# Initiation of
# Abert's Squirrel (*Sciurus aberti*)
# Monitoring on
# Carson National Forest, New Mexico

**A Final Contract R3-02-03-12 Completion Report**
**Submitted by:**


## Jennifer K. Frey, PhD

***Frey Biological Research***
***438 Diaz Rd.***
***Las Cruces, New Mexico 88007***

and

***Department of Fishery and Wildlife Sciences and***
***Department of Biology***
***New Mexico State University***
***P.O. Box 30003, MSC 4901***
***Las Cruces, New Mexico 88003-8003***


**Submitted to:**

**Carson National Forest**
**208 Cruz Alta Road**
**Taos, New Mexico 87571**

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# Executive Summary

Purpose

- The purpose of this study was to initiate Abert's squirrel monitoring on Carson National Forest in order to establish long-term trends in populations and habitat.
- Previously published recommendations for Abert's squirrel and ponderosa pine habitat are based on studies conducted in other geographic locations. Such information may not apply to conditions on Carson National Forest.

Method

- An index of Abert's squirrel density was determined using methods developed by the Arizona Game and Fish Department.
- Over-winter feeding sign was sampled in 256 1 $m^2$ sampling quadrants situated on a 1,607 ft x 1,607 ft. grid (i.e., monitoring plot) in each forest stand.
- A total of 31 monitoring plots were established in ponderosa pine stands across the six Carson National Forest districts.
- Abert's squirrel density on each plot was calculated by using a feeding sign index regression model curve supplied by Arizona Game and Fish Department.

Results

- Abert's squirrel density estimates ranged from 0 to 0.02 per acre (i.e., one squirrel per 50 acres) with an overall mean of 0.005 (i.e., one squirrel per 500 acres).
- Most plots (65 %) had a density estimate of zero Abert's squirrel.
- Most plots (90 %) exhibited evidence of Abert's squirrel occurrence in the past.
- Abert's squirrel density was not significantly related to elevation or any of seven stand variable provided by Carson National Forest including: slope, aspect, habitat structure, site index, tree size, crown cover, and area.

Discussion and Conclusions

- Compared to previous density estimates of Abert's squirrel in high quality habitats in other geographic locations, Abert's squirrel densities observed on Carson National Forest in 2003 were extremely low (e.g., one squirrel per 500 acres compared to one squirrel per 6 acres).
- Based on data collected in adjacent states, Abert's squirrel densities crashed in 2002 with continued declines into 2003. The regional decline in Abert's

squirrel densities is thought to be due to drought conditions that may reduce availability of important foods (i.e., ponderosa pine cones and hypogeous fungi).

- Densities of Abert's squirrels on Carson National Forest were approximately twice as low as compared with density estimates in Utah during 2003.
- Because the Abert's squirrel monitoring on Carson National Forest started later than recommended (i.e., in early June rather than mid-March to late May), it is possible that this resulted in artificially lowered density estimates (e.g., some over-winter feeding sign could have been overlooked as "old" rather than as "fresh").
- The influence of general habitat conditions and management actions on Abert's squirrel densities on Carson National Forest is unknown and requires additional study.
- Stand variables maintained by Carson National Forest were not useful in predicting Abert's squirrel abundance.

Recommendations

- Continue Abert's squirrel monitoring.
- Conduct field work during mid-March to late May.
- Develop additional studies to more fully establish the relationships between habitat characteristics and Abert's squirrel densities on Carson National Forest and to address the impacts of specific forest management strategies.
- Increase the number of stands monitored, especially if habitat data are collected.
- Long-term data on ponderosa pine cone/seed, acorn, and fungal production should be conducted in conjunction with Abert's squirrel monitoring.

# Background

Abert's squirrel (*Sciurus aberti*), also called tassel-eared squirrel, is endemic to southwestern North America. Its range includes the Southern Rocky Mountains and Colorado Plateau in the United States and portions of the Sierra Madre in northwestern Mexico (Hall 1981). This tree squirrel almost exclusively occurs in ponderosa pine (*Pinus ponderosa*) forests (Bailey 1931, Findley et al. 1975). On occasion Abert's squirrel will also occur below the ponderosa pine zone in the upper edge of pinyon (*Pinus*)-juniper (*Juniperus*) woodland and above the ponderosa pine zone in the lower edge of mixed conifer forest (Findley 1999). In mountain ranges where red squirrels (*Tamiasciurus hudsonicus)* are absent, Abert's squirrel may extend higher into the mixed conifer forest zone. Optimum Abert's squirrel habitat consists of groups of even-aged ponderosa pine spaced within an uneven-aged stand. For example, Flyger and Gates (1982) recommended that these stands should have open understories and densities of 496 – 618 ponderosa pines per hectare with an average diameter at breast height (DBH) of 28-33 cm DBH and include one or two large (30-36 cm DBH) Gambel oaks (*Quercus gambelii*). However, there are no known studies of habitat requirement for this species that have been conducted in New Mexico. Thus, recommendations for habitat based on studies in other locations may not be appropriate for Carson National Forest. For example, large diameter Gambel oaks are usually not an evident part of ponderosa pine forests on Carson National Forest.

Abert's squirrel is ecologically dependent on ponderosa pine for both nesting sites and food (Keith 1965). Nests are usually located 5-18 m (= 20-59 ft) above the ground on the south side of a ponderosa pine that has a crown comprising 35-55% of the total tree height and greater than 36 cm DBH (= 14 in DBH; Farentinos 1972a, Flyger and Gates 1982). Suitable nests trees are generally greater than 100 years old and located adjacent to trees of similar size with interlocking canopies to provide escape routes (Flyger and Gates 1982, Brown 1984). Nests are typically constructed of twigs or excavated in dwarf mistletoe (*Arceuthobium pusillum*) "witches broom" infections (Farentinos 1972a, 1972b). Abert's squirrel eat the seeds, inner bark, terminal buds, twigs, and flowers of ponderosa pine in addition to other foods such as mushrooms, fungi, pinyon pine, acorns, carrion, and cones raided from red squirrel middens (Flyger and Gates 1982). There is seasonal variation in food habits. During summer and early fall, hypogeous fungi associated with ponderosa pine constitute a major part of the diet (Rasmussen et al. 1975). During winter apical buds and inner bark (i.e., phloem) of ponderosa pine are the major food. In spring and early summer ponderosa pine staminate (male) flowers and seeds are important (Rasmussen et al. 1975, Brown 1984). Because Abert's squirrels are so dependent on ponderosa pine, their density fluctuates in response to various aspects of this tree such as cone production (Flyger and Gates 1982). This variation is both temporal and spatial (Bailey 1931).

# Purpose

The Abert's squirrel was designated a management indicator species by the Carson National Forest. Consequently, information is needed on their distribution and abundance on the forest. In addition, a long-term monitoring program is required in order to track population changes and to assess the impacts of forest management practices on this species. Thus, the purpose of this study was to initiate monitoring of Abert's squirrel on the Carson National Forest in order to establish trends in population and habitat. The technique for monitoring Abert's squirrel was previously developed by the Arizona Game and Fish Department (Dodd no date, Dodd et al. 1998, Dodd personal communication). This monitoring technique provides an indirect population index based on sign consisting of the remains of over-winter feeding activity. This has been demonstrated to be a reliable, consistent, efficient, and cost-effective technique (Dodd 1998).

# Methods

### *Feeding sign*

The Abert's squirrel monitoring technique is dependent on the ability of the field crew to accurately identify over-winter feeding sign made by Abert's squirrel. Feeding sign includes the clipped terminal ends of ponderosa pine limbs, peeled ponderosa pine twigs, ponderosa pine cone cores, evidence of feeding on ponderosa pine staminate cones, flowers, and apical buds, and hypogeous fungi digs (Dodd no date, Dodd et al. 1998). Feeding sign made by Abert's squirrel can easily be confused with sign made by red squirrel, porcupine (*Erethizon dorsatum*), other small mammals, twig boring insects, and other factors (Rasmussen et al. 1975). A particularly helpful resource for distinguishing Abert's squirrel sign was the key provided by Rasmussen et al. (1975). However, even with this resource, accurate identification of all types of sign was not immediately possible. Consequently, several steps were taken to insure that all field crewmembers were able to accurately identify all feeding sign types. Prior to initiating fieldwork, the mammalogist provided general instruction on the nature and identification of feeding sign. Crewmembers were also provided with instruction and field practice using the Rasmussen et al. (1975) key. Finally, data was collected on several plots as a group. At the conclusion of this training period, all crewmembers were highly confident in their ability to accurately distinguish the different types of feeding sign.

### *Field methods*

Dodd et al. (1998) found that the spring period (mid-March to late May) was the only season with a consistent relationship between feeding sign and squirrel density. However, administrative problems resulted in time delays such that a final contract solicitation was not due until 27 May 2003. This resulted in an ultimate contract start date of 2 June 2003. Consequently, fieldwork began on 3 June 2003. Fieldwork was completed on 15 June 2003.

The establishment of an Abert's squirrel monitoring plot in each of 24 ponderosa pine forest stands was deemed adequate for establishing base-line estimates of Abert's squirrel densities on Carson National Forest. Carson National Forest provided maps and coordinates of stand centers for a randomly selected suite of ponderosa pine stands that were at least 80 ha (= 198 acres) in size and within 1 mile of established roads. Specific stands were selected from this suite based primarily on logistical considerations. These considerations included distributing plots among the six Forest Districts, accessibility, and drive time. In addition, the stand had to consist of ponderosa pine as the dominant tree species. Once a stand was selected, the specific location of the monitoring plot within the stand was determined by use of maps and stand center coordinates. Monitoring plots were situated so that the entire plot (490 m X 490 m; = 1,607 ft x 1,607 ft) fell within the stand and so that roads and habitat types other than ponderosa pine forest were avoided where possible. The sampling design followed that developed and recommended by Norris Dodd (Dodd et al. 1998, Norris Dodd no date, Norris Dodd personal communication). The monitoring plot consisted of an 8 x 8 grid made up of 64 "intervals", each 70 m (= 230 ft) in length. Feeding sign was recorded within 1.0 $m^2$ (= 1,521 square inches) sample quadrants. Within each interval, four 1.0 $m^2$ (= 39 in. x 39 in.) sample quadrants were spaced 17.5 m (= 57 ft.) apart (i.e., at 0, 17.5, 35.0, and 52.5 m along each interval). This resulted in a total of 256 1.0 $m^2$ feeding sign sampling quadrates per plot.

The latitude-longitude coordinate of the starting point (a grid corner) was determined with a hand-held global positioning system unit and the cardinal direction of the first transect was determined with a compass. The starting location was considered Interval 1 at the 0 m sample quadrant. At this point, a 1 $m^2$ (= 10.8 square feet) open-front PVC sample quadrate frame was place on the ground in front of the observer's feet. Presence or absence of Abert's squirrel feeding sign within, or touching, the sampling quadrate frame was recorded. Subsequent sampling locations (i.e., each 17.5 m) were paced with bearing maintained by compass. Observers pace was periodically measured and checked with a meter tape. Coordinates of each of the three remaining plot corners were determined and recorded as encountered. Following completion of the plot, a map of the study area was drawn and notes about the habitat and animals observed were recorded. In addition, other evidence of current or past occupancy of the stand by Abert's squirrel was noted.

## *Data analysis*

The incidence of feeding sign encountered on monitoring plots was used as an index of Abert's squirrel density. On each monitoring plot, the percentage of the 256 1.0 $m^2$ sampling quadrates containing feeding sign was calculated. Density was then estimated using a previously determined feeding sign index regression model curve supplied by Norris Dodd (Figure 1). This model represents the relationships between relative abundance of spring feeding sign and the absolute density of the squirrel population. Density estimates and prediction intervals were calculated for each monitoring plot. These estimates were determined both independently and were provided by Norris Dodd.

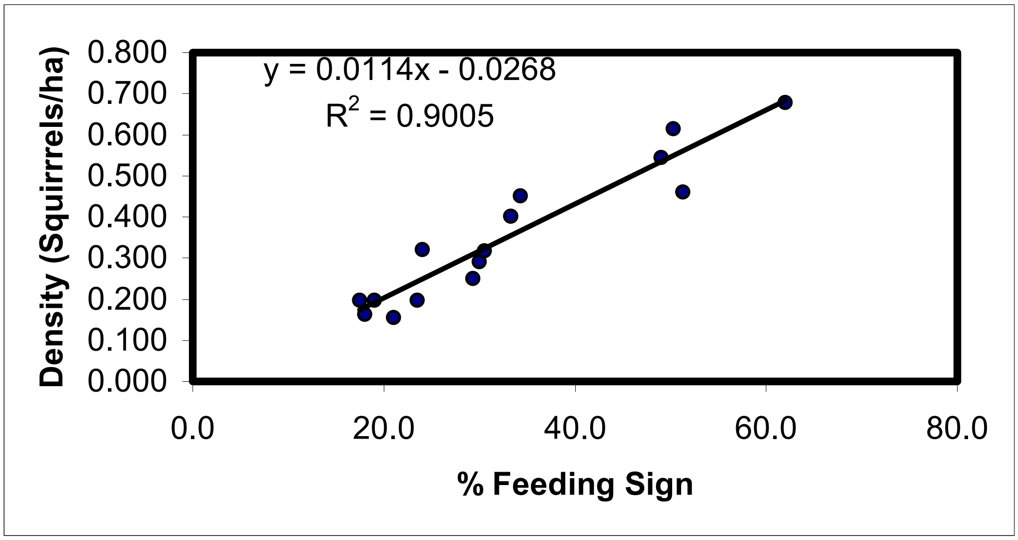


**Figure 1.** Regression model between percentage feeding sign and Abert's squirrel density developed by Norris Dodd in Arizona. This model was used to calculate density of Abert's squirrels in Carson National Forest. To convert density of squirrels per hectare to squirrels per acre, divide the displayed density by 2.471.

Statistical analyses were performed to test whether existing Carson National Forest forest stand variables were predictive of Abert's squirrel densities. Habitat variables provided by Carson National Forest included stand slope percent, aspect, habitat structure, site index, tree size, crown cover, and stand area. All measures were not necessarily available for all stands. Elevation was also included, which was the average GPS reading obtained for the plot corners. All variables were checked for normality using a one-sample Kolmogorov-Smirnov test; where possible, nonparametric tests were performed for non-normal variables. Simple correlations and linear regressions were assessed between Abert's squirrel density estimates and each independent variable. Nonparametric Kruskal Wallis test was used to test if either Abert's squirrel density or percentage feeding sign were significantly related to aspect, tree size or habitat structure, which were rank variables. Multiple regression techniques were used to assess the power with which the independent variables predict Abert's squirrel density.

# Results

An assessment of effort and logistics associated with the Abert's squirrel monitoring is presented in Appendix 1. A total of 31 monitoring plots (7 more than required) were established across the six Forest Districts (Appendix 1). These included 4 in Camino Real District, 1 in Canjilon District, 13 in El Rito District, 4 in Jicarilla District, 2 in Questa District, and 7 in Tres Piedras District. Fresh Abert's squirrel feeding sign was found in at least one of the 256 1 $m^2$ sampling quadrants on only 11 (35.5 %) of the 31 monitoring plots. However, Abert's squirrel were actually found to be present on 7 additional plots based on the direct observation of squirrels or the observation of feeding sign that was not recorded within one of the 256 1 $m^2$ sampling quadrates. Thus, a total of 18 (58 %) of the monitoring plots had evidence of recent or current Abert's squirrel occupancy. Further, most plots (90.3 %) exhibited evidence of Abert's squirrel occurrence at some time in the past based on the presence of old feeding sign.

Abert's squirrel density estimates ranged from 0 to 0.05 per hectare (= 0 - 0.02 per acre); most plots had a calculated density of zero (Figure 2, Appendix 2). The 90 % prediction intervals around these estimates formed a single overlapping group, which indicates that density estimates were similar across all monitoring plots. The average observed density across all plots was 0.005 squirrels per hectare (= 1 squirrel per 500 acres). Squirrel density varied by forest district (Figure 3). However, sample sizes were deemed too small for statistical comparisons.

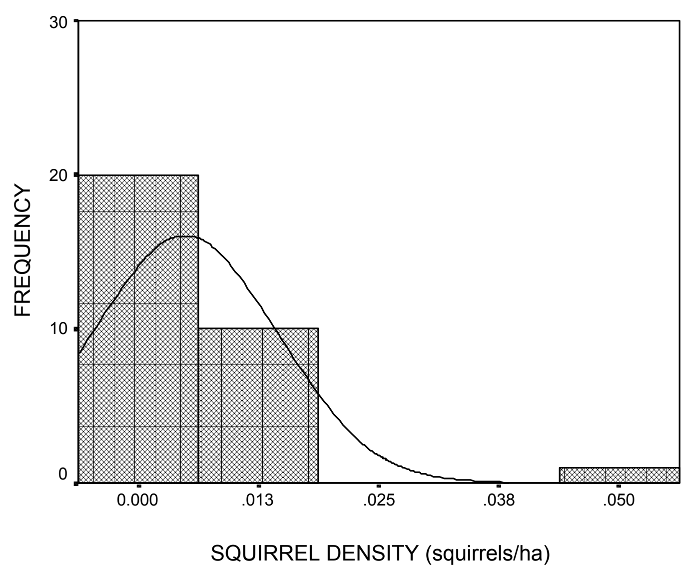


**Figure 2.** Frequency histogram of Abert's squirrel (*Sciurus aberti*) density on Carson National Forest. To convert density of squirrels per hectare to squirrels per acre, divide the displayed density by 2.471.

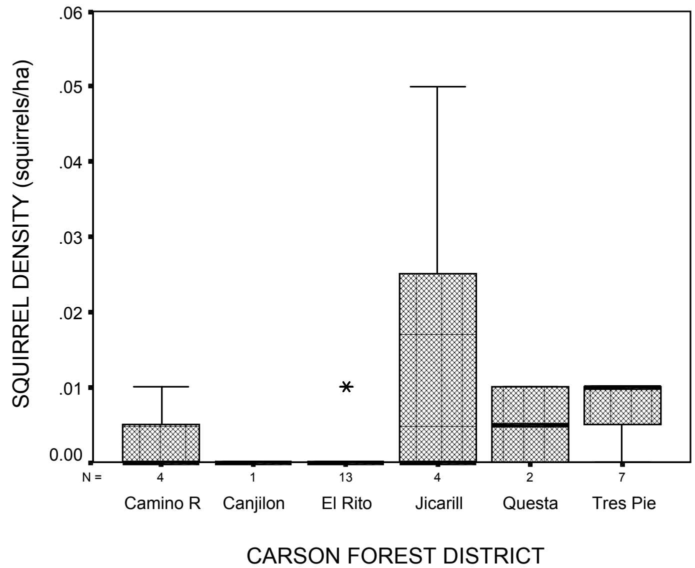


**Figure 3.** Abert's squirrel (*Sciurus aberti*) density on six districts of the Carson National Forest. To convert density of squirrels per hectare to squirrels per acre, divide the displayed density by 2.471.

Six variables were non-normal including Abert's squirrel density, percentage feeding sign on plot, current presence/absence Abert's squirrel, past presence/absence Abert's squirrel, site index, and tree size. Neither Abert's squirrel density nor the percentage feeding sign exhibited significant correlations with any of the eight independent variables ($P > 0.05$). If the critical value is increased to $P = 0.10$, these variables only exhibit a significant positive correlation with stand area ($r_s = 0.325$, $P = 0.075$ for percentage feeding sign; $r_s = 0.305$, $P = 0.095$ for Abert's squirrel density). Simple linear regression of each independent variable with Abert's squirrel density resulted in no significant relationships ($P > 0.05$). When percentage of feeding sign was used as the dependent variable in simple linear regressions, only elevation was near significant ($r = 0.336$, $P = 0.075$). Using various multiple regression techniques, no combination of the five continuous independent variables were significant ($P < 0.05$) predictors of Abert's squirrel density. The Kruskal Wallis tests indicated that Abert's squirrel density was not significantly related to aspect ($\chi^2 = 5.473$, $df = 7$, $P = 0.602$), tree size ($\chi^2 = 1.987$, $df = 2$, $P = 0.370$) or habitat structure ($\chi^2 = 6.500$, $df = 3$, $P = 0.090$).

The three plots with no evidence of Abert's squirrel were located on the Camino Real District (plots 54, 55, 56). Field notes for plot 54 described the site as an area with steep terrain dominated by dense pinyon-juniper woodland and dense, small oaks. Ponderosa pines were described as sparse and in about equivalent density with Douglas fir (*Pseudotsuga menziesii*). It was recommended that this site be excluded from subsequent monitoring efforts. Field notes for plot 55 described the site as having very steep slopes and difficult terrain. Habitat was dominated by mid-aged ponderosa pine with dense small

Gamble oaks and other shrubby undergrowth. Junipers and Douglas fir were sparse. One red squirrel midden was discovered under a Douglas fir in this stand. Field notes for plot 56 described the habitat as a recently thinned near-mature ponderosa pine stand with an understory of small Gamble oak. Junipers were very sparse and localized.

# Discussion

Abert's squirrel densities based on over-winter feeding sign observed on Carson National Forest in June 2003 were extremely low (mean of one squirrel per 200 ha [= 1 squirrel per 500 acres]). Densities in high quality, uncut forests can exceed 1 squirrel per 2.4 ha (= 1 per 5.9 acre; Brown 1984) and a local high density in excess of one squirrel per 0.8 ha (1 per 2.0 acre) has been reported (Keith 1965). More typical levels are one squirrel per every 8 to 16 hectares (ca 1 per 20 to 40 acres; Brown 1984). For example, Dodd et al. (1998) found that Abert's squirrel densities in north-central Arizona during 1996-1997 ranged from one squirrel per 1 to 20 hectares (= one per 2.5 to 49.4 acres). Thus, densities observed during June 2003 on Carson National Forest were substantially lower than typical.

Information on regional patterns in Abert's squirrel densities is available from similar monitoring studies in adjacent Southwest states. For example, a 50 to 70% decline in density of Abert's squirrel was documented in Arizona from 2001 to 2002 (Norris Dodd, personal communication). Arizona did not conduct Abert's squirrel monitoring in 2003 so direct comparisons during this year were not possible. Similarly, at seven sites in Utah Abert's squirrel densities experienced a population "crash" between 2001 and 2002 with continued lowering of densities in 2003. Densities at the Utah sites averaged 1 squirrel per 7.1 hectares (= 1 per 17.5 acres) in 2001, 1 squirrel per 25 hectares (= 1 per 61.8 acres) in 2002 and 1 squirrel per 100 hectares (= 1 per 247.1 acres) in 2003 (Norris Dodd personal communication). Thus, in 2003 Abert's squirrel densities on Carson National Forest were twice as low in comparison with similar data collected in Utah. No other known monitoring studies of Abert's squirrel occurred during 2003. The difference in density between the Utah and New Mexico studies could reflect differences in habitat sampled. However, it is also possible that the late timing of the New Mexico study could have resulted in density estimates that were lower than actual. This is because over-winter feeding sign was only counted as present if it appeared "fresh". Given that the study did not start until June, it is possible that some sign from the 2002-2003 winter was overlooked or recorded as "old". Given this possibility, density estimates presented in this report for Carson National Forest should be considered conservative estimates. It should be recognized that actual densities might be slightly higher.

One reason for the extremely low densities on Carson National Forest in 2003 was likely due to recent drought conditions. Climate in the Southwest is closely tied to the El Niño-Southern Oscillation (ENSO) phenomenon in the central tropical Pacific Ocean. Pacific warm phases (i.e., low southern oscillation index), called El Niño events, produce wet periods in the Southwest, while Pacific cold phases (high southern oscillation index), called La Niña events, produce dry periods. An extended La Niña occurred from late 1999 to 2001 (Sevilleta LTER 2003). The Palmer drought severity index for the north-central mountains region of New Mexico indicates that, in general, drought conditions have existed in the region since late 1999 (NCDC 2003). Recent analyses have suggested that 2002 was the driest year in the Southwest over the past 1,400 years (Tom Sweatnam, in lit).

Drought probably impacts Abert's squirrels primarily through reductions in the availability of ponderosa pine cones and hypogeous fungi. Both of these food resources are important in determining Abert's squirrel distribution and abundance (e.g., States et al. 1988). Dodd et al. (1998) thought that drought conditions affected availability of these food resources. The number of cones produced by a particular tree is influenced by its size, age, health, and location (Larson and Schubert 1970 cited in Brown 1984). Ponderosa pine cone crop production exhibits an annual fluctuation with good cone crops typically every 3 to 4 years in the Southwest (Schubert 1974). Overall seed production may be near zero in some years (e.g., Pearson 1950 as cited in Keith 1965, Rasmussen et al. 1975). The cycle is known to vary with climate but is not reliably periodic (Keyes 2000). In addition to drought, intensive, widespread thinning is thought to adversely impact Abert's squirrels (Dodd et al. 1998). It remains unknown to what extent habitat conditions and management actions on Carson National Forest have contributed to the low Abert's squirrel densities.

Abert's squirrel habitat relations have been fairly well studied in the Southwest. Variation in habitat characteristics is known to influence Abert's squirrel densities. This habitat variation generally relates to the structure of the ponderosa pine forest in terms of nest site selection and food production. Both criteria are likely most optimally met in uncut climax ponderosa pine forests and in managed stands with similar structure. For example, Dodd et al. (1998) found that interlocking canopies was associated with squirrel recruitment while basal area of all trees was associated with squirrel fitness. Patton (1984; Patton et al. 1985) developed a simple model to predict Abert's squirrel densities based on habitat quality of uneven-aged ponderosa pine stands. In this model, habitat quality was a positive function of increasing density and size of trees. Optimum habitats have interlocking canopies of large trees on productive sites. Such forests provide escape routes, nest sites and maximum food. For example, old, large diameter trees (over 60 to 100 years old) produce a maximum number of Ponderosa pine seeds. Poor seed production can result from logging that results in younger and typically denser trees or from fire suppression that prevents nutrient cycling. Similarly, logging can reduce canopy closure and tree basal area, which can result in a decrease in hypogeous fungi production (States and Gaud 1997). This is especially important because truffle production has been shown to be more consistent than production of other foods (States et al. 1988). Because pole sized blackjack ponderosa pine tend to be associated with truffles while mature yellow-pine ponderosa tend to be associated with the greatest cone production, States et al. (1988) suggested that habitat should consist of a combination of tree age classes, with groupings, size, and density that provide all habitat components.

Based on the observation of 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. However, the squirrel density in previous years cannot be assessed. Thus, it remains unknown the extent to which the extremely low densities are a result of climate related factors or to habitat conditions on Carson National Forest. As summarized above, many aspects of forest habitat may impact squirrel distribution and abundance. Other studies have found that Abert's squirrels are less numerous than they were at the turn of the 20th Century (Keith 1965). It has been suggested that this decline has been primarily the result of logging which has altered the structure and function of ponderosa pine forests (e.g., Keith 1965). Proper forest management can create and improve Abert's squirrel habitat (Dodd et al. 1998). Continued monitoring and additional studies of this species should resolve this problem.

# Conclusions

Abert's squirrels are particularly sensitive to habitat changes in climax ponderosa pine ecosystems. Few species are as tightly linked to forest structure and function. As such, the use of this species as a management indicator species on the Carson National Forest is well-founded. This study provides base-line estimates of Abert's squirrel densities across a broad spectrum of ponderosa pine forest stands on Carson National Forest. Squirrel densities were found to be extremely low in comparison with other regions and times. While it is likely that drought conditions are at least partially responsible for these densities, it remains unknown to what extent general habitat conditions and management actions on the forest have contributed to the low densities. Widespread, intensive thinning is thought to be especially adverse for Abert's squirrel populations. The reason for the low densities found in this study cannot be determined without continuing monitoring and perhaps initiating specific habitat-related studies. General stand data maintained by Carson National Forest were found to have no significant relationship with Abert's squirrel density. Consequently, these stand data cannot be used to predict the occurrence or abundance of squirrels in a given ponderosa pine stand. Any future study concerning the relationship between Abert's squirrel densities and habitat conditions must include habitat variables that are more specifically relevant to Abert's squirrels.

# Recommendations

1) Annual over-winter spring feeding sign monitoring of Abert's squirrel should continue long-term.

2) Annual over-winter spring feeding sign monitoring should include all or a consistent subset of plots sampled during 2003 in all subsequent monitoring strategies.

3) In order to preserve the comparability of year-to-year samples, subsequent monitoring methodology should be consistent with those used in 2003.

4) All effort should be made to initiate over-winter spring feeding sign monitoring during spring (i.e., mid-march through late May).

5) Remove plot 54 from future monitoring strategies.

6) Additional studies should be initiated that are designed to assess the impacts of specific forest management strategies on Abert's squirrel populations.

7) Additional studies should be initiated that are designed to specifically determine the relationship between habitat characteristics and Abert's squirrel densities.

8) More plots should be monitored in order to increase representation of forest conditions and increase sample size.

9) A study to monitor ponderosa pine seed, acorn, and hypogeous fungi production should be conducted in conjunction with Abert's squirrel monitoring.

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# Appendix 1

## *Monitoring Effort and Logistics*

Two field crewmembers were able to complete 31 monitoring plots in 13 days, not including travel to and from Carson National Forest. This included part of the training period, which involved a total of three field crewmembers during the first four days of fieldwork. The number of plots completed per day ranged from 1 to 4 with an average of 2.38 plots completed per day. This was similar with the 2 plots per day recommended for a 2-person crew by Norris Dodd. Few plots were generally completed on days that required breaking camp and traveling long distances to new monitoring areas. However, seven additional plots were sampled above what was required by the contract. This was possible because of the efficiency and capability of the field crew, the long hours worked by the field crew (typically at least 10 hours), and because the field crew camped near monitoring sites. Relative to red squirrel and small mammal studies, the fieldwork for Abert's squirrel monitoring was only moderately demanding. Terrain was typically not excessively rugged, heavy loads did not have to be carried, and weather was usually good. However, the fieldwork does require considerable walking, often through extremely dense oak brush.

Appendix 2. Abert's squirrel (*Sciurus aberti*) monitoring on Carson National Forest during 2003.

| Stand Location | | | | | | Abert's Squirrel Density | | | | | Carson National Forest Stand Variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site | Stand Center UTM | | | | Feeding | Squirrels | 90% Prediction | Presence | | | | Habitat | Site | Tree | Crown | Area | Plot |
| District | No. | S | Easting | Northing | Date | Sign % | per ha | Interval | Current | Past | Slope % | Aspect[1] | Structure[2] | Index[3] | Size[4] | Cover % | (acres) | elevation |
| Camino Real | 56 | 13 | 443803 | 4005957 | 5-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 0 | 15 | SO | | 0 | L | 15 | 249.3 | 2541 |
| Camino Real | 54 | 13 | 450024 | 4015811 | 6-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 0 | 25 | SE | | 0 | L | 70 | 258.6 | 2487 |
| Camino Real | 55 | 13 | 450023 | 4008901 | 6-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 0 | 34 | NW | | 0 | L | 75 | 218.1 | 2730 |
| Camino Real | 59 | 13 | 429510 | 3990661 | 6-Jun-03 | 2.734 | 0.01 | 0.01 - 0.12 | 1 | 1 | 12 | SW | 3B | 66 | L | 45 | 443.6 | 2537 |
| Canjilon | 45 | 13 | 375731 | 4029413 | 8-Jun-03 | 0 | 0 | 0 - 0.09 | 1 | 1 | 25 | NW | | 0 | V | 0 | 240.6 | 2521 |
| El Rito | 50 | 13 | 382781 | 4025312 | 7-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 35 | NE | | 0 | L | 35 | 729.6 | 2600 |
| El Rito | 52 | 13 | 383447 | 4022948 | 7-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 30 | WE | | 0 | V | 55 | 273.1 | 2516 |
| El Rito | 49 | 13 | 385470 | 4024223 | 8-Jun-03 | 0 | 0 | 0 - 0.09 | 1 | 1 | 4 | NW | | 0 | M | 0 | 283.3 | 2551 |
| El Rito | 35 | 13 | 394715 | 4047600 | 9-Jun-03 | 0 | 0 | 0 - 0.09 | 1 | 1 | 5 | EA | 4A | 0 | L | 35 | 200.0 | 2540 |
| El Rito | 38 | 13 | 395021 | 4045538 | 9-Jun-03 | 0 | 0 | 0 - 0.09 | 1 | 1 | 10 | SE | 4A | 81 | L | 15 | 197.3 | 2509 |
| El Rito | 44 | 13 | 388871 | 4032843 | 9-Jun-03 | 0.391 | 0.01 | 0.01 - 0.10 | 1 | 1 | 35 | SW | | 0 | L | 0 | 234.1 | 2665 |
| El Rito | 30 | 13 | 412398 | 4048375 | 10-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 0 | | UNEV | 58 | V | 60 | 291.1 | 2495 |
| El Rito | 31 | 13 | 412839 | 4047760 | 10-Jun-03 | 0.781 | 0.01 | 0.01 - 0.10 | 1 | 1 | 0 | | UNEV | 72 | L | 60 | 270.2 | 2520 |
| El Rito | 32 | 13 | 410934 | 4047480 | 10-Jun-03 | 0 | 0 | 0 - 0.09 | 1 | 1 | 0 | | UNEV | 0 | V | 65 | 255.8 | 2592 |
| El Rito | 39 | 13 | 411869 | 4045499 | 10-Jun-03 | 2.344 | 0.01 | 0.01 - 0.11 | 1 | 1 | 0 | | UNEV | 59 | L | 60 | 354.9 | 2555 |
| El Rito | 22 | 13 | 410358 | 4052520 | 11-Jun-03 | 0 | 0 | 0 - 0.09 | 1 | 1 | 10 | EA | UNEV | 78 | V | 0 | 375.9 | 2680 |
| El Rito | 28 | 13 | 400347 | 4049039 | 12-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 10 | SE | | 0 | L | 0 | 249.5 | 2760 |
| El Rito | 34 | 13 | 400670 | 4047797 | 12-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 10 | EA | 3A | 72 | M | 15 | 271.1 | 2737 |
| Jicarilla | J8 | 13 | 298119 | 4074916 | 3-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 0 | NE | | 0 | L | 55 | 458.0 | |
| Jicarilla | J9 | 13 | 299368 | 4073725 | 3-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 0 | SE | | 0 | L | 45 | 297.5 | 2269 |
| Jicarilla | J2 | 13 | 292816 | 4095919 | 4-Jun-03 | 0 | 0 | 0 - 0.09 | 1 | 1 | 0 | SO | | 0 | L | 30 | 284.0 | |
| Jicarilla | J3 | 13 | 294340 | 4094805 | 4-Jun-03 | 7.031 | 0.05 | 0.01 - 0.16 | 1 | 1 | 0 | NW | | 0 | L | 40 | 362.0 | 2283 |
| Questa | 7 | 13 | 487284 | 4071617 | 15-Jun-03 | 0.391 | 0.01 | 0.01 - 0.10 | 1 | 1 | 5 | SE | 3B | 74 | L | 80 | 264.4 | 2540 |
| Questa | 8 | 13 | 488926 | 4068324 | 15-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 5 | LE | 3B | 64 | L | 55 | 212.2 | 2522 |
| Tres Piedras | 25 | 13 | 411940 | 4052019 | 11-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 10 | NE | UNEV | 64 | V | 0 | 445.8 | 2538 |
| Tres Piedras | 13 | 13 | 410021 | 4059205 | 12-Jun-03 | 0 | 0 | 0 - 0.09 | 0 | 1 | 12 | NE | | 0 | L | 0 | 556.2 | 2564 |
| Tres Piedras | 14 | 13 | 409173 | 4058580 | 12-Jun-03 | 0.391 | 0.01 | 0.01 - 0.10 | 1 | 1 | 10 | EA | | 0 | L | 0 | 544.2 | 2608 |
| Tres Piedras | 3 | 13 | 399185 | 4086919 | 13-Jun-03 | 1.953 | 0.01 | 0.01 - 0.11 | 1 | 1 | 8 | NE | 1 | 54 | V | 30 | 513.8 | 2782 |
| Tres Piedras | 4 | 13 | 399474 | 4085729 | 13-Jun-03 | 0.391 | 0.01 | 0.01 - 0.10 | 1 | 1 | 6 | NE | 1 | 56 | V | 30 | 420.7 | 2797 |
| Tres Piedras | 5 | 13 | 403392 | 4081872 | 14-Jun-03 | 0.391 | 0.01 | 0.01 - 0.10 | 1 | 1 | 6 | EA | | 0 | L | 40 | 299.1 | 2738 |
| Tres Piedras | 6 | 13 | 402160 | 4080335 | 14-Jun-03 | 0.391 | 0.01 | 0.01 - 0.10 | 1 | 1 | 0 | LE | | 0 | L | 33 | 359.0 | 2729 |

[1]Aspect codes are: LE--level; NE--northeast;EA--east; SE--southeast; SO--south; SW--southwest; WE--west; NW--northwest.

[2]Habitat Structural Stage codes are: 1--seedlings; 3A--young forest with open canopy; 3B--young forest with moderately closed canopy; 4A--mid-age forest with open canopy; UNEV--uneven age forest.

[3]Site Index is a measure of the vegetative productivity of a stand. It is determined from the height of a tree at a specified index or base age. It is an indicator of the site's ability to grow timber. For example, a value of 75 indicates the site is capable of producing a 75 foot tree over the base period.

[4]Tree Size codes are: M--medium, the majority of tree stocking based on basal area is in live trees 5.0 - 8.9 inches in diameter; L--large, the majority of stocking based on basal area is in trees 9.0 inches in diameter and larger, and within that group, the majority of the basal area is in live trees 9.0 - 15.9 inches in diameter; V--very large, the majority of tree stocking based on basal area is in live trees 9.0 inches in diameter and larger, and within that group, the majority of the basal area is in live trees 16.0 inches and larger in diameter.