Abert's Squirrel (Sciurus aberti)

INDICATOR SPECIES HABITAT

Abert's squirrel (also referred to as the tassel-eared squirrel) principally utilizes the ponderosa pine (*Pinus ponderosa*) forest type. The species is an indicator for the presence of interlocking canopies in ponderosa pine (USDA 1986a, p.97). Abert's squirrel depends on ponderosa pine for basically all its life necessities and requires diversity of age classes and tree densities (Dodd et al. 1998, Keith 2003). Pine twigs, pine cones, pine seeds, pine bark, as well as truffles (underground mushrooms known to form mycorrhizal associations with ponderosa pine) are used by the Abert's squirrel (Farentinos et al. 1981, States 1988). In addition to pure ponderosa pine stands, Abert's squirrels are also associated with Gambel oak (*Quercus gambelii*), true piñon pine (*Pinus edulis*), junipers (*Juniperus* spp.), quaking aspen (*Populus tremuloides*), and Douglas-fir (*Pseudotsuga menziesii*) (Keith 1965 and 2003) and have been documented in mixed conifer and spruce-fir forest in Arizona (Hutton et al. 2003). Findley and others (1975) mention that Abert's squirrels are common in mixed conifer canyons in New Mexico.

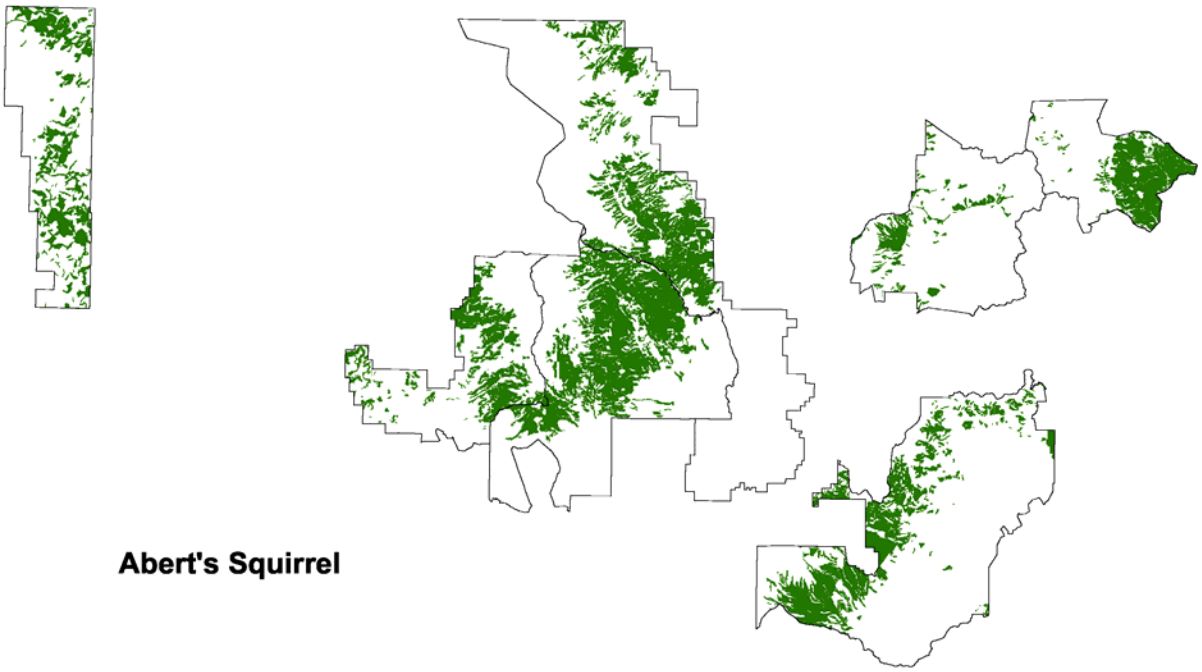
Tree density, diameter, and grouped distribution of trees are the most important components of Abert's squirrel nest cover. The right combinations of these factors provide squirrels with optimum conditions necessary for nest protection. The best cover conditions are found in uneven-aged ponderosa pine stands with trees spaced in small, even-aged groups within the stand. These pine stands have densities between 200 and 250 trees per acre. Average tree diameter for the stand is between 11 and 13 inches in diameter at breast height (DBH), but the presence of small groups of larger trees produces a mosaic of height groups (Patton 1975a). The majority of the use occurs in mid- to late seral stages or vegetation structural stage (VSS) classes 3 through 6. Dwarf mistletoe (*Arceuthobium vaginatum*) infestations that cause the formation of "witches brooms" are often incorporated into or support Abert's squirrel nests (Farentinos 1972).

Abert's squirrels are well distributed throughout the Southwest, but restricted to areas where ponderosa pine is the dominant tree (Patton 1975a). A good sign of squirrel activity is the presence of clipped twigs on the forest floor under ponderosa pine trees. The number of clipped twigs found has been suggested as a good index of Abert's squirrel population density. Large numbers of clippings cannot be present unless a sizable number of squirrels were available to make them (Brown 1982).

Potential Habitat Distribution

On the Carson National Forest, Abert's squirrel occurs sporadically throughout the ponderosa pine habitat type. The species may be casual in the piñon-juniper woodlands, mixed conifer and even spruce-fir (not shown on Map 1), but forest types other than ponderosa pine are not preferred habitat (Keith 1965, Patton and Green 1970, Patton 1975a, Pederson et al. 1976, Hall 1981, Pederson and Welch 1985).

The Carson Forest Plan estimates approximately 301,297 acres of ponderosa pine forest type that provides "potential" habitat for Abert's squirrel, based on vegetation coverage (USDA 2003a). These cumulative acres are generally referred to as "potential habitat" for the species. Map 1 displays the potential habitat for the Abert's squirrel, which is well distributed across the Forest.



Map 1. Abert's Squirrel Potential Habitat Distribution on the Carson National Forest (USDA 2003a)

Management Activities or Natural Events That May Affect Habitat

Negative: Primarily related to long term cumulative effects of forest succession after heavy logging, long term fire suppression and some overstory removal prescriptions, wildfire and drought.

Positive: Thinning, harvest prescriptions that promote larger diameter trees while maintaining patches of interlocking canopy, prescribed fire and low intensity wildfire.

Plans, Regulations and Guidelines Supporting, Maintaining or Improving Habitat

- *Carson National Forest Land and Resource Management Plan, Forest-wide Prescriptions for Wildlife and Fish* (USDA 1986c) are described,

> By creating a diversity of stand conditions and providing juxtaposition of stands over time and space, suitable habitat components of Abert and red squirrels will be maintained over time. During the intensive reconnaissance phase of integrated stand management State and Federal biologists should identify those stands where squirrel activity is especially high and recommend deferment of cutting during the entry (USDA 1986c, p. Wildlife & Fish – 10).

  The desired conditions for Management Areas 4, 5 and 7 are described as quality habitat for Abert's squirrel (USDA 1986c, p. 4. Pine <40% - 1, p. 5. MC/PP >40% - 1, p. 7. Unsuitable - 1).

- *Record of Decision for Amendment of Forest Plans* (USDA 1996) provides guidelines relative to the management of both Mexican spotted owl and northern goshawk habitat.

Standards for ecosystem management in northern goshawk habitat include:

> Manage for old age trees such that as much old forest structure as possible is sustained over time across the landscape. Sustain a mosaic of vegetation densities (overstory and understory), age classes and species composition across the landscape. Provide foods and cover for goshawk prey (USDA 1996, p. 91).

- *Management Recommendations for the Northern Goshawk in the Southwestern United States* (Reynolds et al. 1992) describe the Abert's squirrel as an important prey species for the goshawk and habitat management recommendations include:
  - ✓ Ponderosa pine specialist
    - VSS 3, VSS 4, VSS 5, and VSS 6
  - ✓ Nesting
    - VSS 4, VSS 5, and VSS 6
    - Groups of trees with interlocking crowns are very important
  - ✓ Foraging (considered a food specialist)
    - VSS 3, VSS 4, VSS 5, and VSS 6
    - Large-diameter trees important for cone production
    - Areas of shaded overstory (>60%) necessary for fungi production
  - ✓ Other important habitat attributes
    - Snags may sometimes be used for nest trees
    - Downed logs and woody debris are important for food substrate and cover
    - Large openings are detrimental because they force squirrels, moving from tree to tree, to travel longer distances on the ground. Retention of trees with interlocking crowns may serve as travel ways and escape corridors.

HABITAT CONDITION AND TREND ON THE CARSON NATIONAL FOREST

There are two levels that need to be considered when looking at the ponderosa pine habitats across the Forest. First is the overall ponderosa pine habitat. This is important to help place the subset of interlocking canopies identified in the Forest Plan EIS in perspective. Although there are 301,297 total acres of ponderosa (based on current stand data cover types), the Forest Plan EIS identifies a subset of 53,220 acres of occupied (quality) Abert's squirrel habitat in the ponderosa pine. In 1986, when the Forest Plan was adopted, the key feature used to identify quality habitat was "interlocking canopies" (USDA 1986a, p. 97). Since that time, stands have grown, some have been harvested or burned, and data to estimate conditions has improved. Although there is important data forest-wide, the subset of interlocking canopies is the primary feature by which habitat trend for Abert's squirrel is tracked.

Patton (1984) determined habitat quality for the Abert's squirrel is a major density independent factor controlling squirrel populations. He states, "that habitat quality is a function of kinds, amounts, and distributions of food and cover; and that categories of habitat quality can be defined that will reflect the capability of a habitat to maintain a squirrel population." He also noted that habitat capability is expressed as potential, because high quality habitat may exist where squirrel populations are low due to weather, predators, disease, accidents, or geographic barriers to immigration.

Several factors are used to determine habitat trend. Management activities (primarily timber sales) and wildfire have reduced certain habitats to unsuitable conditions. High intensity wildfire

and certain harvest prescriptions such as overstory removal, seed cuts, and shelterwood harvests are examples of areas that are deducted from the total acres of interlocking canopies. Total stand acres are not deducted. Only the actual acres treated that are estimated to result in acres becoming unsuitable are subtracted. In an appendix, a management indicator species habitat trend analysis explains in more detail how habitat trend is determined.

Suitable stands (1,958 ac) that had experienced high intensity fire were removed from squirrel habitat. In addition, suitable habitat lost to timber harvest (2,603 ac) was deducted. Also taken into account is forest succession, where ponderosa pine stands have progressed towards more quality habitat since 1986. An estimate of stands moving to suitability from forest succession is five percent of the overall ponderosa pine on the Forest from 1986 to 2002 (see Appendix). Table 1 reflects the same rate of ingrowth through 2005.

The habitat trend for Abert's squirrel from 1986 to 2005 is estimated to have increased from 53,220 to 63,794 acres of interlocking canopies or an upward trend of almost 20 percent. From 2002 to 2005 there have been no treatments that reduced squirrel habitat.

Table 1. Abert's Squirrel Suitable Habitat Acres: Change from Wildfire, Logging, and Tree Growth 1986-2005

Ranger District	Total PP Acres	Estimated Acres of Habitat in 2002	Habitat Acres Reduced by Wildfire	Habitat Acres Reduced by Logging	Total Acres Reduced	Total Acres of Ingrowth	Remaining Acres of Abert's Squirrel Habitat
D1, D2, D6[5]	176,966	35,476	371	2,410	2,781	2,106	34,801
D3	33,905	6,729	22	0	22	399	7,106
D4	50,005	17,338	110	194	304	1029	18,063
D7	40,421	5,001	1,474	0	1,474	297	3,824
Total	**301,297**	**64,544**	**1,977**	**2,604**	**4,581**	**3,831**	**63,794**

[5] D1 = Canjilon, D2 = El Rito, D3 = Jicarilla, D4 = Camino Real, D6 = Tres Piedras, D7 = Questa

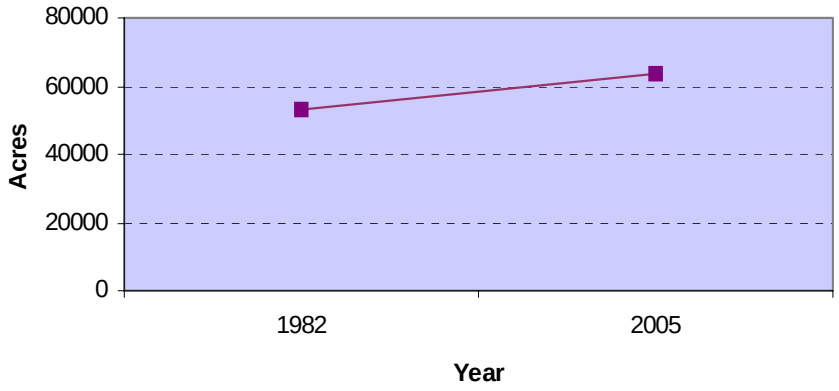


Figure 1. Changes in Abert's Squirrel Suitable Habitat on the Carson National Forest from 1986 to 2005.

Forest Management Activities

Management for quality Abert's squirrel habitat is management for large diameter, cone-producing ponderosa pines (Patton 1975a, Dodd et al. 1998, Halloran and Bekoff 1994; USDA 2002, Keith 2003). Optimum habitat for Abert's squirrels consists of stands of large ponderosa pine at densities greater than 200 trees per acre (Patton 1984; Keith 2003). Patton (1984) finds timber harvest in ponderosa pine stands is not incompatible with Abert's squirrel habitat management; however management goals should include maintenance of small, uneven-aged groups of large trees.

The recommended harvest type is group selection, with retention of ponderosa pine 15 to 20 inches DBH in groups suitable for nesting (Patton 1975a, Pederson et al. 1976, Patton 1984, Patton et al. 1985, Dodd et al. 1998, USDA 2002, Keith 2003). Pederson and others (1976) also recommended the following: established Abert's squirrel nesting and feeding sites should be avoided, harvesting should occur in late summer to early fall (after juveniles have left nests), logging units should be broken into small blocks and worked checkerboard fashion (to minimize direct disturbance of squirrels), and slash should not be piled and burned.

Some logging activities can degrade or remove Abert's squirrel habitat. Lower numbers of Abert's squirrels and lower recruitment rates occur in areas where large pines have been harvested than in unharvested areas. In Utah, Abert's squirrels fed less in logged ponderosa pine plots than in control plots. Abert's squirrels moved away from logged areas to unharvested stands. Plots had been logged with either a 10-inch or 12-inch minimum diameter cut (Pederson et al. 1976). Abert's squirrels consumed more hypogeous fungi in uncut stands than in logged stands. Fewer fungi were produced in logged stands, probably because crown reduction increased drying out of litter and decreased the amount of litter (Pederson et al. 1987). However, Patton and others (1985) note that squirrels moved away from timber harvesting activities, but later moved back into their home range.

While some studies show a dependence on fungi (Dodd et al. 1998, Pederson et al. 1987, States et al. 1988), other studies have shown a strong foraging response to pine cone production (Keith 1965, Pearson 1950, USDA 2005) by Abert's squirrel. Keith (2003) notes there is some confusion resulting from the conflicting findings in different studies. However, he states the studies are not contradictory, but results reflect differences in habitats and food availability in study areas. This makes it important to provide for a variety of available food across the landscape. Most food sources (phloem, mistletoe, truffles, apical buds, and

staminate cones) have similar caloric contents of about 5 kilocalories/gram, but pine seeds offer more energy (> 6.0 kilocalories/gram) and fungi somewhat less (<4.5 kilocalories/gram). Most foods are low in protein (<10 %), but pine seeds and mushrooms/truffles contain higher amounts of protein, 50 percent and 20 percent respectively (Keith 2003). Keith (2003) also notes squirrels have shown to increase their use of fungi in years when seed crops were low or absent and females take more high-energy foods in summer than males, but neither sex chose foods based only on their energy and protein content.

Large ponderosa pines with interlocking canopies are a structural component not as prevalent as desired across the Carson National Forest. The present dominance of mid-seral conditions in ponderosa pine relates primarily to cumulative effects of historic heavy harvesting, such as railroad logging early in the 20th century and fire suppression. Historic overstory removal prescriptions also contributed to the trend towards smaller diameter stands. The long-term trend (pre-forest plan) across the Carson was away from the larger structure stands and towards denser and smaller diameter stands. Some areas of ponderosa pine have also been lost or shifted towards mixed species by the invasion of white fir. However, during the life of the current Forest Plan the conditions for occupied habitat are estimated to have increased by about 20 percent. **As a result, the current habitat condition for this species is considered poor to fair (based on mid-seral dominance), but in an upward trend.**

Recent changes in management practices on the Forest places more emphasis on thinning and prescribed burning, which will increase desired Abert's squirrel habitat. Thinning to create clumpy conditions and reduce competition can make trees grow larger at a faster rate, than keeping stands dense. Prescribed burning controls dense reproduction of ponderosa pine stands. Maintenance of clustered stands is essential in providing the canopy cover needed for truffle production, as well as, cover and nesting sites (Patton 1975a, Dodd et al. 2003, Keith 2003). Reduction of stand heterogeneity and removal of big trees in large disjunctive blocks would likely have a negative effect on this squirrel's habitat (Keith 2003). In some areas there has been little or no activity in this habitat type during the life of the Forest Plan. For example, the Jicarilla Ranger District has not harvested commercial sawtimber since the 1970's, and incidental personal use in the ponderosa type is very limited.

Figure 2 shows between 1986 (when the Carson Forest Plan was implemented) and 2005 approximately 4 percent of potential Abert's squirrel habitat has been reduced by timber activities.[6]

[6] The 2003 Forest-wide MIS Assessment (USDA 2003b, p. 28) included a pie chart reflecting the percent of total ponderosa pine acres actively managed for timber production (7%). This pie chart uses the figures from Table 1 to display the percent of Abert's squirrel habitat in ponderosa pine that resulted in reducing Abert's squirrel habitat (4%) up to 2005.

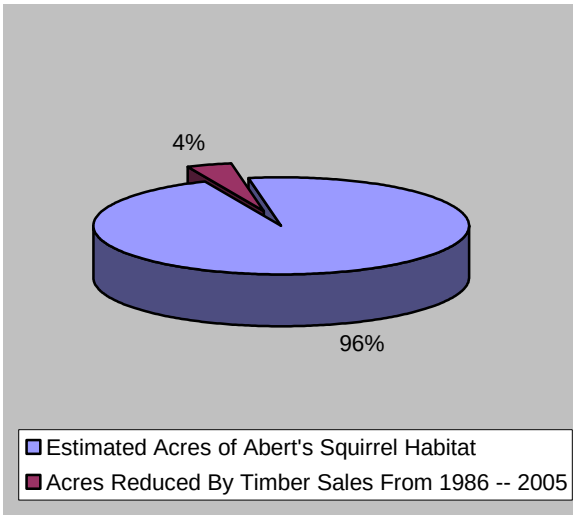


Figure 2. Proportion of Abert's Squirrel Habitat Reduced by Timber Sales on the Carson National Forest From 1986 to 2005 (RMRIS DB, Activity Records)

Unless 20 percent of an ecosystem management area has been allocated to old growth, Carson Forest Plan direction restricts harvesting large trees in the ponderosa pine in a manner that causes the stand to not meet old growth criteria (USDA 1996). More recent management has tended to focus on thinning from below, rather than timber activity primarily used during the early years of the Forest Plan. Management practices of thinning from below and group selections across the Forest enhance Abert's squirrel habitat that, in turn, should assure its survival (Patton 1984, Dodd et al. 1998).

Different thinning methods have been shown to affect Abert's squirrel use (Hope 2003, USDA 2004). Hope (2003) looked at six previously harvested units (4 thinned in 1996, 1 in 1997, and 1 between 1998 and 1999). The older thinning units (1996 and 1997) have limited sign of squirrel activity. The later thinned unit has abundant squirrel sign present in 2003. A good example of improving conditions for Abert's squirrel through thinning from below on the Carson is on the Questa Ranger District (USDA 2004). When surveying the project area prior to thinning, there was no evidence of use by Abert's squirrel. After treatment, monitoring demonstrated that squirrels from adjacent areas likely moved into the treated stands to take advantage of the improved foraging conditions.

POPULATION TREND

Information from the Bison-M database indicates that this species is fairly common throughout New Mexico and Arizona (NMDGF 2004). Findley (1975) also describes Abert's squirrel to be widely distributed throughout its range.

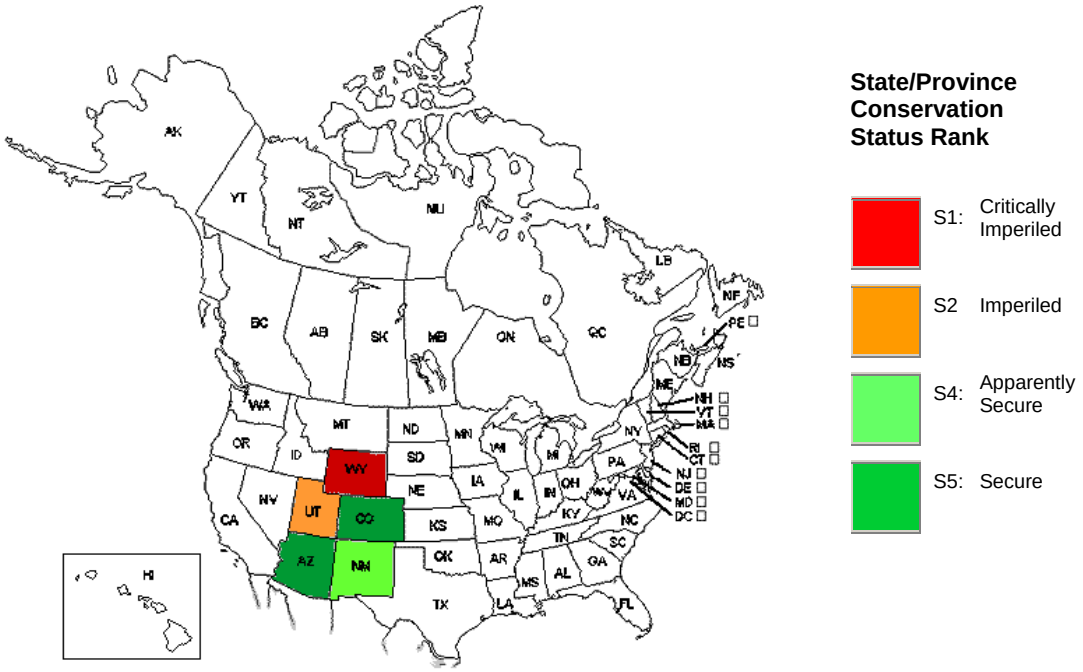
Regional

The NatureServe database (www.natureserve.org/explorer) documents that throughout its range, Abert's squirrel is listed as "G5", (i.e., globally secure and common, widespread and abundant). Reasons given for the G5 ranking are its large range and that it is common in many areas and there is no evidence of large-scale declines. It is not vulnerable in most of its range. Species with this rank typically occur in more than 100 localities, and there are more than

10,000 individuals. Within the United States, the Abert's squirrel is listed as "N5" (i.e., secure and common, widespread and abundant) (NatureServe 2005).

New Mexico

In New Mexico, the Abert's squirrel is listed as "S4" (i.e., apparently secure - uncommon but not rare, and usually widespread in the nation or state/province). An "S4" ranking can imply possible cause of long-term concern (NatureServe 2005). Several years ago on the Jicarilla Ranger District, the Abert's squirrel was determined to be plentiful enough for the New Mexico Department of Game and Fish to expand hunting of the species in the area.



Map 2. Distribution of Abert's Squirrel in North America (NatureServe Explorer 2005)

State wide harvest data indicates a slight decrease in mean harvest from 1983 to 1999 (NMDGF 2001). Population trends, however, are not necessarily directly correlated with harvest data. It is possible that the popularity of squirrel hunting is declining slightly. However, it is just as likely that some degree of correlation can be made. When populations are increasing, the popularity of the squirrel hunting is likely to be more appealing. New Mexico's 2005-2006 hunting season has a bag limit of 8 squirrels per day, with 16 in possession (NMDGF 2005), which is the same bag limit as the 2004-2005 season. All of the Carson National Forest is open to squirrel hunting, except for the Valle Vidal unit, which is closed to all small mammal hunting.

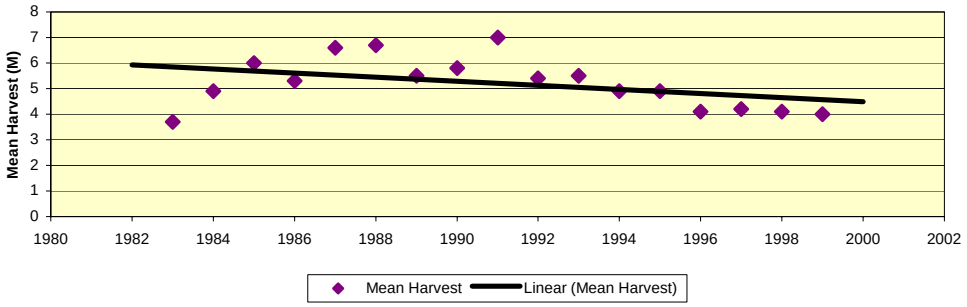


Figure 3. Mean Harvest Abert's Squirrel for New Mexico (NMDGF 2001)

Available evidence suggests populations of Abert's squirrels fluctuate both in the short- and long-term (Pearson 1950, Keith 1965, Keith 2003), but there is in no danger of extinction (UM 1997, Keith 2003). Population numbers of Abert's squirrels appear to fluctuate widely over time and space (Keith 2003, Patton 1984). Population cycles may be related to cyclic variation in the biomass of the pine seed crops. A good and widespread mast crop brings an abundance of squirrels, whereas a year or so of scanty pine cone production results in a scarcity of these animals.

Estimates of squirrel home range size vary as well. Patton (1975b) studied three squirrel home ranges in Arizona. The home range size varied between the squirrels (10 acres, 30 acres, and 85 acres). In Utah, Pederson and others (1976) radio-tracked squirrels during the summer on home ranges before and after timber harvests. Seven home ranges in this study averaged 6.2 acres before harvest, and three of these home ranges averaged 32.0 acres after harvest, indicating that timber harvesting can have an effect on squirrel density.

Optimum densities for excellent Arizona habitat are 50 to 100 per 100 acres (0.02 to 0.40/ha) (Patton 1977). More typical levels are 0.06 to 0.13 per hectare (Frey 2003 and 2004). However, Keith (2003) notes that other researchers have commented on the variations in Abert's squirrel numbers that are apparent over time and from area to area. Densities reported in different studies varies from 0.03 to 0.05/ha; 0.01 to 0.30/ha; 0.31 to 0.56/ha; 0.12 to 1.24/ha; 0.30 to 1.24/ha; and 2.47/ha (Keith 2003).

On the Carson National Forest, the Abert's squirrel ranges from fairly uncommon to common throughout the ponderosa pine type, but by no means approaches the more typical numbers found in Arizona. This is likely linked to the Forest having large areas of mid-seral habitat conditions as opposed to mature stands of ponderosa, coupled with less favorable (more extreme) weather conditions. It is unknown what a typical density number would be for the State of New Mexico in non-drought years. No studies have been conducted in the state or on the Forest since the drought in the Southwest started and when populations likely responded by decreasing in density. Frey (2003) does state, based on old feeding sign on the monitoring sites, "it is clear that during previous years Abert's squirrel had a greater distribution and abundance than observed in 2003."

Carson National Forest

There have been several publications, assessments, reports and inventories completed since the 2003 Forest-wide MIS Assessment (USDA 2003b) was completed for the Carson National Forest. Four years of inventory were completed on the Carson by Dr. Frey and reports have

been prepared for 2003, 2004, 2005, and 2006 (Frey 2003, 2004, 2005, and 2006). Generally these inventories indicate populations are at very low levels. While 2003 and 2004 both showed approximately the same density (0.005 squirrels/ha; 1 squirrel/500 acres), in 2005 the overall mean density was 0.01 squirrel per hectare (1 squirrel/247 acres) (Frey 2005, p. 21). This is a significantly higher density than in previous years. In 2006, on the same 31 plots as 2003-2005 the mean density was the same as 2005. However, six new plots where added in the Valle Vidal and when those plots where included the mean density averages 1 squirrel per 123 acres (Frey 2006). While the numbers are still low in comparison to other studies, they are similar to numbers found in Utah in 2003 and in the San Juan National Forest in 2004 (Frey 2005, p.21).

While comparing monitoring results on the Carson National Forest with other recent studies conducted in Arizona and Utah, two patterns are apparent to Dr. Frey (2005, p.24). First, it appears the entire region experienced declines in Abert's squirrel densities from 2001 to 2004. Second, the regional declines are probably attributable to drought conditions. In north-central New Mexico, drought conditions began in 2000 and extended into the beginning of 2004. In contrast with previous years, moisture was high during 2005; therefore, the increased density of Abert's squirrel on the Forest in 2005 is most likely due to increased moisture.

Dr. Frey (2005, p. 25) notes there may be several reasons why the Carson's surveys are lower than other studies conducted at the same time in adjacent states.

1. The surveys on the Carson are done using randomly selected ponderosa pine forest stands that may represent extreme variation in geography, topography, ecology and management conditions. There was no attempt to select ponderosa pine stands for their potential to harbor high Abert's squirrel populations. For example, some of the plots in the study were located at the lower, more arid edge of the ponderosa pine forest zone where it intergrades with piñon-juniper woodlands. Habitat analysis results indicate that the density of both piñon pine and juniper were associated with lower densities of Abert's squirrels.

   This is shown in the 2006 data, an additional six plots were established on the Valle Vidal Unit in ponderosa pine in or near the mixed-confer interface. These plots were significantly higher than on the other plots with an average density of 1 squirrel per 35 acres (Frey 2006).

2. In other studies, especially those designed to examine Abert's squirrel biology or response to specific forest treatments, the location of study areas may not have been random. Such studies would be more likely to utilize better developed ponderosa pine stands with the potential for higher Abert's squirrel densities in order to insure adequate sample sizes.

3. Climate conditions vary both temporally and spatially. Thus during a period of time when the Carson National Forest is experiencing drought, other areas within the range of Abert's may be experiencing periods of high moisture. Therefore, squirrel populations in different geographic regions may be influenced by different local climate and weather patterns.

4. Another potential reason for relatively low densities of Abert's squirrel might be attributable to spatial variation in topography. The potential for ponderosa pine forest development varies geographically throughout the Southwest. Ponderosa pine forests occur in a narrow elevational zone, with its best development typically between 7,544 and 8,692 feet elevation. Ecologically, ponderosa pine forest generally occurs in a mid-elevation zone between the lower, more arid, piñon-juniper woodland zone and below the cooler, more mesic, mixed conifer forest zone. Large expanses of quality ponderosa pine forest habitat may be best developed in regions, such as the Mogollon Plateau, that have large areas of relatively flat terrain at optimal elevations. In contrast, much of the Carson National Forest consists of rugged mountains with steep terrain that function to compress the 7,500 to 8,700

foot contour into a relatively narrow band around the sides of mountains. This zonal compression puts Abert's populations in relatively close proximity to the piñon-juniper woodland zone, which they appear to avoid, and in relatively close proximity to mixed conifer forest, which is occupied by the aggressive and competitively dominant red squirrel (*Tamiasciurus hudsonicus*). Consequently, in areas of high topographic relief, Abert's squirrel populations may be relatively more constrained by factors such as area of available habitat, climate, and competition.

5. Densities numbers may be due to current habitat conditions as a result of past forest management (no active forest management has occurred on any of the plots during this study).

The current low population numbers are considered to be a result of: 1) the drought; 2) existing forest conditions from activities that occurred before implementation of the Carson Forest Plan (1986c); and 3) how the survey plots were determined. Treatments to move habitats towards a more desired condition for squirrels should not aggravate, contribute to, or result in a downward trend in population numbers. Furthermore, recent management decisions have focused on prescribed treatments that improve cone crop availability, which may also help with recruitment of squirrels in potential habitats. In addition, the Carson Forest Plan addresses management of squirrel habitat by stating, "During the intensive reconnaissance phase of integrated stand management, State and Federal biologists should identify those stands where squirrel activity is especially high and recommend deferment of cutting during the entry" (USDA 1986c, p. Wildlife & Fish – 10).

Stephenson and Brown (1980) estimate population declines resulting from heavy snow packs may take four years of moderate snow cover to recover from only two years of heavy snow pack. Drought reduces the availability of ponderosa pine cones and hypogenous fungi for the squirrel. However, it is not anticipated the wet conditions experienced on the Forest in late-summer 2005 will dramatically improve foraging conditions for the squirrel in 2006 and subsequently cause a rapid increase in numbers. Many stands in 2005 still did not have much pine cone production as it takes two years for pine cones to fully develop (Fruits, per comm. 2005). It is assumed it will take longer to recover from drought than two years of heavy snow fall, due to the time it takes ponderosa pine to start producing an abundant cone crop again.

Keith (2003) notes, "Abert's squirrel is a survivor and will persist as a species, although perhaps in reduced numbers" and "that the squirrel has shown the ability to thrive in sparse populations and to emigrate considerable distances to successfully establish new stable populations."

Populations for Abert's Squirrel on the Carson National Forest are low and with populations' downward trend occurring from 2002-2004. Populations are not considered stable at this time. Populations on the Forest are anticipated to rebound after the drought has ended and ponderosa pine trees once again start producing a more reliable seed crop. Based on the 2005 and 2006 data the squirrel populations already show signs of rebounding. It is probable squirrel populations will continue to increase as long as conditions do not revert back to severe drought. This confirms what the Forest Plan predicts of squirrel populations over the course of plan implementation – "…populations are expected to increase because of improved habitat condition" (USDA 1986c, p. 238). It should be noted, since the implementation of the Forest Plan in 1986, 93 percent of Abert's squirrel habitat on the Forest has not been impacted by management activities and current habitat conditions are primarily the result of pre-forest plan related management and is not associated with how the Forest is managed today. Management activities designed to improve long-term habitat conditions should be a priority.

A noteworthy and consistent characteristic regarding parameters affecting Abert's squirrel demography is their variability. Keith (2003) sums up this variability:

> Food habits differ depending on the availability of foods. Home range varies with the quality of squirrel habitat and the weather. Frequency of breeding, breeding success, and population mortality are all influenced by the weather, which is the most variable and perhaps influential factor of all. Finally, the temporal or spatial abundance of squirrels is determined by the interaction of natality, mortality, and habitat quality. As a result, squirrel numbers vary considerably both spatially and temporally.

REFERENCES

Brown, D.E. (ed.) 1982. Biotic communities of the American Southwest - United States and Mexico. Volume 4, Numbers 1-4. Superior, AZ: University of Arizona. 342 p.

Davis, Russell; Bissell, Steven J. 1989. Distribution of Abert's squirrel (*Sciurus aberti*) in Colorado:evidence for a recent expansion of range. The Southwestern Naturalist. 34(2): 306-309.

Dodd, Norris L. 1996. Taking tassel-eared squirrel management into the 21st century, a research status report. Wildlife Views. November 1996: 1-12.

Dodd, Norris L.; Rosenstock, S. S.; Miller, C. R.; Schweinburg, R. E. 1998. Tassel-eared squirrel population dynamics in Arizona: index techniques and relationships to habitat condition. Arizona Game and Fish Department, Research Branch Technical Report, 27:1-49.

Dodd, Norris L. 2003. Landscape-scale habitat relationships to tassel-eared squirrel population dynamics in north-central Arizona. Arizona Game and Fish Department Technical Guidance Bulletin No. 6, Phoenix, Arizona. 28 p.

Dodd, N.L.; States, J.S.; Rosenstock, S.S. 2003. Tassel-eared squirrel population, habitat condition, and dietary relationships in North-Central Arizona. Journal of Wildlife Management 67(3):622-533.

Farentinos, R.C. 1972. Nests of the tassel-eared squirrel. Journal of Mammalogy. 53(4): 900-903.

Farentinos, R.C.; Capretta, P.J.; Kepner, R.E.; Littlefield, V.M. 1981. Selective herbivory in tassel-eared squirrels: role of monoterpenes in ponderosa pines chosen as feeding trees. Science. 213(11) September 1981: 1273-1275.

Ffolliott, Peter F.; Patton, David R. 1975. Production-rating functions for Abert squirrels in southwestern ponderosa pine. Wildlife Society Bulletin. Winter 1975. 3(4):162-165.

Ffolliott, Peter F.; Patton, David R. 1978. Abert squirrel use of ponderosa pine as feed trees. Res. Note RM-362. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. [18449]

Findley, J.A.; Harris A.H.; Wilson, D.E.; Jones, C. 1975. Mammals of New Mexico. Albuquerque, NM: Univ. of New Mexico Press: xxii + 360 p.

Flyger, Vagn; Gates, J. Edward. 1982. Pine squirrels (*Tamiasciurus hudsonicus* and T. *douglasii*). *In* Rodentia. Johns Hopkins University Press: 230-238.

Frey, J. 2003. Initiation of Abert's squirrel (*Sciurus aberti*) monitoring on Carson National Forest, New Mexico. A Final Contract Report R3-02-03-12 Completion Report. Carson National Forest, December, 31 2003. 18 p.

Frey, J. 2004. Abert's squirrel (Sciurus aberti) monitoring and habitat analysis on Carson National Forest, New Mexico. A Final Contract Report R3-83A7-4-0038 Completion Report. Carson National Forest, December 9, 2004. 21p.

Frey, J. 2005. Abert's squirrel (Sciurus aberti) monitoring on Carson National Forest, New Mexico, 2005. Final Contract Report AG-83A7-P-05-0002 Completion Report. Carson National Forest. December 6, 2005. 32 p.

Frey, J. 2006. Abert's squirrel (Sciurus aberti) Monitoring on Carson National Forest, New Mexico, 2006. Final Contract Report AG-83A7-P-06-0023 Completion Report. Carson National Forest. November 30, 2006. 41 p.

Garnett, Gregg; Mathiasen, Robert; Chambers, Carol. 2004. A comparison of wildlife use in broomed and unbroomed ponderosa pine trees in northern Arizona. Western Journal of Applied Forestry. 19(1): 42-46.

Hall, Joseph. 1967. White tails and yellow pines. National Parks Magazine. April 1967. 3 p.

Halloran, M.E.; Bekoff, M. 1994. Nesting behavior of Abert squirrels (*Sciurus aberti*). Ethology 97: 236-248.

Hope, Andrew. 2003. Abert's Squirrel (*Sciurus aberti*) surveys in four fuel-wood thinning units with the Camino Real Ranger District of the Carson National Forest, NM. Unpublished. 7 p.

Hutton, Kelly A; Koprowski, John L; Greer, Vicki L; Alanen, Marit I; Schauffert, Carol A.; Young, Paul J. 2003. Use of mixed-conifer and spruce fir forests by an introduced population of Abert's squirrels (*Sciurus aberti*). The Southwestern Naturalist 48(2): 257-260.

Keith, James O. 1965. The Abert squirrel and its dependence on ponderosa pine. Ecology. 46: 150-163.

Keith, James O. 2003. Abert's squirrel (S*ciurus aberti)*: a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. August 25, 2003. Available: http://www.fs.fed.us/r2/projects/scp/assessments/abertsquirrel.pdf

Murphy, Shannon; Linhart, Yan. 1999. Comparative morphology of the gastrointestinal tract in the feeding specialist *Sciurus aberti* and several generalist congeners. Journal of Mammology. 80(4):1325-1330.

NatureServe Explorer. 2002. An online encyclopedia of life [web application]. Version 1.6. Arlington, Virginia, USA: NatureServe. Available: http://www.natureserve.org/explorer. (Accessed: April 11, 2002).

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.4. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: June 29, 2005).

New Mexico Department of Game and Fish. 2001. Analysis of New Mexico Department of Game and Fish small game harvest surveys of 1999-2000. Professional Service Contract No. 01-516.35. Santa Fe, NM: Chaparral Systems Corporation.

New Mexico Department of Game and Fish. 2004. BISON-M (Biota Information System of New Mexico): Biological database for New Mexico. NMDGF in cooperation with USDI BLM, USDI FWS, USDI Bureau of Reclamation, US Army Corps of Engineers, USDA Forest Service and

University of New Mexico. Version 1/2004. http://nmnhp.unm.edu/bisonm (Accessed on February 4, 2006)

New Mexico Department of Game and Fish. 2005. New Mexico small game and waterfowl rules and information. [Online version available at http://www.wildlife.state.nm.us/publications/documents/small_game_rib_2005-06.pdf]

Patton, David. 1974a. Characteristics of ponderosa pine stands selected by the Abert's squirrel for cover. A dissertation submitted to Dept. of Watershed Mgmt. University of Arizona. 1974. 40 p.

Patton, David. 1974b. Estimating food consumption from twigs clipped by the Abert squirrel. Research Note RM-272. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p.

Patton, David R. 1975a. Abert's squirrel cover requirements in southwestern ponderosa pine. Research Paper RM-145. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p.

Patton, David R. 1975b. Nest use and home range of three Abert's squirrels as determined by radio tracking. Research Paper RM-281. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. February 1975. 3 p.

Patton, David R. 1977. Managing southwestern ponderosa pine for the Abert squirrel. Journal of Forestry. 75: 264-267.

Patton, David R. 1984. A model to evaluate abert squirrel habitat in uneven-aged ponderosa pine. Wildlife Society Bulletin. 12: 408-414.

Patton, David R.; Green, Win. 1970. Abert's squirrels prefer mature ponderosa pine. Research Note RM-169. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station. 3 p.

Patton, David; Wadleigh, Richard; Hudak, Howard. 1985. The effects of timber harvesting on the Kaibab squirrel. Journal of Wildlife Management. 49(1): 14-19.

Pearson, G.A. 1950. Management of ponderosa pine in the southwest as developed by research and experimental practices. Washington DC: US Department of Agriculture. Monograph 6. 216 p.

Pederson, Jordan C.; Farentinos, R.C.; Littlefield, Victoria M. 1987. Effects of logging on habitat quality and feeding patterns of Abert squirrels. The Great Basin Naturalist. 47(2): 252-258. [6904]

Pederson, Jordan C.; Hasenyager, R.N.; Heggen, A.W. 1976. Habitat requirements of the Abert squirrel (S*. aberti navajo*) on the Monticello district, Manti-Lasal National Forest of Utah. Publication Number 76-9, Utah State Division of Wildlife Resources.

Pederson, Jordan C.; Welch, B.L. 1985. Comparison of ponderosa pine as feed and nonfeed trees for Abert squirrels. Journal of Chemistry Ecology. 11: 149-157.

Rasmussen, Irvin; Brown, David; Jones, Dale. 1975. Use of ponderosa pine by tassel-eared squirrels and a key to determine evidence of their use from that of red squirrels and porcupines. Wildlife Digest. Abstract 10, October 10, 1975. Arizona Game and Fish Dept. 12 p.

Raught, Richard. 1967. Tree squirrels. *In* New Mexico Wildlife Management: 95-100.

Reynolds, Hudson g. 1966. Abert's squirrels feeding on pinyon pine. Journal of Mammology. 47(3): 550.

Reynolds, Richard T.; Graham, Russell T.; Reiser, M. Hildegard; and others. 1992. Management recommendations for the northern goshawk in the southwestern United States. General Technical Report RM-217. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 90 p.

Smith, Jane Kapler, ed. 2000. Wildland fire in ecosystems: effects of fire on fauna. General Technical Report RMRS-GTR-42-vol. 1. Ogden, UT: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 83 p.

States, Jack S.; Gaud, William S. 1997. Ecology of hypogenous fungi associated with ponderosa pine: patterns of distribution and sporocarp production in some Arizona forests. Mycologia. 89(5): 712-721.

States, Jack S.; Gaud, William S.; Allred, W. Sylvester; Austin, William J. 1988. Foraging patterns of tassel-eared squirrels in selected ponderosa pine stands. In Szaro, R.; Severson, K.; Patton, D.; eds. Management of amphibians, reptiles and small mammals in North America. Proceedings of a symposium, General Technical Report RM-166. Fort Collins, CO; US Department of Agriculture, Forest Service, Rocky Mountain Range and Research Station: 425-43.

Stephenson, Richard L.; Brown, David E. 1980. Snow cover as a factor influencing mortality of Abert's squirrels. Journal of Wildlife Management. 44 (4): 951-955.

USDA Forest Service. 1986a. Environmental impact statement, Carson forest plan. Albuquerque, NM: US Department of Agriculture, Forest Service, Southwestern Region. 386 p.

USDA Forest Service. 1986b. Record of decision for the Carson National Forest land and resource management plan. Albuquerque, NM: US Department of Agriculture, Forest Service, Southwestern Region. 6 p.

USDA Forest Service. 1986c. Carson National Forest land and resource management plan, as amended. Albuquerque, NM: US Department of Agriculture, Forest Service, Southwestern Region.

USDA Forest Service. 1987. Terrestrial ecosystems survey of the Carson National Forest. Albuquerque, NM: US Department of Agriculture, Forest Service, Southwestern Region. 552 p.

USDA Forest Service. 1996. Record of decision for amendment of forest plans – Arizona and New Mexico. Albuquerque, NM: US Department of Agriculture, Forest Service, Southwestern Region. 96 p.

USDA Forest Service. 2002. Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.

USDA Forest Service. 2003a. Carson National Forest stand exam summary by cover type (unpublished). 1 p.

USDA Forest Service. 2003b. Management indicator species for the Carson National Forest – July 2003. Unpublished. 147 p.

USDA Forest Service. 2004. An example of where thinning from below can improve habitat for Abert's squirrel: unpublished monitoring report by Charles Kuykendall, Wildlife Biologist, Carson National Forest. November 2, 2004. 3 p.

USDA Forest Service. 2005. Trip to Aqua/Caballos analysis area: unpublished monitoring report by Jack Carpenter, Carson National Forest. May 26, 2005. 5 p.

University of Michigan. 1997. Animal diversity web (animaldiversity.ummz.umich.edu). Ann Arbor, MI. Page last updated 05 December 1997. (Accessed on April 4, 2005)