***, *go to section 2.2.3, and note why these criteria do not reflect the best available information. Consider developing recommendations for revising recovery criteria in section 4.0.*

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

The five factors for listing a species, as outlined in section 4(a)(1) of the Endangered Species Act (Act), are: A) present or threatened destruction, modification, or curtailment of its habitat or range; B) over-utilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors affecting its continued existence.

Current recovery criteria relating to these five listing factors are **not** stated in the 1993 recovery plan. No recovery criteria were presented; however, the plan included a "stabilization" criterion, which was "to provide sufficient habitat for a population of squirrels, never fluctuating below 300, distributed throughout the Pinaleño Mountains." The objective of the plan was to increase and stabilize the existing MGRS population by protecting existing habitat and restoring degraded habitat. It noted that MGRS existed in a survival crisis due to loss and fragmentation of habitat. Since 1993, habitat losses have been significant due to two large wildfires and a four-species insect outbreak that has all but eliminated the spruce-fir forest. Wildfire effects have increased forested edges. These effects and the resultant loss of canopy have altered microclimate temperatures and moisture regimes at some middens (deep piles of cone scales, cones, and fungi cached by presumably one MGRS). Recovery criteria in the revised (ongoing) recovery plan will

[1] Although the guidance generally directs the reviewer to consider criteria from final approved recovery plans, criteria in published draft recovery plans may be considered at the reviewer's discretion.

reflect the five listing factors, but they are not yet finalized and cannot be evaluated herein.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Research and monitoring since 1993 have produced new information regarding the MGRS. Dr. John Koprowski has been actively studying aspects of MGRS biology and behavior (Koprowski, 2005a, 2005b, 2005c; Koprowski, et al., 2005, 2006; unpublished literature 2007). Publications include topics on body mass, status of MGRS in insect-damaged conifer forests, management and conservation of tree squirrels, handling methods, and direct effects of fire on MGRS. Other authors have published work concerning forest management and dead wood in ponderosa pine forests and the effect on small mammals (Chambers 2002), diet and tree use of Abert's squirrels in mixed-conifer (Edelman and Koprowski 2005), and kleptoparasitic behavior and species richness at MGRS middens (Edelman et al. 2005). The MGRS population has been monitored twice annually throughout its range in the Pinaleño Mountains, as well as in a 624 acre area around the Mt. Graham International Observatory (MGIO) (Arizona Game and Fish Department [AGFD] 2007).

Biology:

1. Female MGRS go into estrus for <1 day each year (Koprowski 2005a).

2. Mount Graham red squirrel live a shorter life (2 years) than other red squirrel populations studied (4 years) (Zugmeyer 2007).

3. Most MGRS females only reproduce once in their life due to high adult mortality rates (Zugmeyer 2007).

4. Female MGRS give birth to fewer young (two) compared to other red squirrel populations studied (three or more) (Munroe et al. *in press*).

5. Mount Graham red squirrel's mortality is higher than other red squirrel populations studied. For any given population mortality rate, 80 percent of that is due to predation (Koprowski, unpublished literature 2007).

6. Competition for food and midden sites is likely occurring with the introduced Abert's squirrels, which are occupying the mixed-conifer and ecotone zones. There have historically been higher numbers of MGRS middens located in the ecotone than the spruce-fir or mixed-conifer alone (T. Snow, personal communication 2007). With the loss of the spruce-fir component of the

ecosystem, MGRS have lost significant food and habitat resources once available to them.

Ecology:

1. The MGRS's isolated (about 10,000 years) and small (about 300 or fewer individuals) population makes it increasingly vulnerable to catastrophic events (Koprowski et al. 2005).

2. Forest health and fuel-load reduction projects (including use of prescribed fire) can have adverse short-term effects on the MGRS while moving the forest toward long-term health and fire-resilience.

3. Suitable MGRS habitat continues to degrade and fragment due to drought, catastrophic wildfire, and forest insect outbreaks.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Midden surveys have been conducted by an interangency team since 1986; surveys were expanded to twice annually beginning in 1988. The numbers in Appendix A represent two different estimates (conservative and optimistic). These estimates are derived by simple formulas that use the percent of active middens in each vegetation type found in the random sample and the number of known middens in each vegetation type. The conservative estimate uses only those middens where activity is certain; the optimistic estimates include uncertain classifications (counts those middens that are designated as uncertain as if they were active middens).

A statistical trend cannot be determined based on the population estimates to date. However, estimates in Appendix A show two periods of relative stability punctuated by a spike in population during 1998 to 2000. The mean of MGRS population estimates from 1991 to 1997 was 327 (range 259-423), and during 2001 to 2006, mean population was 272 (range 199-362). During 1998-2000, mean population was 525 (range 462-583). A combination of drought, poor conifer cone crops, two major catastrophic wildfires, and insect damage (with a resultant loss of habitat) has likely caused recent MGRS population reductions.

Small mammal populations tend to be highly variable depending on many factors (habitat, rainfall, food sources, predation, etc.). The population reduction from 327 to 272 is 17 percent. Biologists believe that given the right conditions, MGRS populations may be able to rebound as shown during 1998 to 2000; however, recent loss of habitat, particularly in the spruce-fir community, limits the potential for significant population recovery in the foreseeable future.

Buenau and Gerber (2004) evaluated the interagency census data from 1986-2001 and concluded that the main threat to the MGRS was not the overall growth rate (which they believed may be greater than 1), but rather the high variability in annual growth rates. They found that the population is far more sensitive to changes in survival rates (especially adult survival) than to elements of reproduction. They suggested that managers "…need to be explicit about what it is they want the data to help them decide." They also noted that managers should focus more on reducing sources of survival rate variability, increasing adult survival rates, and filling critical data gaps. Rushton et al. (2006) reported similar findings in their modeling paper. They noted that their model "emphasizes the need to understand the relationship of predation and resource availability, including interspecific competition, to MGRS mortality." This supports the potential importance of resources competition with Abert's squirrels.

The Mt. Graham Red Squirrel Monitoring Program at the University of Arizona was established by the Arizona-Idaho Conservation Act of 1988 to monitor effects of the MGIO on the MGRS. Koprowski et al. (2005) monitored all middens in 624 acres surrounding the observatory from 1989-2002. Middens were visited monthly from 1989-1996, and quarterly thereafter. Their study area contained 17.8 percent of all middens known in the mixed conifer forest and 66.9 percent of all middens known in the spruce-fir forest. From 1994-2002, the mixed conifer forest supported 54-83 middens, while the spruce-fir forest contained 120-224 middens. The population trend in the mixed conifer forest was found to be relatively stable from 1994-2002, with declining occupancy rates from 1999-2002; however, by 2002, only two occupied middens were found in the spruce-fir forest. Population declines in the spruce-fir forest corresponded with a period of insect damage and wildfires that began in 1996 and had devastated that forest type by 2002. Koprowski et al. (2005) characterized the decline of the Mt. Graham red squirrel in their study area as catastrophic. They recommended management actions to increase available habitat and population size in the near and distant future. A captive breeding program was also recommended, the concept of which has been endorsed by the current MGRS Recovery Team.

Census data collected by the Mt. Graham Red Squirrel Monitoring Program indicate a more dramatic decline than do the data of the interagency surveys (which has shown fairly stable populations since Fall 2001 after a steep decline from 1998-2000 – Appendix A). The differences in the results are likely due to differences of scale. The Mt. Graham Red Squirrel Monitoring Program has focused on a subset of the mountain in which impacts of fire and insect damage have been pronounced in the spruce-fire forest, whereas the multi-agency surveys sample the population range-wide.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

The MGRS Recovery Team is seeking grant money to develop a captive propagation plan and pilot propagation program and investigating the possibility of establishing a captive population of MGRS, should the need for them arise in the future. For a successful program, identification of the most appropriate number, age, and gender of MGRS for establishing a founder population, and identification of the best sites for removal (in order to minimize risks to the wild population and risk of genetic loss) must be conducted. The last genetic analysis was conducted more than 10 years ago; a new study will make full use of advanced technology in mitochondrial DNA genetics to provide the best information essential to recovery of this species. A Quick Response Grant to the U.S. Geological Service has been secured to study genetic diversity of MGRS compared to red squirrel populations and different subspecies from the White and southern Rocky Mountain populations. The study will help clarify genetic variation and other genetic factors of MGRS in comparison to these other subspecies.

2.3.1.4 Taxonomic classification or changes in nomenclature:

No taxonomic revisions have been proposed for the MGRS at this point in time; however, the genetic study referred to above may provide new information.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historical range (e.g. corrections to the historical range, change in distribution of the species' within its historical range, etc.):

We designated critical habitat in 1990 (U.S. Fish and Wildlife Service 1990), which is the same as an area designated as the MGRS Refugium. Historically, MGRS inhabited about 11,733 acres in the spruce-fir, mixed-conifer, and ecotone zone between these two distinct forest types in the higher elevations (generally above 8,000 feet) of the Pinaleño Mountains, located in Graham County, Arizona. Historical information indicates MGRS and suitable habitat once existed (in the 1960s) between the West Peak portion of the mountain range and the greater portion of MGRS and habitat a little farther east on the mountain (U.S. Fish and Wildlife Service 1993). Mount Graham red squirrel currently do not occur in the West Peak area, as indicated by surveys and habitat evaluations (Service, P. Barrett and AGFD, T. Snow, personal communication 2007). Information on MGRS territories at the time of their listing (U.S. Fish and Wildlife Service 1987) indicated they preferred the higher-elevation spruce-fir and ecotone zones of the mountain (U.S. Fish and Wildlife Service 1993), and since the 1990s, the highest numbers of middens have occurred in the ecotone zone rather than in the spruce-fir or the mixed conifer alone (AGFD, T. Snow, personal communication 2007).

Mount Graham red squirrel are known to have middens located at elevations lower than 7,500 feet where the mixed-conifer associations extend into drainage bottoms or on the north-facing slopes. Mount Graham red squirrel habitat is generally limited to areas that produce adequate and reliable conifer cone crops and provide cool, moist microclimate conditions suitable for storing closed cones. These conditions are met in old growth stands with closed canopies. A typical MGRS territory is identified by the location of at least one nest (cavity or bolus) and one midden in close association. Mount Graham red squirrel cache a great number of unopened fir and pine cones, as well as air-dried fungi, in these middens. These middens provide food for them through the winter. Middens keep unopened cones relatively cool, which prevents them from losing their seeds and are often used by many generations of MGRS (U.S. Fish and Wildlife Service 1993).

Since the 1986 beginning of systematic surveys to 2005, trained personnel documented 1,251 middens. In 2005, AGFD staff visited all 1,251 midden locations (known at that time) to assess their status (whether or not the midden or habitat had disappeared) and gather other habitat characteristic data. All trees associated with middens showed evidence of past or current insect damage to some degree. Of the 417 middens originally found in the spruce-fir forest, only 46 were not classified as disappeared or had the potential to be occupied by a red squirrel; a decrease of 89 percent. Koprowski et al. (2005, 2006) also documented substantial declines in the spruce-fir forest in their study area. In the mixed-conifer and ecotone forests, only 409 middens remained with the potential to be occupied by a MGRS; a decrease of 51 percent. The high percentage of lost middens in the spruce-fir zone may be attributed to the 10-year plus, widespread insect outbreak and recent occurrences of two catastrophic wildfires, which were likely facilitated by warm winters and drought.

In addition to significant habitat loss, there is some question regarding the potential competition between the MGRS and the introduced Abert's squirrel. Because Abert's squirrels are now found on Mt. Graham from the pine forest to the spruce-fir zones, it is likely that resource competition has increased between these species. Long-term viability of MGRS populations in these situations is unknown and warrants study.

Remaining suitable MGRS habitat is increasingly fragmented and degraded by insect outbreaks, poor forest health, and catastrophic wildfires. At least two roads that were closed (and had begun to reforest themselves) after the MGIO was built were bladed open to successfully fight the catastrophic Nuttall-Gibson Complex wildfire of 2004. There is discussion between the USDA Forest Service (FS) and the Service regarding a FS proposal to keep the bladed roads clear of brush and trees to facilitate future firefighting efforts. There continues to be discussion regarding proposals for additional astrophysical facilities to be added to the existing MGIO site on Mt. Graham. This would entail additional buildings and at least one road with a parking lot for the planned visitor center. Section 7 consultation would be required prior to implementation.

Roads (and accompanying infrastructure such as parking) can fragment and degrade habitat by 1) removing trees and other vegetation; and 2) allowing a drying effect to occur on the edges of the forest alongside the road or open area. This can reduce the quality of the forest to support an adequate moisture regime needed for successful MGRS middens.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Suitable MGRS habitat continues to decline and become more fragmented as large and numerous stands of insect- and fire-killed trees die and fall. Much of the wind-induced deadfall occurs on top of already heavy fuel loads; some areas of the mountain are estimated to contain more than 30 tons of dead wood per acre. The lack of roads needed to access these heavy fuel areas make such large fuel wood removal problematic. Much of the dead, downed wood cannot be feasibly or economically brought to the roads for public use and removal. Dead trees reduce available canopy cover and cones for the MGRS. Lack of suitable middens and midden sites require the squirrels to move to less suitable areas. This means they expend more energy and are more often exposed to predators. Large openings are created in the once-dense forest canopy by windfall; these openings allow desiccation of the surrounding moist forest, making additional acres unsuitable for MGRS food production, food storage, and nesting needs.

Drought on Mt. Graham can be measured (through dendrochronology) through geologic time (Grissino-Mayer et al. 1995). The current (10-year plus) drought could break soon or stretch into decades. Long-term drying and warming trends associated with global climate change are predicted for the Southwest (Seager et al. 2007). Drought puts additional stress on trees; they are less able to successfully repel invasive diseases and insects. This may result in trees being increasingly vulnerable to insect infestations that can destroy entire forest types, such as the loss of the spruce-fir forest on Mt. Graham (beginning in 1996 and continuing; U.S. Forest Service 2001). Many recently documented forest insect outbreaks in the western United States are traced to introduced, invasive forest pests that are not endemic to the forests invaded.

The three documented non-native insect pests on Mt. Graham are the spruce aphid (*Elatobium abietinum*), the spruce beetle (*Dendroctonus rufipennis* (Kirby), and the western balsam bark beetle (*Dryocetes confusus*). The looper moth (*Nepytia janetae*) is a native forest pest that normally occurs in low numbers in the Pinaleños. The looper moth has caused forest mortality on Mt. Graham in the past (Lynch and Fitzgibbon *in press*). It is likely active at low levels and typically results in very low or single-tree mortalities. When its effects were added to those from the three, non-native forest insect pests, the result was devastation of the spruce-fir forest, pure spruce stands, and Engelmann spruce scattered in the mixed-conifer forest on the mountain. By the fall of 1999, approximately 300,000 spruce trees were killed on over 14,800 acres (Wilson et al. 1999).

2.3.1.7 Other:

Since 1993, the following construction and permitted projects have emerged and are now in the planning stages: 1) the Arizona Department of Transportation (ADOT) and the Federal Highway Administration (FHWA) are planning to widen, straighten, and pave Swift Trail (State Highway 366) from the gate at Shannon Campground to the FS Columbine Administrative Work Center (and perhaps farther to Riggs Lake); and 2) the University of Arizona is planning for additional telescopes and a visitor center on Mt. Graham. These projects have the potential to cause additional loss of MGRS habitat.

The FS is considering a proposal to rescind the MGRS Refugium closure and open the area to public dispersed recreational uses. While the Refugium has lost nearly all the spruce-fir within its boundaries, new growth and tree recruitment continues. The FS is planting conifer seedlings (grown from seed taken from cones collected on Mt. Graham) in the best available locations in the high-severity burn portions of the Refugium. This planting is planned to continue until 2012.

The FS will keep Forest Road 507 and 669 open (for use by official vehicles only) until 2012 to facilitate restoration of areas burned in 2004. We note that obliterating and reforesting these two roads were requirements of the 1988 Biological Opinion (BO) (2-21-86-F-75) concerning the creation of an astrophysical observatory in MGRS suitable habitat on Mt. Graham. The 1988 BO's third Reasonable and Prudent Alternative was implemented (in part) by the 1988 Arizona-Idaho Conservation Act (PL 100-696), which required closure of the two roads and established the Refugium. The implementation of this alternative avoided jeopardizing the continued existence of the MGRS.

An ongoing action by the FS is the Pinaleño Ecosystem Restoration Plan, a plan intended to improve overall forest health by prescription thinning and burning to reduce the massive amounts of ground and ladder fuels that increase the intensity and severity of effects of wildfire on the mountain. The plan is designed to restore, in the long-term, MGRS habitat and greatly reduce the likelihood of catastrophic wildfire, while minimizing impacts to the species in the short term. Balancing those needs will require careful planning, effects monitoring, and adaptive management.

Summerhome residences in two areas (Old Columbine and Turkey Flat) and a church facility (Bible Camp) exist through Special Use Permits granted by the FS. The re-issuance of permits for both summerhome areas is currently under consultation (22410-2007-F-0163). These summerhome areas were constructed during the 1920s, with applications being accepted around the years 1929 and

1930. The Old Columbine summerhome area (25 acres) exists in MGRS suitable habitat. The Turkey Flat summerhome area (52 acres) exists at a lower elevation zone with hotter, drier vegetation associations that are unsuitable for MGRS habitat needs.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range: Destructive, catastrophic wildfire, driven by climate change and insect damage, is currently the primary threat to MGRS habitat. In 1996, the Clark Peak wildfire burned about 7,400 acres of MGRS habitat in a mix of low, moderate, and severe intensities (U.S. Fish and Wildlife Service 1999). In 2004, the Nuttall-Gibson Complex wildfire burned about 29,000 acres of oak, ponderosa pine, mixed-conifer, ecotone, and spruce-fir forest types, in a mix of low, moderate, and severe intensities of which about 9,400 acres was MGRS habitat (U.S. Fish and Wildlife Service 2007; U.S. Forest Service 2004). From 1996 to date, a massive four-insect outbreak destroyed most of the spruce-fir forest (including small trees and saplings) on top of the mountain. This outbreak was likely driven by warm winters that allowed the insects to overwinter and a 10-year plus drought that made the trees more susceptible to infestation. The spruce-fir forest is a Pleistocene remnant of forests that was once much more widespread. Prior to the 1996 Clark Peak wildfire, the last documented widespread catastrophic fire in the spruce-fir type was in 1685, as determined by tree-ring data (Grissino-Mayer et al. 1995). The absence of catastrophic fire data in between these years of 1685 and 2004 likely indicates that spruce-fir is a high-elevation, climax forest type, and not adapted to fire. It is possible that after 300 or so years and given the appropriate climate conditions, the spruce-fir forest might return as it did after the fires of 1685, but it also may not, considering the changing climate and meteorological conditions that are occurring and expected to continue. The threat of catastrophic wildfire to the remaining MGRS habitat remains high due to the tons of dead and down fuel load; overcrowded tree conditions leading to poor forest health; dense thickets of small-diameter trees; dry winters; lightning strikes; drought conditions; and the likelihood of an increasing number of mountain visitors (which provide ignition sources) (U.S. Forest Service 2007). Increased opening of the forest canopy to the point of drying out midden sites and other large areas of forest; lack of or poor regeneration of spruce-fir and other conifers after loss to insects and wildfire; and a lack of MGRS-suitable, contiguous canopy and habitat contribute to decline of MGRS.

Since the late 1990s, AGFD has tracked the presence and growth of a small (about 25 in 2007) number of elk on Mt. Graham. Elk apparently colonized Mt. Graham from the north in about 1991. While the major concern regarding these elk is their additional grazing pressure on deer and pronghorn antelope range in lower elevations of the Pinaleños, elk are known to severely impact aspen, particularly new and tender shoots and saplings (J. Heffelfinger, personal communication 2007). Numbers are small on Mt. Graham now, but because of a lack of natural predators (wolves), they are expected to rapidly increase and the herbivory on aspen sprouts, saplings, leaves, and bark will likewise increase. Aspen is an integral part of natural succession of the forest dynamics of Mt. Graham and is returning in large stands since the wildfires of 2004 and 2006.

Disturbance of MGRS and its habitat is continuing to increase from increasing numbers of mountain visitors (including pets); seasonal presence of summerhome residents and visitors; and increases in astrophysical observatory visitors and staff. Increased vehicle numbers and easier access of low-clearance vehicles on a longer portion of the Swift Trail (particularly if the paving project proposed by ADOT and FHWA is implemented) will likely result in an increased probability of road-killed squirrels and further reductions in MGRS movement and dispersal.

Although further study is necessary to quantify the relationship between the introduced Abert's squirrels and the MGRS, resource competition between these species is likely an additional stressor on MGRS populations.

Refer to section 2.3.1.7 for discussion of planned and ongoing projects that may affect MGRS habitat quantity and quality.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: This species is not used for commercial or recreational purposes. Scientific monitoring and studies of MGRS began with the first permitted study conducted from 1989 to 1993. This study included live-trapping, handling, and ear-tagging. Two MGRS (one in 1989 and one in 1993) died during trapping, handling, and tagging operations. Necropsy reports indicated that extremely high stress levels were the cause of death. Protocol handling modifications were made in 1989 and again in 1993, just before that study ended. In 1994, another scientist was permitted to monitor and study MGRS. Live-trapping, handling, and radio-collaring activities were covered in the permit, and methods and equipment were further modified. No mortalities are known to have resulted from this on-going study. The Arizona-Sonora Desert Museum (Tucson, Arizona) is permitted by the Service to hold in captivity two MGRS in order to learn how to care for and successfully rear them for possible future captive propagation.

2.3.2.3 Disease or predation: Parasites and diseases are not known to significantly contribute to declining MGRS population numbers. Regarding predation of MGRS, a radio telemetry study found that 4 of 10 MGRS were killed by avian predators within a period of 5 months (Kreighbaum and Van Pelt 1996). From June 2002 to July 2004, avian predators accounted for >60 percent and mammalian predators >13 percent of 30 mortalities of radio-collared adult MGRS (Koprowski unpublished data). Avian predation rates for MGRS are greater than those documented for other populations of red squirrels (Koprowski unpublished data) and may be related to degradation and alteration of MGRS habitat.

2.3.2.4 Inadequacy of existing regulatory mechanisms: The Coronado National Forest (CNF) administers the lands inhabited by MGRS. Existing laws, rules, regulations, and policies reduce, to some degree, threats to the species and its habitat. These include, but are not limited to, the National Environmental Policy Act of 1969, National Forest Management Act, 1986 Coronado National Forest Land and Range Management Plan (CNF LRMP), Arizona Department of Environmental Quality clean air and water requirements, MGRS Refugium to protect habitat, ADOT roadway and speed limit requirements, AGFD non-game recognition of the species, and developing forest plans regarding fire, forage, water, recreation, and timber management.

We believe that these regulatory mechanisms provide only partial relief from threats to the MGRS and its habitat. Most of the threats to the survival and recovery of the species are not remedied by regulations alone. These include, but are not limited to, future catastrophic wildfires and insect outbreaks that have the potential to destroy part, if not all, remaining acres of MGRS habitat; a high avian predation rate; MGRS short lifespan and small litter sizes; failure or severe reduction in conifer cone crops (especially in consecutive years); drier, warmer winters; and continuing and severe drought. Drier, warmer winters result in less moisture in the snow. Less snow allows closed, cached cones to open sooner, losing seeds and reducing MGRS winter food. Warmer, drier winter seasons also promote insect activity among some forest pest insects and increase the likelihood of future forest pest outbreaks. Eastern Arizona is experiencing a continuing drought ($\geq$10 years) with hotter, more extreme temperatures, and an extended summer season. This produces greater stress on trees, leaving them more vulnerable to insect invasions and outbreaks.

2.3.2.5 Other natural or manmade factors affecting its continued existence: While formal studies have not been conducted, we believe the following also affect the MGRS's continued existence:

- Low adult and juvenile survival and high avian predation rates (compared to other red squirrel populations studied). Improving survival and reducing predation is important to the survival and recovery of the MGRS. Ways and means to accomplish this should be determined and implemented as soon as possible.

- Increased risk of extinction due to genetic and demographic problems associated with small population sizes. Low genetic variability, often characteristic of small populations, is a concern because deleterious alleles are expressed more frequently, disease resistance might be compromised, and there is little capacity for evolutionary change in response to environmental change.

2.4 Synthesis

We recommend that the status of MGRS as endangered remain unchanged. The MGRS continues to face a strong possibility of extinction in the foreseeable future. This is due to many factors, the most immediate being the decline in MGRS habitat quality and quantity due to fire and insect damage. Other factors include human disturbance factors; possible construction of additional facilities, associated roads, or other sites; Swift Trail being paved further into the forest (likely increasing accessibility to increased numbers of low-clearance vehicles that did not travel the unpaved portion previously, raising the speed at which all vehicles travel the road, and increasing the chances of road-kill mortality); increasing numbers of mountain visitors (increases in vehicles, people, and ignition sources); and changes in squirrel food source availability and amounts (natural cone crop fluctuations, drying out of the forest, and possible competition with Abert's squirrels for food and/or shelter (U.S. Fish and Wildlife Service 1993, Koprowski et al. 2005, 2006).

A small, isolated population is more vulnerable to extinction than one that can restock with immigrants (U.S. Fish and Wildlife Service 1993). Mount Graham red squirrel raise fewer young, and those young die sooner, after fewer (if any) reproductive events (Koprowski et al. 2006) than other red squirrel populations studied. Mount Graham red squirrel experience higher avian predation rates than other red squirrel populations (Koprowski unpublished data), and population viability is particularly sensitive to adult mortality (Buenau and Gerber 2004). The MGRS is a relict from cooler and wetter times that is now isolated atop the highest mountain in southern Arizona. Mount Graham red squirrel presumably traveled upslope along with its preferred habitat as the forests moved higher on the mountain as climates became warmer and drier after the end of the last glacial period. If the climate becomes even warmer and drier, as predicted (Seager et al. 2007), this species and its high elevation, moist, cool forests may disappear entirely.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
__X__ No change is needed

3.2 New Recovery Priority Number: No change; it remains 3.

Brief Rationale: The MGRS meets the species recovery priority 3 category due to its high magnitude of threat from catastrophic wildfires, high numbers of insect-killed trees, which made up suitable MGRS habitat, low to moderate recovery potential.

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:

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS:

- Refine understanding of MGRS habitat requirements.
- Reduce frequency of avian predation.
- Monitor forest species composition, cone crops, seral stages, and other variables of areas used by all life stages of the MGRS.
- Finalize and implement the revised MGRS Recovery Plan.
- Assist the CNF with their efforts to regain a healthy forest ecosystem by providing continually updated biological and scientific knowledge.
- Work with the CNF to reduce the probability of catastrophic wildfire and limit its effects to MGRS habitat.
- Work with the CNF to apply methods of insect pest control and limit damage to the remaining conifer forests as appropriate.
- Work with the CNF to replant native and mountain range-specific tree species free of pests in appropriate areas above 7,000 feet in elevation.
- Work with the CNF to improve the quality and quantity of MGRS habitat to reduce impacts and frequency of avian predation to MGRS.
- Work with the CNF and Graham County Sheriff's Office to continue to enforce existing regulatory protections for the MGRS, including increased signage, patrol, and enforcement of the posted speed limits on the Swift Trail.

- Work with the CNF to return once suitable acres in MGRS habitat to suitable MGRS habitat.

- Acquire data on MGRS genetics, biology, demographics, and ecology sufficient to develop a captive propagation program.

- Consistent with the recommendations of Rushton et al. (2006) and Buenau and Gerber (2004), work to reduce sources of survival rate variability and increase adult and juvenile survival rates.

- Develop a captive population plan and a pilot program. Establish a captive population with the objective of conserving the species in the short term in case of catastrophic population and habitat loss, and in the longer term as a means of producing offspring for augmenting the wild population.

5.0 REFERENCES

Arizona Game and Fish Department. 2007. News release: July 25, 2007. Mount Graham red squirrel spring 2007 count announced. Electronic newsletter. <enews@phx-listserv.ad.gf.state.az.us> AGFD, Phoenix, AZ. Accessed August 3, 2007.

Buenau, K.E., and L.R. Gerber. 2004. Developing recovery and monitoring strategies for the endemic Mount Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*) in Arizona. Animal Conservation 7:1-6.

Chambers, C.L. 2002. Forest management and the dead wood resource in ponderosa pine forests: effects on small mammals. USDA Forest Service Gen.Tech. Rep. PSW-GTR-181. 679-693.

Edelman, A.J. and J.L. Koprowski. 2005. Diet and tree use of Abert's squirrels (*Sciurus aberti*) in a mixed-conifer forest. The Southwestern Naturalist 50(4):461-465.

-----, -----, and J.L. Edelman. 2005. Kleptoparasitic behavior and species richness at Mt. Graham red squirrel middens. USDA Forest Service Proceedings RMRS-P-36. 395-398.

Grissino-Mayer, H.D., C.H. Baisan, and T.W. Swetnam. 1995. Fire history in the Pinaleno Mountains of southeastern Arizona: effects of human-related disturbances in: DeBano, Leonard F., Gottfried, Gerald J., Hamre, Robert H., Edminster, Carleton B., Folliott, Peter F., and Ortega-Rubio, Alfredo. Biodiversity and management of the Madrean Archipelago: The sky islands of southwestern United States and northwestern Mexico. RM-GTR-264. Fort Collins, Colorado, Rocky Mountain Forest and Range Experiment Station.

Koprowski, J.L. 2005a. Status of Mt. Graham red squirrels in spruce-fir forests damaged by insects: a final report. University of Arizona agreement 01-JV-11221615-235. Submitted to the U.S. Fish and Wildlife Service, Phoenix, AZ. 88pp.

-----. 2005b. Pine squirrel (*Tamiasciurus hudsonicus*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. 36pp.

-----. 2005c. Management and conservation of tree squirrels: the importance of endemism, species richness, and forest condition. USDA Forest Service proceedings RMRS-P36. 245-250.

-----. M.I. Alanen, and A.M. Lynch. 2005. Nowhere to run and nowhere to hide: response of endemic Mt. Graham red squirrels to catastrophic forest damage. Biological Conservation 126:491-498.

-----. K.M. Leonard, C.A. Zugmeyer, and J.L. Jolley. 2006. Direct effects of fire on endangered Mount Graham Red Squirrels. The Southwestern Naturalist 51(1):59-63.

Kreighbaum, M.E., and W.E. Van Pelt. 1996. Mount Graham red squirrel juvenile dispersal telemetry study. Technical Report 89, Nongame and Endangered Wildlife Program, Arizona Game and Fish Department, Phoenix, AZ. 25pp.

Lynch, A.M. and Fitzgibbon, R.A. *In press*. Observations on the life history of Nepytia janetae in Arizona. The Southwest Entomologist.

Munroe, K.E., J.L. Koprowski, and V.L. Greer. *In press*. The social and mating systems of red squirrels: do Mt. Graham red squirrels fit the pattern? *In*: R. Sanderson and J.L. Koprowski, editors./Ecology of endangerment: the Mt. Graham red squirrel and its last refuge/(tentative title). University of Arizona Press, Tucson, AZ.

Rushton, S.P., D.J.A. Wood, P.W.W. Lurz, and J.L. Koprowski. 2006. Modeling the population dynamics of the Mt. Graham red squirrel: Can we predict its future in a changing environment with multiple threats? Biological Conservation 131:121-131.

Seager, R., M. Ting, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H.-P. Huang, N. Harnik, A. Leetmaa, N.-C. Lau, C. Li, J. Velez, and N. Naik. 2007. Model projections of an imminent transition to a more arid climate in Southwestern North America. Science 316:1181-1184.

U.S. Fish and Wildlife Service. 1987. Endangered and threatened wildlife and plants; determination of endangered status for the Mount Graham red squirrel. Federal Register 52:20, 994-999.

-----. 1990. Endangered and threatened wildlife and plants; designation of critical habitat for the endangered Mount Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*). Final rule. Federal Register 55:4, 425-429.

-----. 1993. Mount Graham red squirrel recovery plan. U.S. Fish and Wildlife Service, Albuquerque, NM. 172pp.

-----. 1999. Clark Peak fire emergency suppression and rehabilitation biological opinion. Arizona Ecological Services Field Office, Phoenix, AZ.

-----. 2007. Nuttall-Gibson complex wildfire final biological opinion. Consultation number 02-21-04-M-0299. Arizona Ecological Services Field Office, Phoenix, AZ.

U.S. Forest Service. 2001. Forest Insect and Disease Condition in the Southwestern Region, 2000. USDA Forest Service, Southwestern Region, R3-02-01, Albuquerque, NM, USA.

-----. 2004. Nuttall Complex Wildfire Biological Assessment. Safford Ranger District, Coronado National Forest, Tucson, AZ.

-----. 2007. Safford Draft Environmental Impact Statement. *In preparation*. Safford Ranger District, Coronado National Forest, Arizona.

Wilson, J.L, R.A. Fitzgibbon, and S. Dudley. 1999. Evaluation of a spruce and western balsam bark beetle outbreak on Mt. Graham, Safford Ranger District, Coronado N.F. In-house evaluation on file with the USDA Forest Service, Southwestern Region, Forestry and Forest Health, Arizona Zone, Flagstaff, AZ.

Zugmeyer, C.A. 2007. Trailblazers in the forest: response of endangered Mt. Graham red squirrels to severe insect infestation. MS Thesis, University of Arizona, Tucson, AZ 68pp.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF THE
MOUNT GRAHAM RED SQUIRREL
(*TAMIASCIURUS HUDSONICUS GRAHAMENSIS*)

Current Classification: 3

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable:

Review Conducted By: Thetis Gamberg, U.S. Fish and Wildlife Service, Arizona Ecological Services Office, Tucson, Arizona.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

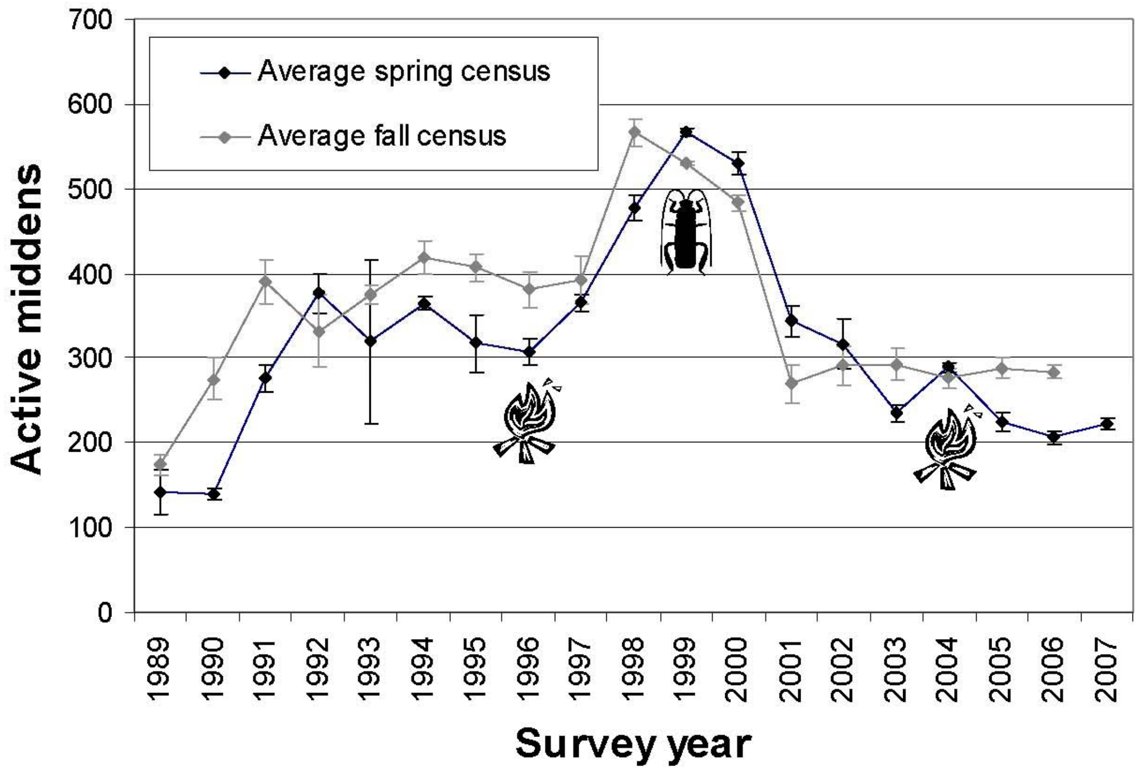
Approve ________________ Date 10/23/07

REGIONAL OFFICE APPROVAL:

Assistant Regional Director, Ecological Services, Fish and Wildlife Service, Region 2

Approve ________________ Acting Date 15 January 2008

FIGURE 1: Spring and fall census results 1989-2007. Symbols indicate occurrence of major wildfires (1996 and 2004) and forest insect outbreaks (1999). Error bars represent the conservative and optimistic estimates for each census.



APPENDIX A

MGRS Population Estimates

Month/Year	Population	Estimate
June 1986	323	
October 1987	242	
March 1988	207 (+/- 62)	
October 1988	conservative	178 (+/- 62)
	optimistic	226 (+/- 62)
	average	202
January 1989	197 (+/- 63)	
April 1989	conservative	99 (+/- 53)
	optimistic	148 (+/- 59)
	average	124
June 1989	conservative	116 (+/- 29)
	optimistic	167 (+/- 32)
	average	142
October 1989	conservative	162 (+/- 15)
	optimistic	185 (+/- 15)
	average	174
May 1990	conservative	132 (+/- 15)
	optimistic	146 (+/- 16)
	average	139
October 1990	conservative	250
	optimistic	300
June 1991	conservative	259
	optimistic	293
October 1991	conservative	364
	optimistic	417
June 1992	conservative	354
	optimistic	399
October 1992	conservative	290
	optimistic	374
June 1993	conservative	223 (+/- 31)
	optimistic	417 (+/- 31)
October 1993	conservative	365 (+/- 22)
	optimistic	385 (+/- 22)

May 1994	conservative	357 (+/- 18)
	optimistic	372 (+/- 18)
October 1994	conservative	398 (+/- 11)
	optimistic	439 (+/- 11)
June 1995	conservative	283 (+/- 12)
	optimistic	352 (+/- 12)
October 1995	conservative	391 (+/- 12)
	optimistic	423 (+/- 12)
Spring 1996	conservative	292 (+/- 10)
	optimistic	323 (+/- 12)
Fall 1996	conservative	360 (+/- 12)
	optimistic	402 (+/- 12)
Spring 1997	conservative	356 (+/- 12)
	optimistic	376 (+/- 12)
Fall 1997	conservative	364 (+/- 12)
	optimistic	420 (+/- 11)
Spring 1998	conservative	462 (+/- 11)
	optimistic	492 (+/- 11)
Fall 1998	conservative	549 (+/-11)
	optimistic	583 (+/-11)
Spring 1999	conservative	562 (+/-12)
	optimistic	571 (+/-11)
Fall 1999	conservative	528 (+/-11)
	optimistic	531 (+/-11)
Spring 2000	conservative	516 (+/-11)
	optimistic	544 (+/-11)
Fall 2000	conservative	474 (+/-11)
	optimistic	493 (+/-11)
Spring 2001	conservative	326 (+/- 12)
	optimistic	362 (+/- 12)
Fall 2001	conservative	247 (+/- 12)
	optimistic	292 (+/- 11)
Spring 2002	conservative	288 (+/- 12)
	optimistic	346 (+/- 12)
Fall 2002	conservative	269 (+/- 8)
	optimistic	315 (+/- 8)
Spring 2003	conservative	224 (+/- 11)
	optimistic	245 (+/- 11)

Fall 2003	conservative	274 (+/- 13)
	optimistic	311 (+/- 13)
Spring 2004	conservative	284 (+/- 13)
	optimistic	295 (+/- 12)
Fall 2004	conservative	264 (+/- 12)
	optimistic	288 (+/- 12)
Spring 2005	conservative	214 (+/- 12)
	optimistic	235 (+/- 12)
Fall 2005	conservative	276 (+/- 12)
	optimistic	301 (+/- 12)
Spring 2006	conservative	199 (+/- 15)
	optimistic	214 (+/- 15)
Fall 2006	conservative	276 (+/- 12)
	optimistic	293 (+/- 11)
Spring 2007	conservation	216 (+/- 12)
	optimistic	230 (+/- 12)