Abert's Squirrel (*Sciurus aberti*) Monitoring on Carson National Forest, New Mexico, 2005

A Final Contract AG-83A7-P-05-0002 Completion Report

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EXECUTIVE SUMMARY

Purpose

- The purpose of this study was to provide a third year of monitoring of Abert's squirrels on Carson National Forest and to provide additional general habitat data in order to establish long-term trends in populations and habitat.

Methods

- An index of Abert's squirrel density was sampled 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 6 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.
- In order to describe general habitat features of each plot, habitat data were collected on 10 random 32.8 x 57.4 ft (10 x 17.5 m) belt transects within each monitoring plot during 2004 and 2005. Habitat variables included: slope, aspect, canopy cover, litter depth, ground cover (of forbs, grasses, litter, bare, and other), woody understory species and cover, number, diameter and species of each tree, number and diameter of snags, and number and diameter of cut stumps.

Results

- During 2005, Abert's squirrel density ranged from 0 to 0.07 per hectare with an overall mean of 0.01 squirrels per hectare (= 1 squirrel per 247 acres).
- Abert's squirrel density in 2005 was significantly higher than in either 2003 or 2004.
- Habitat differed between 2004 and 2005. For most variables, this likely was a reflection of the small area sampled for habitat in each plot during each year. Consequently, habitat data from 2004 and 2005 were combined for subsequent analyses.
- Higher Abert's squirrel densities were associated with stands that had relatively more medium and large diameter ponderosa pine with open, herbaceous ground cover. Low Abert's squirrel densities were associated with dense oak understory and presence of piñon pine and juniper.

Discussion and Conclusions

- Abert's squirrel populations experienced dramatic regional declines in the early 2000's as a result of drought conditions, which may reduce availability of important foods (i.e., ponderosa pine cones and hypogeous fungi).
- Increased precipitation was likely responsible for the increase in Abert's squirrel distribution and density during 2005.
- Compared to other studies conducted at the same time, Abert's squirrel densities observed on Carson National Forest during 2003-2005 were low.
- Reasons for the apparent low densities of Abert's squirrel on Carson National Forest may be due to: 1) the random selection of forest stands for monitoring; 2) geographic variation in climate/weather patterns; 3) geographic variation in topographic features associated with the development of ponderosa pine forest; and 4) past forest management.
- The influence of general habitat conditions and management actions on Abert's squirrel densities on Carson National Forest remains unknown and requires additional study.

Recommendations

Continued monitoring

- Annual over-winter spring feeding sign monitoring of Abert's squirrel should continue long-term using methodology consistent with those used in 2003 - 2005.
- Annual over-winter spring feeding sign monitoring should include all or a consistent subset of plots sampled during 2003 - 2005 in all subsequent monitoring strategies.
- More plots should be monitored in order to increase representation of forest conditions and increase sample size.
- As much as feasible, maintain consistency in field crewmembers to reduce observer biases.
- Data should be collected by teams of two rather than by single individuals. This will increase safety and will help reduce sampling bias and data recording errors.
- To avoid weather related problems (i.e., snow), monitoring should be delayed (e.g., early May to Mid June) relative to the timing recommended for Arizona (i.e., mid March to late May).

Additional study

- Forest Service stand exams should be completed at each monitoring plot. Stand exams would provide detailed data about habitat conditions in terms more relevant to forestry management. Such data would allow for more detailed analyses on the influence of forest conditions on Abert's squirrel densities and would allow for an analysis of relationships between stand exam variables and data collected during habitat monitoring.

- Management history of each of the 30 stands being monitored should be determined.
- Additional studies should be initiated that are designed to assess the impacts of specific forest management strategies on Abert’s squirrel populations.
- A study to monitor ponderosa pine seed, acorn, and hypogeous fungi production should be conducted in conjunction with Abert’s squirrel monitoring.

INTRODUCTION

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 also will occur below the ponderosa pine zone in the upper edge of piñon (*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 11-13 inch (28-33 cm) DBH and include one or two large 12-14 inch (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 20-59 ft (5-18 m) 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 14 in DBH (36 cm 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, piñon 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 density variation is both temporal and spatial (Bailey 1931).

Background and Purpose

Carson National Forest designated the Abert's squirrel as a management indicator species (MIS) for ponderosa pine forest with interlocking canopies in the 1986 Carson Forest Plan. Consequently, information is needed on their distribution and abundance on the forest. A long-term monitoring study for Abert's squirrel was initiated in 2003 in order to track population changes and to assess the impacts of forest management practices on this species. During the initial year of monitoring, analyses indicated that available stand data maintained by Carson National Forest were not useful in describing stand characteristics at monitoring plot locations or for predicting Abert's squirrel occurrence and abundance. Consequently, in 2004 a protocol was developed to collect habitat data that could be rapidly and efficiently collected in conjunction with Abert's squirrel monitoring on each plot. That habitat data were intended to describe the general habitat of the plot and to provide for long-term monitoring of habitat conditions.

The purpose of this study was to provide a third year of monitoring for Abert's squirrel on the Carson National Forest and to continue collection of habitat data. More specifically, the objectives were to implement monitoring protocols, to determine occurrence and density of Abert's squirrel, to determine the relationship between Abert's squirrel density and general habitat characteristics, and to provide a third year of data for a long-term monitoring program.

Methods

Squirrel density

Over-winter feeding sign.—The technique for monitoring Abert's squirrel was developed by the Arizona Game and Fish Department (Dodd undated, Dodd et al. 1998, Norris Dodd personal communication). This monitoring technique provides an indirect population index based on sign consisting of the remains of Abert's squirrel over-winter feeding activity. This technique has been demonstrated to be a reliable, consistent, efficient, and cost-effective (Dodd 1998).

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 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 is not immediately possible. Consequently, several steps were taken to insure that field crewmembers were able to accurately identify all feeding sign types. Prior to initiating fieldwork, crewmembers were provided general instruction on the nature and identification of feeding sign and were provided with instruction and field practice using the Rasmussen et al. (1975) key. Finally, data were 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.

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 in Arizona. However, in 2004 it was recommended that monitoring on Carson National Forest be delayed until early May in order to avoid snow on the ground, which precludes this monitoring technique. Consequently, during 2005, fieldwork occurred from 2 May until 10 June.

Monitoring plots.—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. During 2003, Carson National Forest provided maps and coordinates of stand centers for a randomly selected suite of ponderosa pine stands that were at least 198 acres (80 ha) in size and within 1 mile of established roads. Specific stands for establishing monitoring plots were selected from this suite based primarily on logistical considerations. These considerations included distributing plots among the 6 Forest Districts, accessibility, and drive time among plots. 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 (1,607 ft x 1,607 ft [490 m X 490 m]) 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 230 ft (= 70 m) in length. Feeding sign was recorded within 1.0 m^2 (= 10.8 square feet) sample quadrants. Within each interval, four 1.0 m^2 (= 39 in. x 39 in.) sample quadrants were spaced 57 ft. (17.5 m) 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 monitoring plot.

The UTM coordinate of the starting point (a plot 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, a1 m^2 open-front

PVC sample quadrate frame was placed 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 obtained and recorded as encountered. Following completion of the plot, a map of the study area was drawn and notes about habitat and animals observed were recorded. In addition, other evidence of current or past occupancy of the stand by Abert's squirrel was noted. During 2003, a total of 31 monitoring plots were established (7 more than required by Carson National Forest). The sampling effort in 2004 and 2005 included a repeat of all plots monitored during 2003, with the exception of 1. Plot 54 on the Camino Real District was not repeated after 2003 because the site was predominantly piñon-juniper woodland rather than ponderosa pine forest. A new site (El Pato) in a nearby stand of ponderosa pine was monitored instead of plot 54 during 2004 and 2005.

Habitat

The collection of habitat data was based on a modification of protocols developed for describing red squirrel habitat on Carson National Forest (Frey 2003). Habitat data were collected on 10 randomly placed belt transects on each monitoring plot. Each belt transect was 32.8 x 57.4 ft (10 m x 17.5 m) and was positioned between adjacent feeding sign sample quadrates. Together, the 10 random belt transects sampled a 0.43 acre (0.17 ha) area of a monitoring plot. Slope and aspect of the surrounding terrain were visually estimated. At each end of the belt transect, a spherical densitometer was used to assess canopy cover in the 4 cardinal directions and a ruler was used to measure litter depth. The observer slowly walked the transect recording the species and DBH size class of each tree, snag, and cut stump at least 50% within the belt. All trees were placed into 7 size classes based on diameter at breast height (DBH) including: < 4 in (= 10 cm), 4-8 in (= 10-20 cm), 8-12 in (= 20-30 cm), 12-16 in (= 30-40 cm), 16-20 in (= 40-50 cm), 20-24 in (= 50-60 cm), and > 24 in (= 60 cm). The number of standing dead trees (snags) and cut stumps were counted for 2 size classes including < 8 in (= 20 cm) and > 8 in (= 20 cm) DBH. All tree, snag, and stump densities were reported as the mean number within a 1,883 ft^2 (= 175 $m^{2)}$ area. To calculate the mean density of trees per acre, use the following formula: density = mean number of trees per plot / 0.043. Percent ground cover was visually estimated on the plot. Ground cover classes included forbs, grasses, litter, bare ground, downed logs, and other. Percent cover classes were: 1 (0-5 % cover), 2 (5-25 % cover), 3 (25-50 % cover), 4 (50-75 % cover), 5 (75-95 % cover), and 6 (95-100 % cover). Using the same cover classes, understory cover of woody shrubs and saplings < 39 in (= 1 m) tall were visually estimated. Dominant understory species were recorded.

Data analysis

Squirrel density estimation.—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 relationship between the percentage of quadrates containing feeding sign and the density of the squirrel population. Density estimates and prediction intervals were calculated for each monitoring plot. To convert density of squirrels per hectare to squirrels per acre, divide the displayed density by 2.471.

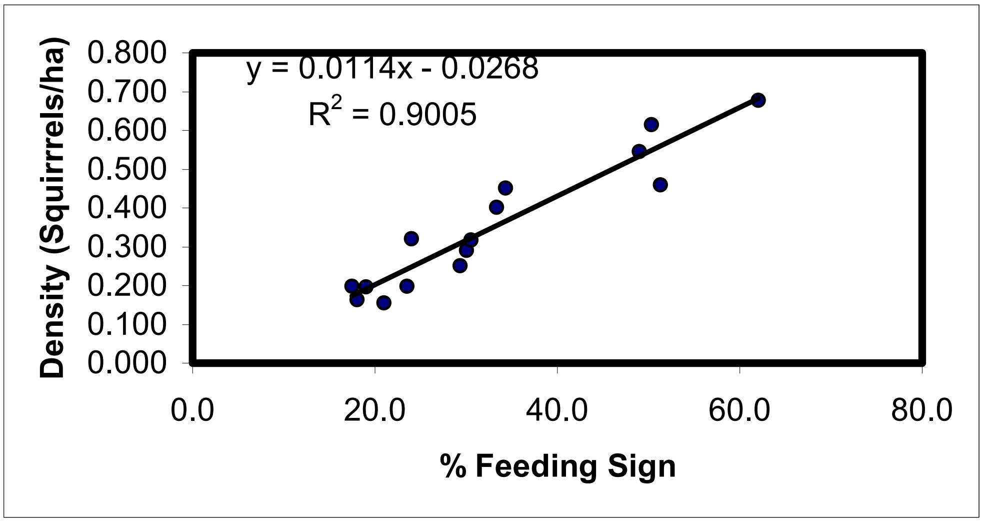

Figure 1. *Regression model between percentage feeding sign and Abert's squirrel density developed by Norris Dodd in Arizona.*

The percent feeding sign on plots and squirrel density were non-normal based on one-sample Kolmogorov-Smirnov tests. Consequently, nonparametric statistics were used where possible in analyses involving these variables. To test for annual differences in squirrel feeding sign and densities, Kruskal-Wallis tests were used for comparisons among the 3 years and Mann-Whitney tests were used for comparisons between pairs of years.

Habitat.—Habitat variables were checked for normality using a one-sample Kolmogorov-Smirnov test. All variables were non-normal ($P < 0.05$) except slope, litter depth, canopy cover, forb cover, grass cover, litter cover, bare cover, understory cover, and number of ponderosa pine in the 4-8, 8-12, 12-16, and 20-24 inch DBH classes. Consequently, nonparametric tests were used for non-normal variables where possible.

Differences in each habitat variable between 2004 and 2005 were tested using independent samples t tests for normal variables and Mann-Whitney tests for non-normal variables. To test for multivariate differences in habitat between 2004 and 2005, a principal components analysis was used to reduce the number of original variables into gradient component variables. The component variables were then subjected to discriminant function analysis. A chi-square transformation of the Wilks' lambda obtained from the discriminant analysis was used to determine significance of any differences between the years.

Spearman correlations were used to assess univariate relationships between Abert's squirrel density estimates and habitat variables. Spearman and Pearson correlations were used to assess univariate relationships among all pair-wise comparisons of habitat variables.

Principal components analysis was used to describe habitat of the monitoring plots in relation to one another. The number of variables was reduced *a priori* in part by reviewing all pair-wise correlations among habitat variables. New variable were created for each tree species by summing size categories of each species or group of ecologically similar species: small diameter (1-8 inch DBH) ponderosa pine, medium diameter (8-20 inch DBH) ponderosa pine, large diameter (> 20 inch DBH) ponderosa pine, total oaks, total piñons and junipers, total Douglas fir and white fir, and total aspen. Small and large stumps were summed into total stumps. Other variables in the principal components analysis included litter depth, forb ground cover, grass ground cover, bare ground, small diameter snags, and large diameter snags. Snag size classes were not summed into a single variable because there was a low correlation between the two (r_s = 0.300, P = 0.107). The final ratio of the number of plots to the number of variables (2.1:1) in the principal components analysis was deemed suitable for descriptive purposes (McGarigal et al. 2000). Only components that had eigenvalues > 1.0 were extracted because these usually sufficiently describe the variance in the variables. Loadings with a minimum absolute value of 0.40 were used to describe patterns (McGarigal et al. 2000). Components retained for interpretation were based on the scree plot criterion, wherein a dramatic break in the curve of a plot between the component number and eigenvalue serves to identify those components for retention. (McGarigal et al. 2000, McCune and Grace 2002).

Stepwise multiple regression (probability of F to enter = 0.05 and F to remove = 0.10) was used to produce models to predict Abert's squirrel density based on habitat variables.

Stands were classified as Abert's squirrel present or absent. To test whether habitat variables differed in stands where squirrels were present versus stands where squirrels were absent, independent samples t tests were used for normal variables and Mann-Whitney tests were used for non-normal variables. A stepwise discriminant function analysis (probability of F to enter = 0.05 and F to remove = 0.10) was used to determine the best variable for predicting presence or absence of Abert's squirrel.

All descriptions, data, analyses, results, and recommendations presented in this report supersede those presented in earlier reports.

RESULTS

Squirrel density

Squirrel distribution and abundance in 2005.—A total of 31 monitoring plots (7 more than required) was sampled across the 6 Forest Districts (Appendix 1). Fresh Abert's squirrel feeding sign was found in at least 1of the 256 1-m^2 sampling quadrants on 22 (71.0 %) of the 31 monitoring plots. However, 1 additional plot had probable sign of current Abert's squirrel occurrence (hypogeous fungal dig; but possibly resulting from chipmunks). Thus, a total of 23 (74.2 %) of the monitoring plots had evidence of Abert's squirrel use. The percent of the 256 quadrants on a plot that had feeding sign ranged from 0 to 8.20 % with a mean of 1.26 % (SD = 1.798). Abert's squirrel density on each plot ranged from 0 to 0.07 per hectare (= 0 - 0.173 per acre). However, 9 (29%) of the 31 plots had a density of 0 (Appendix 1). The 90 % prediction intervals of the density estimates overlapped among all the plots, indicating that squirrel densities were not significantly different among plots (see Appendix 1). The average observed density across all plots in 2005 was 0.01 squirrels per hectare (= 0.025 per acre; ca 1 squirrel per 247 acres [=1 squirrel per 100 ha]).

Annual variation in squirrel distribution and abundance.—In comparing the 30 sites that were repeated during 2003, 2004, and 2005, the plot occupancy of Abert's squirrel was 60.0 % in 2003, dropping to 50.0% in 2004, and rebounding to the highest rate of 73.3% in 2005 (Table 1). The trend in percentage feeding sign and squirrel density were significantly different ($P < 0.05$) among the 3 years and followed the same trend as for plot occupancy (Table 1, Figure 2). These differences were due to the significant increase in feeding sign and densities during 2005 as compared to both 2003 and 2004. There was no significant difference in feeding sign or density between 2003 and 2004 (Z = -0.331, P = 0.741; Z = -0.654, P = 0.513). However, there was a significant difference in feeding sign and squirrel density observed between 2004 and 2005 (Z = -2.645, P = 0.008; Z = -2.016, P = 0.044) and between 2003 and 2005 (Z = -2.367, P = 0.018; Z = -2.510, P = 0.012). The density of Abert's squirrel on Carson National Forest in 2005 was approximately twice as high as during the previous two years.

***Table 1.** Comparison of the percent of plots occupied by Abert's squirrels, the percent of quadrates per plot with feeding sign, and the density of Abert's squirrel on 30 plots monitored in 2003, 2004, and 2005 on Carson National Forest. Kruskal-Wallis test results are presented for differences in feeding sign and density among the 3 years.*

		2003	2004	2005	X^2	*P*
Percent of plots occupied		60.0	50.0	73.3	-	-
Feeding sign percentage						
	mean	0.573	0.390	1.237	8.704	0.013
	SD	0.258	0.102	0.330		
	range	0 - 7.03	0 - 1.95	0 - 8.20		
Density (squirrels/ha)						
	mean	0.005	0.005	0.010	7.237	0.027
	SD	0.002	0.001	0.002		
	range	0 - 0.05	0 - 0.01	0 - 0.07		

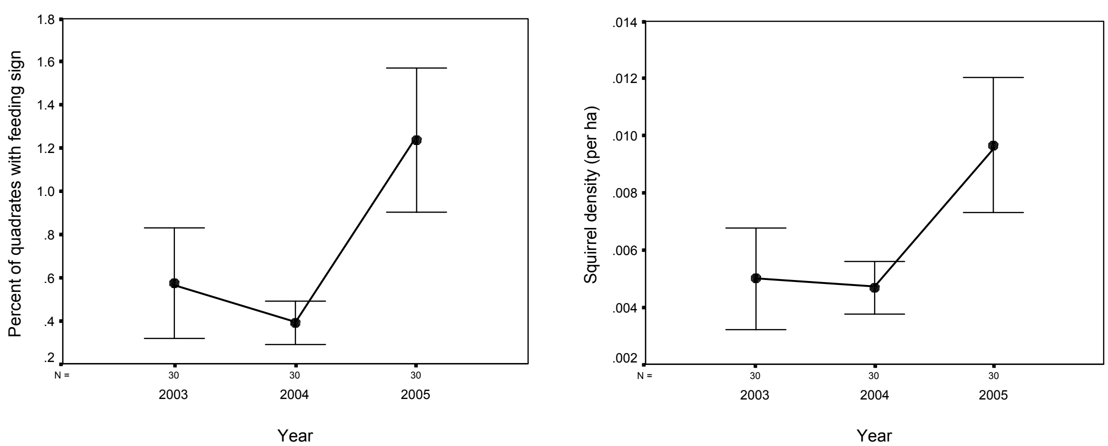

***Figure 2.** Percent feeding sign (left) and density (right) of Abert's squirrels on 30 repeated monitoring plots during 2003 - 2005. Dots represent means and error bars represent 1 standard error around the mean.*

Habitat

Annual differences.—Based on univariate test comparisons, 21 of 46 habitat variables (45.6%) exhibited significant ($P < 0.05$) differences between 2004 and 2005. The principal components analysis resulted in the extraction of 4 components that together accounted for 80.0 % of the variation. The Wilks' lambda obtained from a discriminant function analysis of the 4 component variables indicated that there was a significant difference in habitat between 2004 and 2005 (λ 0.856, $X^2 = 95.776$, $df = 4$, $P = 0.000$). The primary reason for habitat differences between the two years is likely due to the relatively small area of the plot sampled for habitat each year. During each year, only 0.73 % of the area of each plot was sampled for habitat. Consequently, for all subsequent analyses habitat data from 2004 and 2005 were combined.

Univariate relationships with squirrel density.—Mean Abert's squirrel density exhibited a significant positive correlation with 12-16 inch DBH ponderosa pine ($r_s = 0.588$; $P = 0.001$; Figure 3a), 16-20 inch DBH ponderosa pine ($r_s = 0.478$; $P = 0.007$), and 20-24 inch DBH ponderosa pine ($r_s = 0.486$; $P = 0.006$). In contrast, Abert's squirrel density exhibited a significant negative correlation with understory cover ($r_s = -0.490$; $P = 0.006$; Figure 3b), 4-8 inch DBH oak ($r_s = -0.383$; $P = 0.037$), 4-8 inch DBH piñon pine ($r_s = -0.362$; $P = 0.050$), and 4-8 inch DBH juniper ($r_s = -0.454$; $P = 0.012$).

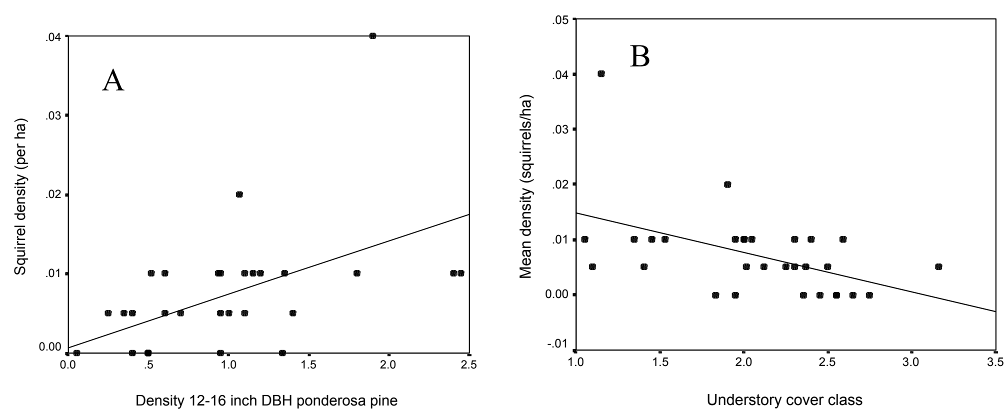

Figure 3. *Significant ($P \leq 0.01$) correlations between mean Abert's squirrel density with A) 12-16 inch DBH ponderosa pine and B) understory cover.*

Principal components analysis.—The principal components analysis resulted in the extraction of 6 components, which together accounted for 75.8 % of the variance. The scree plot criterion indicated that the first 2 components should be retained for interpretation. These components accounted for 39.5 % of the variance in habitat.

On component 1, variables with high positive loadings (listed from highest to lowest) included: medium diameter (8-20 inch DBH) ponderosa pine, total stumps, small diameter (< 8 inch DBH) ponderosa pine, and total firs. Variables with high negative loadings on component 1 (listed from highest absolute value to lowest) included: bare ground, total piñons and junipers, and small snags. Thus, component 1 represents a climate gradient of plots with cool, mesic conditions that support ponderosa pine and firs, and which also show evidence of historical thinning or logging, to plots with warm, arid conditions that support piñons and junipers and that have large numbers of small diameter snags such as occurs after a fire burns through a dense thicket of young ponderosa pine. Plots with the highest squirrel densities had positive scores on component 1 (Figure 3).

On component 2, variables with high positive loadings (listed from highest to lowest) included: litter depth, total piñons and junipers, total oaks. Variables with high negative loadings on component 1 (listed from highest absolute value to lowest) included: forb ground cover, grass ground cover, and large diameter (> 20 inches) ponderosa pine. This component represents a ground cover gradient of plots with much herbaceous ground cover and large ponderosa pines to plots with deep litter and many piñons, junipers, and oaks. Most of the plots with 0 squirrel density had positive scores on component 2 (Figure 3).

The graph of the 30 monitoring plots on components 1 and 2 revealed that monitoring plots with the highest squirrel densities tended to be clustered in the bottom right of the graph (circled area on Figure 3). Based on axis gradients, these plots tended to be mature ponderosa pine forests with herbaceous ground cover located in relatively cool, moist environments that also supported the growth of Douglas fir and white fir.

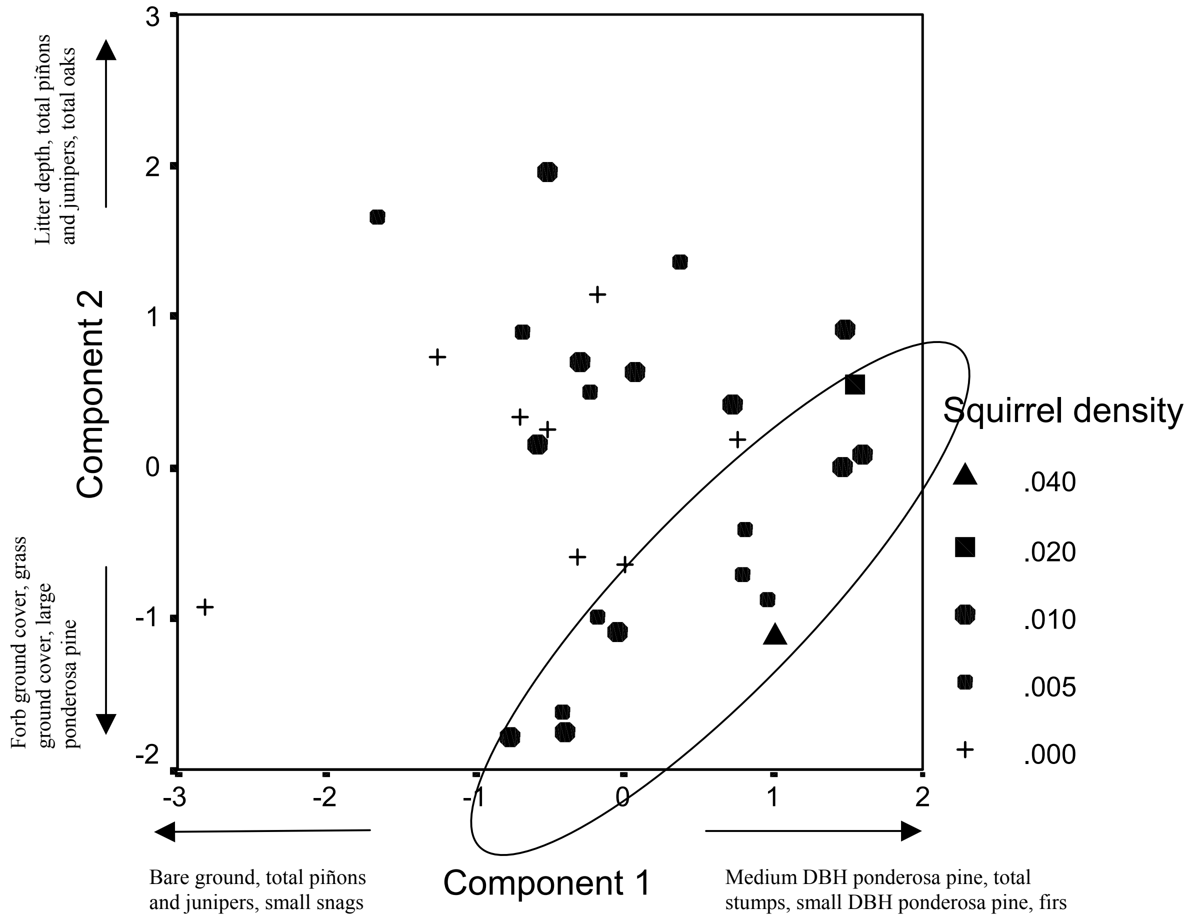

Figure 3. *Scatter plot of habitat characteristics on principal components 1 and 2 for 30 Abert's squirrel monitoring plots sampled during 2004 and 2005 on Carson National Forest. Variables contributing to each axis gradient are indicated besides the arrows.*

***Regression models for predicting squirrel density.*—**The stepwise multiple regression produced 9 highly significant models ($P \leq 0.004$; Table 2). The simplest model contained a single predictor of Abert's squirrel density, which was the density of 20-24 inch DBH ponderosa pine (Table 2, model #1). However, this model had a low $r^{2,}$ indicating that only a small proportion of the variation in density is accounted for by the model (i.e., the model does not fit the data well). Other models with higher r^2 values contained 2 to 6 predictor variables. The model with the highest r^2 value (model #8) also had the greatest number of predictor variables (6). A large number of variables can cause a model to be over fit and more difficult to interpret and use.

Four models (models #3, #5, #6, #7) were regarded as the best for predicting Abert's squirrel density based on their high r^2 values, significance of all coefficients, and low number of variables. Models #3 and #4 both had 3 predictor variables, including understory cover as the most important predictor variable as well as density of 4-8 inch DBH ponderosa pine. However, they differed in that model #3 included density of 20-24 inch DBH ponderosa pine, while model #4 included canopy cover. Canopy cover exhibited a high ($r > 0.7$), significant ($P \leq 0.001$) positive correlation with 16-20 inch DBH ponderosa pine, as well as with litter depth and litter ground cover. Thus, both models with 3 predictor variables include some measure of the density of moderate to large diameter ponderosa pine. Further, these and all other models included understory cover as an important negative coefficient (i.e., increasing understory cover predicts lower squirrel density). Based on high ($r > 0.6$), significant ($P \leq 0.003$) positive correlations, understory cover was primarily associated with small diameter (i.e., 0-8 inch DBH) oak and juniper trees. Models #6 and #7 were similar to model #5 except that model #6 added density of 8-12 inch DBH ponderosa pine, while model #6 added density of 8-12 and 20-24 inch DBH ponderosa pine.

Table 2. Statistics for significant (P ≤ 0.004) regression models produced through stepwise selection of all habitat variables against Abert's squirrel density on Carson National Forest in 2004 and 2005. Non-significant coefficients (*P* > 0.05) are indicated with an asterisk.

Model	*r*	r^2	ANOVA F	Variable	Coefficient	SE
1	0.512	0.262	9.954	Constant	0.0012*	0.002
				PP 20-24	0.0153	0.005
2	0.657	0.431	10.238	Constant	0.0147	0.005
				PP 20-24	0.0135	0.004
				Understory	-0.0068	0.002
3	0.735	0.541	10.206	Constant	0.0117	0.005
				PP 20-24	0.0110	0.004
				Understory	-0.0069	0.002
				PP 4-8	0.0054	0.002
4	0.795	0.632	10.755	Constant	0.0091*	0.005
				PP 20-24	0.0069*	0.004
				Understory	-0.0088	0.002
				PP 4-8	0.0065	0.002
				Canopy cover	0.0002	0.000
5	0.769	0.592	12.559	Constant	0.0109	0.005
				Understory	-0.0097	0.002
				PP 4-8	0.0075	0.002
				Canopy cover	0.0003	0.000
6	0.829	0.688	13.771	Constant	0.0133	0.004
				Understory	-0.0109	0.002
				PP 4-8	0.0117	0.002
				Canopy cover	0.0003	0.000
				PP 8-12	-0.0051	0.002
7	0.860	0.739	13.617	Constant	0.0115	0.004
				PP 20-24	0.0077	0.004
				Understory	-0.0099	0.002
				PP 4-8	0.0108	0.002
				Canopy cover	0.0003	0.000
				PP 8-12	-0.0054	0.002
8	0.883	0.780	13.626	Constant	0.0081*	0.004
				PP 20-24	0.0091	0.003
				Understory	-0.0076	0.002
				PP 4-8	0.0105	0.002
				Canopy cover	0.0001*	0.000
				PP 8-12	-0.0062	0.002
				PP 12-16	0.0041	0.002
9	0.875	0.766	15.753	Constant	0.0074*	0.004
				PP 20-24	0.0107	0.003
				Understory	-0.0062	0.002
				PP 4-8	0.0098	0.002
				PP 8-12	-0.0063	0.002
				PP 12-16	0.0058	0.001

[1]PP = ponderosa pine; numbers are diameter at breast height (inches) size classes.

Squirrel presence or absence.—Plots where Abert's squirrel were present or absent in 2004 and 2005 differed significantly (*P* < 0.05) in several habitat features. Plots where squirrels were absent had significantly more bare ground, understory cover, piñon pine and juniper. In contrast, plots where squirrels were present had significantly more grass ground cover, 12-24 inch DBH ponderosa pine, and > 8 inch diameter cut stumps (Figure 4). In a stepwise discriminant function, 4-8 inch DBH piñon was identified as the single best predictor of Abert's squirrel presence or absence (Figure 5).

Table 3. *Means (top) and standard errors (bottom) of habitat variables that are significantly different (P < 0.10) between plots where Abert's squirrel were absent or present during 2004 and 2005 on Carson National Forest.*

	Squirrels absent	**Squirrels present**	**statistic**	***P***
Grass ground cover	2.356	2.945	*t* = -2.063	0.048
	0.210	0.154		
Bare ground cover	2.088	1.712	*t* = 1.814	0.080
	0.252	0.087		
Understory cover	2.385	1.952	*t* = 2.107	0.044
	0.117	0.116		
12-16 inch DBH ponderosa pine	0.592	1.099	*t* = -2.202	0.036
	0.136	0.129		
16-20 inch DBH ponderosa pine	0.340	0.662	*z* = -1.855	0.063
	0.087	0.102		
20-24 inch DBH ponderosa pine	0.233	0.445	*t* = -2.056	0.049
	0.092	0.052		
4-8 inch DBH piñon pine	0.238	0.057	*z* = -2.313	0.035
	0.099	0.024		
4-8 inch DBH juniper	0.344	0.136	*z* = -2.385	0.018
	0.105	0.045		
> 8 inch diameter cut stump	0.544	1.461	*z* = -1.858	0.063
	0.357	0.380		

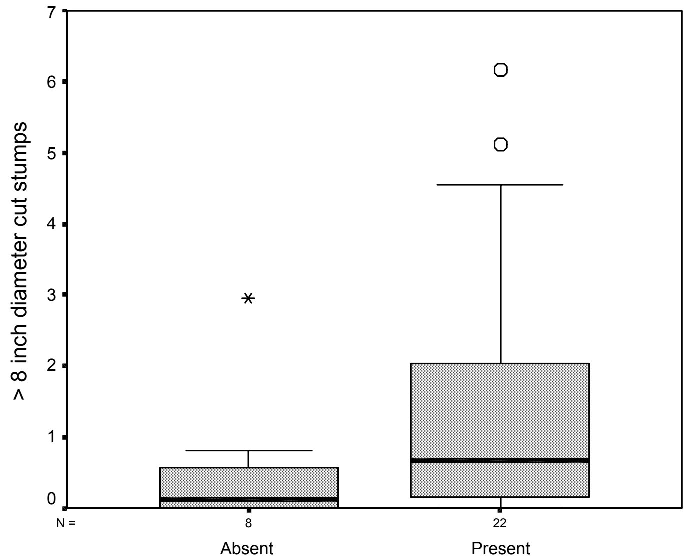

Figure 4. *Mean density of > 8 inch diameter cut stumps on plots where Abert's squirrel were absent or present during 2004 and 2005 on Carson National Forest. Black bars represent medians, boxes represent quartiles, circles represent outliers, and asterisks represent extremes.*

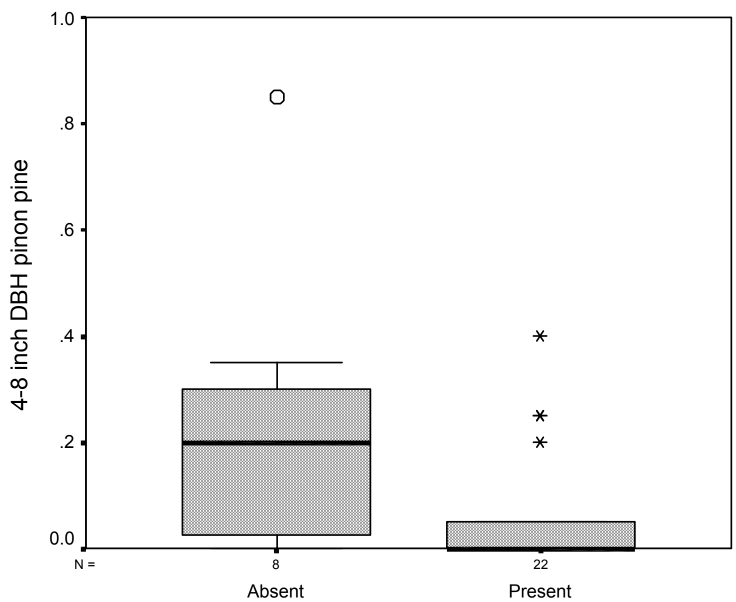

Figure 5. *Mean density of 4-8 inch DBH piñon pine on plots where Abert's squirrel were absent or present during 2004 and 2005 on Carson National Forest. Black bars represent medians, boxes represent quartiles, circles represent outliers, and asterisks represent extremes.*

DISCUSSION

Comparisons with other studies

Although mean Abert's squirrel density on Carson National Forest in 2005 (ca 0.01 squirrel per 1 ha; 1 squirrel per 100 ha; 1 per 247 acre) was double that during the two preceding years, mean density remained low in relation to other studies (Table 4). Maximum Abert's squirrel densities in high quality, uncut forests can exceed 1 squirrel per 2.4 ha (= 41.7 squirrels per 100 ha; 1 squirrel per 5.9 acre; Brown 1984) and a local high density in excess of 1 squirrel per 0.8 ha (=125 squirrels per 100 ha; 1 squirrel per 2.0 acre) has been reported (Keith 1965). However, more typical levels are 1 squirrel per 20 to 40 ha (= 2.5 to 5.0 per 100 ha; 1 squirrel per 8 to 16 acres; Brown 1984). For example, Dodd et al. (1998) found that Abert's squirrel densities in north-central Arizona during 1996-1997 ranged from 1 squirrel per 1 - 20 ha (= 5 to 100 squirrels per 100 ha; 1 squirrel per 2.5 - 49.4 acres). Thus, densities observed during 2003 to 2005 on Carson National Forest were substantially lower than those in Arizona during the 1990's.

However, data collected by similar methods in adjacent states during recent years suggest that Abert's squirrel densities have been low regionally. 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). Similarly, at 7 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 0.14 squirrels/ha in 2001, 0.04 squirrels/ha in 2002, and 0.01 squirrels/ha in 2003 (Norris Dodd personal communication). Thus, Abert's squirrel density on Carson National Forest during 2005 was similar to that during 2003 in Utah (Table 4).

At least 2 other Abert's squirrel monitoring studies occurred during 2004. One was an ongoing study to evaluate the effects of ponderosa pine restoration in northern Arizona (Mount Trumbull area). In 2004 squirrel densities in that study ranged from 0.01 – 0.30 squirrels/ha with a mean of 0.12 squirrels/ha on 5 control plots (Wightman et al 2004). However, densities on treated plots (ca 0.01 squirrels/ha), which had been thinned, burned, and reseeded, were similar to those on Carson National Forest during 2005 (Wightman and Yarborough 2004). Thus, Wightman and Yarborough (2004) concluded that Abert's squirrel density had declined more steeply on treated forest. In San Juan National Forest in southern Colorado, Abert's squirrel density averaged 0.04 squirrels/ha (range 0 - 0.16 squirrel/ha) in 2003, but declined to a mean of 0.01/ha (range 0 - 0.11) in 2004 (Randy Ghormley personal communication). Thus, mean squirrel density on San Juan National Forest during 2004 was similar to that found on Carson National Forest in 2005.

Comparative data from 2005 are available for a study on the Apache-Sitgreaves National Forest in east-central Arizona. This study involved 6 control plots, 6 restoration plots that had been treated to represent pre-settlement conditions, and 13 goshawk plots that had been treated to meet guidelines for goshawk habitat management (Raymound Rugg personal communication). Squirrel density averaged 0.09/ha (range 0.01 – 0.019) in the control plots, 0.15 (range 0.01 – 0.32) in the pre-settlement treatment, and 0.11 (range 0.00 – 0.36) in the goshawk treatment. Overall, Abert's squirrel densities on Apache-Sitgreaves National Forest were about 10 times higher than on Carson National Forest during 2005.

Table 4. *Comparison of Abert's squirrel densities across studies. Moisture is reported as the representative Palmer drought severity index.*

Location	Conditions	Moisture	Year	Density (squirrels/100 ha)	Method	Reference
Coconino NF, northern Arizona	"heavily cutover"	moist (+6)	1941	4.8	trapping	Keith 1965
Coconino NF, northern Arizona	virgin stand	moist (+6)	1941	20.2	trapping	Keith 1965
Coconino NF, northern Arizona	"heavily cutover"	drought (-2)	1954	0.6	trapping	Keith 1965
Coconino NF, northern Arizona	virgin stand	drought (-2)	1954	2.0	trapping	Keith 1965
Black Forest, east-central Colorado	unknown	moist (+3)	1970	4.9	unknown	Ramey 1973
Boulder County, north-central Colorado	medium stocked, all-age stand	moist (+5)	1970	33.3	mark-recapture	Farentinos 1972
Black Forest, east-central Colorado	unknown	normal (0)	1971	2.0	unknown	Ramey 1973
Boulder County, north-central Colorado	medium stocked, all-age stand	moist (+4)	1971	30.6	mark-recapture	Farentinos 1972
southeast Utah	unknown	drought (-2)	2001	14.0	feeding sign	N. Dodd pers. comm.
southeast Utah	unknown	drought (-6)	2002	4.0	feeding sign	N. Dodd pers. comm.
Carson NF, northern New Mexico	**random stands**	**drought (-5)**	**2003**	**0.5**	**feeding sign**	**current study**
southeast Utah	unknown	drought (-4)	2003	1.0	feeding sign	N. Dodd pers. comm.
San Juan NF, southwest Colorado	unknown	drought (-5)	2003	4.0	feeding sign	R. Ghormley pers. comm.
Carson NF, northern New Mexico	**random stands**	**drought (-3) to moist (+1)**	**2004**	**0.5**	**feeding sign**	**current study**
San Juan NF, southwest Colorado	unknown	drought (-4)	2004	1.0	feeding sign	R. Ghormley pers. comm.
Mt Trumbull, northern Arizona	thinned, burned, reseeded	drought (-3)	2004	1.0	feeding sign	Wightman et al 2004
Mt Trumbull, northern Arizona	control stands	drought (-3)	2004	12.0	feeding sign	Wightman et al 2004
Carson NF, northern New Mexico	**random stands**	**moist (+4)**	**2005**	**1.0**	**feeding sign**	**current study**
Apache-Sitgreaves NF east-central Arizona	control stands	moist (+5)	2005	9.0	feeding sign	R. Rugg pers. comm.
Apache-Sitgreaves NF east-central Arizona	goshawk treatment	moist (+5)	2005	11.0	feeding sign	R. Rugg pers. comm.
Apache-Sitgreaves NF east-central Arizona	pre-settlement treatment	moist (+5)	2005	15.0	feeding sign	R. Rugg pers. comm.

Regionally low squirrel densities

In comparing Abert's squirrel monitoring results on Carson National Forest with other recent studies conducted in adjacent states, two patterns are apparent (Table 4). First, it appears that the entire region experienced declines in Abert's squirrel densities from 2001 to 2004. These regional declines are probably attributable to 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. Palmer Drought Indices from the NOAA National Climate Data Center (available at http://lwf.ncdc.noaa.gov/oa/climate/research/drought/palmer-maps/ and at http://lwf.ncdc.noaa.gov/oa/climate/onlineprod/drought/main.html) were reviewed to assess climate patterns (Table 5, Figure 6). In north-central New Mexico, drought conditions began in 2000 and extended into the beginning of 2004, with the most widespread and severe drought conditions in 2002 and 2003 (Table 5, Figure 6). In contrast with previous years, moisture was high during 2005 (Table 5, Figure 6). Thus, the increased density of Abert's squirrel on Carson National Forest in 2005 probably was due to increased moisture.

Table 5. *Palmer drought severity indices for May periods between 1999-2005. Indices are provided for the southwest region within the range of Abert's squirrel as well as the north-central New Mexico region, which includes most of Carson National Forest.*

Year	Southwest Region	Carson NF
1999	moderate drought to extremely moist	moderately moist
2000	extreme drought to moderately moist	moderate drought
2001	extreme drought to very moist	mid-range
2002	severe drought to extreme drought	extreme drought
2003	extreme drought to mid-range	severe drought
2004	extreme drought to moderately moist	moderate drought
2005	moderate drought to extremely moist	very moist

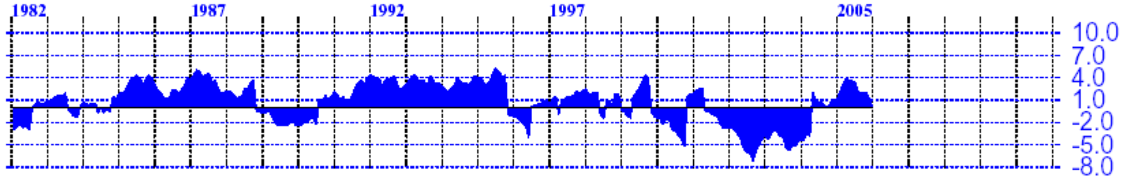

Figure 6. *Monthly Palmer Drought Severity Index for New Mexico region 2, which includes Carson National Forest. An index of 0 = normal precipitation, -2 = moderate drought, -3 = severe drought, and –4 extreme drought. Data are from the National Climate Date Center.*

Drought probably impacts Abert's squirrels primarily through reductions in 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 0 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).

Locally low squirrel densities

Although some studies have reported low Abert's squirrel densities within the range observed for Carson National Forest, densities of Abert's squirrel on Carson National Forest generally were much lower than in other studies conducted at the same time in adjacent states (Table 4). There may be several reasons for this pattern. First, this study used 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 this study were located at the lower, more arid edge of the ponderosa pine forest zone where it intergrades with piñon-juniper woodland. Habitat results indicated that the density of both piñon pine and juniper were associated with lower densities of Abert's squirrels. 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 be random (e.g., Keith 1965). 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.

A second potential reason is that climate conditions vary both temporally and spatially. Thus, during a period of time when Carson National Forest is experiencing drought, other areas within the range of Abert's squirrel may be experiencing periods of high moisture (Table 4). Thus, squirrel populations in different geographic regions may be influenced by different local climate and weather patterns.

A third potential reason for the relatively low densities of Abert's squirrel on Carson National Forest 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 (= 2,300 - 2,650 m; Brown 1994). 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 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 squirrel populations in relatively close proximity to the arid piñon-juniper woodland zone, which they avoid (see habitat results), 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.

A fourth potential reason why Abert's squirrel densities on Carson National Forest were lower than observed in other studies 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). Abert's squirrel habitat relations have been fairly well studied in the Southwest. Based on previous studies, variation in habitat characteristics is known to influence Abert's squirrel densities. This habitat variation generally relates to the structure of ponderosa pine forest in terms of nest site selection and food production. Both criteria likely are 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. A similar relationship was found in this study: higher Abert's squirrel densities were associated with higher densities of medium and large diameter ponderosa pine.

Optimum Abert's squirrel habitats have interlocking canopies of large trees on productive sites. Such forests provide escape routes, nest sites and maximum food. For example, during this study there was a significant negative relationship between understory density (especially Gambel's oak) and squirrel density. Dense understory may influence escape behavior. Further, 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.

It has been suggested that widespread thinning and logging, which has altered the structure and function of ponderosa pine forests, have adversely impact Abert's squirrels (Dodd et al. 1998; Keith 1965). However, it also has been shown that proper forest management can create and improve Abert's squirrel habitat (Dodd et al. 1998). Results of this study indicated that higher numbers of cut stumps were associated with positive scores on principal component 1, which was associated with higher densities of Abert's squirrel (Figure 3). Further, there were significantly more large-diameter cut stumps in monitoring plots where Abert's squirrels were present (Figure 4). These data suggest that past tree cutting has been beneficial to Abert's squirrel on Carson National Forest. Further, dense oak understory, which may be a response to past management actions, was associated with low squirrel densities (Figure 3, Table 3). However, the management history of each stand is unknown and other factors might also be responsible for these patterns. For example, the species of each stump was not determined and it is not known why, or when, trees on each plot were cut (stump age was not measured). More information is need on the history of each stand before conclusions can be drawn. Consequently, it remains unknown the extent to which the low densities of Abert's squirrels on Carson National Forest are a result of sampling biases, climate variation, topographic variation, or past management. 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 provided a third year of monitoring for Abert's squirrel densities across a broad spectrum of ponderosa pine forest stands on Carson National Forest. Although Abert's squirrel density significantly increased during 2005, densities continued to be low in comparison with other studies in adjacent states conducted at the same time. While it is likely that drought conditions during the early 2000's were at least partially responsible for the low densities, it remains unknown to what extent other physical or management actions have contributed to the low densities. Higher Abert's squirrel densities were associated with ponderosa pine forests that had relatively more medium and large diameter trees and with open, herbaceous understories. Dense oak understory and presence of piñon pines and junipers were associated with lower densities of squirrels. Additional studies are needed to better understand the relationships between habitat, management, and Abert's squirrel biology.

RECOMMENDATIONS

Continued monitoring

- Annual over-winter spring feeding sign monitoring of Abert's squirrel should continue long-term using methodology consistent with those used in 2003 - 2005.
- Annual over-winter spring feeding sign monitoring should include all or a consistent subset of plots sampled during 2003 - 2005 in all subsequent monitoring strategies.
- More plots should be monitored in order to increase representation of forest conditions and increase sample size.
- As much as feasible, maintain consistency in field crewmembers to reduce observer biases.
- Data should be collected by teams of two rather than by single individuals. This will increase safety and will help reduce sampling bias and data recording errors.
- To avoid weather related problems (i.e., snow), monitoring should be delayed (e.g., early May to Mid June) relative to the timing recommended for Arizona (i.e., mid March to late May).

Additional study

- Forest Service stand exams should be completed at each monitoring plot. Stand exams would provide detailed data about habitat conditions in terms more relevant to forestry management. Such data would allow for more detailed analyses on the influence of forest conditions on Abert's squirrel densities and would allow for an analysis of relationships between stand exam variables and data collected during habitat monitoring.
- Management history of each of the 30 stands being monitored should be determined.
- Additional studies should be initiated that are designed to assess the impacts of specific forest management strategies on Abert's squirrel populations.
- 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 I

Appendix I. Density Abert's squirrel on 30 monitoring plots located on Carson National Forest, 2003-2005.

		NE Plot Corner					2003		2004		2005	
District	Stand No.	Zone	Easting	Northing	Elevation	Bearing	Density	90% Prediction Interval	Density	90% Prediction Interval	Density	90% Prediction Interval
Camino Real	El Pato	13S	426085	3993090	2406	135	-	-	0.01	0.01 - 0.12	0.01	0.01 - 0.11
Jicarilla	J 02	13S	293567	4096396	2202	180	0	0 - 0.09	0	0 - 0.09	0	0 - 0.09
Jicarilla	J 03	13S	294861	4095390	2262	180	0.05	0.01 - 0.16	0	0 - 0.09	0.01	0.01 - 0.10
Jicarilla	J 08	13S	298768	4075406	2349		0	0 - 0.09	0	0 - 0.09	0	0 - 0.09
Jicarilla	J 09	13S	299723	4074182	2267	146	0	0 - 0.09	0	0 - 0.09	0	0 - 0.09
Tres Piedres	SA 03	13S	399461	4086654	2784	230	0.01	0.01 - 0.11	0.01	0.01 - 0.10	0.01	0.01 - 0.10
Tres Piedres	SA 04	13S	399821	4085576	2740	90	0.01	0.01 - 0.10	0	0 - 0.09	0.01	0.01 - 0.10
Tres Piedres	SA 05	13S	403381	4081874	2742	220	0.01	0.01 - 0.10	0.01	0.01 - 0.10	0	0 - 0.09
Tres Piedres	SA 06	13S	402310	4080712	2715	300	0.01	0.01 - 0.10	0.01	0.01 - 0.10	0.01	0.01 - 0.10
Questa	SA 07	13S	487984	4071439	2543	270	0.01	0.01 - 0.10	0.01	0.01 - 0.10	0.07	0.01 - 0.17
Questa	SA 08	13S	489449	40681978	2546	340	0	0 - 0.09	0.01	0.01 - 0.10	0.01	0.01 - 0.12
Tres Piedres	SA 13	13S	411183	4059645	2552	140	0	0 - 0.09	0	0 - 0.09	0	0 - 0.09
Tres Piedras	SA 14	13S	410299	4058840	2584	170	0.01	0.01 - 0.10	0.01	0.01 - 0.10	0.01	0.01 - 0.10
Tres Piedres	SA 22	13S	409501	4052593	2677	160	0	0 - 0.09	0	0 - 0.09	0.01	0.01 - 0.10
Tres Piedres	SA 25	13S	412264	4052271	2531	290	0	0 - 0.09	0	0 - 0.09	0	0 - 0.09
El Rito	SA 28	13S	400532	4049072	2731	310	0	0 - 0.09	0	0 - 0.09	0.01	0.01 - 0.10
Tres Piedres	SA 30	13S	412727	4048948	2669	220	0	0 - 0.09	0	0 - 0.09	0.01	0.01 - 0.10
Tres Piedres	SA 31	13S	41253	4047992	2510	140	0.01	0.01 - 0.10	0	0 - 0.09	0.01	0.01 - 0.10
Tres Piedres	SA 32	13S	410958	4046777	2566	225	0	0 - 0.09	0.01	0.01 - 0.10	0.01	0.01 - 0.10
El Rito	SA 34	13S	400598	4048165	2730	160	0	0 - 0.09	0	0 - 0.09	0.01	0.01 - 0.10
El Rito	SA 35	13S	395335	4047575	2445	260	0	0 - 0.09	0.01	0.01 - 0.11	0.03	0.01 - 0.14
El Rito	SA 38	13S	395023	4045895	2471	280	0	0 - 0.09	0.01	0.01 - 0.10	0.01	0.01 - 0.13
Tres Piedres	SA 39	13S	410702	4045455	2530	250	0.01	0.01 - 0.11	0.01	0.01 - 0.11	0.01	0.01 - 0.10
El Rito	SA 44	13S	389033	4033016	2672	260	0.01	0.01 - 0.10	0.01	0.01 - 0.10	0.01	0.01 - 0.10
Canjilon	SA 45	13S	376080	4029303	2501	290	0	0 - 0.09	0.01	0.01 - 0.10	0.01	0.01 - 0.12
El Rito	SA 49	13S	385695	4025457	2546	210	0	0 - 0.09	0	0 - 0.09	0	0 - 0.09
El Rito	SA 50	13S	383147	4025372	2613	270	0	0 - 0.09	0	0 - 0.09	0	0 - 0.09
El Rito	SA 52	13S	383674	4023474	2490	150	0	0 - 0.09	0	0 - 0.09	0	0 - 0.09
Camino Real	SA 55	13S	450278	4009371	2732	130	0	0 - 0.09	0	0 - 0.09	0.01	0.01 - 011
Camino Real	SA 56	13S	443990	4005753	2544	135	0	0 - 0.09	0.01	0.01 - 0.10	0.01	0.01 - 011
Camino Real	SA 59	13S	430040	3991180	2539	170	0.01	0.01 - 0.12	0.01	0.01 - 0.10	0.01	0.01 - 0.13